

CORRIGENDUM No. 7

Tender No. CMRL / PHASE 1 / SYS / ARE05 / 2025

**DESIGN, MANUFACTURE, SUPPLY, TESTING, COMMISSIONING OF STANDARD
GAUGE METRO ROLLING STOCK (ELECTRICAL MULTIPLE UNITS) AND DEPOT
MACHINERY & PLANT AND TRAINING OF PERSONNEL**

The Tender Documents for tender No. CMRL / PHASE 1 / SYS / ARE05 / 2025, revised as Revision 02, incorporating all the modifications from Addendum No.1, Addendum No. 2 and Addendum No.3, is being uploaded through this corrigendum.

APPROVED BY COMPETENT AUTHORITY

CMRL



CHENNAI METRO RAIL LIMITED

CHENNAI METRO RAIL PROJECT PHASE 1

BIDDING DOCUMENT

for

Procurement of

**“DESIGN, MANUFACTURE, SUPPLY, TESTING,
COMMISSIONING OF STANDARD GAUGE METRO ROLLING
STOCK (ELECTRICAL MULTIPLE UNITS) AND DEPOT
MACHINERY & PLANT AND TRAINING OF PERSONNEL.”**

IFB No. : CMRL / PHASE 1 / SYS / ARE05 / 2025

Employer : Chennai Metro Rail Limited

Country : India

Project : Chennai Metro Rail Project – Phase 1

Tender No. : ARE05



CHENNAI METRO RAIL LIMITED

CHENNAI METRO RAIL PROJECT PHASE 1

Tender No. ARE05

**DESIGN, MANUFACTURE, SUPPLY, TESTING,
COMMISSIONING OF STANDARD GAUGE METRO
ROLLING STOCK (ELECTRICAL MULTIPLE UNITS)
AND DEPOT MACHINERY & PLANT AND TRAINING
OF PERSONNEL.**

PART 1: BIDDING PROCEDURES

(SINGLE STAGE TWO ENVELOPE BIDDING)

~~NOV 2025~~ ~~APR 2026~~ JUN 2026



CHENNAI METRO RAIL LIMITED

CHENNAI METRO RAIL PROJECT PHASE 1

Tender No. ARE05

BIDDING DOCUMENTS

PART 1	Bidding Procedures
	Section - I Instructions to Bidders (ITB) Section - II Bid Data Sheet (BDS) Section - III Evaluation and Qualification Criteria (EQC) Section - IV Bidding Forms (BF) Section - V Eligible Source Countries (ESC)
PART 2	Employer's Requirements
	Section – VI A Employer's Requirements Technical Specifications (ERTS) – Rolling Stock (RS). Section – VI B Employer's Requirements Technical Specifications (ERTS) – Depot Machinery & Plant (DM&P).
PART 3	Conditions of Contract and Contract Forms
	Section - VII General Conditions of Contract (GCC) Section - VIII Particular Conditions of Contract (PCC) Section – IX Annex to PCC – Contract Forms (CF)

REVISION HISTORY

Rev. No.	Section	Description
0	All	Version Published in CPP
1	BDS EQC BF	As per Addendum No.1: BDS ITB Clause - 1.1, 43.2, 45 EQC Clause - 2.5 Item No. 1 to 10 BF Clause - 4.1.14, 4.1.20, 4.1.30, 4.2, 4.3.2, 4.4.1, 4.4.6, 4.4.9, 4.4.10, 4.4.10.6, 5.15, 6.13, 11, 15
	EQC BF	As per Addendum No.2: EQC Clause - 2.5 Item No.2 BF – 5.15
2	BDS BF	As per Addendum No.3: BDS ITB Clause – 7.1, Annexure to BDS (16) BF Clause – 2, 3.2.1, 3.2.2 (h), 4.4.6



CHENNAI METRO RAIL LIMITED

CHENNAI METRO RAIL PROJECT PHASE 1

Tender No. ARE05

**DESIGN, MANUFACTURE, SUPPLY, TESTING,
COMMISSIONING OF STANDARD GAUGE METRO
ROLLING STOCK (ELECTRICAL MULTIPLE UNITS)
AND DEPOT MACHINERY & PLANT AND TRAINING
OF PERSONNEL.**

PART 1 : BIDDING PROCEDURES

SECTION - I : INSTRUCTION TO BIDDERS (ITB)

~~NOV 2025~~ APR 2026 JUN 2026

TABLE OF CONTENTS

A. General	1
1. Scope of Bid.....	1
2. Source of Funds	1
3. Corrupt and Fraudulent Practices.....	1
4. Eligible Bidders	1
5. Eligible Plant, material and Services.....	2
B. Contents of Bidding Documents.....	3
6. Sections of Bidding Documents	3
7. Clarification of Bidding Documents, Site Visit, Pre-Bid Meeting	3
8. Amendment of Bidding Documents.....	4
C. Preparation of Bids	5
9. Cost of Bidding	5
10. Language of Bid	5
11. Documents Comprising the Bid	5
12. Letter of Bid and Schedules	5
13. Alternatives Bids	6
14. Documents Establishing the Eligibility of Plant, Materials and Services	6
15. Documents Establishing the Eligibility and Qualifications of the Bidder.....	6
16. Documents establishing conformity of the works.....	7
17. Technical Proposal, Subcontractors	7
18. Bid Prices and Discounts.....	8
19. Currencies of Bid and Payment.....	9
20. Period of Validity of Bids.....	9
21. Bid Security.....	9
22. Format and Signing of Bid	10
D. Submission and Opening of Bids	11
23. Submission, Sealing and Marking of Bids.....	11
24. Deadline for Submission of Bids.....	11
25. Late Bids	11
26. Withdrawal, Substitution and Modification of Bids.....	11

27.	Bid Opening	12
E.	Evaluation and Comparison of Bids.....	14
28.	Confidentiality	14
29.	Clarification of Bids	14
30.	Deviations, Reservations, and Omissions	14
31.	Preliminary Examination of Technical Bids.....	14
32.	Qualification of the Bidders	14
33.	Determination of Responsiveness of Technical Bids	15
34.	Nonmaterial Nonconformities.....	15
35.	Detailed Evaluation of Technical Bids	16
36.	Correction of Arithmetical Errors	16
37.	Conversion to Single Currency	17
38.	Evaluation of Price Bids.....	17
39.	Comparison of Bids	17
40.	Employer's Right to Accept Any Bid, and to reject any or All Bids.....	17
F.	Award of Contract	18
41.	Award Criteria.....	18
42.	Notification of Award	18
43.	Signing of Contract	18
44.	Performance Security.....	18

A. General

1. Scope of Bid	1.1 In connection with the Invitation for Bids specified in the Bid Data Sheet (BDS), the Employer, as specified in the BDS, issues these Bidding Documents (hereinafter referred to as “Bidding Documents”) for the procurement of Electrical and Mechanical Plant, and for Building and Engineering Works, Designed by the Contractor as specified in Section VI, Employer’s Requirements. The name, identification and number of the lot(s) (contract(s)) comprising this International Competitive Bidding (ICB) are specified in the BDS. 1.2 Throughout these Bidding Documents: (a) the term “in writing” means communicated in written form and delivered against receipt; (b) except where the context requires otherwise, words indicating the singular also include the plural and words indicating the plural also include the singular; and (c) “day” means calendar day;
2. Source of Funds	2.1 The Employer will fund this work.
3. Corrupt and Fraudulent Practices	3.1 The Bidders and Contractors under contracts shall observe the highest standard of ethics during the procurement and execution of such contracts. In pursuance of this policy, The Employer: (a) will reject a proposal for award if it determines that the Bidder recommended for award has engaged in corrupt or fraudulent practices in competing for the contract in question. (b) will recognize a Bidder or Contractor as ineligible, for a period determined by the Employer, to be awarded a contract if it at any time determines that the Bidder or the Contractor has engaged in any corrupt or fraudulent practice in competing for, or in executing, and;
4. Eligible Bidders	4.1 A Bidder may be a firm that is a single entity or any combination of such entities in the form of a joint venture (JV) under an existing agreement or with the intent to enter into such an agreement supported by a letter of intent. In the case of a JV: (a) all members shall be jointly and severally liable for the execution of the Contract in accordance with the Contract terms, and (b) the JV shall nominate a Representative who shall have the authority to conduct all business for and on behalf of any and all the members of the JV during the bidding process and, in the event the JV is awarded the Contract, during Contract execution. 4.2 A Bidder shall not have a conflict of interest. A Bidder shall not be employed under any of the circumstances set forth below throughout the bidding/selection process and/or the execution of the Contract unless the conflict has been resolved in a manner acceptable to the Employer. (a) A firm shall be disqualified from providing goods or non- consulting services resulting from or directly related to consulting services for the preparation

or implementation of a project that it provided or were provided by any affiliate that directly or indirectly controls, is controlled by, or is under common control with that firm. This provision does not apply to the various firms (consultants, contractors, or suppliers) only due to the reason that those firms together are performing the Contractor's obligations under a turnkey or design and build contract. together are performing the Contractor's obligations under a turnkey or design and build contract.

- (b) A firm that has a close business relationship with the Employer's personnel, who are directly or indirectly involved in any part of:
 - (i) the preparation of the Prequalification Document (if any prepared) and/or the Bidding Document for the Contract,
 - (ii) the prequalification evaluation (if any conducted) and/or the Bid evaluation, or
 - (iii) the supervision of such contract, shall be disqualified.
- (c) Based on the "One Bid Per Bidder" principle, which is to ensure fair competition, a firm and any affiliate that directly or indirectly controls, is controlled by, or is under common control with that firm shall not be allowed to submit more than one Bid, either individually as a single firm or as a member of a JV. A firm (including its affiliate), if acting in the capacity of a subcontractor in one Bid, may participate in other Bids, only in that capacity.
- (d) A firm having any other form of conflict of interest other than (a) through (c) above shall also be disqualified.

- 4.3 The Bidder shall meet the requirements as to eligibility of the Bidders as specified in Section V, Eligible Source Countries
- 4.4 The Bidder that has been determined to be ineligible by the Employer in accordance with ITB 3.1 shall not be eligible to be awarded a Contract.
- 4.5 This bidding is open only to the prequalified Bidders unless **specified in the BDS.**
- 4.6 The Bidder shall provide such evidence of its continued eligibility satisfactory to the Employer, as the Employer shall reasonably request.

5. Eligible Plant, material and Services

- 5.1 The Plant, Material and Services to be supplied under the Contract shall meet the requirements specified in Section V, Eligible Source Countries.
- 5.2 For purposes of ITB 5.1 above, "origin" means the place where the plant, or component parts thereof are mined, grown, produced or manufactured, and from which the services are provided. Plant components are produced when, through manufacturing, processing, or substantial or major assembling of components, a commercially recognized product results that is substantially different in its basic characteristics or in purpose or utility from its components.

B. Contents of Bidding Documents

- 6. Sections of Bidding Documents**
- 6.1 The Bidding Documents consist of Parts 1, 2, and 3, which include all the Sections specified below, and should be read in conjunction with any Addenda issued in accordance with ITB 8.
- PART 1 Bidding Procedures**
- Section I. Instructions to Bidders (ITB)
 - Section II. Bid Data Sheet (BDS)
 - Section III. Evaluation and Qualification Criteria (EQC)
 - Section IV. Bidding Forms
 - Section V. Eligible Source Countries
- PART 2 Employer's Requirements**
- Section VI. Employer's Requirements
- PART 3 Conditions of Contract and Contract Forms**
- Section VII. General Conditions (GC)
 - Section VIII. Particular Conditions (PC)
 - Section IX. Annex to the Particular Conditions - Contract Forms
- 6.2 The Invitation for Bids issued by the Employer is not part of the Bidding Documents.
- 6.3 Unless obtained directly from the Employer, the Employer is not responsible for the completeness of the Bidding Documents, responses to requests for clarification, the minutes of the pre-bid meeting (if any), or Addenda to the Bidding Documents in accordance with ITB 8. In case of any contradiction, documents obtained directly from the Employer shall prevail.
- 6.4 The Bidder is expected to examine all instructions, forms, terms, and Employer's Requirement in the Bidding Documents, and to furnish with its Bid all information and documentation as is required by the Bidding Documents.
- 7. Clarification of Bidding Documents, Site Visit, Pre-Bid Meeting**
- 7.1 A Bidder requiring any clarification of the Bidding Documents shall contact the Employer in writing at the Employer's address **specified in the BDS** or raise his enquiries during the pre-bid meeting if provided for in accordance with ITB 7.4. The Employer will respond in writing to any request for clarification, provided that such request is received no later than fourteen (14) days prior to the deadline for submission of Bids. The Employer shall forward copies of its response to all Bidders who have acquired the Bidding Documents in accordance with ITB 6.3, including a description of the inquiry but without identifying its source. If so **specified in the BDS**, the Employer shall also promptly publish its response at the web page **identified in the BDS**. Should the clarification result in changes to the essential elements of the Bidding Documents, the Employer shall amend the Bidding Documents following the procedure under ITB 8 and ITB 24.2.
- 7.2 The Bidder is advised to visit and examine the Site and its surroundings and obtain for itself on its own responsibility all information that may be necessary for preparing the Bid and entering into a contract for construction of the Works.

- The costs of visiting the site shall be at the Bidder's own expense.
- 7.3 The Bidder and any of its personnel or agents will be granted permission by the Employer to enter upon its premises and lands for the purpose of such visit, but only upon the express condition that the Bidder, its personnel, and agents will release and indemnify the Employer and its personnel and agents from and against all liability in respect thereof, and will be responsible for death or personal injury, loss of or damage to property, and any other loss, damage, costs, and expenses incurred as a result of the inspection.
- 7.4 The Bidder's designated representative is invited to attend a pre-bid meeting, if so **specified in the BDS**. The purpose of the meeting will be to clarify issues and to answer questions on any matter that may be raised at that stage. A site visit will be conducted by the Employer at the time of the pre-bid meeting, if so **specified in the BDS**.
- 7.5 The Bidder is requested to submit any questions in writing, to reach the Employer not later than one (1) week before the meeting.
- 7.6 Minutes of the pre-bid meeting, if applicable, including the text of the questions asked by Bidders, without identifying the source, and the responses given, together with any responses prepared after the meeting, will be transmitted promptly to all Bidders who have acquired the Bidding Documents in accordance with ITB 6.3. Any modification to the Bidding Documents that may become necessary as a result of the prebid meeting shall be made by the Employer exclusively through the issue of an addendum pursuant to ITB 8 and not through the minutes of the pre-bid meeting. Nonattendance at the pre-bid meeting will not be a cause for disqualification of a Bidder.
- 8. Amendment of Bidding Documents**
- 8.1 At any time prior to the deadline for submission of Bids, the Employer may amend the Bidding Documents by issuing addenda.
- 8.2 Any addendum issued shall be part of the Bidding Documents and shall be communicated in writing to all who have obtained the Bidding Documents from the Employer in accordance with ITB 6.3. If so **specified in the BDS**, the Employer shall also promptly publish the addendum on the Employer's webpage in accordance with ITB 7.1.
- 8.3 To give Bidders reasonable time in which to take an addendum into account in preparing their Bids, the Employer may extend the deadline for the submission of Bids, pursuant to ITB 24.2.

C. Preparation of Bids

- 9. Cost of Bidding** 9.1 The Bidder shall bear all costs associated with the preparation and submission of its Bid, and the Employer shall not be responsible or liable for those costs, regardless of the conduct or outcome of the bidding process.
- 10. Language of Bid** 10.1 The Bid, as well as all correspondence and documents relating to the Bid exchanged by the Bidder and the Employer, shall be written in the language **specified in the BDS**. Supporting documents and printed literature that are part of the Bid may be in another language provided they are accompanied by an accurate translation of the relevant passages in the language of Bid, in which case, for purposes of interpretation of the Bid, such translation shall govern.
- 11. Documents Comprising the Bid** 11.1 The Bid shall comprise two envelopes submitted simultaneously, one called the Technical Bid containing the documents listed in ITB 11.2 and the other the Price Bid containing the documents listed in ITB 11.3, both envelopes enclosed together in an outer single envelope.
- 11.2 The Technical Bid submitted by the Bidder shall comprise the following:
- (a) Letter of Technical Bid;
 - (b) Bid Security, in accordance with ITB 21;
 - (c) Written confirmation/Power of Attorney, authorizing the signatory of the Bid to commit the Bidder, in accordance with ITB 22.2;
 - (d) in the case of a Bid submitted by a JV, a copy of the JV agreement, or letter of intent, signed by all members, to enter into a JV including a draft agreement, indicating at least the parts of the Plant to be executed by the respective members;
 - (e) documentary evidence establishing in accordance with ITB 14 that the Works offered by the Bidder in its Bid or in any alternative Bid, if permitted, are eligible;
 - (f) documentary evidence in accordance with ITB 15 establishing the Bidder's eligibility and qualifications to perform the Contract if its Bid is accepted;
 - (g) Technical Proposal in accordance with ITB 17;
 - (h) documentary evidence establishing in accordance with ITB 16 that the Works offered by the Bidder conform to the Bidding Documents;
 - (i) alternative Bids, if permissible, in accordance with ITB 13
 - (j) list of Subcontractors, in accordance with ITB 17.2 and 17.3; and
 - (k) Any other document **required in the BDS**
- 11.3 The Price Bid submitted by the Bidder shall comprise the following:
- (a) Letter of Price Bid;
 - (b) completed Price Schedules, in accordance with ITB 12 and 18;
 - (c) alternative Price Bids, at the Bidder's option and if permissible, in accordance with ITB 13; and
 - (d) any other document **required in the BDS**.
- 12. Letter of Bid** 12.1 The Bidder shall complete the Letters of Technical Bid and Price Bid, including the appropriate Technical and Price Schedules, using the relevant forms

- and Schedules** furnished in Section IV, Bidding Forms. The forms must be completed without any alterations to the text, and no substitutes shall be accepted except as provided under ITB 22.2. All blank spaces shall be filled in with the information requested.
- 13. Alternatives Bids**
- 13.1 **The BDS indicates** whether alternative Bids are allowed. If they are allowed, **the BDS will also indicate** whether they are permitted in accordance with ITB 13.3, **or** invited in accordance with ITB 13.2 and/or ITB 13.4.
- 13.2 When alternatives to the Time for Completion of the whole of the Works or the sections are explicitly invited, a statement to that effect will be **included in the BDS**, and the method of evaluating different time schedules will be described in Section III, Evaluation and Qualification Criteria.
- 13.3 Except as provided under ITB 13.4 below, Bidders wishing to offer technical alternatives to the Employer's Requirements as described in the Bidding Documents must also provide: (i) a price at which they are prepared to offer such alternative meeting the Employer's Requirements; and (ii) all information necessary for a complete evaluation of the alternatives by the Employer, including drawings, design calculations, technical information (particulars), breakdown of prices, and proposed installation methodology and other relevant details. Only the technical alternatives, if any, of the lowest evaluated Bidder conforming to the basic technical requirements shall be considered by the Employer.
- 13.4 When Bidders are **invited in the BDS** to submit alternative technical solutions for specified parts of the Works, such parts shall be described in Section IV, Employer's Requirements. Technical alternatives that comply with the performance and technical criteria specified for the Works shall be considered by the Employer on their own merits, pursuant to ITB 35.2.
- 14. Documents Establishing the Eligibility of Plant, Materials and Services**
- 14.1 To establish the eligibility of Plant, Materials and Services in accordance with ITB 5, Bidders shall complete the country of origin declarations in the Price Schedule Forms, included in Section IV, Bidding Forms.
- 15. Documents Establishing the Eligibility and Qualifications of the Bidder**
- 15.1 In accordance with Section III, Evaluation and Qualification Criteria, if the prequalification process was conducted prior to the bidding process, the Bidder shall provide in the corresponding information sheets included in Section IV, Bidding Forms, (i) updated information on any assessed aspect that changed from that time to establish that the Bidder continues to meet the criteria used at the time of prequalification and (ii) the requested information on the additional qualification criteria stated in Section III, Evaluation and Qualification Criteria, or if the assessment of qualification criteria was not conducted prior to the bidding process, the Bidder shall provide the information requested in the corresponding information sheets included in Section IV, Bidding Forms.
- 15.2 Any change in the structure or formation of a Bidder after being prequalified and invited to bid (including, in the case of a JV, any change in the structure or formation of any member thereto) shall be subject to the written approval of the Employer prior to the deadline for submission of Bids. Such approval shall be denied if (i) such change has not taken place by the free choice of the firms involved; (ii) as a consequence of the change, the Bidder no longer substantially meets the qualification criteria set forth in the Prequalification Documents; or

- (iii) in the opinion of the Employer, the change may result in a substantial reduction in competition. Any such change should be submitted to the Employer not later than fourteen (14) days after the date of the Invitation for Bids.
- 16. Documents establishing conformity of the works**
- 16.1 The documentary evidence of the conformity of the Works with the Bidding Documents may be in the form of literature, drawings and data, and shall include:
- (a) a detailed description of the essential technical and performance characteristics of the Plant, including the Schedule of Guarantees of the proposed Plant, in response to the Employer's Requirement. The Schedule of Guarantees of the proposed Plant shall be stated in the applicable form in Section IV, Bidding Forms;
 - (b) a list giving full particulars, including available sources, of all spare parts, special tools, etc., necessary for the proper and continuing functioning of the Plant for the period **specified in the BDS**, following completion of the Works in accordance with the provisions of Contract; and
 - (c) Adequate evidence demonstrating the substantial responsiveness of the Works to those Employer's Requirements. Bidders shall note that standards for workmanship, materials and equipment designated by the Employer in the Bidding Documents are intended to be descriptive (establishing standards of quality and performance) only and not restrictive. The Bidder may substitute alternative standards, brand names and/or catalog numbers in its Technical Proposal, provided that it demonstrates to the Employer's satisfaction that the alterations are substantially equivalent or superior to the standards designated in the Employer's Requirement.
- 17. Technical Proposal, Subcontractors**
- 17.1 The Bidder shall furnish a Technical Proposal, including a statement of work methods, equipment, personnel, schedule, safety plan, and any other information as stipulated in Section IV, Bidding Forms in sufficient detail to demonstrate substantial responsiveness of the Bidder's proposal to the Employer's Requirements and the completion time.
- 17.2 For major items of the Works as listed by the Employer in Section III, Evaluation and Qualification Criteria, which the Bidder intends to purchase or subcontract, the Bidder shall give details of the name and nationality of the proposed Subcontractors, including manufacturers, for each of those items. In addition, the Bidder shall include in its Technical Proposals information establishing compliance with the requirements specified by the Employer for these items. Bidders are free to list more than one Subcontractor against each item of the Works. Quoted rates and prices will be deemed to apply to whichever Subcontractor is appointed, and no adjustment of the rates and prices will be permitted.
- 17.3 The Bidder shall be responsible for ensuring that any Subcontractor proposed complies with the requirements of ITB 4, and that any Works to be provided by the Subcontractor comply with the requirements of ITB 5 and ITB 16.1.
- 17.4 Unless otherwise **stated in the BDS**, the Employer does not intend to execute any specific elements of the Works by subcontractors selected in advance by the Employer (nominated subcontractors).
- 17.5 In case Prequalification was not conducted prior to the bidding process, Bidders planning to subcontract any of the key activities indicated in Section III, Evaluation and Qualification Criteria, shall clearly identify the proposed

- specialist subcontractor(s) in Forms ELI-2 and EXP-2(b) in Section IV, Bidding Forms. Such proposed specialist subcontractors(s) shall meet the corresponding qualification requirements specified in Section III, Evaluation and Qualification Criteria.
- 17.6 In case Prequalification was conducted prior to the bidding process, the Bidder's Bid shall name the same specialist subcontractor(s) whose experience in the key activities was evaluated in the Prequalification, unless such change is explicitly unless such change is explicitly approved by the Employer in accordance with ITB 15.2.
- 18. Bid Prices and Discounts**
- 18.1 **Unless otherwise specified in the BDS**, Bidders shall quote for the Works such that the total Bid Price covers all the Contractor's obligations mentioned in or to be reasonably inferred from the Bidding Documents in respect of the design, manufacture, including procurement and subcontracting (if any), delivery, construction, installation and completion of the Works. This includes all requirements under the Contractor's responsibilities for testing, pre-commissioning and commissioning of the plant and, where so required by the Bidding Documents, the acquisition of all permits, approvals and licenses, etc.; the operation, maintenance and training services and such other items and services as may be specified in the Bidding Documents, all in accordance with the requirements of the General Conditions. Items against which no price is entered by the Bidder will not be paid for by the Employer when executed and shall be deemed to be covered by the prices for other items.
- 18.2 Bidders are required to quote the price for the commercial, contractual and technical obligations outlined in the Bidding Documents.
- 18.3 Bidders shall provide price in each item in the manner and detail called for in the Price Schedules included in Section IV, Bidding Forms. Further, Bidders may add breakdowns of items and provide the prices in each Price Schedule included in Section IV, Bidding Forms.
- 18.4 The price to be offered in the Letter of Bid, in accordance with ITB 12.1, shall be the total **price of the Bid, excluding any discounts that may be offered**.
- 18.5 **Unless otherwise specified in the BDS and the Contract**, the prices offered by the Bidder are subject to adjustment during the performance of the Contract in accordance with the provisions of the Conditions of Contract. In such a case, the Bidder shall furnish the indices and weightings for the price adjustment formulae in the Schedule of Adjustment Data and the Employer may require the Bidder to justify its proposed indices and weightings.
- 18.6 If so specified in BDS 1.1, Bids are being invited for individual lots (contracts) or for any combination of lots (packages). Bidders wishing to offer discounts for the award of more than one Contract shall specify in their Bid the price reductions applicable to each package, or alternatively, to individual Contracts within the package. Discounts shall be submitted in accordance with ITB 18.4, provided the Bids for all lots (contracts) are opened at the same time.
- 18.7 **Unless otherwise provided in the BDS**, all duties, taxes, and other levies payable by the Contractor under the Contract, or for any other cause, as of the date twenty-eight (28) days prior to the deadline for submission of Bids, shall be included in the rates and prices and the total Bid Price submitted by the Bidder.
- 18.8 Bidders wishing to offer any unconditional discount shall specify in their Letter

- of Price Bid the offered discounts and the manner in which price discounts will apply.
- 19. Currencies of Bid and Payment**
- 19.1 The currency (ies) of the Bid shall be, as **specified in the BDS**. Payment of the Contract Price shall be made in the currency or currencies in which the Bid Price is expressed in the Bid of the successful Bidder.
- 19.2 Bidder may be required by the Employer to justify, to the Employer's satisfaction, their local and foreign currency requirements.
- 20. Period of Validity of Bids**
- 20.1 Bids shall remain valid for the period **specified in the BDS** after the Bid submission deadline date prescribed by the Employer pursuant to ITB 24.1. A Bid valid for a shorter period shall be rejected by the Employer as non-responsive.
- 20.2 In exceptional circumstances, prior to the expiration of the Bid validity period, the Employer may request Bidders to extend the period of validity of their Bids. The request and the responses shall be made in writing. The Bid Security shall also be extended for twenty-eight (28) days beyond the deadline of the extended validity period. A Bidder may refuse the request without forfeiting its Bid Security. A Bidder granting the request shall not be required or permitted to modify its Bid, except as provided in ITB 20.3.
- 20.3 If the award is delayed by a period exceeding fifty-six (56) days beyond the expiry of the initial Bid validity, the Contract Price shall be determined as follows:
- (a) In the case of Fixed Price Contracts, the Contract Price shall be the Bid Price adjusted by the factor **specified in the BDS**.
 - (b) In the case of Adjustable Price Contracts, to determine the Contract Price, the fixed portion of the Bid Price shall be adjusted by the factor **specified in the BDS**.
 - (c) In any case, Bid evaluation shall be based on the Bid Price without taking into consideration the effect of the corrections indicated above.
- 21. Bid Security**
- 21.1 The Bidder shall furnish as part of its Technical Bid, a Bid Security in the amount and currency **specified in the BDS**.
- 21.2 The Bid Security shall be a demand guarantee in any of the following forms at the Bidder's option:
- (a) an unconditional guarantee issued by a bank or financial institution (such as an insurance, bonding or surety company);
 - (b) an irrevocable letter of credit;
 - (c) a cashier's or certified check; or
 - (d) another security **specified in the BDS**,
- from a reputable source from an eligible source country. If the unconditional guarantee is issued by an insurance company or a bonding company located outside the Employer's Country, the issuer shall have a correspondent financial institution located in the Employer's Country to make it enforceable. In the case of a bank guarantee, the Bid Security shall be submitted either using the Bid Security Form included in Section IV, Bidding Forms or in another substantially similar format approved by the Employer prior to Bid submission. In either case, the form must include the complete name of the Bidder. The Bid Security shall be valid for twenty-eight (28) days beyond the original validity period of the Bid,

or beyond any period of extension if requested under ITB 20.2.

- 21.3 Any Bid not accompanied by a substantially responsive Bid Security shall be rejected by the Employer as non-responsive.
- 21.4 The Bid Security of unsuccessful Bidders shall be returned as promptly as possible upon the Bidder is determined disqualified or in case the Bidder pass the technical evaluation.
- 21.5 The Bid Security of the successful Bidder shall be returned as promptly as possible once the successful Bidder has signed the Contract and furnished the required Performance Security.
- 21.6 The Bid Security may be forfeited:
 - (a) if a Bidder withdraws its Bid during the period of Bid validity specified by the Bidder on the Letters of Technical Bid and Price Bid, or any extension thereto provided by the Bidder; or
 - (b) if the successful Bidder fails to:
 - (i) sign the Contract in accordance with ITB 43; or
 - (ii) furnish a Performance Security in accordance with ITB 44.
- 21.7 The Bid Security of a JV shall be in the name of the JV that submits the Bid. If the JV has not been legally constituted into a legally enforceable JV at the time of bidding, the Bid Security shall be in the names of all future members as named in the letter of intent referred to in ITB 4.1 and ITB 11.2.

22. Format and Signing of Bid

- 22.1 The Bidder shall prepare one original of the Technical Bid and one original of the Price Bid as described in ITB 11 and clearly mark it “TECHNICAL BID - ORIGINAL” and “PRICE BID - ORIGINAL”. Alternative Bids, if permitted in accordance with ITB 13, shall be clearly marked “ALTERNATIVE”. In addition, the Bidder shall submit copies of the Technical and Price Bids, in the number **specified in the BDS** and clearly mark them “COPY”. In the event of any discrepancy between the original and the copies, the original shall prevail.
- 22.2 The original and all copies of the Bid shall be typed or written in indelible ink and shall be signed by a person duly authorized to sign on behalf of the Bidder. This authorization shall consist of a written confirmation as specified in the BDS and shall be attached to the Bid. The name and position held by each person signing the authorization must be typed or printed below the signature. All pages of the Bid where entries or amendments have been made shall be signed or initialed by the person signing the Bid.
- 22.3 In case the Bidder is a JV, the Bid shall be signed by an authorized representative of the JV on behalf of the JV, and so as to be legally binding on all the members as evidenced by a power of attorney signed by their legally authorized representatives.
- 22.4 Any interlineations, erasures, or overwriting shall be valid only if they are signed or initialed by the person signing the Bid.

D. Submission and Opening of Bids

23. Submission, Sealing and Marking of Bids	23.1 Bidders may submit their Bids by mail or by hand. Procedures for submission, sealing and marking are as follows: Bidders shall enclose the original of the Technical Bid, the original of the Price Bid, and each copy of the Technical Bid and of the Price Bid, including alternative Bids, if permitted in accordance with ITB 13, in separate sealed envelopes, duly marking the envelopes as “TECHNICAL BID - ORIGINAL”, “PRICE BID - ORIGINAL”, “TECHNICAL BID - COPY”, “PRICE BID - COPY”, and “ALTERNATIVE” as appropriate. These envelopes containing the original, the copies and the alternative(s), if any, shall then be enclosed in one single envelope. The rest of the procedure shall be in accordance with ITB 23.2 through 23.5 23.2 The inner and outer envelopes shall: (a) bear the name and address of the Bidder; (b) be addressed to the Employer in accordance with ITB 24.1; and (c) bear the specific identification of this bidding process specified in BDS 1.1 23.3 The outer envelopes and the inner envelopes containing the Technical Bid shall bear a warning not to open before the time and date for the opening of Technical Bids, in accordance with ITB 27.1. 23.4 The inner envelopes containing the Price Bid shall bear a warning not to open until advised by the Employer in accordance with ITB 27.7. 23.5 If all envelopes are not sealed and marked as required, the Employer will assume no responsibility for the misplacement or premature opening of the Bid.
24. Deadline for Submission of Bids	24.1 Bids must be received by the Employer at the address and no later than the date and time specified in the BDS. 24.2 The Employer may, at its discretion, extend the deadline for the submission of Bids by amending the Bidding Documents in accordance with ITB 8, in which case all rights and obligations of the Employer and Bidders previously subject to the deadline shall thereafter be subject to the deadline as extended.
25. Late Bids	25.1 The Employer shall not consider any Bid that arrives after the deadline for submission of Bids, in accordance with ITB 24. Any Bid received by the Employer after the deadline for submission of Bids shall be declared late, rejected, and returned unopened to the Bidder.
26. Withdrawal, Substitution and Modification of Bids	26.1 A Bidder may withdraw, substitute, or modify its Bid Technical or Price after it has been submitted by sending a written notice, duly signed by an authorized representative, and shall include a copy of the authorization in accordance with ITB 22.2, (except that withdrawal notices do not require copies). The corresponding substitution or modification of the Bid must accompany the respective written notice. All notices must be: (a) prepared and submitted in accordance with ITB 22 and ITB 23 (except that withdrawals notices do not require copies), and in addition, the respective envelopes shall be clearly marked “WITHDRAWAL”, “SUBSTITUTION”, “MODIFICATION”, and

(b) received by the Employer prior to the deadline prescribed for submission of Bids, in accordance with ITB 24.

26.2 Bids requested to be withdrawn in accordance with ITB 26.1 shall be returned unopened to the Bidders.

26.3 No Bid may be withdrawn, substituted, or modified in the interval between the deadline for submission of Bids and the expiration of the period of Bid validity specified by the Bidder on the Letters of Technical Bid and Price Bid or any extension thereof.

27. Bid Opening

27.1 Except in the cases specified in ITB 25 and ITB 26, the Employer shall publicly open and read out in accordance with ITB 27.5 all Technical Bids received by the deadline, at the date, time and place **specified in the BDS**, in the presence of Bidders' designated representatives and anyone who choose to attend. The Price Bids will remain unopened and will be held in custody of the Employer until the time of their opening to be specified in accordance with ITB 27.7.

27.2 First, envelopes marked "WITHDRAWAL" shall be opened and read out and the envelope with the corresponding Bid shall not be opened, but returned to the Bidder. No Bid withdrawal shall be permitted unless the corresponding withdrawal notice contains a valid authorization to request the withdrawal and is read out at the opening of Technical Bids.

27.3 Second, outer envelopes marked "SUBSTITUTION" shall be opened. The inner envelopes containing the Substitution Technical Bid and/or Substitution Price Bid shall be exchanged with for the corresponding envelopes being substituted, which are to be returned to the Bidder unopened. Only the Substitution Technical Bid, if any, shall be opened and read out. Substitution Price Bid will remain unopened in accordance with ITB 27.1. No envelope shall be substituted unless the corresponding substitution notice contains a valid authorization to request the substitution and is read out at the opening of Technical Bids.

27.4 Next, outer envelopes marked "MODIFICATION" shall be opened. No Technical Bid and/or Price Bid shall be modified unless the corresponding modification notice contains a valid authorization to request the modification and is read out at the opening of Technical Bids. Only the Technical Bids, both Original as well as Modification, are to be opened and read out at the opening. Price Bids, both Original as well as Modification, will remain unopened in accordance with ITB 27.1

27.5 All other envelopes holding the Technical Bids shall be opened one at a time, reading out:

- (a) The name of the Bidder;
- (b) whether there is a modification;
- (c) the presence or absence of the Bid Security; and
- (d) any other details as the Employer may consider appropriate.

Only Technical Bids and alternative Technical Bids read out at Bid opening shall be considered for evaluation. The Employer shall neither discuss the merits of any Bid nor reject any Bid (except for late Bids, in accordance with ITB 25.1).

27.6 The Employer shall prepare a record of the opening of Technical Bids that shall include, as a minimum: the name of the Bidder and whether there is a withdrawal, substitution, or modification; alternative proposals; and the presence or absence of a Bid Security. The Bidder's Representative who are present shall be

requested to sign the record. The omission of a Bidder's signature on the record shall not invalidate the contents and effect of the record. A copy of the record shall be distributed to all Bidders.

- 27.7 At the end of the evaluation of Technical Bids, the Employer will invite Bidders who have submitted substantially responsive Technical Bids and who have been determined as being qualified for award to attend the opening of the Price Bids. The date, time, and location of the opening of Price Bids will be advised in writing by the Employer. The opening date should allow Bidders sufficient time to make arrangements for attending the opening.
- 27.8 The Employer will notify, in writing, Bidders who have been rejected on the grounds of their Technical Bids being substantially non-responsive to the requirements of the Bidding Documents and return their Bid security and Price Bids unopened.
- 27.9 The Employer shall conduct the opening of Price Bids of all Bidders who submitted substantially responsive Technical Bids, in the presence of Bidders' representatives who choose to attend at the address, date and time specified by the Employer. The Bidders' representatives who are present shall be requested to sign a register evidencing their attendance.
- 27.10 All envelopes containing Price Bids shall be opened one at a time, reading out:
- (a) the name of the Bidder;
 - (b) whether there is a modification;
 - (c) the Bid Price(s), including any discounts and alternative Bids; and
 - (d) any other details as the Employer may consider appropriate.
- Only Price Bids discounts, and alternative bids read out and recorded during the opening of Price Bids shall be considered for evaluation. No Bid shall be rejected at the opening of Price Bids.
- 27.11 The Employer shall prepare a record of the opening of Price Bids that shall include, as a minimum: the name of the Bidder, the Bid Price, (per lot if applicable), including any discounts, and alternative Bids. The Bidder's Representative who are present shall be requested to sign the record. The omission of a Bidder's Signature on the record shall not invalidate the contents and effect of the record. A copy of the record shall be distributed to all Bidders.

E. Evaluation and Comparison of Bids

28. Confidentiality	28.1 Information relating to the evaluation of Bids and recommendation of Contract award, shall not be disclosed to Bidders or any other persons not officially concerned with such process until information on Contract award is communicated to all Bidders in accordance with ITB 42. 28.2 Any attempt by a Bidder to influence the Employer in the evaluation of the Bids or Contract award decisions may result in the rejection of its Bid. 28.3 Notwithstanding ITB 28.2, from the time of Bid opening to the time of Contract award, if any Bidder wishes to contact the Employer on any matter related to the bidding process, it shall do so in writing.
29. Clarification of Bids	29.1 To assist in the examination, evaluation, and comparison of the Technical and Price Bids, and qualification of the Bidders, the Employer may, at its discretion, ask any Bidder for a clarification of its Bid, giving a reasonable time for a response. Any clarification submitted by a Bidder that is not in response to a request by the Employer shall not be considered. The Employer's request for clarification and the response shall be in writing. No change in the substance of the Technical Bid or prices in the Price Bid, including any voluntary increase or decrease in the prices, shall be sought, offered, or permitted, except to confirm the correction of arithmetical errors discovered by the Employer in the evaluation of the Price Bids, in accordance with ITB 36. 29.2 If a Bidder does not provide clarifications of its Bid by the date and time set in the Employer's request for clarification, its Bid may be rejected.
30. Deviations, Reservations, and Omissions	30.1 During the evaluation of Bids, the following definitions apply: (a) "Deviation" is a departure from the requirements specified in the Bidding Document; (b) "Reservation" is the setting of limiting conditions or withholding from complete acceptance of the requirements specified in the Bidding Document; and (c) "Omission" is the failure to submit part or all of the information or documentation required in the Bidding Document.
31. Preliminary Examination of Technical Bids	31.1 The Employer shall examine Technical Bids to confirm that all documents and technical documentation requested in ITB 11.2 have been provided, and to determine the completeness of each document submitted. 31.2 The Employer shall confirm that the following documents and information have been provided in the Technical Bid. If any of these documents or information is missing, the Bid shall be rejected. (a) Letter of Technical Bid; (b) Written confirmation of authorization to commit the Bidder; (c) Bid Security; and (d) Technical Proposal.
32. Qualification of the Bidders	32.1 The Employer shall determine to its satisfaction whether Bidders meet the qualification criteria specified in Section III, Evaluation and Qualification Criteria, during the evaluation of Technical Bids. However, if prequalification was carried out prior to the bidding process, the Employer may carry out the assessment of

the qualification criteria specified in Section III, Evaluation and Qualification Criteria, for the Bidder who submitted the lowest evaluated and substantially responsive Bid only.

32.2 The determination shall be based upon an examination of the documentary evidence of the Bidder's qualifications submitted by the Bidder, pursuant to ITB 15.

32.3 An affirmative determination shall be a prerequisite for award of the Contract to the Bidder. A negative determination shall result in disqualification of the Bid, in which event the Employer shall return the unopened Price Bid to the Bidder.

If the assessment of the Bidder's qualification is conducted for the lowest evaluated Bidder only, in accordance with ITB 32.1, and the result of such assessment is negative, the Employer shall proceed to the next lowest evaluated Bid to make a similar determination.

32.4 The capabilities of the manufacturers and Subcontractors proposed in its Bid to be used by the Bidder will also be evaluated for acceptability in accordance with Section III, Evaluation and Qualification Criteria. Their participation should be confirmed with a letter of intent between the parties, as needed. Should a manufacturer or Subcontractor be determined to be unacceptable, the Bid will not be rejected, but the Bidder will be required to substitute an acceptable manufacturer or Subcontractor without any change to the Bid Price. Prior to signing the Contract, the corresponding Appendix to the Contract Agreement shall be completed, listing the approved manufacturers or Subcontractors for each item concerned.

33. Determination of Responsiveness of Technical Bids

33.1 The Employer's determination of a Technical Bid's responsiveness is to be based on the contents of the Technical Bid itself, as defined in ITB 11.2.

33.2 A substantially responsive Technical Bid is one that meets the requirements of the Bidding Documents without material deviation, reservation, or omission. A material deviation, reservation, or omission is one that,

(a) if accepted, would:

(i) affect in any substantial way the scope, quality, or performance of the Works specified in the Contract; or

(ii) limit in any substantial way, inconsistent with the Bidding Document, the Employer's rights or the Bidder's obligations under the proposed Contract; or

(b) if rectified, would unfairly affect the competitive position of the other Bidders presenting substantially responsive Bids

33.3 The Employer shall examine the technical aspects of the Technical Bid submitted in accordance with ITB 17, in particular, to confirm that all requirements of Section VI, Employer's Requirements have been met without any material deviation, reservation, or omission.

33.4 If a Technical Bid is not substantially responsive to the requirements of the Bidding Documents, it shall be rejected by the Employer and may not subsequently be made responsive by correction of the material deviation, reservation, or omission.

34. Nonmaterial Nonconformities

34.1 Provided that a Technical Bid is substantially responsive, the Employer may waive any nonconformity in the Technical Bid that does not constitute a material

deviation, reservation or omission.

34.2 Provided that a Technical Bid is substantially responsive, the Employer may request that the Bidder submit the necessary information or documentation, within a reasonable period of time, to rectify nonmaterial nonconformities in the Technical Bid related to documentation requirements. Requesting information or documentation on such nonconformities shall not be related to any aspect of the price of the Price Bid. Failure of the Bidder to comply with the request may result in the rejection of its Bid.

34.3 Provided that a Technical Bid is substantially responsive, the Employer shall rectify quantifiable nonmaterial nonconformities related to the Bid Price. To this effect, the Bid Price shall be adjusted, for comparison purposes only, to reflect the price of a missing or non-conforming item or component. The adjustment shall be made using the method indicated in Section III, Evaluation and Qualification Criteria.

35. Detailed Evaluation of Technical Bids

35.1 The Employer will carry out a detailed technical evaluation of the Bids not previously rejected as being substantially non-responsive, in order to determine whether the technical aspects are in compliance with the Bidding Documents. The Bid that does not meet minimum acceptable standards of completeness, consistency and detail, and the specified minimum (or maximum, as the case may be) requirements for specified Schedule of Guarantees, will be rejected for non-responsiveness. In order to reach such a determination, the Employer will examine and compare the technical aspects of the Bids on the basis of the information supplied by the Bidders, taking into account the following:

- (a) overall completeness and compliance with the Employer's Requirements; conformity of the Works offered with specified performance criteria, corresponding to each Schedule of Guarantees, as indicated in the Technical Requirements; suitability of the Works offered in relation to the environmental and climatic conditions prevailing at the site; and quality, function and operation of any process control concept included in the Bid;
- (b) other relevant factors, if any, listed in Section III, Evaluation and Qualification Criteria.

35.2 Where alternative technical solutions have been allowed in accordance with ITB 13.4, and offered by the Bidder, the Employer will make a similar evaluation of the alternatives. Where alternatives have not been allowed but have been offered, they shall be ignored.

36. Correction of Arithmetical Errors

36.1 During the evaluation of Price Bids, the Employer shall correct arithmetical errors on the following basis:

- (a) where there are errors between the total of the amounts given under the column for the price breakdown and the amount given under the Total Price, the former shall prevail and the latter will be corrected accordingly;
- (b) if there is an error in a total corresponding to the addition or subtraction of subtotals, the subtotals shall prevail and the total shall be corrected; and
- (c) if there is a discrepancy between words and figures, the amount in words shall prevail, unless the amount expressed in words is related to an arithmetic error, in which case the amount in figures shall prevail subject to (a) and (b) above.

36.2 The Bidders shall be requested to accept correction of arithmetical errors.

- Failure to accept the correction in accordance with ITB 36.1, shall result in the rejection of the Bid.
- 37. Conversion to Single Currency** 37.1 For evaluation and comparison purposes, the currency(ies) of the Bid shall be converted into a single currency as specified in the BDS.
- 38. Evaluation of Price Bids** 38.1 The Employer shall use the criteria and methodologies indicated in this Clause. No other evaluation criteria or methodologies shall be permitted.
- 38.2 To evaluate a Price Bid, the Employer shall consider the following:
- (a) the Bid Price, excluding Provisional Sums in the Price schedules, but including Daywork items, where priced competitively;
 - (b) price adjustment for correction of arithmetic errors in accordance with ITB 36.1;
 - (c) price adjustment due to discounts offered in accordance with ITB 18.6 or ITB 18.8;
 - (d) price adjustment due to quantifiable nonmaterial nonconformities in accordance with ITB 34.3;
 - (e) converting the amount resulting from applying (a) to (d) above, if relevant, to a single currency in accordance with ITB 37; and
 - (f) the evaluation factors indicated in Section III, Evaluation and Qualification Criteria.
- 38.3 If price adjustment is allowed in accordance with ITB 18.5, the estimated effect of the price adjustment provisions of the Conditions of Contract, applied over the period of execution of the Contract, shall not be taken into account in Bid evaluation.
- 38.4 If these Bidding Documents allow Bidders to quote separate prices for different lots (contracts), and the award to a single Bidder of multiple lots (contracts), the methodology to determine the lowest evaluated price of the lot (contract) combinations, including any discounts offered in the Letter of Price Bid, is specified in Section III, Evaluation and Qualification Criteria.
- 38.5 If the Bid, which results in the lowest evaluated Bid Price, is seriously unbalanced or front loaded in the opinion of the Employer, the Employer may require the Bidder to produce detailed price analyses for any or all items of the Price Schedules, to demonstrate the internal consistency of those prices with the methods and the Price Schedules proposed. After evaluation of the price analyses, taking into consideration the Schedule of Payment, the Employer may require that the amount of the Performance Security be increased at the expense of the Bidder to a level sufficient to protect the Employer against financial loss in the event of default of the successful Bidder under the Contract.
- 39. Comparison of Bids** 39.1 The Employer shall compare the evaluated prices of all substantially responsive Bids in accordance with ITB 38.2 to determine the lowest evaluated Bid.
- 40. Employer's Right to Accept Any Bid, and to reject any or All Bids** 40.1 The Employer reserves the right to accept or reject any Bid, and to annul the bidding process and reject all Bids at any time prior to Contract award, without thereby incurring any liability to Bidders. In case of annulment, all Bids submitted and specifically, Bid Securities shall be promptly returned to the Bidders.

F. Award of Contract

41. Award Criteria	41.1 Subject to ITB 40.1, the Employer shall award the Contract to the Bidder whose offer has been determined to be the lowest evaluated Bid and is substantially responsive to the Bidding Documents, provided further that the Bidder is determined to be eligible and qualified to perform the Contract satisfactorily.
42. Notification of Award	42.1 Prior to the expiration of the period of Bid validity, the Employer shall notify the successful Bidder, in writing, that its Bid has been accepted. The notification letter (hereinafter and in the Conditions of Contract and Contract Forms called the "Letter of Acceptance") shall specify the sum that the Employer will pay the Contractor in consideration of the execution and completion of the Works (hereinafter and in the Conditions of Contract and Contract Forms called "the Accepted Contract Amount"). 42.2 At the same time, the Employer shall also notify all other Bidders of the results of the bidding. 42.3 After a contract has been determined to be eligible for award by THE EMPLOYER, the following information may be made public by THE EMPLOYER: (a) Name of each Bidder who has submitted a Bid; (b) Bid Prices as read out at Bid Opening; (c) Name and address of the successful Bidder; (d) Name and address of the supplier (if applicable); and (e) Award date and amount of the contract. 42.4 Until a formal contract is prepared and executed, the Letter of Acceptance shall constitute a binding Contract 42.5 After notification of award, unsuccessful Bidders may request, in writing, to the Employer a debriefing seeking explanations on the grounds on which their Bids were not selected. The Employer shall promptly respond, in writing, to any unsuccessful Bidders who, after the notification of award in accordance with ITB 42.1, request a debriefing.
43. Signing of Contract	43.1 Promptly upon notification, the Employer shall send the successful Bidder the Contract Agreement. 43.2 Within twenty-eight (28) days of receipt of the Contract Agreement, the successful Bidder shall sign, date, and return it to the Employer.
44. Performance Security	44.1 Within twenty-eight (28) days of the receipt of the Letter of Acceptance from the Employer, the successful Bidder shall furnish the Performance Security in accordance with the General Conditions of Contract, subject to ITB 38.5, using for that purpose the Performance Security Form included in Section IX Contract Forms, or another form acceptable to the Employer. If the Performance Security furnished by the successful Bidder is in the form of a bond, it shall be issued by a bonding or insurance company that has been determined by the successful Bidder to be acceptable to the Employer. A foreign institution providing a bond shall have a correspondent financial institution located in the Employer's Country. 44.2 Failure of the successful Bidder to submit the above- mentioned Performance

Security or sign the Contract shall constitute sufficient grounds for the annulment of the award and forfeiture of the Bid Security. In that event the Employer may award the Contract to the next lowest evaluated Bidder whose Bid is substantially responsive and is determined by the Employer to be qualified to perform the Contract satisfactorily.



CHENNAI METRO RAIL LIMITED

CHENNAI METRO RAIL PROJECT PHASE 1

Tender No. ARE05

**DESIGN, MANUFACTURE, SUPPLY, TESTING,
COMMISSIONING OF STANDARD GAUGE
METRO ROLLING STOCK (ELECTRICAL
MULTIPLE UNITS) AND DEPOT MACHINERY &
PLANT AND TRAINING OF PERSONNEL.**

PART - 1 : BIDDING PROCEDURES

SECTION - II : BID DATA SHEET (BDS)

~~NOV 2025 APR 2026~~ **JUN 2026**

BID DATA SHEET (BDS)

The following specific data for the Design & Build works to be procured shall complement, supplement, or amend the provisions in the Instructions to Bidders (ITB).

Whenever there is a conflict, the provisions herein shall prevail over those in ITB.

For Procedure and guidelines for e-tendering, reference shall be made to E-tendering toolkit (**Annexure to BDS**).

A. General

ITB 1.1 1	The number of the Invitation for Bids (IFB) is: CMRL / PHASE 1 / SYS / ARE05 / 2025 The Employer is: Chennai Metro Rail Limited (CMRL), located in Chennai, Tamil Nadu, India. The name of the Open International Competitive Bidding (OCB) (ICB) is: “DESIGN, MANUFACTURE, SUPPLY, TESTING, COMMISSIONING OF STANDARD GAUGE METRO ROLLING STOCK (ELECTRICAL MULTIPLE UNITS) AND DEPOT MACHINERY & PLANT AND TRAINING OF PERSONNEL.” The identification number of the OCB ICB is: ARE05 Order Quantity of Rolling Stock : 168 Cars (28 Trainsets of 6 car configuration) Order Quantity of Depot Machinery & Plant : Refer to Table 1-1, Table 1-2, Table 1-3 and Table 1-4 in Chapter 1 of Part 2 Section VI B ERTS – DM&P. The number and identification of lots comprising this OCB ICB is: Not Applicable.
ITB 1.2	<u>Add the following at the end of Sub-clause 1.2:</u> (d) “firm” means a private entity, a state-owned enterprise or institution; and (e) “Joint Venture” or “JV” means any combination of two or more firms in the form of a joint venture, consortium, association or other unincorporated grouping under an existing agreement or with the intention to enter into such an agreement supported by a formal Letter of Intent.
ITB 1.2 (a)	<u>Add the following at the end of ITB 1.2 (a):</u> The Employer shall use the e-procurement module of the Central Public Procurement Portal at http://eprocure.gov.in/eprocure/app The electronic-procurement system shall be used to manage the following aspects of the bidding process: • Publishing of Bid document • Publishing Responses to Prebid queries. • Publishing of Addendum / Corrigendum • Submission of Bids • Opening of Bids • Evaluation of Technical Bid • Evaluation of Financial Bid • Selection of Bidder • Issue of Notice of Award of Contract

ITB 2.1	The Employer / Government of Tamil Nadu will fund this work through loan or lease funding proceedings from domestic funding agencies, hereinafter called as "Funding Agency".
ITB 4.1	<u>Replace Sub-Clause 4.1 with the following:</u> A Bidder may be a firm that is a single entity or any combination of such entities in the form of a joint venture (JV) under an existing agreement or with the intent to enter into such an agreement supported by a letter of intent. In the case of a JV: (a) all members shall be jointly and severally liable for the execution of the Contract in accordance with the Contract terms, and (b) the JV shall nominate a Representative who shall have the authority to conduct all business for and on behalf of any and all the members of the JV during the bidding process and, in the event the JV is awarded the Contract, during Contract execution. c) In the case of a Joint Venture / Consortium each member shall participate with a minimum stake of 15% in the overall Joint Venture / Consortium.
ITB 4.5	This bidding is not subject to prequalification.
ITB 4.7	<u>Add the following at end of Sub-Clause 4.7:</u> Where the Bidder is a Joint Venture (JV), the Bidder shall submit the following additional information to meet the qualification criteria for eligibility: (a) A Memorandum of Understanding / JV Agreement shall be provided. (b) Nomination of one of the Members of the Joint Venture to be in-charge ("Lead member"); and this authorization shall be covered in the Power of Attorney signed by the legally authorized signatories of all Members of Joint Venture. (c) Details of the intended percentage participation by each member shall be furnished with complete details of the work distribution of project execution responsibilities. (d) Authorized Representative of the JV shall be authorized to receive instructions for and on behalf of any or all Members of the Joint Venture. (e) All members of the Joint Venture shall be jointly and severally responsible for the execution of the Contract in accordance with the terms and conditions of the Contract. The Letter of Technical Bid and the Letter of Price Bid and other forms wherever required shall be stamped & signed by the authorized representative of the JV and shall be legally binding on all the Members of the JV.
ITB 4.8	<u>Add a new Sub-Clause 4.8:</u> Each Bidder (each Member in the case of a JV) is required to confirm and declare with its Bid that no agent, middleman or any intermediary has been, or will be, engaged to provide any services, or any other item or work related to the award and performance of this Contract. Such Bidder or Member will have to further confirm and declare in the Bid that no agency commission or any payment which may be construed as an agency commission has been, or will be, paid and that the Contract Price will not include any such amount. If the Employer subsequently finds to the contrary, the Employer reserves the right to declare the Bidder as non-compliant and declare any Contract if already awarded to the Bidder to be null and void.

ITB 4.9	<u>Add a new Sub-Clause 4.9:</u> Canvassing or offer of an advantage or any other inducement by any person with a view to influencing acceptance of a Bid will be an offence under laws of India. Such action will result in the rejection of the Bid, in addition to other punitive measures.
ITB 4.10	<u>Add a new sub-clause ITB 4.10</u> (a) Indian Bidder(s), or Indian Members of a JV shall submit, a copy of the Permanent Account Number (PAN) issued by the Income Tax Authorities and a copy of the last 3 years (including the latest Financial Year) income tax return, duly acknowledged by Income Tax department with their Bid and the Technical Package. A copy of GST certificate, Service Tax / VAT registration certificate, PF registration, ESI registration, License under Contract Labour Act, 1970, shall also be submitted. (b) Foreign Bidder(s) should be covered under the grant of general permission to establish project offices in India (as per RBI Master Circular No. 10/2015-16 updated up to the last date for bid submission) on securing the subject project if have not already opened project office in India. In case of award of contract to a foreign bidder such foreign bidder has to submit proof of having opened project office in India before submitting any interim payment application, failing which no payment shall be made till such time. Particulars to be noted by foreign bidders (non-residents as per Income Tax Act, 1961): Foreign bidders should be aware of the following particulars. Upon award of the work these particulars of the successful contractor are required to be furnished by the Employer to Income Tax Department for complying with the requirements for making remittances to non-residents as per Income Tax Act, 1961 (as amended from time to time): (i) Whether the non-resident has a Fixed Place Permanent Establishment (PE) or a Dependent Agency PE in India, in terms of the Double Taxation Avoidance Agreement (DTAA) between India and his country of tax residence through which the non-resident carries on business activities in relation to its engagement by the Employer and if, yes, address of the Fixed Place PE or name & address of the Dependent Agent. (ii) Whether by carrying on activities in relation to its engagement by the Employer, the non-resident constitutes an Installation / Construction PE or a Service PE in India in terms of the DTAA between India and his country of tax residence. (iii) If the non-resident has PE in India, whether the remittances to be made to him under his engagement by the Employer are attributable to such PE. (iv) If the remittances to be made to the non-resident under his engagement by the Employer are attributable to a PE which it has in India, what quantum of the profits resulting to the non-resident from his engagement by the Employer, can be said to be attributable to the role played by the PE, and the basis of arriving at such quantum. (v) If no part of the remittances to be made to the non-resident under his engagement by the Employer is attributable to a PE which it has in India, what are the reasons for the same. (vi) Non-resident's complete address (not necessarily in India). (vii) If the non-resident has an Indian Income Tax Permanent Account Number

	(PAN). (viii) Country of tax residence of the non-resident supported by a Tax Residency Certificate from the tax authorities of that country or the non-resident's own certificate (only if it is not possible for the nonresident to obtain & submit Tax Residency Certificate to the Employer within a reasonable time). (ix) Country which can be called the non-resident's principal place of business. This could be the same as his country of tax residence or different depending on facts. (x) Non-resident's e-mail address. (xi) Non-resident's phone number with International Dialing code. (xii) Whether the non-resident is constituted as a company, a partnership firm, or any other form of business organization. <i>In addition to above particulars, the bidder should also be required to provide upon award of work any other information as may be required later for determining the taxability of the amount to be remitted to the non-resident.</i> All foreign investments or transactions under this Agreement shall comply with applicable FEMA regulations and Act and any other applicable Government regulations, including any requirement for prior government approval.
ITB 4.11	<u>Add a new sub-clause ITB 4.11</u> <u>Ineligibility:</u> A Bidder will be recognized as ineligible to be awarded a contract if the Bidder / the JV or consortium member has been debarred by Multilateral and Bilateral funding agencies / Government of India / Railway Administration / Any State Government in India / Central or State Government Undertaking as on the due date of submission of this bid. A Bidder will be recognized as ineligible to be awarded a contract if the Bidder / JV or consortium member has been banned to do the business with Metro Rail Companies in India / Other Metro Operators in India / Railways Administration / MoHUA / Ministry of Commerce / Any Other Central or State Government Organizations in India, as on the due date of submission of this bid. A Bidder will be recognized as ineligible to be awarded the contract if the Bidder, any member(s) of its joint venture or consortium members, associates, parent company, its affiliates or subsidiaries, is subject to, or is controlled by any entity or individual that is subject to, a temporary suspension or a debarment or termination or declared ineligible, or blacklisted or rescinded of a contract (not limited to similar works) of value more than INR 10 Cr. by any Metro Rail Company in India, other Metro Operators in India, Indian Railways, or any Central or State Government Organization in India due to non-performance, within the last five (5) years prior to the last date for bid submission.
B. Contents of Bidding Documents	
ITB 6.1	<u>Replace ITB 6.1 with the following</u> The Bidding Documents consist of Parts 1, 2 & 3 which include all the Sections indicated below and should be read in conjunction with any Addenda issued in accordance with ITB 8.

	PART 1 - Bidding Procedures Section - I Instructions to Bidders (ITB) Section - II Bid Data Sheet (BDS) Section - III Evaluation and Qualification Criteria (EQC) Section - IV Bidding Forms (BF) Section - V Eligible Source Countries (ESC) PART 2 - Employer's Requirements Section – VI A: Employer's Requirements Technical Specifications (ERTS) – Rolling Stock (RS). Section – VI B: Employer's Requirements Technical Specifications (ERTS) – Depot Machinery & Plant (DM&P). PART 3 - Conditions of Contract and Contract Forms Section - VII General Conditions of Contract (GCC) Section - VIII Particular Conditions of Contract (PCC) Section - IX Annex to PCC - Contract Forms (CF) The Bidder shall check the pages of all documents against page numbers given in the Contents Page and in the event of discovery of any discrepancy, the Bidder shall seek clarification through pre-bid query in writing.
ITB 6.3	<u>Replace ITB 6.3 with the following:</u> Unless obtained directly by the Bidder from the CPP E-Tender portal, the Employer is not responsible for the completeness of the Bidding Documents, responses to requests for clarification, the minutes of the pre-Bid meeting (if any), or Addenda / Corrigenda to the Bidding Documents in accordance with ITB 8. In case of any contradiction, documents available on CPP E-tender portal shall prevail. Failure to comply with the requirements of the Bidding Documents and to furnish all information required by the Bidding Documents or submission of a Bid not substantially responsive to the Bidding Documents in every respect will be at the Bidder's risk and may result in rejection of its Bid.
ITB 6.5	<u>Add a new Sub-Clause 6.5:</u> The documents including the Bid Documents and all attached documents provided by CMRL are and shall remain or become the property of CMRL and are uploaded in the E-Procurement Portal to the Bidders solely for the purpose of preparation and the submission of a Bid in accordance herewith.
ITB 7.1	For clarification purposes and for any update / addendum / corrigendum / pre-bid queries the Employer's address is: Attention: ~~Chief General Manager (RS, S&T).~~ Chief General Manager (S&T, RS). Address: ~~3rd Floor, METROS,~~ 4th Floor, METROS, No: 327, Anna Salai, Nandanam, Chennai-600035, Tamil Nadu, India. Telephone: +91 44 24378000 Extn. ~~28939~~ 28099 E-Mail Address: rajendran.ar@cmrl.in mani.k@cmrl.in

	Web page: https://chennaimetrorail.org/ E-tendering portal: https://eprocure.gov.in/eprocure/app Responses to any request for clarification, if any, will be published on the Employer's web page / e-tendering portal indicated above. Should the Bidder for any reason whatsoever, be in doubt about the meaning of anything contained in the Bid Documents or the extent of detail in the Employer's Requirements and the Technical Specifications, the Bidder shall seek clarification from the Employer in the format attached in Section IV A: Bidding Forms (PDF and editable copy) while seeking clarifications. The last date for seeking clarification shall be as per the date mentioned in CPP portal and the Employer shall not be obligated to respond to query received after the due date.
ITB 7.4	A Pre-bid meeting will take place at the following date, time and place: Date: As specified in NIT Time: As specified in NIT Place: As specified in NIT Site visit will not be organized by the Employer..
ITB 7.6	<u>Replace ITB 7.6 with the following</u> Pre-bid replies, including the text of the questions asked by Bidders, without identifying the source, and the responses given, together with any responses prepared after the meeting, will be published in the CPP portal https://eprocure.gov.in/eprocure/app. Any modification to the Bidding Documents that may become necessary as a result of the pre-bid meeting shall be made by the Employer exclusively through the issue of an addendum / corrigendum pursuant to ITB 8 and shall be published on the CPP portal https://eprocure.gov.in/eprocure/app and the same shall also be part and parcel of the Bid Document. Non-attendance at the pre-bid meeting will not be a cause for disqualification of the Bidder.
ITB 8.2	<u>Replace ITB 8.2 with the following</u> Addenda/Corrigenda, if any, will be published on the Employer's web page and also on CPP portal (E-tendering) mentioned above. The onus is on the Bidders to visit the CPP portal regularly to see the addenda / corrigenda published by the Employer.
C. Preparation of Bids	
ITB 9.1	<u>Add the following at the end of ITB 9.1:</u> A non-refundable 'Cost of Bid' of INR 40,000/- (Rupees Forty Thousand only) or equivalent amount in USD (with conversion rate as of the date of Invitation For Bids) shall be paid through NEFT / RTGS / SWIFT in the name of "Chennai Metro Rail Limited" payable at Chennai. <u>Bank account details for payment:</u> a) Beneficiary name: M/s Chennai Metro Rail Limited b) Beneficiary bank: Canara Bank, Teynampet Branch, Chennai-600 018 c) Current Account No: 0416214000030

	IFSC Code: CNRB0000416
ITB 10.1	The Language of the Bid is: English The supporting documents and printed literature that are part of the Bid may be in another language, provided they are accompanied by an accurate translation of the relevant passages in the English language; in which case, for purposes of interpretation of the Bid, such translation shall govern. The documents that are in a language other than English shall be translated into English and carry an apostille.
ITB 11.1	<u>Replace Sub-Clause 11.1 with the following:</u> The Bidder shall, on or before the date given in the Notice of Invitation to the Bid, upload his Bid (Technical + Financial) on e-tendering portal (https://eprocure.gov.in/eprocure/app) in accordance with provisions of BDS 23.
ITB 11.2	<u>Replace Sub-Clause 11.2 with the following:</u> The Bidder shall follow the procedure and steps of E-tender Portal of CPP as provided in E-tender Tool Kit (Annexure to BDS). A. Cost of the bid: Shall be paid by NEFT / RTGS / SWIFT (Scanned copy to be uploaded online at the time of bid submission). B. Bid Security / EMD: As per Clause BDS 21 below. Shall be paid by eBG / NEFT / RTGS / SWIFT. Electronic copy of eBG / NEFT / RTGS / SWIFT to be uploaded online at the time of bid submission. If EMD is submitted in the form of Bank Guarantee, it shall be as per format given in bid documents, from a Public Sector Bank or Scheduled Commercial Bank as defined in Section 2(e) of RBI Act 1934 as listed under Schedule of Commercial Banks by The Reserve Bank of India (RBI). C. Technical Package: To be submitted at appropriate place i.e. Technical Envelope on CPP portal. D. Financial Package: Financial bid form to be duly filled up directly in the Commercial Envelope only on CPP portal and not anywhere else. Bidder should ensure that no part of the Financial Bid should be uploaded anywhere in the Technical Bid; if the bidder does so, then his bid will be rejected out rightly. <u>Add the following Sub-Clause to the end of Sub-Clause 11.2:</u> 11.2.1 The Bidder in his Technical Package of the Bid shall submit/upload (with digital signature of the Authorized Signatory in E-tender portal of CPP) the following documents, duly completed. These documents can be uploaded in multiple files, each file not exceeding 40MB. - Letter of Technical Bid; - Proof of payment of cost of bid and Bid Security / EMD, in accordance with BDS 9.1, BDS 21.1 and 21.2; - All Forms in the relevant formats given in Section IV: Bidding Forms, signed by the Authorized Signatory. - Power of Attorney along with a board resolution for a single entity. In case of JV, JV agreement/MoU/letter of intent with Power of Attorney of authorized signatories of each member, along with board

	resolution. e) Written confirmation authorizing the signatory of the Bid to commit the Bidder, in accordance with BDS 22.2; f) In the case of a Bid submitted by a JV, a copy of the MoU or JV agreement signed by all members, to enter into a JV, indicating the specified activities of the Works to be executed by the respective members; g) Technical Proposal in accordance with ITB 16 and ITB 17; h) Copy of all financial documents (in line with Section-III Evaluation and Qualification Criteria) i) Relevant work experience certificate (in line with Section III: Evaluation and Qualification Criteria). j) list of Subcontractors, in accordance with ITB 17.2 and 17.3; and Any other compliance documents which are requested by the Employer in the submission of the Bid which may form part of the Contract.
ITB 11.3 (d)	The Bidder shall submit the following additional documents in its Price Bid: Tables mentioned under Part 1 – Bidding Forms (Section 4) shall be attached in price bid (Signed and Sealed copy in PDF version and Editable excel format).
ITB 13.1	Alternate bids are not permitted.
ITB 16.1 (b)	The period following completion of the Works during which spare parts, special tools etc. shall be available, is 10 years .
ITB 17.6	In case Prequalification was conducted prior to the bidding process, the Bidder's Bid shall name the same specialist subcontractor(s) whose experience in the key activities was evaluated in the Prequalification, unless such change is explicitly approved by the Employer in accordance with ITB 15.2.
ITB 18	"and Discounts" deleted.
ITB 18.1	Bidders shall quote for the entire Works on a single responsibility basis
ITB 18.4	<u>Replace Sub-clause 18.4 with the following:</u> The price to be offered in the Letter of Bid, in accordance with ITB 12.1, shall be the total price of the Bid.
ITB 18.5	<u>Replace Sub-Clause 18.5 with the following:</u> The rates and prices quoted by the Bidder are subject to adjustment during the performance of the Contract in accordance with the provisions of the Conditions of Contract. The Bidder shall use the indices and/or weightings as per Schedule of Adjustment Data and price adjustment formula specified in Cl. 3.2 of "Part 1 – Bidding Forms – Instructions for Completing the Pricing document".
ITB 18.8	Deleted.
ITB 19.1	The currency(ies) of the Bid shall be as described below: The unit rates and prices shall be quoted by the Bidder in the Price Schedule separately in the following currencies:

	(i) For those inputs to the Works that the Bidder expects to supply from within the Employer's country, in INR (Indian Rupees), and further referred to as "the local currency", with no decimal places; and (ii) For those inputs to the Works that the Bidder expects to supply from outside the Employer's country, in up to any two foreign currencies (JPY / USD / EUR), with no decimal places;
ITB 20.1	The Bid validity period shall be 180 days.
ITB 20.3 (b)	The fixed portion of the Bid Price shall not be adjusted.
ITB 21.1	The Bidder shall furnish Bid Security in the amount of INR 24,00,00,000 (Indian Rupees Twenty-Four Crore only) or in an equivalent amount in JPY / USD / EUR, calculated at the exchange rate published by the Financial Benchmarks India Pvt. Ltd. (FBIL) prevailing 28 (twenty-eight) days prior to the last date for submission of Bids.
ITB 21.2	<u>Replace Sub-Clause 21.2 with the following:</u> The Bidder shall submit with his Bid, a Bid Security for the sum as specified in BDS 21.1 above in the form of eBG or via RTGS / NEFT transactions. Such bid security shall be valid for a period of 28 days beyond the bid validity period. In case the EMD is submitted in the form of e-Bank Guarantee, it shall be as per format given in bid documents, from a Scheduled Commercial Bank as defined in Section 2(e) of RBI Act 1934. For EMD, the Bidders shall upload the scanned copies eBG / RTGS / NEFT / SWIFT transactions of payment at the time of online bid submission. If the Bidder fails to upload the scanned copy of the eBG / Transaction receipt of NEFT / RTGS / SWIFT along with his Bid, his Bid shall not be considered for evaluation and shall be summarily rejected. In case the submission date of bid is extended, the bid security shall also be extended to twenty eight (28) days beyond the extended bid validity period.
ITB 22. 1	<u>Replace Sub-clause 22.1 with the following:</u> The Bid submission is through E-tender portal of CPP only. In addition to the original of the Bid, the number of copies to be submitted is: None
ITB 22.2	<u>Replace Sub-clause 22.2 with the following:</u> The entire Bid Document available on e-tender portal of CPP with all Corrigendum and Addendum issued from time to time shall be downloaded. All document that are necessary to be filled shall be duly filled, signed, scanned and uploaded on the E-tender portal by the authorized signatory on behalf of the Bidder with his digital signature (DSC). The Bidder who fails to submit as mentioned aforesaid, his Bids shall be treated as non-responsive and not considered for evaluation. The written confirmation of Authorization to sign on behalf of the Bidder shall consist of: The Power of Attorney authorizing to sign on behalf of the bidder shall be submitted in the format provided in Section IV – Bidding Forms – Form: 'Power of Attorney for Signing of Bid'.
D. Submission and Opening of Bids	
ITB 23	<u>Replace Sub-Clause 23 with the following</u> (a) It is the directive of Govt. of India to process tendering online to ensure transparency, and fairness in the process and security of documents. Hence,

	the bidder has to submit the bids online in the system available at the above referred portal. The bidder has to agree to the online user portal agreement. Then only, the system will permit the bidder to proceed further in the system. Bidder has to fill all mandatory fields indicated by an asterisk (*). (b) All bids are to be submitted online on the website http://eprocure.gov.in/eprocure/app (c) It is the bidder's responsibility to comply with the system requirement i.e. hardware, software and internet connectivity at bidder's premises to access the e-tender website. Under any circumstances, CMRL shall not be liable to the bidders for any direct / indirect loss or damages incurred by them arising out of incorrect use of the e-tender system or internet connectivity failures. (d) The bidder has to digitally sign and upload the required Bidding documents one by one as indicated in the Bidding document. (e) The bidder shall upload copy of EMD, proof of payment of Cost of Bidding Documents (scanned copies of NEFT / RTGS receipts) and Technical documents and financial documents in Bid submission page of CPP. After uploading successfully, the system shall generate tick marks against the "Technical" and "Finance" folders icons. The uploaded documents can be viewed by the bidder. After uploading all the required documents bidder can press "Freeze Bid" button to mark completion of tender uploading and shall take print out of the acknowledgement which shows the details of the uploaded tender. (f) Bidder should log into the CPP Portal site with USER ID and Password well in advance for tender submission so that they can upload the bid in time i.e. on or before the last date and time of bid submission as given in NIT. Bidder shall have a valid DSC to digitally sign the documents. Attempting to upload the bid in the last minute, may result in JAVA or other related software failures and internet connectivity failures. Bidder will be solely responsible for any delay due to such issues or other related issues and CMRL does not take any responsibility/liability towards bid submission failure in such circumstances. (g) For detailed e-procurement procedure, please refer Annexure to BDS – "E-tender tool kit (Annexure to BDS)" of this document.
ITB 24.1	<u>Replace Sub-Clause 24.1 with the following:</u> The Bid Documents comprising Technical Bid and Financial Bid shall be uploaded in the E-procurement portal of CPP on or before the date and time for submission as indicated in the NIT or as amended by Corrigendum and as per instructions in E-tender Tool Kit.
ITB 25.1	<u>Replace Sub-Clause 25.1 with the following:</u> The Bidder shall submit their Bid through E-tender portal of CPP before the date and time for submission specified in the NIT or amended by a corrigendum/addendum in accordance with ITB 8.2. Submission of bids shall be closed on CPP portal at the date & time of submission as specified in the NIT or as amended by Corrigendum after which no bid can be uploaded. Any other means of bid submission other than CPP portal will not be accepted by CMRL.
ITB 26.1	<u>Replace Sub-Clause 26.1 with the following:</u> Bidder may withdraw, substitute or modify their bid, before the bid submission date and time using their DSC by logging into the e-tendering portal with their Login ID and Password.

ITB 26.2	Not applicable
ITB 27	<u>Replace Sub-Clause 27 with the following:</u> The technical bids will be decrypted and opened online, on or after the scheduled date and time as mentioned in NIT. Till such time, the bids will be only in the encrypted form. After the scheduled time, the bids will be opened by stipulated bid openers with their Digital Signature Certificates (DSC) key. The technical-bids will be evaluated based on the information furnished by bidders. If any clarification regarding non-material non-conformities required from bidder, CMRL will seek such clarifications at their discretion. After evaluation of technical-bids, only successful bidders who have participated in the tender will be informed regarding the acceptance of their tender. Thereafter, a system generated e-mail confirmation will be sent to the successful bidders communicating the date and time of opening of price-bid. The price-bid of the successful bidders (qualified in technical-bid) will be decrypted and opened on-line, on or after the scheduled date and time by the bid openers with their Digital Signature Certificates (DSC). The presence of the bidder's representatives in CMRL office during bid opening is not necessary.
ITB 34.3	Not applicable
E. Evaluation and Comparison of Bids	
ITB 37.1	The currency that shall be used for Bid evaluation and comparison purposes to convert all Bid Prices expressed in various currencies into a single currency is: Indian Rupees (INR) The source of exchange rate shall be: Financial Benchmarks India Pvt. Ltd (FBIL) as delegated by the Reserve Bank of India vide their order no. RBI / 2018-19 / 34DBR. Ret. BC. No. 01 / 12.01.001 / 2018-19 dated August 02, 2018. In case such rates are not available in the source identified above, any other publicly available source acceptable to the Employer shall be used for the evaluation. Any error in determining the exchange rates may be corrected by the Employer. The date for the exchange rate shall be: 28 days before last date of submission of the Bid. If the date that is 28 days prior to the stipulated date of submission happens to fall on a public holiday, then the rate of Exchange at the close of business of FBIL's website on the previous working day shall be considered for the conversion of Foreign Currency to Indian Rupees.
ITB 38.2	<u>Replace ITB 38.2 with the following</u> To evaluate a Price Bid, the Employer shall consider the following: (a) The bid price excluding Provisional Sums. (b) Price adjustment for correction of arithmetic errors in accordance with ITB 36.1; (c) Converting the amount resulting from applying (a) to (b) above, if relevant, to a single currency in accordance with ITB 37; (d) the evaluation factors indicated in Section 3 (Evaluation and Qualification Criteria).
ITB 38.4	<u>Replace sub-clause 38.4 with the following :</u> If these Bidding Documents allow Bidders to quote separate prices for different lots (contracts), and the award to a single Bidder of multiple lots (contracts), the methodology to determine the lowest evaluated price of the lot (contract)

	combinations, is specified in Section III, Evaluation and Qualification Criteria.
ITB 43.2 1	Deleted <u>Add the following to Sub-Clause 43.2:</u> ~~In case of Joint venture (JV), all members are required to sign and seal all the pages of the Contract Agreement & Documents.~~
ITB 45 1	<u>Add a new Clause 45:</u> ~~Ministry of Finance, Department of Expenditure, Public Procurement Division, Government of India has issued an Order (Public Procurement No.1) on 23 February 2023 on Restrictions Under Rule 144 (xi) of the General Financial Rules (GFRs), 2017. Based on which any bidder from a country which shares a land border with India will be eligible to bid in any procurement whether of goods, services (including consultancy services and non-consultancy services) or works (including turnkey projects) only if the bidder is registered with the Competent Authority.~~ ~~For details refer to Part 1, Section V-A, 'Requirements of a Bidder from a Country which Shares Land Border with India'.~~ ~~Further, refer Office Memorandum published by Department of Expenditure (DoE), Ministry of Finance (MoF) OM No. F.7/10/2021-PPD dated 23.02.2023 or any subsequent orders/notification issued from time to time, regarding the import of raw materials and sub-contracting with the firms from the countries sharing land boundaries with India.~~
F. Award of Contract	
ITB 42.1	<u>Add at the end of the ITB 42.1 with the following:</u> Notification of award of Contract shall be intimated to the successful bidder by sending scanned copy of the letter through e-mail and hardcopy of the letter by post.
ITB 43.2	<u>Replace ITB 43.2 with the following:</u> Within Twenty-Eight (28) days from the date of receipt of Letter of Acceptance (LOA), the successful Bidder shall submit Performance Security and execute / sign the Contract agreement with the Employer. In case of JV, all members are required to sign and affix their seal in all the pages of the Contract Agreement and associated Documents.
ITB 45 1	<u>Add a new Clause 45:</u> Ministry of Finance, Department of Expenditure, Public Procurement Division, Government of India has issued an Order (Public Procurement No.1) on 23 February 2023 on Restrictions Under Rule 144 (xi) of the General Financial Rules (GFRs), 2017. Based on which any bidder from a country which shares a land border with India will be eligible to bid in any procurement whether of goods, services (including consultancy services and non-consultancy services) or works (including turnkey projects) only if the bidder is registered with the Competent Authority. For details refer to Part 1, Section V-A, 'Requirements of a Bidder from a Country which Shares Land Border with India'. Further, refer Office Memorandum published by Department of Expenditure (DoE), Ministry of Finance (MoF) OM No. F.7/10/2021-PPD dated 23.02.2023 or any subsequent orders/notification issued from time to time, regarding the import of raw

	materials and sub-contracting with the firms from the countries sharing land boundaries with India.

ANNEXURE TO BDS

E-TENDER TOOL KIT

INSTRUCTIONS FOR ONLINE BID SUBMISSION

The bidders are required to submit soft copies of their bids electronically on the Central Public Procurement Portal (CPP Portal), using valid Digital Signature Certificates. The instructions given below are meant to assist the bidders in registering on the CPP Portal, prepare their bids in accordance with the requirements and submitting their bids online on the CPP Portal

More information useful for submitting online bids on the CPP Portal may be obtained at: <https://eprocure.gov.in/eprocure/app>.

1. REGISTRATION

- a) Bidders are required to enroll on the e-Procurement module of the Central Public Procurement Portal (URL: <https://eprocure.gov.in/eprocure/app>) by clicking on the link “**Online bidder Enrollment**” on the CPP Portal which is free of charge.
- b) As part of the enrolment process, the bidders will be required to choose a unique username and assign a password for their accounts.
- c) Bidders are advised to register their valid email address and mobile numbers as part of the registration process. These would be used for any communication from the CPP Portal.
- d) Upon enrolment, the bidders will be required to register their valid Digital Signature Certificate (DSC) (Class III Certificates with signing key usage) issued by any Certifying Authority recognized by CCA India (e.g. Sify / nCode / eMudhra etc.), with their profile.
- e) Only one valid DSC should be registered by a bidder. Please note that the bidders are responsible to ensure that they do not lend their DSC's to others which may lead to misuse.
- f) Bidder then logs in to the site through the secured log-in by entering their user ID / password and the password of the DSC / e-Token.

2. COST OF BIDDING DOCUMENTS

- a) A non-refundable ‘cost of bid’ as mentioned in IFB shall be transferred through NEFT / RTGS / SWIFT to **Chennai Metro Rail Limited account**.
- b) The **scanned copy of RTGS / NEFT / SWIFT** has to be uploaded along with the submission of Bid.
- c) Not used
- d) Not used
- e) Indian bidders are to provide their GST registration details. However, If the foreign bidders or JV turn out to be successful bidders, they shall obtain the GST registration details and submit to the Engineer before getting any payments

3. SEARCHING FOR TENDER DOCUMENTS

- a) There are various search options built in the CPP Portal, to facilitate bidders to search active tenders by several parameters. These parameters could include Tender ID,

Organization Name, Location, Date, Value, etc. There is also an option of advanced search for tenders, wherein the bidders may combine a number of search parameters such as Organization Name, Form of Contract, Location, Date, Other keywords etc. to search for a tender published on the CPP Portal.

- b) Once the bidders have selected the tenders they are interested in, they may download the required documents / tender schedules. These tenders can be moved to the respective 'My Tenders' folder. This would enable the CPP Portal to intimate the bidders through SMS / e-mail in case there is any corrigendum issued to the tender document.
- c) The bidder should make a note of the unique E-Tender ID assigned to each tender, in case they want to obtain any clarification / help from the Helpdesk.
- d) For CMRL tenders, tender documents shall be viewed under the section heading "Tender by organization>Chennai Metro Rail Limited>".

4. PREPARATION OF BIDS

- a) Bidder shall consider any Corrigendum / Addendum published on the tender document before submitting their bids.
- b) Bidder shall read the tender advertisement and the tender document carefully to understand the documents required to be submitted as part of the bid. Please note the number of covers in which the bid documents have to be submitted, the number of documents - including the names and content of each of the document that need to be submitted. Any deviations from these may lead to rejection of the bid.
- c) Bidder, in advance, should get ready the bid documents to be submitted as indicated in the tender document / schedule and generally, they can be in PDF / XLS / RAR / DWF/JPG formats.
- d) To avoid the time and effort required in uploading the same set of standard documents which are required to be submitted as a part of every bid, a provision of uploading such standard documents (e.g. PAN card copy, annual reports, auditor certificates etc.) has been provided to the bidders. Bidders can use "My Space" or "Other Important Documents" area available to them to upload such documents. These documents may be directly submitted from the "My Space" area while submitting a bid, and need not be uploaded again and again. This will lead to a reduction in the time required for bid submission process.

Note: "My space" is only a repository given to the Bidders to ease the uploading process. If Bidder has uploaded his Documents in "My space", this does not automatically ensure these Documents being part of Technical Bid.

5. SUBMISSION OF BIDS

- a) It is the directive of Govt. of India to process tendering on line to ensure transparency, and fairness in the process and security of documents. Hence, the bidder has to submit the bids on line in the system available at the above referred portal. The bidder has to agree to the online user portal agreement. Then only, the system will permit the bidder to proceed further in the system. He has to fill all mandatory fields indicated by an asterisk (*).
- b) All bids are to be submitted on-line on the website <http://eprocure.gov.in/eprocure/app>
- c) It is the bidder's responsibility to comply with the system requirement i.e. hardware, software and internet connectivity at bidder's premises to access the e-tender website.

Under any circumstances, CMRL shall not be liable to the bidders for any direct/indirect loss or damages incurred by them arising out of incorrect use of the e-tender system or internet connectivity failures.

- d) The bidder has to digitally sign and upload the required bid documents one by one as indicated in the tender document.
- e) Bidder has to select the payment option as “offline” to pay the ‘cost of bid’ / Bid Security as applicable and enter details of the instrument.
- f) Bidder should log into the CPP Portal site well in advance for bid submission so that they can upload the bid in time i.e. on or before the last date and time of bid submission. Attempting to upload the bid in the last minute, may result in JAVA or other related software failures and internet connectivity failures. Bidder will be solely responsible for any delay due to such issues or other related issues and CMRL does not take any responsibility/liability towards bid submission failure in such circumstances.
- g) Bidders are requested to note that they should necessarily submit their financial bids in the format provided and no other format is acceptable. If the price bid has been given as a standard BOQ format with the tender document, then the same is to be downloaded and to be filled by all the bidders. Bidders are required to download the BOQ file, open it and complete the white coloured (unprotected) cells with their respective financial quotes and other details (such as name of the bidder). No other cells should be changed. Once the details have been completed, the bidder should save it and submit it online, without changing the filename. If the Bill of Quantities/ Schedules file is found to be modified by the bidder, the bid will be rejected.
- h) The server time (which is displayed on the bidders’ dashboard) will be considered as the standard time for referencing the deadlines for submission of the bids by the bidders, opening of bids etc. The bidders should follow this time during bid submission.
- i) All the documents being submitted by the bidders would be encrypted using Public Key Infrastructure (PKI) encryption techniques to ensure the secrecy of the data. The data entered cannot be viewed by unauthorized persons until the time of bid opening. The confidentiality of the bids is maintained using the secured Socket Layer 128 bit encryption technology. Data storage encryption of sensitive fields is done. Any bid document that is uploaded to the server is subjected to symmetric encryption using a system generated symmetric key. Further this key is subjected to asymmetric encryption using buyers/bid opener’s public keys.
- j) The uploaded tender documents become readable only after the tender opening by the authorized bid openers.
- k) Upon the successful and timely submission of bids (i.e. after Clicking “Freeze Bid Submission” in the portal), the portal will give a successful bid submission message & a bid summary will be displayed with the bid no. and the date & time of submission of the bid with all other relevant details.
- l) The bid summary has to be printed and kept as an acknowledgement of the submission of the bid. This acknowledgement may be used as an entry pass for any bid opening meetings.

6. OPENING OF BIDS

- a) The Technical bids will be decrypted and opened online, on or after the scheduled date and time. Till such time, the bids will be only in the encrypted form. After the scheduled

time, the bids will be opened by stipulated Bid Openers with their Digital Signature Certificates (DSC).

- b) After evaluation of Technical-bids, all the bidders who participated in the tender will get information regarding their acceptance or otherwise of their technical bid. Thereafter, a system generated e-mail confirmation will be sent to all Technically qualified bidders communicating the date and time of opening of price-bid, in case of TWO BID SYSTEM ONLY.

7. GOVERNING OF TENDER

Any order resulting from this tender enquiry, shall be governed by the terms & conditions of the tender, and the tenderer quoting against this enquiry, shall be deemed to have read and understood the same.

8. COST OF TENDERING

The tenderer shall bear all the costs associated with the preparation and submission of its offer, and CMRL will in no case be responsible or liable for those costs, regardless of the conduct or outcome of the tendering process including cancellation of this tender process.

9. ASSISTANCE TO BIDDERS

- a) Any queries relating to the tender document and the terms and conditions contained therein should be addressed to the Tender Inviting Authority for a tender or the relevant contact person indicated in the tender.
- b) Any queries relating to the process of online bid submission or queries relating to CPP Portal in general may be directed to the 24x7 CPP Portal Helpdesk.
- c) **For any uploading related queries please call the Helpdesk. The 24 x 7 Help Desk Number +91 0120-4200462, +91 0120-4001002, +91 0120-4001005 and**
 - (i) E-Mail : support-eproc@nic.in
 - (ii) Note- Bidders are requested to kindly mention the URL of the Portal and Tender Id in the subject while emailing any issue along with the Contact details.

10. PRICE BID

The Price bid for item of works will be in Excel format and shall be downloaded by the bidder and shall quote his prices against each Price Centre item which shall be inclusive of all taxes, duties etc. In the 'format the bidder should quote for all the tendered items. Where, any row or column is not applicable, the bidder has to indicate '0' against this. The system will generate a comparative statement. Therefore, all costs are to be indicated in the format. Order will be finalized on technically cleared, L-1 offer. The bidder may modify and resubmit the bid on-line, if he wishes before the bid submission date and time. The system will accept only the last submitted bid. Bidder can find out the status of his tender on line, any time after opening the bids. **The tenderer should not rename the file or modify the format while uploading in the system. The file name should be the same as the file name given in the tender. The filled price bid shall be uploaded and submitted ONLY in the e-procurement portal.**

11. WITHDRAWAL OF BID

Bidder may withdraw a bid submitted already before the bid Submission date and time.

12. VALIDITY OF TENDER

The Tender must be valid for a **minimum period of 180 days** from the date of submission of Bid. In exceptional circumstances, CMRL may request for extending the period of validity for a specified additional period. CMRL request and tenderer response shall be made in writing / e-mail.

13. Any special conditions mentioned in any document by the bidder will not be acceptable to CMRL. Conditional Bids will be rejected.

14. Any other means of tender submission will not be accepted by CMRL.

15. CMRL BANK ACCOUNT & GST DETAILS

Beneficiary Name	Chennai Metro Rail Limited
Name of the Bank	Canara Bank
Beneficiary Account No	0416214000030
Branch Address	Teynampet, Chennai 600018
Type of Account	Current account
IFSC Code	CNRB0000416
MICR	600017014
CMRL GST Number	33AADCC2233K1Z0
CMRL PAN Number	AADCC2233K
Corporate Identity Number	U60100TN2007SGC065596

16. The Name and Designation of Officer for submission of Bid Security, Bid document cost, Pre bid Meeting and for clarification Purposes is:

“Chief General Manager (RS, S&T)

3rd Floor, METROS,

No: 327, Anna Salai, Nandanam, Chennai-600035, Tamil Nadu, India

Telephone: +91 44 24378000 Extn. 28939

Email: rajendran.ar@cmrl.in

2

“Chief General Manager (S&T, RS)”

4th Floor, METROS,

No: 327, Anna Salai, Nandanam, Chennai-600035, Tamil Nadu, India

Telephone: +91 44 24378000 Extn. 28099

Email: mani.k@cmrl.in

17. It shall be the responsibility of the tenderer to ensure that his tender is submitted on time before the deadline of submission through CPP portal.

Procedure for Obtaining Digital Signature by Foreign Bidders

This document gives the procedure to be followed by bidders who are resident of countries other than India for participating in Online Tendering Activity.

As per the IT ACT 2000, all bidders who participate in the online bidding process in this site should possess a valid Digital Signature issued by any of the Digital Signature Certificate (DSC) vendors approved by CCA, India (<https://cca.gov.in>). The following document gives the procedure that is generally followed by various vendors.

Generally, the documents that are required to be submitted by Foreign Nationals are as follows:

1. Identity Proof (ID Proof) of the person in whose name DSC has to be issued (E.g., Passport copy)
2. Bank account statement in country of residence, duly attested by Indian Embassy / High Commission / Consulate / Apostille in the country where the applicant is currently located. (At least 6 months of Bank transactions) with the proof indicating the account is owned by the Individual.
3. Copy of the Trade license attested by any one of the authorities as specified in Point 2 above.
4. As the Individual is representing the company, an Authorization on company's letter head as given in the form.
5. Copy of the Authorization letter or invitation letter from department for the participation in the tender by any one of the tender inviting authority.

As of now, it is learnt that GNFC, issue DSCs with the above procedure. The copy of the nCodes and eMudhra Format is enclosed as Annexure; the Copies of other vendors will be made available on receipt of information from these vendors.

Note: The Information given by the vendors is attached for facilitating the Foreign Nationals to procure DSCs from the Indian CA authorized vendors for information purpose only as shared by the respective CA's.

Please find below the details of various vendors and application form for obtaining DSC:

- a) GNFC
- b) eMudhra



Customer Identification Number: _____ (For Office Use Only)

Instructions:

1. This Form is divided into 2 parts: Form A and Form B.
2. Form A contains details of certificate applicant and needs to be filled up each time.
3. Form B contains organizational details and needs to be filled up only once for an Enterprise / Organization.
4. Please fill the form in BLOCK LETTERS in English only.
5. (n)Pro refers Class 3 Organization and will bear Object Identification as 2.16.356.100.2.3.
6. As per New Inter-portability Guidelines ver. 2.1, all the DSCs issued from 4th April 2011 to 31st Dec 2011 will carry the validity of ONE year
7. Separate DSC for Signing & Encryption will be issued

FORM A

Affix recent
Passport Size
Photograph of the
applicant

(Sign across photo)

TYPE OF DIGITAL CERTIFICATE:

1. Class IIb: ☐ 2. Class IIIb: ☐ 3. Class IIIc: ☐ Validity: 1Year: ☐ 2Years: ☐

NAME OF THE APPLICANT (As required in the DIGITAL CERTIFICATE)

(Please ensure that the name as it appears in the Identity Proof matches with the name mentioned below)

Surname

First Name

Initials

Office Address:

Town / City / District:

State / Union Territory:

Pin Code:

Department

Contact No.:

STD Code:

Ph:

Fax:

Mobile Phone No.:

Date of Birth:

DD

MM

YYYY

E-Mail Address:

Identity Details: No.

(Please Tick & Fill Any One)

Passport

FORM B

Organizational Details to be Filled up only Once for an Organization (Please disregard if already submitted)

Company Name:

Corporate / Register

Company Address:

Town / City / District

State / Union Territory

Pin Code

Contact No.

STD Code:

Ph:

Fax:

Corporate Website (URL)

Income Tax Pan No.:

Bank Details

Bank Name

Bank A/C No

I hereby agree that I have read and understood (n)Code Solutions CA CPS and the subscriber agreement and promise to abide the same. I acknowledge that informations provided in Form A & Form B are correct to my knowledge.

Place:

Date:

Signature Of Applicant

[Name:

]



Customer Identification Number: _____ (For Office Use Only)

Documents Required and Submitted by the Applicant (POR : Proof of rights documents)

Documents required only once for an Organization / Enterprise for all classes of certificates: Iib, IIib, IIic

Certified true copy (from Company Secretary / Director / Partner / Proprietor of the organization:

- Valid business license document
- Authorization Letter in favor of the certificate applicant from the applicant organization (as per the format attached herewith, on the Company's Letterhead Only)

Documents to be Attested by Indian Embassy/High Commission / Consulate / Apostille in the country where applicant is located:

- Latest photograph of the applicant on the form
- Passport Copy
- Bank account statement in country of residence

PHYSICAL PRESENCE IS REQUIRED FOR CLASS IIib CERTIFICATE APPLICANT

For further details contact (+91 33 2637 4024 / +91 33 2640 4086)

Or, can be deposited directly in any of the HDFC Bank's Branch,

H R Infracon Limited, A/C No.: 02082320001689

G T Road Branch, Howrah, IFSC - HDFC0000208

Bank Swift Code No.: HDFCINBB

Visit Us : www.hrinfracon.com E-Mail : hrinfracon@gmail.com Phone No.: (+91 33 - 2640 4086 / 2637 4051)

Note :

¹ Applicants for Class IIib & Class IIic certificate shall present themselves at the LRA location where the registration form for Digital Certificate was sent, for verification of physical presence.

² Please refer to the CPS for more information.

Signature Verification (Authorization) Letter (This Authorization Letter is required on the Organization's letterhead)

To,
(n) Code Solutions,
A Division of Gujarat Narmada Valley Fertilizers Company Limited.

This is to certify that Mr. / Ms. _____ (Certificate applicant) has provided correct information in the Application form for issue of Digital Certificate to the best of my knowledge and belief and is working with _____ (organization name). He / She is hereby authorized to obtain a Class IIb, IIib & IIic Digital Certificate Issued by (n)Code Solutions CA.

Details of Authorized Signatory:

Name : _____
Designation : _____
Organization Name : _____
Signature of Authorized Person : _____
(with stamp of Organization / Office)
Date : _____
Place : _____

Organisation's: *

Bank Name	
Branch Name & Place	
Account Type	☐ Savings ☐ Current
Account Number	

IDENTIFICATION DETAILS*
15a.Passport Details:*

Passport number	
Passport Issuing Authority	
Passport Expiry Date	

15b.Visa Details: (Mandatory and Applicable if the applicant is in India)*

Visa issued By	
Visa valid from	
Visa Expiry Date	

15c.Valid Identity Details:*

(Please tick any one and fill the ID number and attach attested copy of ID proof)

☐ Passport ☐ Driving License ☐ PAN Card

PAYMENT DETAILS*
16. Mode of Payment *

☐ Online / Net Banking ☐ At Par Cheque/DD ☐ NEFT

Online Payment Details

Transaction/Reference No.	
Bank Name	
Account Type	
Amount Rs.	
Date	

Cheque/DD Payment Details

Cheque /DD No.	
Bank & Branch Name	
Account Type	
Amount Rs.	
Date	

DECLARATION*

I hereby agree that I have read and understood the provisions of eMudhra Certification Practice Statement (CPS) and the subscriber agreement and will abide by the same. The information provided in this Digital Signature Certificate request form is true and correct to the best of my knowledge and I accept publishing my certificate information in eMudhra repository.

Date :*

Name of the Applicant:

Place:*

Signature:

Seal and Stamp (as applicable):

TO BE FILLED BY RA OFFICE ONLY*

I declare that the applicant has provided correct information in this application form. I have checked and verified the application form and supporting documents.

RA Name :

Signature :

Place :

Date :

RA Seal & Stamp

CHECKLIST OF DOCUMENTS TO BE SUBMITTED ALONG WITH THE APPLICATION for INDIVIDUAL CERTIFICATE *

a. Attested copy of any one as per the list in serial no. 15c

☐ Passport ☐ Driving License ☐ PAN Card

NB : Passport with a valid copy of the visa is a must if the applicant is in India

b. ☐ Attested Copy of PAN CARD (Mandatory if PAN number has been provided)

c. Attested Copy of any one for address proof

☐ Passport ☐ Driving License ☐ Electricity Bill ☐ Telephone Bill

Checklist of Documents to be Submitted along with Application for Organisation Certificate

- a. ☐ Attested Copy of anyone as per the list is S.No. 15c
- b. Attested copy of any one
☐ Certificate of Incorporation ☐ Memorandum of Association Regd. ☐ Partnership Deed ☐ Valid Business License
- c. Attested Copy of any one
☐ Annual report ☐ Latest Income Tax Return ☐ Latest organisation Details from the Bank ☐ Statement of Income issued by Chartered Accountant
- d. ☐ Attested Copy of the Organisation PAN Card or equivalent for the corresponding country
- e. ☐ Authorisation letter in favour of the certificate applicant from the Organisation as per format below
- f. ☐ List of Partners / members / Directors with their complete name and address details

AUTHORISATION LETTER FORMAT* (This Authorisation Letter is required on the Organisation's Letterhead)

To,

eMudhra Consumer Services Limited
3rd Floor, Sai Arcade, 56 Outer Ring Road
Deverabeesanahalli, Opp Intel
Bangalore 560103
Phone: +91 80 4336 0000

Date:

Dear Sir,

Sub: **Authorisation letter for obtaining Digital Signature Certificate.**

This is certify that Mr./Mrs./Miss. _____ (Certificate applicant) has provided correct information in the 'Application form for issue of Digital Signature Certificate' to the best of my knowledge and belief vide application form dated DD-MM-YYYY. I hereby authorize him/her, on behalf of our Organisation to apply for obtaining the following Class of Digital Signature Certificate issued by eMudhra.

Class of Digital Signature Certificate issued by e-Mudhra.

☐ Class 2 Gold Organisation ☐ Class 3 Platinum Organisation

Signature:

Name:

Designation:

CONTACT DETAILS

eMudhra Consumer Services Limited, D.No.2 / 30 A, 1st Floor, Natesa Pandaram Colony, Cherry Road, Landmark: Opp to Post Office, Salem - 636 007. Tamil Nadu
Phone : +91 80 4336 0000 Fax : +91 80 4227 5306 Email : info@e-Mudhra.com Website : www.e-Mudhra.com



CHENNAI METRO RAIL LIMITED

CHENNAI METRO RAIL PROJECT PHASE 1

Tender No. ARE05

**DESIGN, MANUFACTURE, SUPPLY, TESTING,
COMMISSIONING OF STANDARD GAUGE METRO
ROLLING STOCK (ELECTRICAL MULTIPLE UNITS)
AND DEPOT MACHINERY & PLANT AND TRAINING
OF PERSONNEL.**

**PART 1 : BIDDING PROCEDURES
SECTION - III : EVALUATION AND QUALIFICATION
CRITERIA (EQC)**

~~NOV 2025~~ ~~APR 2026~~ **JUN 2026**

Evaluation and Qualification Criteria (Without Prequalification)

1. Evaluation

1.1 Not Used.

1.2 Economic Evaluation

In addition to the criteria listed in ITB 38.2 (a) – (c) the following criteria shall apply.

1.2.1 Quantifiable nonmaterial nonconformities

Pursuant to ITB 34.3 and ITB 38.2 (d), the cost of all quantifiable nonmaterial nonconformities or omissions (minor omissions or missing items) will be evaluated. The Employer will make its own assessment of the cost of any nonmaterial nonconformities and omissions for the purpose of ensuring fair comparison of Bids.

1.2.2 Other Factors

The following factors and methods will apply under ITB 38.2 (f):

- (a) Operating Costs – Not considered for Bid evaluation.
- (b) Specific additional criteria - Not used

1.2.3 Award Criteria for Multiple Contracts (ITB 38.4)

Not applicable

1.3 Alternative Completion Times

Alternative Completion Times shall not be permitted.

1.4 Alternatives Technical Solutions

Alternatives technical solutions shall not be permitted.

2. Qualification

(i) Exchange Rate for Qualification Criteria

Wherever a Form in Section IV, Bidding Forms, requires a Bidder to state a monetary amount, Bidders should indicate the **INR equivalent** using the rate of exchange determined as follows:

- (a) For turnover or financial data required for each year - Exchange rate prevailing on the last day of the respective calendar year.
- (b) Value of single Contract - Exchange rate prevailing on the date of completion / date given in substantial completion certificate as applicable.

Exchange rates shall be taken from the publicly available source **identified in ITB 37.1** or, in case such rates are not available in the source identified above, any other publicly available source acceptable to the Employer. Any error in determining the exchange rates may be corrected by the Employer.

(ii) Qualification Criteria for Multiple Contracts

Not applicable

Eligibility and Qualification Criteria			Compliance Requirements				Documentation
No.	Factor /Sub-Factor	Requirement	Single Entity	Joint Venture (Existing or Intended)			Submission Requirements
				All Parties Combined	Each Member	Lead Member	
2.1 Eligibility							
2.1.1	Nationality	Nationality in accordance with ITB 4.3.	Must meet requirement	N/A	Must meet requirement	N/A	Form ELI –1 and 2, with attachments
2.1.2	Conflict of Interest	No conflicts of interest as described in ITB 4.2.	Must meet requirement	N/A	Must meet requirement	N/A	Letter of Technical Bid
2.1.3	Ineligibility	Not having been declared ineligible by Employer, as described in BDS and ITB 4.	Must meet requirement	N/A	Must meet requirement	N/A	Letter of Technical Bid
2.2 Historical Non-Performance							
2.2.1	History of non-performing Contracts	Non-performance of a Contract ⁽ⁱ⁾ did not occur as a result of Contractor’s default within five (5) years of the bid submission deadline.	Must meet requirement ⁽ⁱⁱ⁾	N/A	Must meet requirement ⁽ⁱⁱ⁾	N/A	Form CON
2.2.2	Pending Litigation	All pending litigation shall in total not represent more than Seventy Five percent (75%) of the Bidder’s net worth and shall be treated as resolved against the Bidder.	Must meet requirement ⁽ⁱⁱ⁾	N/A	Must meet requirement ⁽ⁱⁱ⁾	N/A	Form CON

Eligibility and Qualification Criteria			Compliance Requirements				Documentation
No.	Factor /Sub-Factor	Requirement	Single Entity	Joint Venture (Existing or Intended)			Submission Requirements
				All Parties Combined	Each Member	Lead Member	
2.2.3	Litigation History	No consistent history of court / arbitral award decisions against the Bidder ⁽ⁱⁱⁱ⁾ within five (5) years of the bid submission deadline.	Must meet requirement ⁽ⁱⁱ⁾	N/A	Must meet requirement ⁽ⁱⁱ⁾	N/A	Form CON

Notes for the Bidder

- (i) Non-performance, as decided by the Employer, shall include all Contracts:
- (a) where nonperformance was not challenged by the Contractor, including through referral to the dispute resolution mechanism under the respective Contract, and
 - (b) that were so challenged but fully settled against the Contractor.
- Non-performance shall not include Contracts where Employers decision was overruled by the dispute resolution mechanism. Non-performance must be based on all information on fully settled disputes or litigation, i.e. dispute or litigation that has been resolved in accordance with the dispute resolution mechanism under the respective Contract and where all appeal instances available to the Applicant have been exhausted.
- (ii) This requirement also applies to Contracts executed by the Bidder as a JV member.
 - (iii) The Bidder shall provide accurate information on the related Bidding Form about any litigation or arbitration resulting from Contracts completed or ongoing under its execution over the last five (5) years. A consistent history of awards against the Bidder or any member of a joint venture may result in rejection of the Bid.

Eligibility and Qualification Criteria			Compliance Requirements				Documentation Submission Requirements
No.	Factor /Sub-Factor	Requirement	Single Entity	Joint Venture (Existing or Intended)			
				All Parties Combined	Each Member	Lead Member	
2.3 Financial Situation							
2.3.1	Financial Performance	The audited balance sheets or, if not required by the law of the Bidder's country, other financial statements acceptable to the Employer, for the last FIVE (5) years of the bid submission deadline shall be submitted and must demonstrate the current soundness of the Bidder's financial position and its prospective long-term profitability. As the minimum requirement, a Bidder's net worth calculated as the difference between total assets and total liabilities should be positive for any three years out of five years	Must meet requirement	Must meet requirement (i), (ii), (iii) & (iv)	N/A	N/A	Form FIN – 1 with attachments
2.3.2	Average Annual Turnover	Minimum average annual turnover of INR 440 crores calculated as total certified payments received for Contracts in progress and/or completed, within the last FIVE (5) years of the bid submission deadline.	Must meet requirement	Must meet requirement (i), (ii), (iii) & (iv)	N/A	N/A	Form FIN – 2
2.3.3	Financial Resources	(i) The Bidder shall demonstrate that it has access to, or has available, liquid assets, unencumbered real assets, lines of credit, and other financial means (independent of any contractual advance payment) sufficient to meet the cash flow requirements estimated as INR 70 crores for the subject Contract(s) net of the Bidder's other commitments.	Must meet requirement	Must meet requirement (i), (ii), (iii) & (iv)	N/A	N/A	Form FIR – 1

Eligibility and Qualification Criteria			Compliance Requirements				Documentation Submission Requirements
No.	Factor /Sub-Factor	Requirement	Single Entity	Joint Venture (Existing or Intended)			
				All Parties Combined	Each Member	Lead Member	
		(ii)The Bidder shall also demonstrate, to the satisfaction of the Employer, that it has adequate sources of finance to meet the cash flow requirements on works currently in progress and for future contract commitments.	Must meet requirement	Must meet requirement (i), (ii), (iii) & (iv)	N/A	N/A	Form FIR – 1 Form FIR – 2
2.4 Experience							
2.4.1	General Experience	Experience under Contracts in the role of Prime Contractor (single entity or JV member), Subcontractor, or management Contractor ^(vi) for at least the last five (5) years of the bid submission deadline.	Must meet requirement	N/A	N/A	Must meet requirement	Form EXP - 1
2.4.2 (a)	Specific Experience	A minimum number of 114 cars (Metro, LRT, Suburban EMUs, Train sets) must have been manufactured as a prime Contractor (single entity or JV member) during the last TEN (10) years of the bid submission deadline.	Must meet requirement	Must meet requirement (i), (ii), (iii) & (iv)	N/A	N/A	Form EXP-2 Form EXP-2 (a)
2.4.2 (b)	Specific Experience	(A) A minimum of 57 cars (Metro, LRT, Suburban EMUs, Train sets) with stainless steel / Aluminum must have been designed and manufactured (OR) (B) A minimum of 57 cars comprising stainless steel / Aluminum / Corten steel / steel EMU / MEMU / Metro car manufactured in India	Must meet requirement	Must meet requirement (i), (ii), (iii) & (iv)	N/A	N/A	Form EXP-2, Form EXP-2 (b) Form EXP-2(c)

Eligibility and Qualification Criteria			Compliance Requirements				Documentation Submission Requirements
No.	Factor /Sub-Factor	Requirement	Single Entity	Joint Venture (Existing or Intended)			
				All Parties Combined	Each Member	Lead Member	
		for either metro company or Indian Railways (OR) (C) Assembled more than 100 aluminum / stainless steel metro cars in premises in India. <i>Note: For (B) and (C) the bidder should either have design experience or procure / subcontract design from experienced designer or form a JV with a company having design experience. The credential to this effect should be submitted with the bid.</i> <i>Here, “experienced designer” means a firm / company having relevant design experience.</i>					
2.4.2 (c)	Specific Experience	Quantity stipulated under 2.4.2 (b) must have been supplied to 1. Outside the parent company or group company (and) 2. Country other than the country of origin (or) India	Must meet requirement	Must meet requirement (i), (ii), (iii) & (iv)	N/A	N/A	Form EXP-2 Form EXP - 2(d)

Eligibility and Qualification Criteria			Compliance Requirements				Documentation Submission Requirements
No.	Factor /Sub-Factor	Requirement	Single Entity	Joint Venture (Existing or Intended)			
				All Parties Combined	Each Member	Lead Member	
2.4.2 (d)	Specific Experience	A minimum of 57 cars (Metro, LRT, Suburban EMUs, Train sets) for a period of three years shall be in satisfactory revenue operation at the time of bid submission. "NOTE: Experience certificates can be submitted in any format. It is bidder's responsibility to ensure that all the necessary information sought above are captured."	Must meet requirement	Must meet requirement (i), (ii), (iii) & (iv)	N/A	N/A	Form EXP-2 Form EXP- 2(e)

Notes for the Bidder

- (i) For a Consortium / JV the credentials (Technical as well as Financial) of all member(s) having a minimum 15% participation each in JV/Consortium will be required to be submitted by the bidder and shall be considered for evaluation. In case of Net worth, Liquidity and turnover, the financial credentials will be considered based on the summation of weighted credential of individual members in proportionate to their share in JV / Consortium. In the case of JV / Consortium between companies with subsidiaries, the consolidated numbers of the parent company will only be considered. However, in case of technical eligibility, the credential will be based on the algebraic aggregated credential of each member. The credential (Technical as well as Financial) of a member who has less than 15% participation in JV/Consortium shall not be considered.
- (ii) For the participation by Subsidiary company / Parent company with credentials of other company :
 - a) Applicant in the capacity of a Subsidiary as a single entity is not permitted to use the credential of its Parent Company and/or its sister Subsidiary Company / Companies unless the Applicant participates in bid as JV / Consortium with its Parent Company and/or its sister Subsidiary Company / Companies as a member(s) in JV with minimum 15% participation each for such member(s).
 - b) Also, Applicant in the capacity of a Parent Company as a single entity is not permitted to use the credential of its Subsidiary Company / Companies unless the Applicant participates in bid as JV / Consortium with minimum 15% participation each for such member(s).
- (iii) However, in case of consortium / JV between companies and their subsidiaries where either the parent or the subsidiary or both is/are (an) Indian company / companies registered in India, parent company shall be eligible to bid on the basis of credentials of their owned subsidiaries. Subsidiaries shall be eligible to bid on the basis of credentials of their parent company. Here it will be mandatory that the bidders must enter into a consortium / JV agreement with a token participation of such parent / subsidiary whose credentials are being

sought to be used. This consortium / JV agreement should clearly stipulate that the individual companies (i.e. the parent and the JV) shall be jointly and severally responsible and liable for the timely execution of the contract and failure to do so will make all of the them liable to the penal conditions of the contract. In such a case there will be no requirement of the minimum threshold of 15% participation by each member of the consortium / JV.

- (iv) For contracts under which the Bidder participated as a JV member, only the Bidder's share, by value, shall be considered to meet this requirement.
- (v) The bidder, as stipulated in 2.4.2 (b) should have performed the train integration as well as interface with other systems like Signalling, Telecom, etc.
- (vi) A management contractor is a firm which takes on the role of contract management as a "general" contractor of sort could do. It does not normally perform directly the construction work(s) associated with the contract. Rather, it manages the work of other (sub) contractors while bearing full responsibility and risk for price, quality, and timely performance of the work contract

2.5 Subcontractors / Manufacturers

Subcontractors / Manufacturers for the following major items of supply or services must meet the following minimum criteria, herein listed for that item:

1

Item No.	Description of Item	Minimum Criteria to be met	Form
1	Bogie	Minimum of 114 cars of similar standard gauge with wheel mounted or Axle mounted Disc brakes or tread brake bogies as proposed for this bid should have been designed, manufactured and commissioned in the last ten (10) years at the bid submission deadline and at least 57 cars with the similar bogies should have been supplied and proven in service for a period of minimum three (3) years. The proposed system shall be in satisfactory revenue operation for at least three (3) years ~~of as~~ on the bid submission deadline, in a country other than the country of origin of manufacturer or in India. ~~at the time of bid submission.~~	Form Sys-1
2	Propulsion (Traction converter, Auxiliary converter and Traction motors)	~~The designer of the Traction Converter Inverter shall be considered as the integrator of the Propulsion System and shall individually have a minimum of ten (10) years of experience in the design and manufacturing of Traction Converter Inverters for Metro Rolling Stock. Additionally, the system supplied shall have been in satisfactory revenue operation for at least five (5) years in a country other than the country of origin of manufacturer or in India, in a minimum aggregate of 300 cars, comprising both powered and non-powered cars, supplied against at least three (3) different contracts in Metro Railway. The integrator of the propulsion system shall have full responsibility for any warranty obligations and design modifications of the propulsion system during the contract period, for which adequate past experience is required. Furthermore, other suppliers must qualify for their respective scope of work against the eligibility criteria as mentioned in the respective tenders of the Metro Railway.~~ The designer of Traction converter-inverter shall be considered as the integrator of the Propulsion system and shall individually have experience of minimum ten (10) years in the Design and Manufacturing of Traction converter-inverter / Inverter for Metro rolling stock AND the system supplied have been in satisfactory revenue operation for at least five (5) years in minimum aggregate 500 cars comprising of both powered and non-powered cars, supplied against minimum five (5) different contracts in the Metro Railway (i.e. MRT, LRT, Suburban Railways or high speed railways) of minimum two (2) different countries outside the country of origin or in India. Integrator of the propulsion system shall have the entire responsibility for any warranty obligations and design modifications of propulsion system during the contract period for which it should have adequate	Form Sys-2

1

Item No.	Description of Item	Minimum Criteria to be met	Form
		past experience. Besides, other suppliers must qualify for respective scope of work against the eligibility criteria as per the eligibility conditions mentioned in the respective tenders of the metros (or) ~~The manufacturer of the propulsion equipment (Traction Converter Inverter, Auxiliary Converter Inverter, and Traction Motor) proposed by the bidder as a sub-contractor for the supply of propulsion equipment against this bid shall have a minimum of ten (10) years of experience in the field of design and manufacturing of the propulsion equipment. The propulsion equipment designed, manufactured, and supplied by the said manufacturer must have been in satisfactory revenue operation for at least five (5) years in a country other than the country of origin of manufacturer or in India, in a minimum aggregate of 300 cars comprising both powered and non-powered cars, supplied against at least three (3) different contracts in the Metro Railway.~~ Manufacturer of the Propulsion Equipment (Traction Converter-Inverter, Auxiliary Converter-Inverter and Traction Motor) proposed by the Bidder as a sub-contractor for supply of the Propulsion Equipment against this Bid, shall have minimum ten (10) years experience in the field of Design and Manufacturing of the Propulsion Equipment AND do the Propulsion Equipment Designed, Manufactured and Supplied by the said manufacturer have been in satisfactory revenue operation for at least five (5) years in minimum aggregate 500 cars comprising of both powered and non-powered cars, supplied against minimum five (5) different contracts in the Metro Railway (i.e. MRT, LRT, Sub-urban Railways or high speed railways) of minimum two (2) different countries outside the country of origin or in India. Note: Bidders shall note that experience of propulsion equipment supplied for Light Rail Vehicle, Tramways shall not be considered for fulfillment of the above eligibility criteria	
1	3	Passenger Doors The proposed system shall be in satisfactory revenue operation for at least three (3) years ~~of as on~~ the bid submission deadline, in a country other than the country of origin of manufacturer or in India. ~~at the time of bid submission.~~	Form Sys-3
1	4	Ventilation Air Conditioning System The proposed system shall be in satisfactory revenue operation for at least three (3) years ~~of as on~~ the bid submission deadline, in a country other than the country of origin of manufacturer or in India. ~~at the time of bid submission.~~	Form Sys-4
	5	Train Control and Monitoring The proposed system shall be in satisfactory revenue operation in GoA4 for at least three (3) years ~~of as on~~ the bid submission deadline, in a country other than the country	Form Sys-5

1	Item No.	Description of Item	Minimum Criteria to be met	Form
		System (TCMS)	of origin of manufacturer or in India. ~~at the time of bid submission.~~	
1	6	Pneumatic & Brake Equipment (including Air Generation and Treatment unit)	The proposed system shall be in satisfactory revenue operation for at least three (3) years ~~of as on~~ the bid submission deadline, in a country other than the country of origin of manufacturer or in India. ~~at the time of bid submission.~~	Form Sys-6
1	7	Couplers and Draft Gear	The proposed system shall be in satisfactory revenue operation for at least three (3) years ~~of as on~~ the bid submission deadline, in a country other than the country of origin of manufacturer or in India. ~~at the time of bid submission.~~	Form Sys-7
1	8	Communication system	The proposed system shall be in satisfactory revenue operation for at least three (3) years ~~of as on~~ the bid submission deadline, in a country other than the country of origin of manufacturer or in India. ~~at the time of bid submission.~~	Form Sys-8
1	9	Main transformer	The proposed Main Transformer shall be in satisfactory revenue operation for at least Ten years ~~of as on~~ the bid submission deadline, in a country other than the country of origin of manufacturer or in India. ~~at the time of bid submission.~~	Form Sys-9
1	10	VCB	The proposed VCB shall be in satisfactory revenue operation for at least Ten years ~~of as on~~ the bid submission deadline, in a country other than the country of origin of manufacturer or in India. ~~at the time of bid submission.~~	Form Sys-10

Note:

1. The bidder shall submit ~~tentative the proposed~~ subcontractors list and proof of eligibility (Form Sys-1 to Form Sys-10) for each item mentioned in the above table.
2. Failure to comply with this requirement will result in rejection of the Subcontractor.
3. In the case of a Bidder who offers to supply and install major items of supply under the Contract that the Bidder did not manufacture or otherwise produce, the Bidder shall provide the manufacturer's authorization, using 5.16 Form MAN provided in Section IV, Bidding Forms, showing that the Bidder has been duly authorized by the manufacturer or producer of the related plant and equipment or component to supply and install that item in the Employer's country. The Bidder is responsible for ensuring that the manufacturer or producer complies with the requirements of ITB 4 and ITB 5 and meets the minimum criteria listed above for that item.
4. ~~Consortium/JV or a sub-contractor is permitted in the case of~~ Item Nos. 1 to 10.
5. ~~The Member of the Consortium/Joint Venture or the Manufacturer must have been the manufacturer of the subsystem and supplied as per the criteria. The overall responsibility of meeting the contractual obligations for the subsystem shall lie with the manufacturer of the respective subsystem. The bidder shall remain responsible for all contractual obligations, not withstanding the engagement of any manufacturer or subcontractor for any subsystem.~~

2.6 Establishment of a Rolling Stock manufacturing facility in India:

The successful bidder shall ensure that 100% of the Rolling Stock ordered in this bid shall be achieved by establishing / in the established metro cars manufacturing facility of their own, in India, to manufacture the Rolling Stock.

By way of declaration, Bidders shall fill Part 1: Section IV – Bidding Forms, Clause 6.11 “Form Manufacturing Facility: Establishment of manufacturing facility in India”.

2.7 Purchase Preference

The requirements of stipulations pertaining to Public Procurement Order, 2017 dated 16th September 2020 issued by Ministry of Commerce and Industry, Department of Promotion of Industry and Internal Trade (Public Procurement Section) shall apply.

Minimum Local Content (MLC) for Class – 1 local supplier shall be 60% (Derived on Total Contract Price) as per the order No.K – 14011 / 08 / 2017 / MRTS – Coord dated 14th October 2020 issued by Ministry of Housing and Urban Affairs (MoHUA).

The Undertaking / Confirmation shall be submitted by the Bidder as per the prescribed Form 5.15 ‘CERTIFICATE CONFIRMING MINIMUM LOCAL CONTENT’ in Section IV - Bidding Forms.



CHENNAI METRO RAIL LIMITED

CHENNAI METRO RAIL PROJECT PHASE 1

Tender No. ARE05

**DESIGN, MANUFACTURE, SUPPLY, TESTING,
COMMISSIONING OF STANDARD GAUGE METRO
ROLLING STOCK (ELECTRICAL MULTIPLE
UNITS) AND DEPOT MACHINERY & PLANT AND
TRAINING OF PERSONNEL.**

**PART 1: BIDDING PROCEDURES
SECTION - IV: BIDDING FORMS**

~~NOV 2025 APR 2026~~ **JUN 2026**

Table of Contents

1.	LETTERS	3
1.1	LETTER OF TECHNICAL BID.....	3
1.2	LETTER OF PRICE BID.....	5
2.	SCHEDULE OF ADJUSTMENT DATA	7
3.	INSTRUCTIONS FOR COMPLETING THE PRICING DOCUMENT:.....	16
3.1	GENERAL REQUIREMENTS:.....	16
3.2	PRICE VARIATION / PRICE ADJUSTMENT:	16
3.3	OPTION QUANTITY VARIATION:	20
4	PRICE SCHEDULES.....	20
4.1	PREAMBLE.....	20
4.2	PRICING SUMMARY (BID TOTAL)	26
4.3	DETAILS OF TAXES / DUTIES / LEVIES ETC. INCLUDED IN THE LUMP SUM PRICE (PRICE CENTRE WISE)	29
4.4	SCHEDULE OF PAYMENTS	52
5	TECHNICAL PROPOSAL.....	85
5.1	SITE ORGANISATION	85
5.2	METHOD STATEMENT	85
5.3	MOBILIZATION SCHEDULE	85
5.4	CONSTRUCTION SCHEDULE	85
5.5	PRELIMINARY DESIGN	85
5.6	PLANT	85
5.7	OCCUPATIONAL, HEALTH, SAFETY AND ENVIRONMENTAL PLAN	85
5.8	FORM SOG: SCHEDULE OF GUARANTEE	85
5.9	FORM PER-1: PROPOSED PERSONNEL	85
5.10	FORM PER-2: RESUME OF PROPOSED PERSONNEL	85
5.11	FORM EQU: EQUIPMENT	86
5.12	FORM SPA: SPARE PARTS	86
5.13	FORM SUB: PROPOSED SUBCONTRACTORS FOR MAJOR ITEMS OF PLANT AND INSTALLATION SERVICES	86
5.14	CERTIFICATE CONFIRMING NO DEVIATION FROM TENDER CONDITIONS	87
5.15	CERTIFICATE CONFIRMING MINIMUM LOCAL CONTENT	88
5.16	FORM MAN: MANUFACTURER'S AUTHORIZATION	89
5.17	CERTIFICATE CONFIRMING PERSONNEL TO THE WORKS	90
6.	BIDDER'S QUALIFICATION	91
6.1	FORM ELI-1: BIDDER INFORMATION FORM	92
6.2	FORM ELI-2: JV MEMBER INFORMATION FORM	93
6.3	FORM CON: HISTORICAL CONTRACT NON-PERFORMANCE AND LITIGATION	94
6.4	FORM FIN-1: FINANCIAL SITUATION	97
6.5	FORM FIN-2: AVERAGE ANNUAL TURNOVER.....	99
6.6	FORM FIR -1: FINANCIAL RESOURCES.....	100
6.7	FORM FIR-2: CURRENT CONTRACT COMMITMENTS.....	101
6.8.1	FORM EXP-1: GENERAL EXPERIENCE.....	102
6.9	FORM EXP-2: SPECIFIC EXPERIENCE.....	103

6.10.1	FORM EXP-2(A): SPECIFIC EXPERIENCE.....	105
6.10.2	FORM EXP-2(B): SPECIFIC EXPERIENCE.....	106
6.10.3	FORM EXP-2(C): SPECIFIC EXPERIENCE.....	107
6.10.4	FORM EXP-2(D): SPECIFIC EXPERIENCE.....	108
6.10.5	FORM EXP-2(E): SPECIFIC EXPERIENCE.....	109
6.11	FORM MANUFACTURING FACILITY: ESTABLISHMENT OF MANUFACTURING FACILITY IN INDIA	110
6.12.1	FORM SYS-1: SUBCONTRACTORS / MANUFACTURERS.....	111
6.12.2	FORM SYS-2: SUBCONTRACTORS / MANUFACTURERS.....	112
6.12.3	FORM SYS-3: SUBCONTRACTORS / MANUFACTURERS.....	113
6.12.4	FORM SYS-4: SUBCONTRACTORS / MANUFACTURERS.....	114
6.12.5	FORM SYS-5: SUBCONTRACTORS / MANUFACTURERS.....	115
6.12.6	FORM SYS-6: SUBCONTRACTORS / MANUFACTURERS.....	116
6.12.7	FORM SYS-7: SUBCONTRACTORS / MANUFACTURERS.....	117
6.12.8	FORM SYS-8: SUBCONTRACTORS / MANUFACTURERS.....	118
6.12.9	FORM SYS-9: SUBCONTRACTORS / MANUFACTURERS.....	119
6.12.10	FORM SYS-10: SUBCONTRACTORS / MANUFACTURERS.....	120
6.13	~~FORM MINIMUM LOCAL CONTENT (APPLICABLE ONLY FOR CLASS-I LOCAL SUPPLIER)-DELETED~~	~~121~~
6.14	CERTIFICATE CONFIRMING PERSONNEL TO THE WORKS.....	122
6.15	UNDERTAKING ON NO CHILD LABOUR OR BONDED LABOUR IN SUPPLY CHAINS.....	123
7.	FORM FOR SEEKING CLARIFICATION ON BIDDING DOCUMENTS	124
8.	SAMPLE FORMAT FOR BANKING REFERENCE LIQUIDITY	125
9.	UNDERTAKING REGARDING RESTRICTIONS ON PROCUREMENT FROM A BIDDER OF A COUNTRY WHICH SHARES A LAND BORDER WITH INDIA	126
10.	FORM OF BID SECURITY.....	127
11.	FORM POA – POWER OF ATTORNEY FOR SIGNING THE BID	128
12.	UNDERTAKING REGARDING RESTRICTIONS ON PROCUREMENT FROM A BIDDER OF A COUNTRY WHICH SHARES A LAND BORDER WITH INDIA AND ON SUB-CONTRACTING	129
13.	ADDITIONAL CERTIFICATE BY BIDDERS IN THE CASES OF SPECIFIED TOT:	130
14.	CERTIFICATE CONFIRMING NO MIDDLEMAN ENGAGEMENT	131
15.	~~FORM – UNDERTAKING REGARDING RESTRICTIONS ON PROCUREMENT FROM A BIDDER OF A COUNTRY WHICH SHARES A LAND BORDER WITH INDIA.....~~	~~132~~

1

1

1. LETTERS

[Prepare this Letter of Technical Bid on stationery with its letterhead clearly showing the Bidder's complete name and business address.]

1.1 LETTER OF TECHNICAL BID

Date : [insert date of Bid submission]
IFB No. : **ARE05**

To,

The Managing Director,
Chennai Metro Rail Limited,
METROS Building,
No: 327, Anna Salai, Nandanam,
Chennai 600 035, Tamil Nadu, India.

We, the undersigned, declare that:

- (a) We have examined and have no reservations to the Bidding Document, including addenda issued in accordance with Instructions to Bidders (ITB) 8. [insert the number and issuing date of each addendum];
- (b) We, including any Subcontractors / manufacturers, for any part of the Contract, meet the eligibility requirements in accordance with ITB 4 and ITB 5;
- (c) We, including any Subcontractors / manufacturers, for any part of the Contract, have no conflict of interest in accordance with ITB 4;
- (d) We offer to execute in conformity with the Bidding Document the following Works: **“DESIGN, MANUFACTURE, SUPPLY, TESTING, COMMISSIONING OF STANDARD GAUGE METRO ROLLING STOCK (ELECTRICAL MULTIPLE UNITS) AND DEPOT MACHINERY & PLANT AND TRAINING OF PERSONNEL.”**
- (e) Our Bid shall be valid for a period of **180** days from the date fixed for the Bid submission deadline in accordance with the Bidding Document, and it shall remain binding upon us and may be accepted at any time before the expiration of that period.
- (f) We are not participating, as a Bidder or as a subcontractor / manufacturer, in more than one Bid in this bidding process in accordance with ITB 4.2(c); and
- (g) We hereby certify that we have taken steps to ensure that no person acting for us or on our behalf will engage in any type of fraud or corruption.
- (h) We (Single Entity or JV / Consortium member) hereby declare that we have not been debarred by Multilateral and bilateral funding agencies / Government of India / Railway Administration / any State Government / any State Government undertaking as on the due date of submission of bid.
- (i) We (Single Entity or JV / Consortium member) hereby declare that we have not been banned to do the business with Metro Rail Companies in India / Other Metro Operators in India / Railways

Administration / MoHUA / Ministry of Commerce / Any Other Central or State Government Organizations in India, as on the due date of submission of this bid.

- (j) We hereby declare that neither we, nor any of our joint venture/consortium member(s), nor any of our associates, parent company, affiliates, subsidiaries, are subject to, or are controlled by any entity or individual that is subject to, has had any contract (including but not limited to similar works) of value more than INR 10 Crore temporarily suspended, debarred, declared ineligible, blacklisted, rescinded or terminated due to non-performance, by any Metro Rail Company in India, other Metro Operators in India, Indian Railways, or any Central or State Government Organization in India, within the last five (5) years prior to the due date of submission of this bid.

We understand that any misrepresentation or concealment of information in this declaration may lead to our disqualification and/or appropriate legal action by the Employer.

Name of the Bidder¹ *[insert name of the Bidder]*

Name of the person duly authorized to sign the Bid on behalf of the Bidder² *[insert complete name of person duly authorized to sign the Bid]*

Title of the person signing the Bid *[insert complete title of the person signing the Bid]*

Signature of the person named above *[insert signature of person whose name and capacity are shown above]*

Date signed *[insert date of signing]* day of *[insert month]*, *[insert year]*

Notes for the Bidders

- 1. In the case of a Bid submitted by a Joint Venture, specify the name of the Joint Venture as Bidder.*
- 2. Person signing the Bid shall have the Power of Attorney given by the Bidder to be included in the Technical Bid.*

[Prepare this Letter of Price Bid on stationery with its letterhead clearly showing the Bidder's complete name and business address.]

1.2 LETTER OF PRICE BID

Date : [insert date of Bid submission]
IFB No. : ARE05

To:
The Managing Director,
Chennai Metro Rail Limited,
METROS Building,
No: 327, Anna Salai, Nandanam,
Chennai 600 035, Tamil Nadu, India.

We, the undersigned, declare that:

- (a) We have examined and have no reservations to the Bidding Document, including addenda issued in accordance with Instructions to Bidders (ITB) 8. [insert the number and issuing date of each addendum];
- (b) We offer to execute in conformity with the Bidding Document and Technical Bid the following Works: **“DESIGN, MANUFACTURE, SUPPLY, TESTING, COMMISSIONING OF STANDARD GAUGE METRO ROLLING STOCK (ELECTRICAL MULTIPLE UNITS) AND DEPOT MACHINERY & PLANT AND TRAINING OF PERSONNEL.”**
- (c) The total price of our Bid is:
[Insert the total Bid Price in words and figures, indicating the amounts in the respective currencies.]
- (d) We hereby confirm that all the tables mentioned under Part 1 – Bidding Forms (Section 4) is attached in this price bid (Signed and Sealed copy in PDF version and Editable excel format).
- (e) Our Bid shall be valid for a period of **180** days from the date fixed for the Bid submission deadline in accordance with the Bidding Document, and it shall remain binding upon us and may be accepted at any time before the expiration of that period;
- (f) If our Bid is accepted, we commit to obtain a Performance Security in accordance with the Bidding Documents.
- (g) We understand that this Bid, together with your written acceptance thereof included in your Letter of Acceptance, shall constitute a binding contract between us, until a formal contract is prepared and executed; and
- (h) We understand that you are not bound to accept the lowest evaluated Bid or any other Bid that you may receive.

Name of the Bidder¹ [insert name of the Bidder]

Name of the person duly authorized to sign the Bid on behalf of the Bidder² [insert complete name of person duly authorized to sign the Bid]

Title of the person signing the Bid [insert complete title of the person signing the Bid]

Signature of the person named above [insert signature of person whose name and capacity are shown above]

Date signed [insert date of signing] day of [insert month], [insert year]

Notes for the Bidders

1. In the case of a Bid submitted by a Joint Venture, specify the name of the Joint Venture as Bidder.
2. Person signing the Bid shall have the Power of Attorney given by the Bidder to be attached along with the Bid.

2

2. SCHEDULE OF ADJUSTMENT DATA**Table A: Local Currency (Indian Rupees)**

DETAILS ARE NOT TO BE SUBMITTED WITHIN THE TECHNICAL BID. THEY ARE TO BE FILLED AND UPLOADED IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL ONLY.

(a)	(b)	(c)	(d)	(e)	(f)	(g)
Index Code	Index Description	Source of Index	Base value and date	Currency of Index	Weightage	Weightage to be filled by Bidder
	Non-adjustable (Fixed)	=	=		0.33	0.33
L _n L ₀	Labour	All India Consumer Price Index for Industrial Workers Published by RBI Bulletin (base year 2016)			0.10 ~ 0.25	
S _n S ₀ A _n A ₀	Stainless steel (Or) Aluminium	CRU ALCOA			0.15 ~ 0.25	
F _n F ₀	Carbon Steel	CRUspi			0.10 ~ 0.30	
C _n C ₀	Copper	LME			0.04 ~ 0.10	
Total					1.00	1.00

Legend:

RBI— Reserve Bank of India

Price adjustment shall be calculated as per the above table and as per Cl. 3.2 of “Part 1— Bidding Forms— Instructions for Completing the Pricing document”.

Note:

- a) ~~Bidders shall quote the applicable weightage / co-efficient against each component listed above within the range specified therein and the sum total of all the components (including Non-adjustable (Fixed) component) shall be equal to 1 (100%).~~
- b) ~~Bidders shall duly fill and submit the above table (Column d, Column e & Column g) and include along with their Price Bid and necessary proof. Indices values which are not available during the bid submission date shall be submitted before signing of Contract Agreement.~~
- c) ~~Bidders shall fill ‘Column d’ with the value as on 28 days prior to last date of bid submission.~~
- d) ~~In cases where a Bidder fills in weightages that are not within the range specified, CMRL will adjust the weightage according to the limits of the range specified.~~
- e) ~~In cases where a Bidder fills in weightages whose sum is not equal to 0.67 (excluding Nonadjustable), then CMRL will adjust the indices on prorated basis based on the Bidder’s submission.~~
- f) ~~Not used.~~
- g) ~~Appropriate CRU / CRUspi— North America / Europe / Asia / Global is to be indicated by the Bidder.~~

2

Table B. Foreign Currency 1 (FC1)

DETAILS ARE NOT TO BE SUBMITTED WITHIN THE TECHNICAL BID. THEY ARE TO BE FILLED AND UPLOADED IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL ONLY.

(a)	(b)	(c)	(d)	(e)	(f)	(g)
Index Code	Index Description	Source of Index	Base value and date	Currency of Index	Weightage	Weightage to be filled by Bidder
	Non-adjustable (Fixed)	=	=		0.33	0.33
L _n L ₀	Labour	All India Consumer Price Index for Industrial Workers Published by RBI Bulletin (base year 2016)			0.10 ~ 0.25	
S _n S ₀ A _n A ₀	Stainless steel (Or) Aluminium	CRU ALCOA			0.15 ~ 0.25	
F _n F ₀	Carbon Steel	CRUspi			0.10 ~ 0.30	
C _n C ₀	Copper	LME			0.04 ~ 0.10	
Total					1.00	1.00

~~Price adjustment shall be calculated as per the above table and as per Cl. 3.2 of “Part 1 – Bidding Forms – Instructions for Completing the Pricing document”.~~

Note:

- ~~a) Bidders shall quote the applicable weightage / co-efficient against each component listed above within the range specified therein and the sum total of all the components (including Non-adjustable (Fixed) component) shall be equal to 1 (100%).~~
- ~~b) Bidders shall duly fill and submit the above table (Column d, Column e & Column g) and include along with their Price Bid and necessary proof. Indices values which are not available during the bid submission date shall be submitted before signing of the Contract Agreement.~~
- ~~c) Bidders shall fill ‘Column d’ with value as on 28 days prior to last date of bid submission.~~
- ~~d) In cases where a Bidder fills in weightages that are not within the range specified, CMRL will adjust the weightage according to the limits of the range specified.~~
- ~~e) In cases where a Bidder fills in weightages whose sum is not equal to 0.67 (excluding Nonadjustable), then CMRL will adjust the indices on prorated basis based on the Bidder’s submission.~~
- ~~f) Not used.~~
- ~~g) Appropriate CRU / CRUspi – North America / Europe / Asia / Global is to be indicated by the Bidder.~~

2

Table C. Foreign Currency 2 (FC2)

DETAILS ARE NOT TO BE SUBMITTED WITHIN THE TECHNICAL BID. THEY ARE TO BE FILLED AND UPLOADED IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL ONLY.

(a)	(b)	(c)	(d)	(e)	(f)	(g)
Index Code	Index Description	Source of Index	Base value and date	Currency of Index	Weightage	Weightage to be filled by Bidder
	Non-adjustable (Fixed)	=	=		0.33	0.33
L _n L ₀	Labour	All India Consumer Price Index for Industrial Workers Published by RBI Bulletin (base year 2016)			0.10 ~ 0.25	
S _n S ₀ A _n A ₀	Stainless steel (Or) Aluminium	CRU ALCOA			0.15 ~ 0.25	
F _n F ₀	Carbon Steel	CRUs _{pi}			0.10 ~ 0.30	
C _n C ₀	Copper	LME			0.04 ~ 0.10	
Total					1.00	1.00

~~Price Adjustment shall be calculated as per the above table and as per Cl. 3.2 of "Part 1 – Bidding Forms – Instructions for Completing the Pricing document".~~

~~Note:~~

- ~~a) Bidders shall quote the applicable weightage / co-efficient against each components listed above within the range specified therein and the sum total of all the components (including Non-adjustable (Fixed) component) shall be equal to 1 (100%).~~
- ~~b) Bidders shall duly fill and submit the above table (Column d, Column e & Column g) and include along with their Price Bid and necessary proof. Indices values which are not available during the bid submission date shall be submitted before signing of the Contract Agreement.~~
- ~~c) Bidders shall fill 'Column d' with value as on 28 days prior to last date of bid submission.~~
- ~~d) In cases where a Bidder fills in weightages that are not within the range specified, CMRL will adjust the weightage according to the limits of the range specified.~~
- ~~e) In cases where a bidder fills in weightages whose sum is not equal to 0.67 (excluding Nonadjustable), then CMRL will adjust the indices on prorated basis based on bidder's submission.~~
- ~~f) Not used.~~
- ~~g) Appropriate CRU / CRUs_{pi} – North America / Europe / Asia / Global to be indicated by the bidder.~~

2

2. SCHEDULE OF ADJUSTMENT DATA**Table A: Local Currency (Indian Rupees)**

DETAILS ARE NOT TO BE SUBMITTED WITHIN THE TECHNICAL BID. THEY ARE TO BE FILLED AND UPLOADED IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL ONLY.

(a)	(b)	(c)	(d)	(e)	(f)	(g)
Index Code	Index Description	Source of Index	Base value and date	Currency of Index	Weightage	Weightage to be filled by Bidder
	Non-adjustable (Fixed)	—	—		0.33	0.33
L _n L ₀	Labour	All India Consumer Price Index for Industrial Workers Published by RBI Bulletin (base year 2016)			0.10 ~ 0.25	
S _n S ₀ A _n A ₀	Stainless steel (Or) Aluminium	WPI (Comm_Code: 1314000000)			0.15 ~ 0.25	
EL _n EL ₀	Electronics/ computer items, Software etc.	WPI (Comm_Code: 1316000000)			0.05 ~ 0.10	
C _n C ₀	Electrical Machines (Motors, Transformer etc.)	WPI (Comm_Code: 1317000000)			0.10 ~ 0.20	
F _n F ₀	Fabricated Metal products	WPI (Comm_Code: 1315000000)			0.01 ~ 0.06	
J _n J ₀	Wholesale price index	WPI (Comm_Code: 1000000000)			0.10 ~ 0.20	
Total					1.00	1.00

Legend:

RBI – Reserve Bank of India

Price adjustment shall be calculated as per the above table and as per Cl. 3.2 of “Part 1 – Bidding Forms – Instructions for Completing the Pricing document”.

Note:

- Bidders shall quote the applicable weightage / co-efficient against each component listed above within the range specified therein and the sum-total of all the components (including Non-adjustable (Fixed) component) shall be equal to 1 (100%).
- Bidders shall duly fill and submit the above table (Column d, Column e & Column g) and include along with their Price Bid and necessary proof. Indices values which are not available during the bid submission date shall be submitted before signing of Contract Agreement.
- Bidders shall fill ‘Column d’ with the value as on 28 days prior to last date of bid submission.

- d) In cases where a Bidder fills in weightages that are not within the range specified, CMRL will adjust the weightage according to the limits of the range specified.*
- e) In cases where a Bidder fills in weightages whose sum is not equal to 0.67 (excluding Nonadjustable), then CMRL will adjust the indices on prorated basis based on the Bidder's submission.*
- f) Not used.*
- g) The Applicable Indices for INR shall be as published by the Office of the Economic Advisor, Ministry of Commerce, and Industry, GOI website <https://eaindustry.nic.in/>. Except Consumer Price Index for Industrial Workers shall be as published by Labour Bureau, Government of India*

Table B. Foreign Currency 1 (FC1)

2

DETAILS ARE NOT TO BE SUBMITTED WITHIN THE TECHNICAL BID. THEY ARE TO BE FILLED AND UPLOADED IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL ONLY.

(a)	(b)	(c)	(d)	(e)	(f)	(g)
Index Code	Index Description	Source of Index	Base value and date	Currency of Index	Weightage	Weightage to be filled by Bidder
	Non-adjustable (Fixed)	—	—		0.68	0.68
S _n S ₀ A _n A ₀	Stainless steel (Or) Aluminium	WPI / equivalent indices issued by the government of the country of manufacturer			0.10~ 0.25	
EL _n EL ₀	Computer, Electronic, Software and Optical products	WPI / equivalent indices issued by the government of the country of manufacturer			0.05 ~ 0.10	
C _n C ₀	Electrical Equipment (Motors, Transformer etc.)	WPI / equivalent indices issued by the government of the country of manufacturer			0.10 ~ 0.20	
Total					1.00	1.00

Price adjustment shall be calculated as per the above table and as per Cl. 3.2 of “Part 1 – Bidding Forms – Instructions for Completing the Pricing document”.

Note:

- Bidders shall quote the applicable weightage / co-efficient against each component listed above within the range specified therein and the sum-total of all the components (including Non-adjustable (Fixed) component) shall be equal to 1 (100%).
- Bidders shall duly fill and submit the above table (Column d, Column e & Column g) and include along with their Price Bid and necessary proof. Indices values which are not available during the bid submission date shall be submitted before signing of the Contract Agreement.
- Bidders shall fill ‘Column d’ with value as on 28 days prior to last date of bid submission.
- In cases where a Bidder fills in weightages that are not within the range specified, CMRL will adjust the weightage according to the limits of the range specified.
- In cases where a Bidder fills in weightages whose sum is not equal to 0.32 (excluding Nonadjustable), then CMRL will adjust the indices on prorated basis based on the Bidder’s submission.
- Not used.
- The Applicable Indices for Foreign Currency shall be as equivalent indices issued by the government of the country of manufacturer of the respective item under the index description tabulated above.
- Source agency and base indices shall be submitted by the contractor prior to the signing of the contract agreement.

- i) *If the price index quoted by the bidder do not match with the WPI / equivalent indices issued by the Govt. of the manufacturing Country (Foreign Country), the same shall be reviewed by the Engineer and incorporated in the agreement before signing the Contract.*

Table C. Foreign Currency 2 (FC2)

2

DETAILS ARE NOT TO BE SUBMITTED WITHIN THE TECHNICAL BID. THEY ARE TO BE FILLED AND UPLOADED IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL ONLY.

(a)	(b)	(c)	(d)	(e)	(f)	(g)
Index Code	Index Description	Source of Index	Base value and date	Currency of Index	Weightage	Weightage to be filled by Bidder
	Non-adjustable (Fixed)	—	—		0.68	0.68
S _n S ₀ A _n A ₀	Stainless steel (Or) Aluminium	WPI / equivalent indices issued by the government of the country of manufacturer ALCOA			0.10~ 0.25	
EL _n EL ₀	Computer, Electronic, Software and Optical products	WPI / equivalent indices issued by the government of the country of manufacturer			0.05 ~ 0.10	
C _n C ₀	Electrical Equipment (Motors, Transformer etc.)	WPI / equivalent indices issued by the government of the country of manufacturer			0.10 ~ 0.20	
Total					1.00	1.00

Price Adjustment shall be calculated as per the above table and as per Cl. 3.2 of “Part 1 – Bidding Forms – Instructions for Completing the Pricing document”.

Note:

- Bidders shall quote the applicable weightage / co-efficient against each components listed above within the range specified therein and the sum-total of all the components (including Non-adjustable (Fixed) component) shall be equal to 1 (100%).
- Bidders shall duly fill and submit the above table (Column d, Column e & Column g) and include along with their Price Bid and necessary proof. Indices values which are not available during the bid submission date shall be submitted before signing of the Contract Agreement.
- Bidders shall fill ‘Column d’ with value as on 28 days prior to last date of bid submission.
- In cases where a Bidder fills in weightages that are not within the range specified, CMRL will adjust the weightage according to the limits of the range specified.
- In cases where a bidder fills in weightages whose sum is not equal to 0.32 (excluding Nonadjustable), then CMRL will adjust the indices on prorated basis based on bidder’s submission.
- Not used.
- The Applicable Indices for Foreign Currency shall be as equivalent indices issued by the government of the country of manufacturer of the respective item under the index description tabulated above.

- h) Source agency and base indices shall be submitted by the contractor prior to the signing of the contract agreement.*
- i) If the price index quoted by the bidder do not match with the WPI / equivalent indices issued by the Govt. of the manufacturing Country (Foreign Country), the same shall be reviewed by the Engineer and incorporated in the agreement before signing the Contract.*

3. INSTRUCTIONS FOR COMPLETING THE PRICING DOCUMENT:

3.1 General Requirements:

- 3.1.1 The quoted lumpsum price by the bidder is inclusive of all taxes, levies, duties, cess as per GST / Custom tariff act etc., royalty, insurance, freight and fees required to be paid by him under the Contract.

The Bidder shall be required to provide the breakdown of the tax components considered in their lumpsum price in 'Table 4.3.1 and 4.3.2' of the Pricing Schedule and in compliance with the notes specified therein.

- 3.1.2 The successful Bidder shall maintain complete records of duties, taxes, and levies etc. payable to various authorities in respect of completely assembled / manufactured trains and Depot Machinery & Plant and submit the receipts / records as and when demanded in writing by the Employer for verification.

- 3.1.3 As single rate of custom duty is available under project imports scheme under heading 98.01 of Custom Tariff Act 1975 for import of capital goods, the advantage of the same may be considered under project import scheme. After award of the Contract, Employer at the written request of a Contractor shall facilitate the Contractor for obtaining sponsoring / recommendation letter from the Ministry of Housing and Urban Affairs (MoHUA) / GOI for getting themselves registered for availing Project Import benefits. However, the responsibility to avail the concessional benefits under Project Import or otherwise as extended in accordance with the law of the land shall solely rest with the Contractor.

Should the Employer obtain a waiver or exemption for any taxes and duties etc. in full or part thereof, the Contractor will be advised on the process to be followed to obtain exemption / refund of such taxes, duties etc., from the concerned Authorities. The Contractor shall arrange for the remittance of the refund so obtained to the Employer. In case of exemption, the Contractor shall pay the amount calculated by the Employer on account of exemption to the Employer either separately or the Employer at its discretion shall deduct the calculated amount from any payments due to the Contractor under the Contract. In case of failure by the Contractor to obtain and remit the refund within one month time to the Employer, the same will be recovered by the Employer from the amounts due as payment to the Contractor or as debt due from the Contractor. If the Contractor fails to take the required action to obtain refund or exemption, the Employer may take action in accordance with the Conditions of Contract.

3.2 Price Variation / Price adjustment:

- 3.2.1 Price adjustment is applicable on all the Price Centre payable to the Contractor excluding taxes & duties, excluding 'Price Centre RS-H - Training, operation and maintenance manuals', 'Price Centre DM&P-Q - Major machinery & plant', 'Price Centre DM&P-R - Other machinery & plant', 'Price Centre DM&P-S - Storage items', and 'Price Centre DM&P-T - Tools & Minor items' in accordance with the Contract, during performance of the Contract to reflect changes in the cost of labor, ~~copper, carbon steel~~, stainless steel / aluminum components, ~~Electrical Equipment, Computer, Electronic, Software and Optical products~~ and other inputs to the Works, in accordance with the following general formula specified;

(i) For Indian Rupees

Price Adjustment for Coaches with Stainless Steel Car-body:

$$P_n = R \times \{a + b (S_n/S_o) + c (C_n/C_o) + d (F_n/F_o) + f (L_n/L_o)\} - R$$

$$P_n = R \times \{a + b (S_n/S_o) + c (C_n/C_o) + d (F_n/F_o) + f (L_n/L_o) + g (EL_n/EL_o) + h (J_n/J_o)\} - R$$

2

Price Adjustment for Coaches with Aluminium Car-body:

$$P_n = R \times \{a + e (A_n/A_o) + c (C_n/C_o) + d (F_n/F_o) + f (L_n/L_o)\} - R$$

$$P_n = R \times \{a + e (A_n/A_o) + c (C_n/C_o) + d (F_n/F_o) + f (L_n/L_o) + g (EL_n/EL_o) + h (J_n/J_o)\} - R$$

Where:

“P_n” is the Price adjustment amount payable to or deductible from the Contractor against the respective certified milestone payment during the period ‘n’ under consideration.

“R” is the certified payment against the respective milestone during the period under consideration.

“a” is a fixed coefficient as specified in the Schedule of Adjustment Data shown in Bidding forms, Section IV, 2. SCHEDULE OF ADJUSTMENT DATA, Table A representing the non-adjustable portion in contractual payments;

“b”, “c”, “d”, “e”, “f”, “g” and “h” are coefficients representing the estimated proportion of each cost element (Stainless steel / Aluminium, Copper, Carbon steel Labor, Electrical Equipment, Computer, Electronic, Software and Optical products) in the Works or sections thereof, as quoted by the bidder in ‘Schedule of Adjustment Data’, Table A, in Section IV - Bidding forms.

“S_n”, “A_n”, “C_n”, “F_n”, “L_n”, “EL_n” and “J_n” are the current cost indices for the period “n”, determined pursuant to Schedule of Adjustment Data, Table A, in Bidding forms, Section IV of PART 1, applicable to each cost element; and

“S_o”, “A_o”, “C_o”, “F_o”, “L_o”, “EL_o” and “J_o” are base cost indices corresponding to the above cost elements at the date specified in Schedule of Adjustment Data, Table A, in Section IV - Bidding forms.

Subscript ‘o’ refers to indices as on 28 days prior to date of submission of bid. Subscript ‘n’ refers to indices as on 28 days prior to date of submission of bill.

(ii) For Foreign Currency (FC1 & FC2)Price Adjustment for Coaches with Stainless Steel Car-body:

$$P_n = R \times \{a + b (S_n/S_o) + c (C_n/C_o) + g (EL_n/EL_o)\} - R$$

Price Adjustment for Coaches with Aluminium Car-body:

$$P_n = R \times \{a + e (A_n/A_o) + c (C_n/C_o) + g (EL_n/EL_o)\} - R$$

Where:

“P_n” is the Price adjustment amount payable to or deductible from the Contractor against the respective certified milestone payment during the period ‘n’ under consideration.

“R” is the certified payment against the respective milestone during the period under consideration.

“a” is a fixed coefficient as specified in the Schedule of Adjustment Data shown in Bidding forms, Section IV, 2. SCHEDULE OF ADJUSTMENT DATA, Table B / C, representing the non-adjustable portion in contractual payments;

“b”, “c”, “e” and “g” are coefficients representing the estimated proportion of each cost element (Stainless steel / Aluminium, Copper, Carbon steel, Labor, Electrical Equipment, Computer, Electronic, Software and Optical products) in the Works or sections thereof, as quoted by the bidder in ‘Schedule of Adjustment Data’, Table B / C, in Section IV - Bidding forms.

“Sn”, “An”, “Cn” and “ELn” are the current cost indices for the period “n”, determined pursuant to Schedule of Adjustment Data, Table B / C, in Bidding forms, Section IV of PART 1, applicable to each cost element;

and

“So”, “Ao”, “Co” and “ELo” are base cost indices corresponding to the above cost elements at the date specified in Schedule of Adjustment Data, Table B / C, in Section IV - Bidding forms.

Subscript ‘o’ refers to indices as on 28 days prior to date of submission of bid. Subscript ‘n’ refers to indices as on 28 days prior to date of submission of bill.

To the extent that full compensation for any rise or fall in Costs is not covered by the provisions of this or other Clauses, the Accepted Contract Amount shall be deemed to have included amounts to cover the contingency of other rises and falls in costs.

3.2.2 Conditions Applicable to Price Adjustment:

The source of indices shall be as per ‘Schedule of Adjustment Data’ in Section IV - Bidding forms. Base dates are as follows;

- (a) The base cost indices or prices shall be those Bases, prevailing on the day 28 days prior to the closing date for submission of bids. Current indices or prices for Payments against price centre RS-CST, RS-FAI, RS-CPT, RS-C and RS-G shall be those prevailing on the day 120 days prior to NOWC / NONO date of respective milestone payment. Current Indices of prices for centre RS-A, RS-E and RS-F shall be those prevailing on the day 28 days prior to NOWC / NONO date of respective milestone payment. If at any time the current indices are not available, provisional indices as determined by the Engineer will be used, subject to subsequent correction of the amounts paid to the Contractor when the current indices become available.
- (b) No price adjustment shall be payable on advance payment. Price adjustment is not applicable on Price Centre RS-H (Training, operation and maintenance manuals), Price Centre DM&P-Q (Major machinery & plant), Price Centre DM&P-R (Other machinery & plant), Price Centre DM&P-S (Storage items), Price Centre DM&P-T (Tools & Minor items) and on taxes & duties components.
- (c) The responsibility for arranging copies of the all the above mentioned indices, from the listed sources as per Schedule of Adjustment Data in Section IV - Bidding Forms rests with the Contractor and shall be delivered to the Engineer along with each bill.
- (d) Whenever the nomenclature, classification or description of the indices undergo a change to what was available on the Base date, the Engineer will choose an appropriate indices closer to the one available on the Base date for the purpose of determining the variation. The decision of the Engineer in this regard shall be final and binding.
- (e) During Contract Execution, if Indices series for Indian Currency (INR) undergo a change then the linking factor will be arrived by using the Arithmetic Conversion Method as defined by the Office of Economic Advisor, GoI as a Migration methodology for arriving at the amounts payable to Contractor. The decision of the Employer / Engineer in this regard shall be final and binding.
- (f) The Contractor has to submit the Price Adjustment bill preferably on every quarter (every three month interval) or upto maximum of Half yearly (Six months interval) basis without fail, in compliance with all the conditions stated above.
- (g) Not used.
- (h) If the currency of the index specified in ‘Schedule of adjustment data’ of Section IV – Bidding Forms is different from the currency of payment, the value of the index on the Base date will be converted into a notional index in the currency of payment using the exchange rate on the base date between

2

the currency of the index and the currency of payment. This notional index value will be used as “S_o”, “A_o”, “E_{Lo}” and “C_o” “F_o” and “L_o” as applicable. The value of the index on the adjustment date in notional terms will be computed likewise using the exchange rate on the date of adjustment. These notional index values will correspond to “S_n”, “A_n”, “E_{Ln}” and “C_n” “F_n” and “L_n” as applicable.

For instance, consider currency of index as ‘USD’ and currency of Payment as ‘JPY’. Here, currency of index is different from Currency of payment,

Exchange rate of USD to JPY on base date = X_o

Exchange rate of USD to JPY on date of adjustment = X_n

“Exchange rate” means equivalent value of JPY for 1 USD

Cost index of stainless-steel S_n and S_o considered for calculation. The cost Index fraction of stainless steel is S_n/S_o.

Notional Index fraction calculated is = (S_n / S_o) x (X_n / X_o) = (S_n notional / S_o notional).

- (i) To the extent that full compensation for any rise or fall in Costs is not covered by the provisions of this or other Clauses, the Accepted Contract Amount shall be deemed to have included amounts to cover the contingency of other rises and falls in costs.

3.2.3 Application of Price Variation Clause to extra items and Provisional Sum:

Price variation is not applicable on Extra items, Provisional Sum and Non-scheduled items for which the rates are separately fixed as per conditions of contract.

If the rate of the proposed new item is derived from any Schedule of rates or market prices, the price variation will be applicable if the work is likely to continue for more than 18 months. For Works not continuing for more than 18 months, price variation will not be granted.

3.2.4 Adjustment on Account of Price Variation

Adjustments on account of Price Variations may be positive (in which case an additional amount shall be paid to the Contractor), or negative (in which case the amount of Price Variation shall be recovered from the Contractor). Adjustment on account of Price Variation shall be calculated separately, for each period between two successive dates of the Contractor’s statements and paid with the IPC.

After verifying the statement, the Engineer shall certify the adjustment amount and advise the same to the Employer along with the IPC. Should any extra amount be due to Contractor, the Employer shall pay the same as far as possible within 28 days of certification by the Engineer. Any amount due from the Contractor on account of negative adjustment shall be recovered from his pending or other statements at the earliest.

3.2.5 Procedure in case of delay in availability of final indices

Where the final Price Indices are not available in the listed sources as per Schedule of Adjustment Data in Section IV - Bidding forms, while making payment towards an IPC, payment towards the Price Variation will be made on provisional basis based on the indices available, to be adjusted in subsequent statements as and when the final Indices figures become available.

3.2.6 Price Variation during extended period of completion

The price adjustment as worked out above i.e. either increase or decrease will be applicable up to the stipulated Completion Date (applicable to all milestone dates) of the Works, including the extended period of completion where such extension has been granted under Sub-Clauses 8.4 of the Part 3 - General Conditions, and where such an extension has not been granted, the price adjustment will be due as follows:

- a) In case the indices increase above the indices applicable to a bill made on the last date of original completion period or the extended period under Sub-Clauses 8.4, the price adjustment for the period of extension not granted in accordance with GCC sub-clause 8.4 will be limited to the amount payable as per the indices applicable to a statement made on the last date of the original completion period or the extended period as determined by the Employer as the case may be.
- b) In case the indices fall below the indices applicable to a statement made on the last date of the original or extended period of completion, then the lower indices will be adopted for Price Adjustment for the period of extension.

No price increase will be allowed for periods of delay for which the Contractor is held responsible. The Employer will, however, be entitled to any price decrease occurring during such periods of delay.

3.3 Option Quantity Variation:

- 3.3.1 The Employer may at its entire discretion advise the Contractor in writing of its intention to increase the total quantity by up to 60 cars (10 Trainsets of 6 Car configuration).

For any increase in quantity, the Employer may exercise this option at anytime prior to the date that is twelve (12) months' before the scheduled date for delivery of the last trainset. The Contractor shall be required to supply the requested additional quantities in accordance with the existing contract terms and conditions and determined prices as detailed in Cl. 3.3.2 and Cl. 3.3.3 below and no additional amount on account of quantity variation or any other account whatsoever shall be payable to the Contractor.

- 3.3.2 The Price of each 6-car train-set to be supplied against Quantity Variation shall be derived from the contracted cost of the original tendered quantity, against 'RS-C', 'RS-E' and 'RS-F'.

- 3.3.3 For any increase in Quantity by the Employer as per Cl. 3.3.1 above, the computed cost of a 6-car trainset, calculated as per Cl. 3.3.2 above will be used to determine the cost of increased quantity and the total Contract Price will be adjusted accordingly and no additional amount for the Quantity Variation (on any other account whatsoever) shall be payable to the Contractor.

However, Price Adjustment as per Cl. 3.2 of Section IV – Bidding Forms – 'Instructions for completing the Pricing Document' shall be applicable for the milestone payments pertaining to the above Quantity Variations. The Key Dates for increased quantities shall be decided at the time of exercising the quantity variation by the Employer.

- 3.3.4 Reimbursement of 'taxes and duties' by the Employer to the Contractor for trains under quantity variation shall be calculated on prorated basis from the 'Taxes & Duties' details submitted by the Bidder in the 'Table 4.3 of Part 1, Section IV, Bidding Forms and the associated conditions specified therein.

4 PRICE SCHEDULES

4.1 Preamble

- 4.1.1 The Price Schedules shall be read in conjunction with NIT, Instructions to Bidders and all bidding documents, General conditions of contract, Particular Conditions of Contract and the Employer's Requirement etc., as listed in contents of Bidding documents.
- 4.1.2 The Schedules may not generally give a full description of the Works to be performed and the plant or equipment to be supplied under each item. Bidders shall be deemed to have read the Employer's Requirements and other sections of the Bidding Documents including the Drawings to ascertain the full scope of the requirements included in each item when filling the rates and prices.
- 4.1.3 The item descriptions given, are general summaries only, therefore no omission from, or error in item descriptions within this Pricing Document shall warrant an adjustment of the Contract Price nor entitle

the Contractor to seek an extension of time under the Contract.

- 4.1.4 This is lumpsum price Contract for “Design, Manufacture, Supply, Testing, Commissioning of Standard Gauge Metro Rolling Stock (Electrical Multiple Units) And Depot Machinery & Plant and Training of Personnel.” Bidder shall quote its lumpsum price inclusive of all taxes, levies, duties and other charges, including taxes to be deducted at source, leviable and payable to the authorities.
- 4.1.5 Payments to the Contractor will be according to achieved milestones unless otherwise specified in Contract.
- 4.1.6 The whole of the Works are divided into Price Centres. Each of these Price Centres represents a major item associated with the Works. Each respective Price Centre is named according to their general scope of Work.
- 4.1.7 A rate or price shall be entered against each item in the Price Schedules, whether quantities are stated or not. The cost of items against which the Bidder has failed to enter a rate or price shall be deemed to be covered by other rates and prices entered in the Price Schedules.
- 4.1.8 The lump sum price for Rolling Stock (28 trainsets of 6-car each) shall be apportioned by the Bidder among the Price Centre ‘RS-A’, ‘RS-CST’, ‘RS-FAI’, ‘RS-CPT’, ‘RS-C’, ‘RS-E’ and ‘RS-F’. The details of the Price Centre and the apportioned amount for each Price Centre will be further distributed among various Milestones based on the currency or currencies in which the Bid Price is expressed in the Bid of the successful Bidder. The Bidder shall quote actuals for Price Centre ‘RS-G’, ‘RS-H’, ‘DM&P-Q’, ‘DM&P-R’, ‘DM&P-S’ & ‘DM&P-T’.
- 4.1.9 In case the successful bidder being a JV / Consortium, payment will be made only to the Bank account of JV / consortium and not to the Bank account of individual member of JV / Consortium.
- In cases where a Consortium Bidder desires separate payments to be made to each Consortium member, Payments to individual members will be permitted upon submission of separate Invoices for each Consortium member made through the Consortium Lead member. Likewise, receipts for Payments Received by each consortium member shall be generated and submitted by the Lead Consortium member.
- In such case, the Bidder shall clearly lay down the Milestones / Currencies allocated to the different members of the Consortium, which shall be in agreement with the intended percentage share of the members as indicated in the Consortium agreement for this Contract. This information shall be made clear in Form Table 4.3.2 which shall be produced for each Consortium member and submitted as part of the Price Bid.
- 4.1.10 The sum of amounts shown against Milestones in a Price Centre is the Price Centre Amount that is to be carried forward to the Bid Total. Payment of the Contract Price shall be made in the currency or currencies in which the Bid Price is expressed in the Bid of the successful Bidder.
- 4.1.11 Not Used.
- 4.1.12 The Milestones under each Price Centre shall identify verifiable steps towards the completion of the work within that Price Centre. The Bidder shall note the periods (in days from the Commencement Date of the Works) within which they should achieve each Milestone. Milestones that lead to the achievement of a Stage (as described in the Key Date schedule provided under Section VII. Particular Conditions, Part A – Contract Data ‘Table – Summary of Sections’) must always precede the Key Date for achievement of that Stage. Milestones shall be converted to calendar dates from the Commencement date as given in the Notice to Proceed.
- 4.1.13 Price Centres and Milestones thereunder are fixed and shall not be changed by the Bidder. These represent the major items of the Works for which the Employer will pay the Contractor, and the Bidder shall ensure that it has allowed for all costs it requires for the Contract to be apportioned among the Price Centre.

- 4.1.14 **Price Centre 'RS-A'** – Preliminaries & General Requirements, comprises all those obligations and ongoing activities throughout the Contract related to Preliminaries, General Requirements, Design submission which are not associated directly with any other Price Centre. This Price Centre shall comply with the conditions mentioned under Part 2 Section VIA – Appendix H.

This includes but not limited to:

- a) Project Management Plan; Interface Management Plan; Works Program; Design Submission Program; Quality Assurance Plan; System Safety Program Plan; Environmental Plan; Software Quality Assurance Plan; Inspection Plan; Testing & Commissioning Plan;
- b) Liaison with other Designated Contractors during the design process;
- c) Preliminary Design, Pre-Final Design & Final Design documents
- d) Preparation of 3D virtual model of Rolling Stock;
- e) Any other item considered necessary to comply with the Scope of Work.
- f) Validation and certification of the design of proposed Rolling Stock and design of signalling system on conformity with Automatic level of GoA-4

1

- 4.1.15 **Price Centre 'RS-CST'** – 'Carshell Structural Qualification Testing', comprises all requirements activities associated with the successful completion of the Car Shell Qualification Test as specified in Clause 17.5.2.3 of the Employer's Requirement Technical Specification.

- 4.1.16 **Price Centre 'RS-FAI'** – First Article Inspection, comprises all requirements activities associated with the successful completion of the First Article Inspection as specified in ERTS-RS clause 18.9.7, for the items (but not limited to) listed in ERTS-RS clause 2.4.3.

- 4.1.17 **Price Centre 'RS-CPT'** – Car Performance Tests, comprises all requirements activities associated with the successful completion of the Car Performance Test as specified in Employer's Requirements – Technical Specification Section 17.5.4.8.

- 4.1.18 **Price Centre 'RS-C'** comprises of all those obligations and ongoing activities throughout the Contract associated with 'Indigenous Manufacture'. This includes but not limited to:

- a) For the first train / Prototype train,
 - (i) selection of suppliers for major system and sub-systems for trains;
 - (ii) completion of all routine and type testing of equipment;
 - (iii) completion of Main Tooling for manufacture;
 - (iv) completion of all Factory Acceptance Tests;
 - (v) completion of test running in factory;
 - (vi) completion of manufacture, testing, running etc and inspection / clearance of first prototype train by CMRL and shipping to port in India;
- b) For subsequent Manufacturing
 - (i) Provision of insurance, dispatch, transit insurance ex-Factory to Depot site in Chennai.
 - (ii) transportation costs of indigenously manufactured trains from factory in India to Depot in Chennai
 - (iii) all handling costs & incidental charges at factory in India, Depot & any intermediate location in India;
 - (iv) all costs associated with special traffic arrangements necessary for transportation;
 - (v) Completion of manufacture, testing, inspection, dispatch, transportation and delivery to CMRL Depot of balance trains.

- 4.1.19 **Price Centre 'RS-E'** comprises of all those obligations and ongoing activities throughout the Contract associated with Formation and running of 'Indigenous manufacture' of trains respectively in Depot / test track. This includes but is not limited to.

- a) Formation of trains,
- b) completion of functional tests and
- c) running of trains in the Depot and test track.
- d) All inspection, testing of train static and dynamic in Depot and mainline as per ERTS section 17.8

4.1.20 **Price Centre 'RS-F'** comprises of all those obligations and ongoing activities throughout the Contract associated with 'Integrated Testing and Commissioning of trains'. This includes but not limited to.

- a) Integrated testing and commissioning of trains in the Depot and on the sections in conjunction with other Designated Contractors.
- b) Instrumentation Tests, Oscillation trials etc., on prototype trains only as necessary for obtaining sanction of statutory authorities in regard to introduction of train for carriage of passengers.
- c) Service trial of trains.
- d) All instrumentation, computers, and any other item including supervisory and operating staff essential for testing, commissioning and service trials of trains etc. will be provided by the Contractor.
- e) Any other item considered necessary to comply with the scope of Works.

1

f) [Payment for Testing and Commissioning activities in Automatic Train Protection \(ATP\) & Automatic Train Operation \(ATO\) \(GoA2\) and Unattended Train Operation \(UTO\) \(GoA4\) shall be made separately, as detailed in Price Centre 'RS-F'.](#)

g) [Integrated test related to GoA4 mode of operation: Within a period of two years from the date of introduction of 1st Trainset into the revenue operation in GoA2 mode / TOC, the contractor shall complete the integrated tests and trials under the above clause applicable to GoA4 mode of operation under interface with the signaling and PSD contractors to the satisfaction of the Employer.](#)

4.1.21 **Price Centre 'RS-G'** comprises all those obligations and activities throughout the Contract connected with the provision and supply of spares, special tools, testing and diagnostic equipment. This includes but is not limited to:

- a) Supply of Unit exchange spares, Mandatory Spares, Recommended Spares.
- b) Supply of consumable spares up to expiry of Defect Liability Period.
- c) Supply of Special tools, testing and diagnostic equipment.
- d) Supply of special jigs, fixtures and gauges for repair and maintenance.
- e) Supply of Intermediate Overhauling Spares
- f) Any other item considered necessary to comply with the scope of works.

Note:

1. *The costs indicated in this Price Centre for all the Milestones G1 to G6 shall be the actual costs and not the apportioned costs.*
2. *For Milestones G3, G4, G5 & G6: Bidder shall furnish the list and unit price for each item*
3. *For Milestone G4: In case of increase in quantities of ordered train sets on account of exercising of quantity variation by the Employer, the quantity of consumables, quoted under this Milestone will be increased on pro-rata basis. There shall be no change in the unit cost of consumables quoted by the Bidder. Price adjustment shall apply.*

4.1.22 **Price Centre 'RS-H'** comprises of all those obligations and activities throughout the Contract associated with:

- a) Training of operating and maintenance personnel and provision of Operation, Maintenance and Training Manuals. This includes but is not limited to:
- (i) Deputation of Instructors by the Contractors for training of operating and maintenance personnel of the Employer in India.
 - (ii) Furnishing of Training Manual and connected Materials.
 - (iii) Any other item considered necessary for the Contractor to comply with the Scope of Works,

Notes:

- (A) *The Bidder shall not fill the column “Period of completion of Milestone from commencement date” for above activities.*
- (B) *The dates of operation of the Milestone Activities will be at the discretion of the Employer.*
- (C) *Price Centre ‘RS-H’ will be included for Bid Total but will not be included for Price Variation.*
- (D) *The Employer has the right to execute part of the milestone and make payments on pro-rata basis.*
- (E) *The travel, boarding and lodging expenses for the Employer’s trainees sent overseas will be borne by the Employer.*

- b) Provision of Operation, Maintenance and Training Manuals. This includes but not limited to:

- (i) Provision of Operating Manuals (Hard copies and in Electronic format).
- (ii) Provision of Maintenance Manuals (Hard copies and in Electronic format).
- (iii) Provision of Spare parts Catalogue (Hard copies and in Electronic format).
- (iv) Any other item considered necessary by the Contractor to comply with the Scope of Works.

4.1.23 Not used.

4.1.24 **Price Centre ‘DM&P-Q’, ‘DM&P-R’, ‘DM&P-S’ & ‘DM&P-T’** comprises of all those obligations and activities throughout the Contract but not be limited to the following scope

a) Design

- i. List of subcontractors /manufacturer
- ii. Quality and Safety procedure
- iii. Proposed planning and planning of manufacturing and execution
- iv. General assembly drawing
- v. Foundation drawing
- vi. Summary report of design
- vii. Design calculation for structure
- viii. Technical details
- ix. Manufacturing test program
- x. Estimation of implementation period
- xi. Commissioning test program
- xii. O&M manuals
- xiii. List of Standards etc
- xiv. Monthly progress report

- xv. Submission of the Final Design Document.
- xvi. Submission of “As-Built drawings”.
- xvii. Any other item considered necessary to comply with the Scope of Work.

b) Manufacturing, Factory Acceptance test, Delivery of Machinery to site.

- i. Factory Acceptance Tests;
- ii. completion of manufacture, factory testing etc and inspection/approval by CMRL and shipping to Chennai metro site in India.
- iii. Marine /Transit Insurance from ex-factory to Depot Site in Chennai
- iv. Transportation of machinery and plant from the ex-factory to Depot in Chennai.
- v. Custom duty, clearance and/or other levies.
- vi. All handling costs and incidental charges at port in India, Depot and any intermediate location in India;
- vii. All costs associated with special traffic arrangements necessary for transportation.
- viii. Loading and unloading of machinery and plant at site. Storage and security of M&P till handing over of machine at site.
- ix. Completion of manufacture, factory testing, inspection, dispatch, transportation, and delivery to CMRL Depot of all M&Ps.

c) Installation, Testing & Commissioning, Training for personnel

- i. Submission of SAT program in advance.
- ii. Installation of the M&Ps.
- iii. Handling and special machine / equipment / instrument etc., required for Installation and commissioning of M&Ps.
- iv. Integrated and load testing and commissioning of M&Ps in the Depot with other Designated Contractors (Rolling stock, Signalling, etc.,) as applicable.
- v. Training for CMRL personnel for each M&Ps as per requirement.
- vi. Attending and resolving punch list/pending items if any.
- vii. Handing over of machine upon with compliance to scope.
- viii. Any other item considered necessary to comply with the scope of works

d) DNP/ DLP

- i. Submission of maintenance program with schedule.
- ii. To maintain Spare parts at depot.
- iii. Perform maintenance activity as per scope
- iv. Any other item considered necessary to comply with the scope of works.

4.1.25 Not used.

4.1.26 Not used.

4.1.27 Not used.

4.1.28 The Contractor shall only be entitled to receive full payment for each milestone specified in respective BOQ / Price Centers upon 100% completion of the activity and issuance of a Notice of No Objection

(NONO) by the Engineer. The Contractor while submitting IPA (Interim Payment Application) towards any milestone(s), shall submit all necessary documents and evidences associated to the completion of respective milestone(s) to the Engineer for processing of IPC (Interim Payment Certificate) appropriately.

Without prejudice individual Price Centers which explicitly define NOWC status as the requirement; The Engineer / Employer may consider release of 80% payment (based on the actual work completed) on an interim basis in cases where a No Objection With Comments (NOWC) has been issued.

The issuance of NONO by the Engineer shall not relieve or absolve the Contractor of any obligations under this Contract.

- 4.1.29 The Contractor shall be solely responsible for all the Rolling Stock and Depot Machinery & Plant statutory clearances including customs, excise, taxes / duties, levies, octroi, transportation, technical clearances by the Government, safety audits, etc. required for the successful execution of this Contract. The Lumpsum price quoted by the bidder is deemed inclusive of all these costs.

- 4.1.30 The Contractor shall note that for ease of administration, the Employer will recover costs for the PMIS System (described in Part 2 Section VIA Clause 16.17) at a rate equal to 0.05% of the Contract Amount for the project period from a single Price Centre 'RS-C2'.

4.2 Pricing Summary (BID TOTAL)

The bidder may quote his offer in any of the following currencies or in any combination: **Indian Rupees (INR)** and in **TWO freely convertible foreign currency (FC)**.

The offer should be submitted in the proforma as given in Price Bid Form of e-procurement portal:

S. No	Description	Total Amount with taxes			Allowable apportionment
		INR	FC1	FC2	
1.	Price Sub-Total (Rolling Stock) Design, Manufacture, Supply, Testing, Commissioning, Training of Personnel, Delivery of Spares, Special Tools, etc. and DNP.				Lumpsum Price (Rolling Stock) + Price Centre RS-G + Price Centre RS-H
1.1	Lumpsum Price (Rolling Stock) Design, Manufacture, Supply, Testing and Commissioning and DNP of Rolling Stock				(RS-A + RS-CST + RS-FAI + RS-CPT + RS-C + RS-E + RS-F) 100%
1.1.1	Price Centre RS-A: Preliminaries, General Requirements, Design of Rolling Stock, and Provision of 3D Virtual models.				8.0%
1.1.2	Price Centre RS-CST: 'Car shell structural qualification testing' as per ERTS-RS and the Scope of Works covered in Part-2				2.0%
1.1.3	Price Centre RS-FAI: 'First Article Inspections' as per ERTS-RS and the Scope of Works covered in Part-2				3.0%
1.1.4	Price Centre RS-CPT: 'Car Performance tests (Pilot train)' as per ERTS-RS and the Scope of Works covered in Part-2				2.0%

S. No	Description	Total Amount with taxes			Allowable apportionment
		INR	FC1	FC2	
1.1.5	Price Centre RS-C: <i>Indigenous Manufacture, Factory Testing, Inspection and Dispatch, transit insurance from factory to Depot Site.</i> <i>Inland Transportation of Indigenous manufactured trains within India including handling charges at depot or at any other place, and all other incidental costs, receipt of cars in depot.</i>				70%
1.1.6	Price Centre RS-E: <i>Formation of Indigenous manufactured trains, satisfactory completion of tests and running of train in the depot.</i>				8.0%
1.1.7	Price Centre RS-F: <i>Integrated testing and commissioning of trains and service trials.</i>				7.0% Carried over from Price Centre RS-F
1.1.7.1	Price Centre RS-F1: <i>Integrated testing and commissioning of trains and service trials, in ATP & ATO (GoA2) mode of operation.</i>				5.00%
1.1.7.2	Price Centre RS-F2: <i>Integrated testing and commissioning of trains and service trials, in UTO (GoA4) mode of operation.</i>				2.00%
1.2	Price Centre RS-G: <i>Unit exchange spares, mandatory spares, recommended spares, consumable spares, special tools, testing and diagnostic equipment.</i>				Carried over from Price Centre RS-G
1.3	Price Centre RS-H: <i>Training, operation and maintenance manuals</i>				Carried over from Price Centre RS-H
2.	Price Sub-total (Depot Machinery & Plant) Design, Manufacture, Supply, Testing, Commissioning, Training of Personnel				(DM&P-Q+ DM&P-R+ DM&P-S+ DM&P-T)
2.1	Price Centre DM&P-Q: Design, Manufacture, supply, delivery, installation, testing & commissioning of Depot Machinery & plant (Major Items)				Carried over from Price Centre DM&P-Q
2.2	Price Centre DM&P-R: Design, Manufacture, supply, delivery, installation, testing & commissioning of Depot Machinery & plant (Other Machinery & Plant Items)				Carried over from Price Centre DM&P-R
2.3	Price Centre DM&P-S: Design, Manufacture, supply, delivery, installation, testing & commissioning of Depot Machinery & plant (Storage Items)				Carried over from Price Centre DM&P-S
2.4	Price Centre DM&P-T: Design, Manufacture, supply, delivery, installation, testing & commissioning of Depot Machinery & plant (Tools and Other items)				Carried over from Price Centre DM&P-T
3.	Tender Total = 1 + 2 <i>Price Sub-total (Rolling Stock) + Price Sub-total (Depot Machinery & Plant)</i>				
4.	Provisional Sum	INR 2 Crore (DB Charges)			

Note:

- (i) The Bidder shall quote his Lumpsum price in INR and/or any two freely convertible foreign Currency.

- (ii) *Not used.*
- (iii) *Payment of the Contract Price shall be made in the currency or currencies in which the Bid Price is expressed in the Bid of the successful Bidder.*
- (iv) *Bidders shall quote for the above Price Centres including all taxes and duties including GST, Customs Duty, levies and fees.*
- (v) *The 'Price centre total' mentioned above, shall be converted into Indian Rupees (INR) if other currencies are used and the exchange rates(s) shall be as published by the Reserve Bank of India selling rates of exchange/FBIL reference rates at the close of business hours of Financial Benchmarks India Pvt Ltd (FBIL) as delegated by the Reserve Bank of India vide their order no. RBI/2018-19/34 DBR.Ret. BC.No. 01/12.01.001/2018-19 dated August 02, 2018, 28 days prior to submission of the Bid. If the date that is 28 days prior to the stipulated date of submission happens to fall on a public holiday, then the rate of Exchange at the close of business of FBIL's website on the previous working day shall be considered for the conversion of Foreign Currency to Indian Rupees. The Bid Total (i.e. the Price Centre Total) mentioned above shall be considered in INR equivalent for bid evaluation. In case such rates are not available in the source identified above, any other publicly available source acceptable to the Employer. Any error in determining the exchange rates may be corrected by the Employer.*
- (vi) *Provisional Sum shall not be considered during evaluation.*
- (vii) *The bidder shall be responsible to ensure that their quoted price towards individual Price Centres in various currencies (if any), converted into INR equivalent as above, comply with the apportionment percentage ratio indicated against each Price Centre. In case of any deviation in the quoted price towards individual Price Centres with respect to its allowable apportionment percentage, the Employer will readjust the prices among the Price Centres without altering the Total Bid Price, before entering into the Contract agreement.*

4.3 DETAILS OF TAXES / DUTIES / LEVIES ETC. INCLUDED IN THE LUMP SUM PRICE (PRICE CENTRE WISE)**DETAILS NOT TO BE FILLED HERE. IT SHALL BE FILLED AND UPLOADED IN THE PRICE BID OF E-PROCUREMENT PORTAL ONLY.****Table 4.3.1: Taxes, Duties, Levies, etc.**

Price Centre	Taxes, Duties, Levies etc. (In INR)												
	Customs Duty						Goods and Services Tax				Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
RS-A													
RS-CST													
RS-FAI													
RS-CPT													
RS-C													
RS-E													
RS-F													
RS-G													
RS-H													
DM&P-Q													
DM&P-R													
DM&P-S													
DM&P-T													
Total													

Note :

1. Bidder Shall Specify the values in the above table (Details of taxes/duties/levies etc.) in INR only. Cost towards currency Hedging if any shall be included in the Lumpsum Price.

Table 4.3.2: Overview of Contract Price

DETAILS NOT TO BE FILLED HERE. IT SHALL BE FILLED AND UPLOADED IN THE PRICE BID OF E-PROCUREMENT PORTAL ONLY.

1

Price Centre	Contract Price without tax			Customs Duty INR	GST INR	Any other taxes/duties INR	Contract Price with tax		
	INR	FC1	FC2				INR	FC1	FC2
RS-A									
RS-CST									
RS-FAI									
RS-CPT									
RS-C									
RS-E									
RS-F									
RS-G									
RS-H									
DM&P-Q									
DM&P-R									
DM&P-S									
DM&P-T									
Total									

Table Filling Instructions:

- Bidders' are required to **submit the duly filled in tables along with the Letter of Price Bid.**
- Goods and Services Tax (GST)** amounts shall only be filled for indigenously manufactured complete / finished Trainsets, Depot Machinery & Plant Price Centres.
- Customs Duty** is only applicable for Price Centres RS-C, RS-G, DM&P-Q, DM&P-R, DM&P-S and DM&P-T.
 - The Contractor shall fill the data based on their own estimation of the quantity of goods that will be imported to fulfil the Works and shall serve as the ceiling amounts considered for reimbursement.

- b) The successful bidder shall then submit a detailed breakdown list (in a format that is approved by the Engineer & the Employer) by NTP + 330 days showing values for all Equipment / Sub-assemblies / Components that will be imported. Reimbursement of Customs Duty by CMRL shall be in accordance with the detailed breakdown list (supported by evidence of actual duties incurred and utilisation during manufacturing) but will be capped at the ceiling amounts declared in accordance with 3(a).

Notes on Taxes / Duties / Levies:

The following shall apply to ALL tables which indicates Taxes, Duties or Levies:

4. Wherever Customs Duty has been blocked out as “Not Applicable” within the pricing table it is clarified that the Contractor will not be eligible to claim any reimbursement, nor can the Contractor make any adjustment claims whatsoever in the event of any future changes in law / legislation (GCC 13.7) which may affect Customs Duty rates.
5. All Customs Duty, GST, levies, etc. indicated in the above table are considered to be included in the lumpsum price (Price centre wise) i.e. Bid Total in INR currency. Reimbursement of Customs Duty, GST, levies, etc. indicated in the above table by the Employer shall be in INR only, upon submission of proof of discharge of Contractor's liability subject to the ceiling of the amounts indicated in the above table.
6. Ceiling limit(s) shall be proportionately increased or decreased in the event that the Option Quantity Variation is exercised or other Variation to the Works is awarded by the Employer during the Contract period.
7. In case the customs duty rate is increased, decreased or abolished due to a change in tax law, the customs duty ceiling amount applied to any reimbursement (Defined in Note-3b) shall be proportionately increased / decreased by a corresponding amount.
8. If any rates of taxes and duties are increased or decreased, a new tax is introduced or an existing tax is abolished during the course of performance of the Contract, an equitable adjustment of the Contract Price shall be applied to fully take into account any such change by addition to the Contract Price or deduction therefrom, as the case may be.

Table 4.3.3: DETAILS OF TAXES / DUTIES / LEVIES ETC. INCLUDED IN DM&P-Q**DETAILS NOT TO BE FILLED HERE. IT SHALL BE FILLED AND UPLOADED IN THE PRICE BID OF E-PROCUREMENT PORTAL ONLY.**

Milestone Number	DM&P-Q : Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
DM&P-Q1															
DM&P-Q2															
DM&P-Q3															
DM&P-Q4															
DM&P-Q5															
DM&P-Q6															
DM&P-Q7															
DM&P-Q8															
DM&P-Q9															
DM&P-Q10															
DM&P-Q11															
DM&P-Q12															
DM&P-Q13															
DM&P-Q14															
DM&P-Q15															
DM&P-Q16															
DM&P-Q17															
DM&P-Q18															
Total															

Notes: 1) Bidders' must enter "Not Applicable" for the Customs Duty amount that is shown for each Indigenously manufactured item(s).
2) Table Filling Instructions and Notes that were previously shown under Table 4.3.2 also apply here.

Table 4.3.4: DETAILS OF TAXES / DUTIES / LEVIES ETC. INCLUDED IN DM&P-R**DETAILS NOT TO BE FILLED HERE. IT SHALL BE FILLED AND UPLOADED IN THE PRICE BID OF E-PROCUREMENT PORTAL ONLY.**

Milestone Number	DM&P-R : Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
DM&P-R1															
DM&P-R2															
DM&P-R3															
DM&P-R4															
DM&P-R5															
DM&P-R6															
DM&P-R7															
DM&P-R8															
DM&P-R9															
DM&P-R10															
DM&P-R11															
DM&P-R12															
DM&P-R13															
DM&P-R14															
DM&P-R15															
DM&P-R16															
DM&P-R17															
DM&P-R18															
DM&P-R19															
Total															

Notes: 1) Bidders' must enter "Not Applicable" for the Customs Duty amount that is shown for each Indigenously manufactured item(s).
2) Table Filling Instructions and Notes that were previously shown under Table 4.3.2 also apply here.

Table 4.3.5: DETAILS OF TAXES / DUTIES / LEVIES ETC. INCLUDED IN DM&P-S**DETAILS NOT TO BE FILLED HERE. IT SHALL BE FILLED AND UPLOADED IN THE PRICE BID OF E-PROCUREMENT PORTAL ONLY.**

Milestone Number	DM&P-S : Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
DM&P-S1															
DM&P-S2															
DM&P-S3															
DM&P-S4															
DM&P-S5															
DM&P-S6															
DM&P-S7															
DM&P-S8															
DM&P-S9															
DM&P-S10															
DM&P-S11															
DM&P-S12															
DM&P-S13															
Total															

- Notes:** 1) Bidders' must enter "Not Applicable" for the Customs Duty amount that is shown for each Indigenously manufactured item(s).
2) Table Filling Instructions and Notes that were previously shown under Table 4.3.2 also apply here.

Table 4.3.6: DETAILS OF TAXES / DUTIES / LEVIES ETC. INCLUDED IN DM&P-T**DETAILS NOT TO BE FILLED HERE. IT SHALL BE FILLED AND UPLOADED IN THE PRICE BID OF E-PROCUREMENT PORTAL ONLY.**

Milestone Number	DM&P-T : Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
DM&P-T1															
DM&P-T2															
DM&P-T3															
DM&P-T4															
DM&P-T5															
DM&P-T6															
DM&P-T7															
DM&P-T8															
DM&P-T9															
DM&P-T10															
DM&P-T11															
DM&P-T12															
DM&P-T13															
DM&P-T14															
Total															

Notes: 1) Bidders' must enter "Not Applicable" for the Customs Duty amount that is shown for each Indigenously manufactured item(s).
2) Table Filling Instructions and Notes that were previously shown under Table 4.3.2 also apply here.

Table 4.3.7: DETAILS OF TAXES / DUTIES / LEVIES ETC. INCLUDED IN UNIT EXCHANGE SPARE (G1)**DETAILS NOT TO BE FILLED HERE. IT SHALL BE FILLED AND UPLOADED IN THE PRICE BID OF E-PROCUREMENT PORTAL ONLY.**

Milestone Number	UNIT EXCHANGE SPARE (G1) : Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
G1.1															
G1.2															
G1.3															
G1.4															
G1.5															
G1.6															
G1.7															
G1.8															
G1.9															
G1.10															
G1.11															
G1.12															
G1.13															
G1.14															
G1.15															
G1.16															
G1.17															
G1.18															
G1.19															
G1.20															
G1.21															
G1.22															

Milestone Number	UNIT EXCHANGE SPARE (G1) : Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
G1.23															
G1.24															
G1.25															
G1.26															
G1.27															
G1.28															
G1.29															
G1.30															
G1.31															
Total															

Notes: 1) Bidders' must enter "Not Applicable" for the Customs Duty amount that is shown for each Indigenously manufactured item(s).
2) Table Filling Instructions and Notes that were previously shown under Table 4.3.2 also apply here.

Table 4.3.8: DETAILS OF TAXES / DUTIES / LEVIES ETC. INCLUDED IN MANDATORY SPARE (G2)**DETAILS NOT TO BE FILLED HERE. IT SHALL BE FILLED AND UPLOADED IN THE PRICE BID OF E-PROCUREMENT PORTAL ONLY.**

Milestone Number	MANDATORY SPARE (G2) : Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
G2.1															
G2.1a															
G2.1b															
G2.1c															
G2.1d															
G2.1e															
G2.1f															
G2.1g															
G2.1h															
G2.1i															
G2.1j															
G2.1k															
G2.1l															
G2.1m															
G2.1n															
G2.1o															
G2.1p															
G2.1q															

Milestone Number	MANDATORY SPARE (G2) : Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
G2.2															
G2.2a															
G2.2b															
G2.2c															
G2.2d															
G2.2e															
G2.2f															
G2.2g															
G2.2h															
G2.2i															
G2.2j															
G2.2k															
G2.2l															
G2.2m															
G2.2n															
G2.2o															
G2.2p															
G2.2q															
G2.2r															
G2.2s															
G2.2t															
G2.2u															
G2.2v															

Milestone Number	MANDATORY SPARE (G2) : Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
G2.2w															
G2.3															
G2.3a															
G2.3b															
G2.3c															
G2.3d															
G2.3e															
G2.3f															
G2.3g															
G2.3h															
G2.3i															
G2.3j															
G2.3k															
G2.3l															
G2.3m															
G2.4															
G2.4a															
G2.4b															
G2.4c															
G2.4d															
G2.4e															
G2.4f															
G2.4g															
G2.4h															
G2.4i															

Milestone Number	MANDATORY SPARE (G2) : Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
G2.5															
G2.5a															
G2.5b															
G2.5c															
G2.5d															
G2.5e															
G2.5f															
G2.5g															
G2.5h															
G2.5i															
G2.5j															
G2.5k															
G2.5l															
G2.5m															
G2.5n															
G2.6															
G2.6a															
G2.6b															
G2.6c															
G2.6d															
G2.6e															
G2.6f															
G2.6g															
G2.6h															
G2.7															

Milestone Number	MANDATORY SPARE (G2) : Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
G2.7a															
G2.7b															
G2.7c															
G2.7d															
G2.7e															
G2.8															
G2.8a															
G2.8b															
G2.8c															
G2.9															
G2.9a															
G2.9b															
G2.10															
G2.10a															
G2.10b															
G2.10c															
G2.10d															
G2.10e															
G2.10f															
G2.10g															
G2.11															
G2.11a															
G2.11b															
G2.11c															
G2.12															

Milestone Number	MANDATORY SPARE (G2) : Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
G2.12a															
G2.12b															
G2.12c															
G2.12d															
G2.13															
G2.13a															
G2.13b															
G2.13c															
G2.13d															
G2.13e															
G2.14															
G2.14a															
G2.14b															
G2.14c															
G2.14d															
G2.14e															
G2.14f															
G2.14g															
G2.14h															
G2.15															
G2.15a															
G2.15b															
G2.15c															
G2.15d															
G2.15e															

Milestone Number	MANDATORY SPARE (G2) : Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
G2.15f															
G2.15g															
G2.15h															
G2.15i															
G2.15j															
G2.15k															
G2.15l															
G2.15m															
G2.15n															
G2.15o															
G2.15p															
G2.15q															
G2.15r															
G2.15s															
G2.15t															
G2.15u															
G2.15v															
G2.15w															
G2.15x															
G2.15y															
G2.15z															
G2.15aa															
G2.16															
G2.16a															
G2.16b															

Milestone Number	MANDATORY SPARE (G2) : Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
...															
Total															

- Notes:** 1) Bidders' must enter "Not Applicable" for the Customs Duty amount that is shown for each Indigenously manufactured item(s).
2) Table Filling Instructions and Notes that were previously shown under Table 4.3.2 also apply here.

Table 4.3.9: DETAILS OF TAXES / DUTIES / LEVIES ETC. INCLUDED IN RECOMMENDED SPARES (G3)**DETAILS NOT TO BE FILLED HERE. IT SHALL BE FILLED AND UPLOADED IN THE PRICE BID OF E-PROCUREMENT PORTAL ONLY.**

Milestone Number	RECOMMENDED SPARES (G3): Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
G3.1															
G3.2															
G3.3															
...															
...															
...															
Total															

Notes: 1) Bidders' must enter "Not Applicable" for the Customs Duty amount that is shown for each Indigenously manufactured item(s).
2) Table Filling Instructions and Notes that were previously shown under Table 4.3.2 also apply here.

Table 4.3.10: DETAILS OF TAXES / DUTIES / LEVIES ETC. INCLUDED IN CONSUMABLE SPARES (G4)**DETAILS NOT TO BE FILLED HERE. IT SHALL BE FILLED AND UPLOADED IN THE PRICE BID OF E-PROCUREMENT PORTAL ONLY.**

Milestone Number	CONSUMABLE SPARES (G4): Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
G4.1															
G4.1a															
G4.1b															
G4.1c															
G4.1d															
G4.1e															
G4.1f															
G4.1g															
G4.1h															
G4.1i															
G4.1j															
G4.1k															
G4.1l															
G4.1m															
G4.1n															
G4.1o															
G4.1p															
G4.1q															
G4.1r															
G4.2															
G4.2a															

Milestone Number	CONSUMABLE SPARES (G4): Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
G4.2b															
...															
Total															

- Notes:** 1) Bidders' must enter "Not Applicable" for the Customs Duty amount that is shown for each Indigenously manufactured item(s).
2) Table Filling Instructions and Notes that were previously shown under Table 4.3.2 also apply here.

Table 4.3.11: DETAILS OF TAXES / DUTIES / LEVIES ETC. INCLUDED IN SPECIAL TOOLS, JIGS, FIXTURES, GAUGES, TESTING AND DIAGNOSTIC EQUIPMENT (G5)

DETAILS NOT TO BE FILLED HERE. IT SHALL BE FILLED AND UPLOADED IN THE PRICE BID OF E-PROCUREMENT PORTAL ONLY.

Milestone Number	SPECIAL TOOLS, JIGS, FIXTURES, GAUGES, TESTING AND DIAGNOSTIC EQUIPMENT (G5): Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
G5.1															
G5.2															
G5.3															
G5.4															
G5.5															
G5.6															
G5.7															
G5.8															
G5.9															
G5.10															
G5.11															
G5.12															
G5.13															
G5.14															
G5.15															
G5.16															
G5.17															
G5.18															
G5.19															
G5.20															

Milestone Number	SPECIAL TOOLS, JIGS, FIXTURES, GAUGES, TESTING AND DIAGNOSTIC EQUIPMENT (G5): Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
G5.21															
G5.22															
G5.23															
G5.24															
G5.25															
G5.26															
G5.27															
G5.27a															
G5.27b															
...															
Total															

Notes: 1) Bidders' must enter "Not Applicable" for the Customs Duty amount that is shown for each Indigenously manufactured item(s).
2) Table Filling Instructions and Notes that were previously shown under Table 4.3.2 also apply here.

Table 4.3.12: DETAILS OF TAXES / DUTIES / LEVIES ETC. INCLUDED IN INTERMEDIATE OVERHAULING SPARES (G6)**DETAILS NOT TO BE FILLED HERE. IT SHALL BE FILLED AND UPLOADED IN THE PRICE BID OF E-PROCUREMENT PORTAL ONLY.**

Milestone Number	INTERMEDIATE OVERHAULING SPARES (G6): Taxes, Duties, Levies etc. (In INR) (Calculated for the total amount of each milestone)														
	Customs Duty						Goods and Services Tax						Any other taxes /duties / levies		Total amount of all taxes, duties, levies, cess etc.
	Basic Custom Duty		IGST		Social Welfare Surcharges		CGST		SGST		IGST				
	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Rate (%)	Amount	Amount
G6.1															
G6.2															
G6.3															
G6.4															
G6.5															
G6.6															
G6.7															
G6.8															
G6.9															
G6.10															
G6.11															
G6.12															
G6.13															
G6.14															
G6.15															
G6.16															
G6.16a															
G6.16b															
...															
Total															

Notes: 1) Bidders' must enter "Not Applicable" for the Customs Duty amount that is shown for each Indigenously manufactured item(s).
2) Table Filling Instructions and Notes that were previously shown under Table 4.3.2 also apply here.

4.4 SCHEDULE OF PAYMENTS

4.4.1 PRICE CENTRE 'RS-A' – PRELIMINARIES, GENERAL REQUIREMENTS, DESIGN OF ROLLING STOCK AND PROVISION OF 3D VIRTUAL MODELS.

DETAILS NOT TO BE SUBMITTED IN TECHNICAL BID. IT SHALL BE FILLED AND UPLOADED ONLY IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL.

MILESTONE NUMBER	WORK DESCRIPTION MILESTONE ACTIVITY	APPORTIONED AMOUNT			PERIOD OF COMPLETION OF MILESTONE FROM COMMENCEMENT DATE (QUANTITY)	ALLOWABLE APPORTIONMENT (under Lumpsum Price (Rolling Stock) – Project) (%)
		INR	FC1	FC2		
		COLUMN A	COLUMN B	COLUMN C		
Obtain "No Objection With Comments (NOWC)" / "Notice of No Objection (NONO)" from the Employer / Engineer for:						
1 RS-A1	All Preliminary Design Documents (PDR) as listed in Design Submission Programme.				NTP + 240	2.0 % 1.95%
RS-A2	Acceptance of 3D view of prototype train model to allow issue of NONO / NOWC by the Employer / Engineer.				NTP+ 280	0.05 %
RS-A3	All Pre-Final Design Documents (PFDR) as listed in Design Submission Programme.				NTP + 450	2.0 %
RS-A4	All Final Design Documents (FDR) as listed in Design Submission Programme.				NTP + 550	2.0 %
RS-A5	Test Reports (RPT) as listed in Design Submission Programme.				NTP + 1190	1.0 %
RS-A6	All As Built Drawing & Manufacturing Drawing as listed in Design Submission Programme.				NTP + 600	0.8 %
RS-A7	For Compliance Matrix (for all Works).				NTP + 450	0.15 %
1 RS-A8	Validation and certification of the design of proposed Rolling Stock and design of signalling system on conformity with Automatic level of GoA-4				NTP + 1780	0.05%
RS-A : PRICE CENTRE TOTAL (RS-A1 ~ RS-A7 RS-A8)		Carried over from Price Centre 'RS-A'				8 %

Note :

- Bidders shall quote for the above Price Centres including all taxes and duties.
- In the event that the values entered in above table mismatch with the BOQ values submitted by the bidder; the BOQ values shall be considered.

4.4.2 **PRICE CENTRE ‘RS-CST’ – CAR SHELL STRUCTURAL QUALIFICATION TESTING**

This Price Centre comprises of all requirements/ activities associated with the successful completion of the Car Shell Qualification Test as specified in ERTS - RS, Section 17.5.2.3

DETAILS NOT TO BE SUBMITTED IN TECHNICAL BID. IT SHALL BE FILLED AND UPLOADED ONLY IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL.

MILESTONE NUMBER	WORK DESCRIPTION	APPORTIONED AMOUNT			PERIOD OF COMPLETION OF MILESTONE FROM COMMENCEMENT DATE (QUANTITY)	ALLOWABLE APPORTIONMENT (under Lumpsum Price (Rolling Stock) – Project)
		INR	FC1	FC2		%
	MILESTONE ACTIVITY	COLUMN A	COLUMN B	COLUMN C		
Obtain the “No Objection With Comments (NOWC) or Notice of No Objection (NONO)” from the Employer / Engineer for:						
RS-CST1	Car Shell Structural Qualification Test and Report				NTP + 480	2 %
RS-CST : PRICE CENTRE TOTAL		<i>Carried over from Price Centre ‘RS-CST’</i>				2 %

Note :

- Bidders shall quote for the above Price Centres including all taxes and duties.*
- In the event that the values entered in above table mismatch with the BOQ values submitted by the bidder; the BOQ values shall be considered.*

4.4.3 **PRICE CENTRE ‘RS-FAI’ – FIRST ARTICLE INSPECTIONS**

This Price Centre comprises of all requirements / activities associated with the successful completion of the First Article Inspections as specified in ERTS - RS, Section 2.4.3 & 18.9.7.

DETAILS NOT TO BE SUBMITTED IN TECHNICAL BID. IT SHALL BE FILLED AND UPLOADED ONLY IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL.

MILESTONE NUMBER	WORK DESCRIPTION	APPORTIONED AMOUNT			PERIOD OF COMPLETION OF MILESTONE FROM COMMENCEMENT DATE (QUANTITY)	ALLOWABLE APPORTIONMENT (under Lumpsum Price (Rolling Stock) – Project)
		INR	FC1	FC2		%
	MILESTONE ACTIVITY	COLUMN A	COLUMN B	COLUMN C		
Obtain the “No Objection With Comments (NOWC) or Notice of No Objection (NONO)” from the Employer / Engineer for:						
RS-FAI1	First Article Inspections and Reports.				NTP + 480	3 %
RS-FAT : PRICE CENTRE TOTAL		Carried over from Price Centre ‘RS-FAT’				3 %

Note :

1. Bidders shall quote for the above Price Centres including all taxes and duties.
2. In the event that the values entered in above table mismatch with the BOQ values submitted by the bidder; the BOQ values shall be considered.

4.4.4 PRICE CENTRE 'RS-CPT' – CAR PERFORMANCE TESTS

This Price Centre comprises of all requirements/ activities associated with the successful completion of the Car Performance tests as specified in ERTS - RS, Section 17.5.4.8

DETAILS NOT TO BE SUBMITTED IN TECHNICAL BID. IT SHALL BE FILLED AND UPLOADED ONLY IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL.

MILESTONE NUMBER	WORK DESCRIPTION	APPORTIONED AMOUNT			PERIOD OF COMPLETION OF MILESTONE FROM COMMENCEMENT DATE (QUANTITY)	ALLOWABLE APPORTIONMENT
		INR	FC1	FC2		(under Lumpsum Price (Rolling Stock) – Project)
	MILESTONE ACTIVITY	COLUMN A	COLUMN B	COLUMN C		%
Obtain the “No Objection With Comments (NOWC) or Notice of No Objection (NONO)” from the Employer / Engineer for:						
RS-CPT1	Car Performance test (Prototype cars on site) and reports.				NTP + 900	2 %
RS-CPT : PRICE CENTRE TOTAL		Carried over from Price Centre ‘RS-CPT’				2 %

Note :

1. Bidders shall quote for the above Price Centres including all taxes and duties.
2. In the event that the values entered in above table mismatch with the BOQ values submitted by the bidder; the BOQ values shall be considered.

4.4.5 **Not Used.**

4.4.6 **PRICE CENTRE ‘RS-C’ – INDIGENOUS MANUFACTURE, TESTING, INSPECTION, TRANSPORTATION AND DELIVERY TO CMRL DEPOT**

DETAILS NOT TO BE SUBMITTED IN TECHNICAL BID. IT SHALL BE FILLED AND UPLOADED ONLY IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL.

MILESTONE NUMBER	WORK DESCRIPTION	APPORTIONED AMOUNT			PERIOD OF COMPLETION OF MILESTONE FROM COMMENCEMENT DATE (QUANTITY)	ALLOWABLE APPORTIONMENT (under Lumpsum Price (Rolling Stock) – Project)
		INR	FC1	FC2		%
	MILESTONE ACTIVITY	COLUMN A	COLUMN B	COLUMN C		
Obtain the “No Objection With Comments (NOWC)” / “Notice of No Objection (NONO)” from the Employer / Engineer for:						
a. Issue of Inspection/ clearance Certificate on satisfactory completion of all Factory Tests;						
b. Transit Insurance;						
c. Dispatch documents						
d. Delivery of cars to CMRL’s property.						
RS-C1	First 6-car rake (Pilot Rake)				~~NTP + 630~~ NTP + 690	2.5 %
RS-C2	Obtain as above for first 3 train sets				NTP + 780	7.5 %
RS-C3	Obtain as above for next 3 train sets				NTP + 840	7.5 %
RS-C4	Obtain as above for next 3 train sets				NTP + 900	7.5 %
RS-C5	Obtain as above for next 3 train sets				NTP + 960	7.5 %
RS-C6	Obtain as above for next 3 train sets				NTP + 1020	7.5 %
RS-C7	Obtain as above for next 3 train sets				NTP + 1080	7.5 %
RS-C8	Obtain as above for next 3 train sets				NTP + 1140	7.5 %
RS-C9	Obtain as above for next 3 train sets				NTP + 1200	7.5 %
RS-C10	Obtain as above for next 3 train sets				NTP + 1260	7.5 %
RS-C : PRICE CENTRE TOTAL (RS-C1 ~ RS-C10)		<i>Carried over from Price Centre ‘RS-C’</i>				70 %

Notes:

- The apportioned amounts (both foreign currency and local currency) in the above Table shall in proportion to the number of trains in all Milestones relevant to the Price Centre.
- Speciy ‘Not Applicable’ against each of the rows which are not applicable under this milestone.
- Bidders shall quote for the above Price Centres including all taxes and duties.
- In the event that the values entered in above table mismatch with the BOQ values submitted by the bidder; the BOQ values shall be considered.
- Payment against the above milestones may be considered on a train set-wise basis.

1

4.4.7 **Not Used.**

4.4.8 **PRICE CENTRE ‘RS-E’ – FORMATION, TESTING IN THE DEPOT FOR INDIGENOUSLY MANUFACTURED TRAINS**

DETAILS NOT TO BE SUBMITTED IN TECHNICAL BID. IT SHALL BE FILLED AND UPLOADED ONLY IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL.

MILESTONE NUMBER	WORK DESCRIPTION	APPORTIONED AMOUNT			PERIOD OF COMPLETION OF MILESTONE FROM COMMENCEMENT DATE (QUANTITY)	ALLOWABLE APPORTIONMENT (under Lumpsum Price (Rolling Stock) – Project)
		INR	FC1	FC2		
	MILESTONE ACTIVITY	COLUMN A	COLUMN B	COLUMN C		%
Obtain the “No Objection With Comments (NOWC)” / “Notice of No Objection (NONO)” from the Employer / Engineer for:						
a) Formation of train, obtaining certificate of satisfactory completion of functional tests and running of train in the Depot and train static & dynamic tests in the mainline. For;						
RS-E1	First 6-car rake (Pilot Rake)				NTP + 900	0.26 %
RS-E2	Obtain as above for first 3 train sets				NTP + 900	0.86 %
RS-E3	Obtain as above for next 3 train sets				NTP + 960	0.86 %
RS-E4	Obtain as above for next 3 train sets				NTP + 1020	0.86 %
RS-E5	Obtain as above for next 3 train sets				NTP + 1080	0.86 %
RS-E6	Obtain as above for next 3 train sets				NTP + 1140	0.86 %
RS-E7	Obtain as above for next 3 train sets				NTP + 1200	0.86 %
RS-E8	Obtain as above for next 3 train sets				NTP + 1260	0.86 %
RS-E9	Obtain as above for next 3 train sets				NTP + 1320	0.86 %
RS-E10	Obtain as above for next 3 train sets				NTP + 1380	0.86 %
RS-E: PRICE CENTRE TOTAL (RS-E1 ~ RS-E10)		Carried over from Price Centre ‘RS-E’				8 %

Notes:

1. The apportioned amounts (both foreign currency and local currency) in the above Table shall in proportion to the number of trains in all Milestones relevant to the Price Centre.
2. Specify ‘Not Applicable’ against each of the rows which are not applicable under this milestone.
3. Bidders shall quote for the above Price Centres including all taxes and duties.
4. In the event that the values entered in above table mismatch with the BOQ values submitted by the bidder; the BOQ values shall be considered.

4.4.9 PRICE CENTRE 'RS-F' – INTEGRATED TESTING AND COMMISSIONING OF TRAINS AND SERVICE TRIALS

1

DETAILS NOT TO BE SUBMITTED IN TECHNICAL BID. IT SHALL BE FILLED AND UPLOADED ONLY IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL.

MILESTONE NUMBER	WORK DESCRIPTION	APPORTIONED AMOUNT			PERIOD OF COMPLETION OF MILESTONE FROM COMMENCEMENT DATE (QUANTITY)	ALLOWABLE APPORTIONMENT (under Lumpsum Price (Rolling Stock) – Project) %
		INR	FC1	FC2		
	MILESTONE ACTIVITY	COLUMN A	COLUMN B	COLUMN C		
Obtain the “No-Objection-With Comments (NOWC)” / “Notice of No-Objection (NONO)” from the Employer / Engineer for:						
a. Completion of Integrated Testing and Commissioning in the Depot;						
b. Completion of Integrated testing and Commissioning on the section in conjunction with Designated Contractors;						
c. Instrumentation Tests of First train, conducting oscillation trials as per requirement of Statutory Authorities, compilation of test Results, obtaining sanction of Statutory Authorities for fitness of train for carriage of passengers in respect of Prototype Trains only.						
d. Service Trials, for;						
RS-F1	First 6-car rake (Pilot Rake)				NTP + 1050	0.25%
RS-F2	Obtain as above for first 3 train sets				NTP + 1050	0.75%
RS-F3	Obtain as above for next 3 train sets				NTP + 1095	0.75%
RS-F4	Obtain as above for next 3 train sets				NTP + 1140	0.75%
RS-F5	Obtain as above for next 3 train sets				NTP + 1185	0.75%
RS-F6	Obtain as above for next 3 train sets				NTP + 1230	0.75%
RS-F7	Obtain as above for next 3 train sets				NTP + 1275	0.75%
RS-F8	Obtain as above for next 3 train sets				NTP + 1320	0.75%
RS-F9	Obtain as above for next 3 train sets				NTP + 1365	0.75%
RS-F10	Obtain as above for next 3 train sets				NTP + 1410	0.75%
RS-F : PRICE CENTRE TOTAL (RS-F1 – RS-F10)		<i>Carried over from Price Centre 'RS-F'</i>				7%

Notes:

- ~~The apportioned amounts (both foreign currency and local currency) in the above Table shall in proportion to the number of trains in all Milestones relevant to the Price Centre.~~
- ~~Specify 'Not Applicable' against each of the rows which are not applicable under this milestone.~~
- ~~Bidders shall quote for the above Price Centres including all taxes and duties.~~
- ~~In the event that the values entered in above table mismatch with the BOQ values submitted by the bidder; the BOQ values shall be considered~~

4.4.9 PRICE CENTRE 'RS-F' – INTEGRATED TESTING AND COMMISSIONING OF TRAINS AND SERVICE TRIALS

1

PRICE CENTRE RS-F1: INTEGRATED TESTING AND COMMISSIONING OF TRAINS AND SERVICE TRIALS, IN ATP & ATO (GOA2) MODE OF OPERATION

DETAILS NOT TO BE SUBMITTED IN TECHNICAL BID. IT SHALL BE FILLED AND UPLOADED ONLY IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL.

MILESTONE NUMBER	WORK DESCRIPTION	APPORTIONED AMOUNT			PERIOD OF COMPLETION OF MILESTONE FROM COMMENCEMENT DATE (QUANTITY)	ALLOWABLE APPORTIONMENT (under Lumpsum Price (Rolling Stock) – Project) %
		INR	FC1	FC2		
	MILESTONE ACTIVITY	COLUMN A	COLUMN B	COLUMN C		
Obtain the "No Objection With Comments (NOWC)" / "Notice of No Objection (NONO)" from the Employer / Engineer for:						
a. Completion of Integrated Testing and Commissioning in the Depot;						
b. Completion of Integrated testing and Commissioning on the section in conjunction with Designated Contractors;						
c. Instrumentation Tests of First train, conducting oscillation trials as per requirement of Statutory Authorities, compilation of test Results, obtaining sanction of Statutory Authorities for fitness of train for carriage of passengers in respect of Prototype Trains only.						
d. Service Trials, for;						
RS-F1.1	First 6-car rake (Pilot Rake)				NTP + 1050	0.14%
RS-F1.2	Obtain as above for first 3 train sets				NTP + 1050	0.54%
RS-F1.3	Obtain as above for next 3 train sets				NTP + 1095	0.54%
RS-F1.4	Obtain as above for next 3 train sets				NTP + 1140	0.54%
RS-F1.5	Obtain as above for next 3 train sets				NTP + 1185	0.54%
RS-F1.6	Obtain as above for next 3 train sets				NTP + 1230	0.54%
RS-F1.7	Obtain as above for next 3 train sets				NTP + 1275	0.54%
RS-F1.8	Obtain as above for next 3 train sets				NTP + 1320	0.54%
RS-F1.9	Obtain as above for next 3 train sets				NTP + 1365	0.54%
RS-F1.10	Obtain as above for next 3 train sets				NTP + 1410	0.54%
RS-F : PRICE CENTRE TOTAL (RS-F1.1 ~ RS-F1.10)		Carried over from Price Centre 'RS-F1'				5 %

Notes:

- The apportioned amounts (both foreign currency and local currency) in the above Table shall in proportion to the number of trains in all Milestones relevant to the Price Centre.
- Specify 'Not Applicable' against each of the rows which are not applicable under this milestone.
- Bidders shall quote for the above Price Centres including all taxes and duties.
- In the event that the values entered in above table mismatch with the BOQ values submitted by the bidder; the BOQ values shall be considered

1 PRICE CENTRE RS-F2: INTEGRATED TESTING AND COMMISSIONING OF TRAINS AND SERVICE TRIALS, IN UTO (GOA4) MODE OF OPERATION

DETAILS NOT TO BE SUBMITTED IN TECHNICAL BID. IT SHALL BE FILLED AND UPLOADED ONLY IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL.

MILESTONE NUMBER	WORK DESCRIPTION	APPORTIONED AMOUNT			PERIOD OF COMPLETION OF MILESTONE FROM COMMENCEMENT DATE (QUANTITY)	ALLOWABLE APPORTIONMENT (under Lumpsum Price (Rolling Stock) – Project) %
		INR	FC1	FC2		
	MILESTONE ACTIVITY	COLUMN A	COLUMN B	COLUMN C		
Obtain the “No Objection With Comments (NOWC)” / “Notice of No Objection (NONO)” from the Employer / Engineer for: a. Completion of Integrated Testing and Commissioning in the Depot; b. Completion of Integrated testing and Commissioning on the section in conjunction with Designated Contractors; c. Instrumentation Tests of First train, conducting oscillation trials as per requirement of Statutory Authorities, compilation of test Results, obtaining sanction of Statutory Authorities for fitness of train for carriage of passengers in respect of Prototype Trains only. d. Service Trials, for;						
RS-F2.1	First 6-car rake (Pilot Rake)				NTP + 1780	0.11%
RS-F2.2	Obtain as above for first 3 train sets				NTP + 1780	0.21%
RS-F2.3	Obtain as above for next 3 train sets				NTP + 1825	0.21%
RS-F2.4	Obtain as above for next 3 train sets				NTP + 1870	0.21%
RS-F2.5	Obtain as above for next 3 train sets				NTP + 1915	0.21%
RS-F2.6	Obtain as above for next 3 train sets				NTP + 1960	0.21%
RS-F2.7	Obtain as above for next 3 train sets				NTP + 2005	0.21%
RS-F2.8	Obtain as above for next 3 train sets				NTP + 2050	0.21%
RS-F2.9	Obtain as above for next 3 train sets				NTP + 2095	0.21%
RS-F2.10	Obtain as above for next 3 train sets				NTP + 2140	0.21%
RS-F : PRICE CENTRE TOTAL (RS-F2.1 ~ RS-F2.10)		Carried over from Price Centre ‘RS-F2’				2 %

Notes:

- The apportioned amounts (both foreign currency and local currency) in the above Table shall in proportion to the number of trains in all Milestones relevant to the Price Centre.
- Specify ‘Not Applicable’ against each of the rows which are not applicable under this milestone.
- Bidders shall quote for the above Price Centres including all taxes and duties.
- In the event that the values entered in above table mismatch with the BOQ values submitted by the bidder; the BOQ values shall be considered

4.4.10 PRICE CENTRE ‘G’ – UNIT EXCHANGE SPARES, MANDATORY SPARES, RECOMMENDED SPARES (FOR USE BEYOND DEFECT LIABILITY PERIOD), CONSUMABLE SPARES (FOR PERIOD UP TO EXPIRY OF DEFECT LIABILITY PERIOD), INTERMEDIATE OVERHAULING SPARES, SPECIAL TOOLS, JIGS, FIXTURES, TESTING AND DIAGNOSTIC EQUIPMENT.

DETAILS NOT TO BE SUBMITTED IN TECHNICAL BID. IT SHALL BE FILLED AND UPLOADED ONLY IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL.

MILESTONE NUMBER	WORK DESCRIPTION	APPORTIONED AMOUNT			PERIOD OF COMPLETION OF MILESTONE FROM COMMENCEMENT DATE (QUANTITY)
		INR	FC1	FC2	
	MILESTONE ACTIVITY	COLUMN A	COLUMN B	COLUMN C	
Obtain the “No Objection With Comments (NOWC)” / “Notice of No Objection (NONO)” from the Employer / Engineer for the Delivery of the following:					
RS-G1	<u>Unit Exchange Spares</u> (Refer below for complete list of G1.1 ~ G1.31)				90 Days prior to completion of DNP
RS-G2	<u>Mandatory Spares</u> (Refer below for complete list of G2.1 ~ G2.16)				90 Days prior to completion of DNP
RS-G3	<u>Recommended Spares</u> (Refer below for complete list of G3.1 ~ G3.)				90 Days prior to completion of DNP
RS-G4	<u>Consumable Spares</u> (Refer below for complete list of G4.1 ~G4.)				Along with TOC of 1st Trainset.
RS-G5	<u>Special Tools, Jigs, Fixtures, Gauges, Testing and Diagnostic Equipment</u> (Refer below for complete list of G5.1 ~ G5.)				90 Days prior to completion of DNP
RS-G6	<u>IOH Spares</u> (Refer below for complete list of G6.1 ~ G6.)				90 Days prior to completion of DNP
RS-G : PRICE CENTRE TOTAL (RS-G1 ~ RS-G6)		Carried over from Price Centre ‘RS-G’			

Note :

- 1) The costs indicated in this Price Centre for all the Milestones G1 to G6 shall be the actual costs and not the apportioned costs.
- 2) For milestones G1 & G2: Bidder must furnish unit price for each item under these Milestones and shall not alter the quantities indicated under these Milestones for each item.
- 3) For Milestones G3, G4, G5 & G6: Bidder shall furnish the list and unit price for each item (Refer Employer’s Requirements – Technical Specification)
- 4) For Milestone G4: In case of increase / decrease of quantities of ordered train sets on account of exercising of option by the Employer, the declared quantity by the Bidder of consumables required under this Milestone will be increased / decreased on pro-rata basis. There shall be no change in the unit cost of consumables quoted by the Bidder. Price adjustment shall apply.
- 5) Employer at his sole discretion may exercise the option to increase / decrease the quantities (to any extent) of spares indicated under milestones G1, G2, G3, G5 and G6. Payment to the contractor shall be on the basis of actual supplies made and quoted unit rates and price adjustment will be applied. Any decrease in quantities shall be intimated by Employer within 18 months of the Commencement date. However increase in quantities may be intimated at any time during the execution of Contract and the delivery period for the enhanced quantities only shall be mutually agreed.

6) Accomplishment of Milestone 'G6' will be a pre-requisite for issue of the Performance Certificate.

7) ~~Contractor shall indicate the annual percentage that will be applicable for increase or decrease of the unit cost of each item/spare listed in Annexures GA1 to GA6 for procurement by Employer for a period of up to ten years after the date of issue of the Performance Certificate.~~

1

~~The increase or decrease in the unit cost of each item/spare listed in Annexures GA1 to GA6 for procurement by the Employer for a period of up to ten (10) years from the date of issue of the Performance Certificate. The increase or decrease in unit cost shall be determined in accordance with the Price Adjustment Formula as specified in PC Clause 13.8 of the Contract.~~

8) ~~Employer may exercise the option to procure individual Spares listed in Annexures GA1 to GA6 by the bidder at any time within ten years of the date of issue of Performance Certificate. Procurement Price in such case shall be calculated by considering the percentage of increase/decrease per annum (with minimum duration as one month) as quoted by the Contractor in Annexures GA1 to GA6.~~

~~The Employer may exercise the option to procure individual spares listed in Annexures GA1 to GA6 from the Contractor at any time within ten (10) years from the date of issue of the Performance Certificate. The procurement price in such cases shall be calculated by applying the Price Adjustment Formula as specified in PC Clause 13.8 of the Contract, to the prices stated in Annexures GA1 to GA6.~~

9) Important note regarding evaluation of cost quoted under this Price Centre:

Wherever Bidders do not quote for spares against Milestones G1, G2 and G5 (Mandatory List) exactly as per specified list in the Bidding Documents, following methodology for loading of prices for Milestones G1, G2 and G5 (Mandatory List) will be considered:

- a. Cases where the Bidder has quoted unit rates but the quoted quantity do not match with the specified quantity in the Bidding Documents. Unit price quoted will be considered for calculating the procurement price of the quantities specified in the Bidding Documents and this calculated price will be considered for evaluation.
- b. Cases where Bidder has mentioned unit rates as "Zero / 0 / - / NIL", for all such items the prices shall be considered as 0 (zero) for evaluation. Also, during actual contract execution, such items, if any, will be considered as to be supplied free of cost to the Employer
- c. Cases where Bidder has either left unit rates blank or some items have been excluded from the specified list
 - i. For all such items, the maximum prices quoted by any of the other responsive bidder for such item will be considered and added to the respective Milestone price quoted by the Bidder. This calculated price will be considered for evaluation
 - ii. However, during actual contract execution, such items, if any, will be considered as to be supplied free of cost to the Employer
- d. Cases where the Bidder has quoted for additional items (over and above the items specified in the Bidding Documents), price of additional items quoted by the Bidder will not be considered for evaluation and such items will not form part of the contract.

4.4.10.1 RS-G1 - Unit Exchange Spares

DETAILS NOT TO BE SUBMITTED IN TECHNICAL BID. IT SHALL BE FILLED AND UPLOADED ONLY IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL.

*Note : (*Wherever the Unit is mentioned as 'Set', it means '6-Car Train Set' and wherever it is mentioned as 'No', it means 'Numbers')*

Sl. No	Description	Unit	QTY	Unit Rate			Amount		
				INR	FC1	FC2	INR	FC1	FC2
Milestone G1 : Unit Exchange Spares (G1.1 ~ G1.31)									
G1.1	Main Transformer	Set	1						
G1.2	Traction motor with coupling	No	4						
G1.3	Traction converter and Inverter	Set	1						
G1.4	Auxiliary converter with battery charger	Set	1						
G1.5	Vacuum circuit breaker with control box	No.	2						
G1.6	Complete motor bogie equipped with traction motors with power and earthing cables, wheel sets and brake units etc.	Set	1						
G1.7	All types of complete trailer bogie equipped with wheel sets and brake units etc.	Set	1						
G1.8	Motor car wheel sets complete with drive mechanism, brake discs, axle box and bearing etc.	Nos.	2						
G1.9	Trailer car wheel set complete with brake discs, axle box, bearing etc.	Nos.	2						
G1.10	25kV cable with HV bushing and connectors	Set	1						
G1.11	Complete Battery box for 3-car unit with inter connectors and associated components	Set	2						
G1.12	Pantograph with base insulators and its control panel	Set	1						
G1.13	Coupler: Semi-permanent and Fully-automatic;	Set	1						
G1.14	Complete Gangway and its accessories	Set	1						
G1.15	Master controller & mode selector	Set	2						
G1.16	PWM Generator (if applicable) and interface panel	Set	1						
G1.17	Main Motor Compressor Set for pneumatic system with Starter box/Control box	Set	1						
G1.18	Auxiliary motor compressor set	Set	2						
G1.19	Secondary suspension (Air suspension) complete set	Set	1						
G1.20	Primary suspension	Set	1						
G1.21	Disc brake complete set excluding disc OR Tread Brake complete set	Set	2						

G1.22	Brake control unit (Electronic and pneumatic) complete with brake application (actuator) units	Set	1						
G1.23	Complete PA/PIS & CCTV system with its accessories	Set	1						
G1.24	Complete saloon door with drive mechanism and its accessories	No	8						
G1.25	Saloon Air-conditioning Unit including control unit.	Set	1						
G1.26	Complete TCMS Equipment with its accessories	Set	1						
G1.27	Complete WFL system with its accessories	Set	3						
G1.28	Surge Arrester	Set	1						
G1.29	Current Transformer	Set	1						
G1.30	Potential Transformer	Set	1						
G1.31	Fire Detection Unit	Set	1						
RS-G1 : Price Centre Unit Exchange Spares Total (G1.1 ~ G1.31)									

4.4.10.2 RS-G2 - Mandatory Spares

DETAILS NOT TO BE SUBMITTED IN TECHNICAL BID. IT SHALL BE FILLED AND UPLOADED ONLY IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL.

*Note : (*Wherever the Unit is mentioned as 'Set', it means '6-Car Train Set' and wherever it is mentioned as 'No', it means 'Numbers')*

Sl. No	Description	Unit	QTY	Unit Rate			Amount		
				INR	FC1	FC2	INR	FC1	FC2
Milestone G2 : Mandatory Spares (G2.1 ~ G2.16)									
G2.1	VAC Unit (G2.1a ~ G2.1q)								
G2.1a	Microprocessor based control unit	Nos.	2						
G2.1b	Set of temperature sensor	Set	2						
G2.1c	Humidity Sensor	Nos.	3						
G2.1d	Smoke Sensor	Nos.	3						
G2.1e	Fresh & Return air Damper motors	Nos.	2						
G2.1f	Compressor unit with motor and mounts	Nos.	4						
G2.1g	Condenser fans with motor	Nos.	4						
G2.1h	Evaporator fans with motor	Nos.	4						
G2.1i	Emergency Inverter with control unit	Nos.	4						
G2.1j	Electrical control unit	Set	1						
G2.1k	Heater Assembly	Set	1						
G2.1l	Complete HVAC Duct Assembly & its Accessories	Nos.	1						
G2.1m	Condenser Fans	Nos.	1						
G2.1n	Evaporator Fans	Nos.	1						
G2.1o	Relays, Thermal Relay, Contactors, Terminal Blocks, Aux. Contacts, Selector Switch, Circuit Breaker, Sockets, Connectors & Electrical Accessories	Set	1						
G2.1p	Set of connectors, fittings, cables, terminations, glands, lugs, conduits, protective covers, mounting hardware, and other associated electrical accessories	Set	1						
G2.1q	Rubber gaskets, Rubber beads, Copper tube, fitting, Heat shrink tubes, Seals & Other Accessories.	Set	1						
G2.2	Brake & Pneumatics (G2.2a ~ G2.2w)								
G2.2a	Set of PCB cards for Brake electronic control unit of DMC & TC car	Set	1						
G2.2b	Set of Power module card	Set	1						
G2.2c	Set of Input Output Card	Set	1						
G2.2d	Speed Sensor	No	6						
G2.2e	Brake actuator & Cylinder	No	8						
G2.2f	Set of pneumatic Valves	Set	2						
G2.2g	Set of magnet Valves	Set	2						
G2.2h	Set of safety Valves	Set	2						

G2.2i	Set of gauges	Set	2						
G2.2j	Set of Sensors	Set	2						
G2.2k	Set of Pressure switches	Set	2						
G2.2l	Set of Pressure governors	Set	2						
G2.2m	Set of all types of isolating cocks	Set	2						
G2.2n	Drivers' brake valve	No	2						
G2.2o	Analog Converter	No	3						
G2.2p	Set of Pneumatic Pipe fittings	Set	1						
G2.2q	Set of Pneumatic Hoses, Connectors, & Hose Accessories	Set	1						
G2.2r	Pneumatic Gaskets & Seals	Set	1						
G2.2s	Set of Speed Sensors, Connectors & Accessories	Set	1						
G2.2t	Set of Test Points	Nos.	10						
G2.2u	Set of Reservoir & Drain Valves	Set	1						
G2.2v	Set of Filter element, Filters & Other Accessories	Set	1						
G2.2W	Set of connectors, fittings, cables, terminations, glands, lugs, conduits, protective covers, mounting hardware, and other associated electrical accessories	Set	1						
G2.3	PA/PIS CCTV (G3.3a ~ G3.3m)								
G2.3a	Set of PCB cards	Set	1						
G2.3b	Set of Power Module Cards	Set	1						
G2.3c	Main operating Panel with Microphone	No	2						
G2.3d	Train Number Indicator	No	2						
G2.3e	Destination Indicator	No	2						
G2.3f	Digital Route map indicator	No	24						
G2.3g	Amplifier	No	4						
G2.3h	Speaker	Set	1						
G2.3i	Passenger emergency activation device	Set	1						
G2.3j	Auxiliary operating panel	No	2						
G2.3k	Set of Cameras	Set	1						
G2.3l	Set of Internal displays	No	10						
G2.3m	Set of connectors, fittings, cables, terminations, glands, lugs, conduits, protective covers, mounting hardware, and other associated electrical accessories	Set	1						
G2.4	DOORS (G2.4a ~ G2.4i)								
G2.4a	Door control unit	Set	1						
G2.4b	Door leaves (Right)	No	8						
	Door leaves (Left)		8						
G2.4c	Door motor including gear mechanism if any	No	8						
G2.4d	Set of rollers	Set	1						

G2.4e	Set of sensors / switches of saloon doors	Set	1						
G2.4f	Emergency Door	Set	1						
G2.4g	Emergency Door operating mechanism	Set	1						
G2.4h	Set of relays, contactors for emergency door	Set	1						
G2.4i	Set of sensors / switches of emergency doors	Set	1						
G2.5	Traction Converter / Inverter (G2.5a ~ G2.5n)								
G2.5a	Set of PCB cards	Set	1						
G2.5b	Power module card	No	4						
G2.5c	Input Output Card	No	4						
G2.5d	Set of Contactors	Set	1						
G2.5e	Current Transformer	No	2						
G2.5f	Potential Transformer	No	2						
G2.5g	Converter Power Module	No	4						
G2.5h	Inverter Power Module	No	4						
G2.5i	Gate Control Unit	No	4						
G2.5j	DC link Charging circuit module	No	2						
G2.5k	DC link capacitor	Set	1						
G2.5l	Earthing protection circuit module	No	4						
G2.5m	Cooling Unit (if applicable)	Set	1						
G2.5n	Set of connectors, fittings, cables, terminations, glands, lugs, conduits, protective covers, mounting hardware, and other associated electrical accessories	Set	1						
G2.6	Auxiliary Converter (G2.6a ~ G2.6h)								
G2.6a	Set of PCB cards	Set	1						
G2.6b	Power module card including IGBT	No	4						
G2.6c	Input Output Card	No	4						
G2.6d	Set of Contactors	Set	1						
G2.6e	Battery Charger	No	4						
G2.6f	Cooling Unit (if applicable)	Set	1						
G2.6g	Battery cells	Set	1						
G2.6h	Set of connectors, fittings, cables, terminations, glands, lugs, conduits, protective covers, mounting hardware, and other associated electrical accessories	Set	1						
G2.7	Main Transformer (G2.7a ~ G2.7e)								
G2.7a	Oil Pump	No	2						
G2.7b	Radiator blower including fan	No	2						
G2.7c	Set of valves and relays	Set	1						
G2.7d	Set of sensors/gauges	Set	1						
G2.7e	Set of connectors, fittings, cables, terminations, glands, lugs, conduits, protective covers, mounting hardware,	Set	1						

	and other associated electrical accessories								
G2.8	TCMS (G2.8a ~ G2.8c)								
G2.8a	Set of PCB cards	Set	1						
G2.8b	Display Unit	No	2						
G2.8c	Backlight of Display Unit	No	2						
G2.9	Master Controller (G2.9a ~ G2.9b)								
G2.9a	Set of Switches	Set	1						
G2.9b	Potentiometer	No	2						
G2.10	Pantograph (G2.10a ~ G2.10g)								
G2.10a	Control Panel	No	2						
G2.10b	Control box having regulator, filter, etc.,	No	2						
G2.10c	Overhead Detection valve	No	2						
G2.10d	Pantograph pan	No	10						
G2.10e	Pantograph raising cylinder	No	4						
G2.10f	Air Feed insulator	No	4						
G2.10g	Pantograph Foot insulator	No	4						
G2.11	Vacuum Circuit Breaker (G2.11a ~ G2.11c)								
G2.11a	Control box including auxiliary contact, pressure regulator etc.	No	3						
G2.11b	Set of Sensors	Set	1						
G2.11c	Set of Valves & Pneumatics Valves & Accessories	Set	1						
G2.12	Coupler (G2.12a ~ G2.12d)								
G2.12a	Proximity sensor	Set	1						
G2.12b	Set of Pneumatic hoses	Set	1						
G2.12c	Set of electrical jumpers with connectors	Set	1						
G2.12d	Set of Mechanical Bushes, Sleeves, Adaptor, Fitting, Hoses, valves & Other Accessories	Set	1						
G2.13	Bogie (G2.13a ~ G2.13e)								
G2.13a	Set of Hydraulic Dampers	Set	1						
G2.13b	Reaction rod / traction links / axle box links etc.,	Set	1						
G2.13c	Axle boxes including bearing	Set	1						
G2.13d	Drive gear unit complete with bearings and gear case	Set	1						
G2.13e	Set of Mechanical Bushes, Sleeves, Adaptor, Fitting, Hoses, valves & Other Accessories	Set	1						
G2.14	Electrical Items (G1.14a ~ G1.14h)								
G2.14a	Set of luminaries – Head light, Tail light, Flasher light, Console light, Gangway light etc., for 3-car unit	Set	1						
G2.14b	Complete headlight with lamp & housing	Set	1						
G2.14c	Set of DC-DC converter	Set	1						
G2.14d	Saloon light inverter	Set	1						

G2.14e	Earthing Ground Switch	No	2						
G2.14f	Lightening Arrestor	No	2						
G2.14g	Neutral Section Detector (NSD) if used	No	4						
G2.14h	Wiper Motor	No	4						
G2.15	Miscellaneous items (G2.15a ~ G2.15aa)								
G2.15a	Set of all hardware – mounting, bolts, washers etc., for Converter/Inverter	Set	2						
G2.15b	Set of all hardware – mounting, bolts, washers etc., for Auxiliary converter	Set	2						
G2.15c	Set of all hardware – mounting, bolts, washers etc., for pneumatic Compressor	Set	2						
G2.15d	Set of all hardware – mounting, bolts, washers etc., for Transformer	Set	2						
G2.15e	Set of all hardware – mounting, bolts, washers etc., for Air reservoirs	Set	2						
G2.15f	Set of all hardware – mounting, bolts, washers etc., for Valve boxes	Set	2						
G2.15g	Set of all hardware – mounting, bolts, washers etc., for Door	Set	2						
G2.15h	Set of all hardware – mounting, bolts, washers etc., for Air conditioning unit	Set	2						
G2.15i	Set of all hardware – mounting, bolts, washers etc., for Traction Motor	Set	2						
G2.15j	Set of all connectors with pins of MAKE A, B..... (BIDDER to specify)	Set	1						
G2.15k	Set of all relays of MAKE A, B..... (BIDDER to specify)	Set	1						
G2.15l	Set of all pushbuttons of MAKE A, B..... (BIDDER to specify)	Set	1						
G2.15m	Set of all contactors for MAKE A, B..... (BIDDER to specify)	Set	1						
G2.15n	Set of all MCBs for MAKE A, B..... (BIDDER to specify)	Set	1						
G2.15o	Set of all indicators for MAKE A, B..... (BIDDER to specify)	Set	1						
G2.15p	Set of all fuses for MAKE A, B..... (BIDDER to specify)	Set	1						
G2.15q	Set of air filters	Set	3						
G2.15r	Set of housing/casing/cover for tail light, console light, flasher light, read light , gangway light	Set	1						
G2.15s	Housing/casing/cover for saloon light	Set	1						
G2.15t	Set of Driver Seats	Set	1						
G2.15u	Set of Glasses of Door & window	Set	1						
G2.15v	Windshield glass	Set	1						
G2.15w	Battery Box	Set	1						
G2.15x	Draught Screen	Set	1						
G2.15y	Low Voltage box Assembly with Complete Accessories	Set	1						

G2.15z	High Voltage Jumper Box Assembly & Cable mounting Bracket sets	Set	1						
G2.15aa	Crash Box assembly for DMC Car & TC car	Set	1						
G2.16	Any other items recommended by Bidder (G1.16a ~ G6.16__)								
G2.16a									
G2.16b									
...									
RS-G2 : Price Mandatory Spares Total (G2.1 ~ G2.16)									

4.4.10.3 RS-G3 – Recommended Spares

DETAILS NOT TO BE SUBMITTED IN TECHNICAL BID. IT SHALL BE FILLED AND UPLOADED ONLY IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL.

*Note : (*Wherever the Unit is mentioned as 'Set', it means '6-Car Train Set' and wherever it is mentioned as 'No', it means 'Numbers')*

Sl. No	Description	Unit	QTY	Unit Rate			Amount		
				INR	FC1	FC2	INR	FC1	FC2
Milestone G3 : Recommended Spares (G3.1 ~ 3.__)									
G3.1									
G3.2									
G3.3									
...									
...									
RS-G3 : Price Recommended Spares Total (G3.1 ~ G3.__)									

4.4.10.4 RS-G4 – Consumable Spares

DETAILS NOT TO BE SUBMITTED IN TECHNICAL BID. IT SHALL BE FILLED AND UPLOADED ONLY IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL.

*Note : (*Wherever the Unit is mentioned as 'Set', it means '6-Car Train Set' and wherever it is mentioned as 'No', it means 'Numbers')*

Sl. No	Description	Unit	QTY	Unit Rate			Amount		
				INR	FC1	FC2	INR	FC1	FC2
Milestone G4 : Consumable Spares (G4.1 ~ G4.2)									
G4.1	Mandatory Consumable Spares (G4.1a ~ G4.1r)								
G4.1a	Lubricants								
G4.1b	Oils								
G4.1c	Greases								
G4.1d	Sealants								
G4.1e	Brake Pads								
G4.1f	Brake Blocks								
G4.1g	Filters								
G4.1h	Gaskets								
G4.1i	O rings								
G4.1k	Seal kits								
G4.1l	Lamps								
G4.1m	Pantograph strip								
G4.1n	Other wearable parts								
G4.1o	Anti-protection Coating/ Rust prevention coating								
G4.1p	Primer & Paints								
G4.1q	Cleaning Agent/Chemicals								
G4.1r	Any other item whose declared life is less than one year								
G4.2	Recommended Consumable Spares (G4.2a ~ G4.2__)								
G4.2a									
G4.2b									
...									
RS-G4 : Price Consumable Spares Total (G4.1 ~ G4.2)									

4.4.10.5 RS-G5 – Special Tools, Jigs, Fixtures, Gauges, Testing and Diagnostic Equipment

DETAILS NOT TO BE SUBMITTED IN TECHNICAL BID. IT SHALL BE FILLED AND UPLOADED ONLY IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL.

*Note : (*Wherever the Unit is mentioned as 'Set', it means '6-Car Train Set' and wherever it is mentioned as 'No', it means 'Numbers')*

Sl. No	Description	Unit	QTY	Unit Rate			Amount		
				INR	FC1	FC2	INR	FC1	FC2
Milestone G5 : Special Tools (G5.1 ~ G5.27)									
G5.1	Pantograph	No	1						
	Pantograph test bench equipped with contact pressure measuring system, raising & lowering times, alignment fixtures etc.								
G5.2	VCB	No	1						
	VCB test bench with handling trolley including jigs and fixtures, Interpreter Travel, Current Measuring device & Leak tester & electrical Operation Test rig								
G5.3	Main Transformer	No	1						
	Dissolved gas analyser								
	Oil filling equipment								
	Oil filtration unit								
G5.4	Converter / Inverter	No	1						
	Portable test unit								
	GDU tester								
	converter-inverter testing unit								
	converter-inverter repair unit jig								
	Mounting / dismounting trolley & tools								
G5.5	Traction Motor	No	1						
	Test bench								
	Assembly / disassembly Jig & tools								
G5.6	Auxiliary Power Supply	No	1						
	converter testing unit								
	converter repair unit jig								
	Mounting / dismounting trolley & tools								
	Portable test unit								
G5.7	Battery	No	1						
	Capacity measuring instrument								
	Portable Charging & discharging equipment								
	Assembly / disassembly Jig & tools								
	Insulated torque wrench								
G5.8	Brake System	No	1						
	Compressor test bench								
	Air dryer test bench								

	Compressor overhauling tools								
	Compressor air quality test facilities								
	Assembly / disassembly Jig & tools								
	Automatic Universal Pneumatic valve test bench								
	Complete Brake electronics test bench								
	Complete Brake electronics calibration unit								
	Brake Calliper test bench								
G5.9	Axle boxes	No	1						
	Bearing cleaning,								
	assembly & disassembly tools								
G5.10	Axle	No	1						
	Ultrasonic testing machine								
	go gauge / no go gauge for end screw								
G5.11	Drive gear	No	1						
	Assembly / disassembly tools								
	test bench								
G5.12	PA/PIS & CCTV	No	1						
	Portable test unit,								
	Application software for Papis & CCTV changes								
	Complete Papis & CCTV electronics test bench								
	PAPIS / CCTV electronics repair unit								
G5.13	Air Conditioning equipment	No	1						
	Portable test unit								
	Leakage detectors								
	HVAC electronics test bench								
	HVAC electronics repair unit								
	HVAC Unit Testing kit								
	Assembly / disassembly Jig & tools								
	Oil less refrigerated changing / reclaiming unit including vacuum pump, suction equipment, leakage detector etc.								
	Special Tools – ceiling piler, crimping tool, Fin comb, tube cutter, pressure gauge.								
G5.14	Door	No	1						
	Portable test unit including drive control unit								
	Force detection gauge,								
	power supply with adjustable limiting current and voltage,								
	door handling unit,								
	Door control box for local operations,								
	Door test jig, alignment tools.								

G5.15	Coupler	No	1						
	Profile checking gauge								
	Assembly / disassembly tools & jig								
G5.16	Bogie	No	1						
	Tools for Assembly / Disassembly of Bogie suspensions,								
	WFL alignment tools								
	Bearings, Components including rubber items used in transmission & suspension, Connecting rods etc.								
	Template for Checking the Bogies Vital clearance.								
G5.17	Wheel	No	1						
	Profile checking gauge with memory and card to card compatibility, Measurement gauges for wheel (data shall be sent to AMS system for analysis)								
	Template for Checking Wheel Profile and Identifying Wheel Defects								
G5.18	Primary Suspension	No	1						
	Assembly / Disassembly tools								
	Spring & damper Testing unit								
	Damper repair tools,								
	Repair tools for sphere blocks								
	Shimming adding tools including jacks, Hydraulic Pump, Jigs to adjust the height								
G5.19	Secondary Suspension	No	1						
	Suspension testing jig								
G5.20	Gangway	No	1						
	Gangway lifting jig								
	Assembly / Disassembly tools								
G5.21	Master Controller	No	1						
	Assembly / disassembly tools								
	calibration tools								
	test units								
G5.22	TCMS	No	1						
	Complete Electronic card tester								
	Application software for TCMS changes								
G5.23	Programming & Diagnostic tools	No	1						
	Laptop, Interface boards / accessories / software and any other item required for meeting specification requirements, uploading / downloading & trouble shooting of propulsion, Vehicle/train non-propulsion & other equipments. Like Up-gradation software / DLP of software								
G5.24	Depot maintenance tools	No	1						
	Software tools for train equipment maintenance & monitoring equipment.								

G5.25	Others	No	1						
	Test/repair kits for optical fibre connectors if need, inter vehicular connectors, power & control cable and connectors.								
	Tools for Mounting and Dismounting Under-Frame Components Using a Portable Trolley in the Pit Area								
	Tools for Mounting and Dismounting Under-Frame Components Using a Portable Trolley in Embedded Track area								
	Tools for Mounting & Dismounting the Brake cylinder in Carbody assembled condition								
	Jig assembly for the Roof Equipment Viz, HVAC, Pantograph, VCB, EGS, & etc.								
G5.26	Fire Detection Unit	No	1						
	Complete Electronic card tester								
	Application software for TCMS changes								
	Calibration unit								
G5.27	Recommended Special Tools								
G5.27a									
G5.27b									
...									
RS-G5 : Price Special Tools Total (G5.1 ~ G5.27)									

4.4.10.6 RS-G6 – Intermediate Overhauling Spares

DETAILS NOT TO BE SUBMITTED IN TECHNICAL BID. IT SHALL BE FILLED AND UPLOADED ONLY IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL.

*Note : (*Wherever the Unit is mentioned as 'Set', it means '6-Car Train Set' and wherever it is mentioned as 'No', it means 'Numbers')*

1

Sl. No	Description	Unit	QTY	Unit Rate			Amount		
				INR	FC1	FC2	INR	FC1	FC2
Milestone G6 : Intermediate Overhauling Spares (G6.1 ~ G6.16)									
G6.1	Pantograph:	Set	2						
	Kit for overhauling of pantograph, raising cylinder, various items of pantograph panel and control box								
G6.2	VCB:	Set	2						
	Kit for overhauling of VCB & its control box								
G6.3	Main transformer:	Set	2						
	Kit for overhauling of various valves, oil pump and radiator fan								
G6.4	Compressor:	Set	2						
	Kit for overhauling of Main & auxiliary compressor, Compressor test bench								
G6.5	Pneumatics:	Set	2						
	Kit for overhauling of all Pneumatic valves & Magnet valves & mechanically operated Valves								
G6.6	Axle Boxes:	Set	2						
	Kit for overhauling of Axle boxes								
G6.7	Drive Gear:	Set	0						
	Kit for overhauling of Drive gear								
G6.8	Air Condition:	Set	2						
	Kit for overhauling of valves, relays etc.								
G6.9	Door:	Set	1						
	Kit for overhauling of operating mechanism of door								
G6.10	Bogie:	Set	1						
	Kit for overhauling of Bogie including bushes, pins, etc								
G6.11	Brake:	Set	1						
	Kit for overhauling of disc brake unit								
G6.12	Master Controller:	Set	2						
	Kit for overhauling of Master Controller								
G6.13	Coupler:	Set	1						
	Kit for overhauling of valves.								
G6.14	Converter / Inverter:	Set	2						
	Kit for overhauling of contactors, relays etc..								

Sl. No	Description	Unit	QTY	Unit Rate			Amount		
				INR	FC1	FC2	INR	FC1	FC2
G6.15	Auxiliary Inverter:	Set	2						
	Kit for overhauling of contactors, relays etc..								
G6.16	Recommended Intermediate Overhauling Spares								
G6.16a									
G6.16b									
...									
RS-G6 : Price Intermediate Overhauling Spares Total (G6.1 ~ G6.16)									

4.4.11 **PRICE CENTRE ‘RS-H’ – TRAINING AND MANUALS.**

This Price Centre comprises of all requirements / activities associated with ERTS - RS, Section 15.

DETAILS NOT TO BE SUBMITTED IN TECHNICAL BID. IT SHALL BE FILLED AND UPLOADED ONLY IN THE PRICE BID DOCUMENT OF E-PROCUREMENT PORTAL.

MILESTONE NUMBER	WORK DESCRIPTION	AMOUNT			PERIOD OF COMPLETION OF MILESTONE FROM COMMENCEMENT DATE
		INR	FC1	FC2	
	MILESTONE ACTIVITY	COLUMN A	COLUMN B	COLUMN C	
Obtain the “No Objection With Comments (NOWC)” / “Notice of No Objection (NONO)” from the Employer / Engineer for completion of all training including delivery of final training manuals for the following					
RS-H0	Training for the Employer's staff (Two Trainer Man months) shall be arranged and will be conducted at: i) the site of an Operating Railway (must be part of a network that has provided GoA4 / UTO operations for a period >10 years) ii) the Contractor's design/primary car building facility iii) the site where System's Integration simulation testing is undertaken The training syllabus shall be jointly decided between the Contractor and the Employer. It may consist of but shall not be limited to: Rolling Stock design, manufacturing, Testing and Commissioning, Systems Integration Testing and UTO Signalling Technology.				
RS-H1	Not used				
RS-H2	Not used				
RS-H3	Not used				
RS-H4	Provision of Contractor's Driving Instructors (2 man months) for Training of Employer's operating personnel in India.				
RS-H5	*Provision of Contractor's Instructors and OEM's Experts (40 man months) for on job Training and supervision of Employer's maintenance personnel in the metro train depot of CMRL in India.				
RS-H6	Submission of Training manuals (Original plus five hard copies) and in Electronic format.				
RS-H7	Operating Manual (Original plus 5 Hard copies).				
RS-H8	Operating Manual in Electronic format (interactive version).				
RS-H9	Maintenance Manual (Original plus 5 hard copies).				
RS-H10	Maintenance Manual in Electronic format (interactive version).				
RS-H11	Spare parts Catalogue (Original plus 5 Hard copies).				
RS-H12	Spare parts Catalogue in Electronic format				
RS-H13	Any other item considered necessary by the Contractor to comply with the scope of Works				

MILESTONE NUMBER	WORK DESCRIPTION	AMOUNT			PERIOD OF COMPLETION OF MILESTONE FROM COMMENCEMENT DATE
		INR	FC1	FC2	
	MILESTONE ACTIVITY	COLUMN A	COLUMN B	COLUMN C	
RS-H : Price Centre Total (RS-H1 ~ RS-H13)					

- On job training and supervision during maintenance includes theoretical training as well as practical training at the time of maintenance during day and night in the Depot.
- Any other specific training as provided in the Employer's Requirement Technical Specification is deemed to be included under this Milestone's scope.
- The manuals will be given for training of operation and maintenance staff. These manuals have to be updated taking into account the experience during the O&M phase regarding troubleshooting, modifications to control / eliminate failures etc. Final manuals to be supplied before expiry of Defects Liability Period.

Notes :

1. The Bidder shall not complete the column "Weeks for completion of Milestone from commencement date" for Milestones RS-H1 to RS-H6 and RS-H13
2. The dates of operation of the Milestones Activities for Milestones RS-H1 to RS-H6 and RS-H13 will be at the discretion of the Employer. However, the training plan of the Contractor shall ensure that training of Employer's personnel for carrying out the scheduled maintenance tasks are completed.
3. Not used.
4. The travel, boarding and lodging expenses for the employer's trainees sent overseas will be borne by the Employer.
5. Amount quoted in this Price Centre shall be the Apportioned Amount.
6. Bidders shall quote for the above Price Centres including all taxes and duties.
7. In the event that the values entered in above table mismatch with the BOQ values submitted by the bidder; the BOQ values shall be considered

4.4.12 **Not used.**

4.4.13 **PRICE CENTRE ‘DM&P-Q’ – Obligations and activities throughout the Contract associated with Design, Manufacture, supply, delivery, installation, testing, commissioning and maintenance of Major machinery & plant.**

This Price Centre comprises of all requirements / activities associated with ERTS – DM&P.

Milestone Number	Description	Unit	QTY	Unit Rate			Amount		
				INR	FC1	FC2	INR	FC1	FC2
	Obtain the “No Objection With Comments (NOWC) or Notice of No Objection (NONO)” from the GC/CMRL for: a. Design document delivery. b. Manufacture, Installation in depot c. Testing and Commissioning.			<i>The bidder shall not fill the amounts here. The amounts for this price centre inclusive of all milestone numbers is to be filled in <u>Pricing Summary sheet only</u>.</i> <i>The amounts for the individual milestone under this price centre will be filled by the successful bidder only at the time of signing the agreement; they will be based on the amounts filled in Bid Total sheet and the payment procedure described in Pricing Schedule and Part 2 of the bid document, subject to the ceiling of the values in the Bid total sheet for respective currencies.</i>					
DM&P-Q1	Under Floor Wheel Lathe	Nos	1						
DM&P-Q2	Automatic Train Wash Plant	Nos	1						
DM&P-Q3	Synchronised Pit Jacks for 6 Car Length	Set	1						
DM&P-Q4	Bogie Turn Table	Nos	4						
DM&P-Q5	Battery Operated Rail Cum Road Shunter- For 6 Car Shunting	Nos	2						
DM&P-Q6	Synchronised Mobile Lifting Jacks for 6 Car Length	Set	1						
DM&P-Q7	Car Body Stand for 6 Car Length	Set	1						
DM&P-Q8	Diesel Operated Relief and Rescue Vehicle With Rerailing & Rescue Equipment	Nos	1						
DM&P-Q9	Bogie Manipulator	Nos	1						
DM&P-Q10	Bogie Testing Unit	Nos	1						
DM&P-Q11	EOT Crane 15/5t (Category 1)	Nos	1						
DM&P-Q12	EOT Crane 15/5t (Category 2)	Nos	1						
DM&P-Q13	EOT Crane 5t for Depot Store	Nos	1						
DM&P-Q14	Double Cylinder Hydraulic Wheel Press	Nos	1						
DM&P-Q15	Vertical Turning Lathe	Nos	1						
DM&P-Q16	Tack & Tunnel Cleaning Vehicle	Nos	1						
DM&P-Q17	Driver Desk Simulator (Static)	Nos	1						
DM&P-Q18	Maintenance Desk Simulator	Nos	1						
RS-DM&P-Q : Price Centre Total (DM&P-Q1 ~ DM&P-Q18)									

Note : Bidders shall quote for the above Price Centres including all taxes and duties.

4.4.14 PRICE CENTRE ‘DM&P-R’ – Obligations and activities throughout the Contract associated with Design, Manufacture, supply, delivery, installation, testing, commissioning and maintenance of Other machinery & plant.

This Price Centre comprises of all requirements / activities associated with ERTS – DM&P.

Milestone Number	Description	Unit	QTY	Unit Rate			Amount		
				INR	FC1	FC2	INR	FC1	FC2
	Obtain the “No Objection With Comments (NOWC) or Notice of No Objection (NONO)” from the GC/CMRL for: a. Design document delivery. b. Manufacture, Installation in depot c. Testing and Commissioning.			<i>The bidder shall not fill the amounts here. The amounts for this price centre inclusive of all milestone numbers is to be filled in <u>Pricing Summary sheet only</u>.</i> <i>The amounts for the individual milestone under this price centre will be filled by the successful bidder only at the time of signing the agreement; they will be based on the amounts filled in Bid Total sheet and the payment procedure described in Pricing Schedule and Part 2 of the bid document, subject to the ceiling of the values in the Bid total sheet for respective currencies.</i>					
DM&P-R1	Ultrasonic Flaw Detector (Handheld Device)	Nos	1						
DM&P-R2	Battery Operated Platform Truck (2t)	Nos	3						
DM&P-R3	Battery Operated Scissor Lift	Nos	4						
DM&P-R4	High Pressure Water Jet cleaning machine (Hot & Cold wash)	Nos	2						
DM&P-R5	Pallet Truck (MANUAL)- 2.5t	Nos	5						
DM&P-R6	Battery Operated Forklift Truck (3t)	Nos	2						
DM&P-R7	Mobile Lifting Table (MLT) 5t	Nos	1						
DM&P-R8	Mobile Lifting Table (MLT) 2t	Nos	1						
DM&P-R9	Automatic Key Management System	Nos	1						
DM&P-R10	Vertical Storage System	Nos	1						
DM&P-R11	Mobile Air Compressor 21cfm	Nos	2						
DM&P-R12	Induction Heater	Nos	1						
DM&P-R13	Battery Operated Cart/Buggy (6-Seater)	Nos	2						
DM&P-R14	RS Pusher (Battery Operated)	Nos	2						
DM&P-R15	Hydraulic Floor Crane 2t	Nos	2						
DM&P-R16	Traction Motor Drying Oven	Nos	1						
DM&P-R17	Wheel Profile Measurement device - Hand Held Contact Type	Nos	1						
DM&P-R18	Industrial Videoscope	Nos	1						
DM&P-R19	Two Post Lifting Jack	Nos	1						
DM&P-R: Price Centre Total (DM&P-R1 ~ DM&P-R19)									

Note : Bidders shall quote for the above Price Centres including all taxes and duties.

4.4.15 PRICE CENTRE ‘DM&P-S’ – Obligations and activities throughout the Contract associated with Design, Manufacture, supply, delivery, installation, testing, commissioning and maintenance of Storage items.

This Price Centre comprises of all requirements / activities associated with ERTS – DM&P.

Milestone Number	Description	Unit	QTY	Unit Rate			Amount		
				INR	FC1	FC2	INR	FC1	FC2
	Obtain the “No Objection With Comments (NOWC) or Notice of No Objection (NONO)” from the GC/CMRL for: a. Design document delivery. b. Manufacture, Installation in depot c. Testing and Commissioning.			<i>The bidder shall not fill the amounts here. The amounts for this price centre inclusive of all milestone numbers is to be filled in <u>Pricing Summary sheet only</u>.</i> <i>The amounts for the individual milestone under this price centre will be filled by the successful bidder only at the time of signing the agreement; they will be based on the amounts filled in Bid Total sheet and the payment procedure described in Pricing Schedule and Part 2 of the bid document, subject to the ceiling of the values in the Bid total sheet for respective currencies.</i>					
DM&P-S1	Storage Racks	Nos	40						
DM&P-S2	Mechanical Work Bench	Nos	10						
DM&P-S3	Storage Bins – Type 1	Nos	50						
DM&P-S4	Storage Bins – Type 2	Nos	50						
DM&P-S5	Storage Bins – Type 3	Nos	50						
DM&P-S6	Pallet (Heavy Duty)	Nos	25						
DM&P-S7	Storage Cabinet – Almirah type	Nos	25						
DM&P-S8	Personnel Lockers	Set	10						
DM&P-S9	Flammable Liquid Storage Safety Rack-	Nos	5						
DM&P-S10	Stand for HVAC Filter Cleaning	Nos	2						
DM&P-S11	Industrial Vacuum Cleaner	Nos	1						
DM&P-S12	Movable Platform(Upto train Door Level)	Nos	10						
DM&P-S13	Manual Mobile Ladder for window glass access	Nos	5						
DM&P-S: Price Centre Total (DM&P-S1 ~ DM&P-S9)									

Note : Bidders shall quote for the above Price Centres including all taxes and duties.

4.4.16 PRICE CENTRE ‘DM&P-T’ – Obligations and activities throughout the Contract associated with Design, Manufacture, supply, delivery, installation, testing, commissioning and maintenance of Tools, Measurement & Other items.

This Price Centre comprises of all requirements / activities associated with ERTS – DM&P.

Milestone Number	Description	Unit	QTY	Unit Rate			Amount		
				INR	FC1	FC2	INR	FC1	FC2
	Obtain the “No Objection With Comments (NOWC) or Notice of No Objection (NONO)” from the GC/CMRL for: a. Design document delivery. b. Manufacture, Installation in depot c. Testing and Commissioning.			<i>The bidder shall not fill the amounts here. The amounts for this price centre inclusive of all milestone numbers is to be filled in <u>Pricing Summary sheet</u> only.</i> <i>The amounts for the individual milestone under this price centre will be filled by the successful bidder only at the time of signing the agreement; they will be based on the amounts filled in Bid Total sheet and the payment procedure described in Pricing Schedule and Part 2 of the bid document, subject to the ceiling of the values in the Bid total sheet for respective currencies.</i>					
DM&P-T1	Weighing Machine (Capacity 1000kg)	Nos	2						
DM&P-T2	Piece Counting Weighting Machine	Nos	2						
DM&P-T3	Welding Machine Portable	Nos	2						
DM&P-T4	Portable Hand Grinder	Nos	2						
DM&P-T5	Drilling Machine Portable	Nos	2						
DM&P-T6	Pedestal Grinding Machine (2 Disc Type)	Nos	1						
DM&P-T7	Pillar Drilling Machine	Nos	1						
DM&P-T8	Metal Cutting Machine	Nos	2						
DM&P-T9	Dewatering Pump Portable	Nos	3						
DM&P-T10	Coupling/Bearing Puller	Nos	2						
DM&P-T11	Tool Cabinet Trolley	Nos	5						
DM&P-T12	Bench Vise 6"	Nos	5						
DM&P-T13	Mechanical hand Tool Kits	Nos	5						
DM&P-T14	Ratchet socket set	Nos	3						
DM&P-T: Price Centre Total (DM&P-T1 ~ DM&P-T9)									

Note : Bidders shall quote for the above Price Centres including all taxes and duties.

5 TECHNICAL PROPOSAL

5.1 SITE ORGANISATION

Bidders shall submit detailed Technical Proposal for Site Organization & Site Management Plan, which shall include both Onshore & Offshore team details.

5.2 METHOD STATEMENT

Bidders shall submit detailed Technical Proposal for Manufacturing Plan. The document shall cover the methodology adopted for proposed Major Subassemblies, Onshore Manufacturing of Cars.

5.3 MOBILIZATION SCHEDULE

Bidders shall submit detailed Technical Proposal for Mobilization Schedule Plan. The document shall cover the methodology adopted for proposed Project, Engineering, Onshore Manufacturing, Test & Commissioning, Defect Notification Period, etc.,

5.4 CONSTRUCTION SCHEDULE

Bidders shall submit detailed Technical Proposal for Work Programme & Design Submission Programme.

5.5 PRELIMINARY DESIGN

[Insert and/or draw Preliminary Design in accordance with Employer's Requirement and Drawing.]

5.6 PLANT

[Insert technical proposal for proposed plants]

5.7 OCCUPATIONAL, HEALTH, SAFETY AND ENVIRONMENTAL PLAN

[Insert Technical Proposal for OHSE Plan.]

5.8 FORM SOG: SCHEDULE OF GUARANTEE

(NOT USED)

5.9 FORM PER-1: PROPOSED PERSONNEL

(NOT USED)

5.10 FORM PER-2: RESUME OF PROPOSED PERSONNEL

(NOT USED)

5.11 FORM EQU: EQUIPMENT

(NOT USED)

5.12 FORM SPA: SPARE PARTS

(NOT USED)

5.13 FORM SUB: PROPOSED SUBCONTRACTORS FOR MAJOR ITEMS OF PLANT AND INSTALLATION SERVICES

A list of major items of Plant and Installation Services is provided below.

The following Subcontractors and/or manufacturers are proposed for carrying out the item of the facilities indicated. Apart from the items indicated below, Bidders can propose any other Major items based on their Previous Project experience. Bidders are free to list more than ONE Subcontractor.

Table : Rolling Stock – Subcontractor details.

Major Items of Plant and Installation Services	Proposed Subcontractors / Manufacturers	Nationality
Bogie		
Propulsion (Traction converter and Traction motors)		
Passenger Doors		
VAC		
Train Control and Monitoring System (TCMS)		
Pneumatic and Brake Equipment (including Air Generation and Treatment unit)		
Couplers and Draft Gear		
Communication system		
Carbody (Roof Structure, Side Structure, Underframe Structure, End Structure & Cab Structure).		
Main Transformer		
VCB		

5.14 CERTIFICATE CONFIRMING NO DEVIATION FROM TENDER CONDITIONS

This is to certify that we, M/s. [Insert name of the company (Single Entity / JV)] have carefully examined all the contents of the bidding documents including all Addendums / Corrigendum.

We hereby confirm that our technical bid is fully and truly compliant with the tender conditions in totality (Part 1, Part 2 and Part 3) inclusive of all addendums / corrigendum.

We hereby confirm that all implicit and explicit deviations, comments, remarks, mentioned elsewhere in our technical bid shall be treated as NULL and VOID and stand withdrawn.

It is further certified that there are no additional comments, remarks, deviations, terms & conditions in our financial package. If any deviation found, it shall be treated as NULL and VOID and stands 'withdrawn from bid.'

Signature of the Bidder

5.15 CERTIFICATE CONFIRMING MINIMUM LOCAL CONTENT

We hereby jointly and severally certify in accordance with clause ‘9.a’ of the Order no. P- 45021 / 2 / 2017 - PP (BE-II) - Part (4) Vol. II of Ministry of Commerce and Industry, Department of Promotion of Industry and Internal Trade (DPIIT) {formerly Department of Industrial Policy and Promotion (DIPP)}, Government of India dated 19 July 2024 that the item(s) offered meets the Minimum Local Content (MLC) of

(i) 60% (For Class I Local Supplier)	}	Strike off whichever is not applicable.
(ii) 20% (For Class II Local Suppliers)		
(iii) < 20% (For Non-Local Suppliers)		

(60% MLC ~~for Rolling Stock~~ (derived on Total Contract Price) as specified in MoHUA Order No. K - 14011 / 08 / 2017 / MRTS - Coord dated 14th October 2020). The details including name of proposed vendor(s), location(s) at which the local value addition is made, and percentage of local content will be provided within 15 days of issue of LoA.

We acknowledge that false declaration by the tenderer regarding local value addition including payments to be made to their vendors for local value addition shall be treated as a fraudulent practice under this tender for which the tenderer or its successor can be debarred for a period up to three years along with such other actions as may be permissible under the law.

In case of procurement for a value in excess of Rs. 10 crores, we also undertake to submit a certificate from statutory auditor or cost auditor of the company (in the case of companies) or from a practicing cost accountant or practicing chartered accountant (in respect of suppliers other than companies) giving the percentage of local content, in accordance with clause ‘9.b’ of the Order no. P – 45021 / 2 / 2017 - PP (BE – II) of Ministry of Commerce and Industry, Department for Promotion of Industry and Internal Trade (DPIIT) {formerly Department of Industrial Policy and Promotion (DIPP)}, Government of India dated 16th September 2020 or latest order, after completion of works to the Engineer.

Signature of the Bidder

5.16 Form MAN: MANUFACTURER'S AUTHORIZATION

[The Bidder shall require the Manufacturer (listed by the Bidder under 5.13, Form SUB) to fill in this Form in accordance with the instructions indicated. This letter of authorization should be signed by a person with the proper authority to sign documents that are binding on the Manufacturer.]

Date: *[insert date (as day, month and year) of Bid Submission]*

To: *[insert complete name of Purchaser]*

WHEREAS

We *[insert complete name of Manufacturer or Manufacturer's authorized agent]*, who are official manufacturers of *[insert type of goods manufactured]*, having factories at *[insert full address of Manufacturer's factories]*, do hereby authorize *[insert complete name of Bidder]* to submit a Bid the purpose of which is to provide the following goods, manufactured by us *[insert name and/or brief description of the goods]*, subject to successful negotiation of a procurement Contract between both parties.

We hereby confirm that we have read Clause 11, Defect Liability, of the General Conditions of Contract and would have no objection in principle to these terms and conditions being replicated in the aforementioned procurement Contract.

We understand that the manufacturing or assembly of cars / trains cannot be subcontracted.

Name: *[insert complete name of person signing the Bid]*

In the capacity of *[insert legal capacity of person signing the bid]*

Signed: *[insert signature of person whose name and capacity are shown above]*

Duly authorized to sign the bid for and on behalf of: *[insert complete name of Bidder]*

Dated on _____ day of _____, _____ *[insert date of signing]*

5.17 CERTIFICATE CONFIRMING PERSONNEL TO THE WORKS

This is to certify that we, M/s. *[Insert name of the company (Single Entity / JV)]* have carefully examined all the specified requirements stated in Part 2 - Section VIA Chapter 16, Part 2 - Section VIB Chapter 1 & Part 2 - Section VIC Chapter 1.

We hereby confirm that upon award of the Contract, we shall (prior to commencement of the Works), submit resumes of the Key Staff proposed for deployment; subject to acceptance of the Engineer / Employer. We further commit to ensure that the staff proposed shall be sufficiently qualified and experienced to the extent that they will comply with the requirements of the tender.

Signature of the Bidder

6. BIDDER'S QUALIFICATION

To establish its qualifications to perform the contract in accordance with Section III, Evaluation and Qualification Criteria, the Bidder shall provide the information requested in the corresponding Forms included hereunder:

- 6.1 Form ELI -1 : Bidder Information Form
- 6.2 Form ELI -2 : JV Member Information Form
- 6.3 Form CON : Historical Contract Non-Performance and Litigation
- 6.4 Form FIN -1 : Financial Situation
- 6.5 Form FIN -2 : Average Annual Turnover
- 6.6 Form FIR -1 : Financial Resources
- 6.7 Form FIR -2 : Current Contract Commitments
- 6.8 Form EXP -1 : General Experience
- 6.9 Form EXP-2 : Specific Experience
- 6.10 Form EXP -2(a), 2(b), 2(c), 2 (d) : Specific Experience
- 6.11 Form 'Manufacturing Facility' : Establishment of manufacturing facility in India
- 6.12 Form Sys-1 to Sys 10 : Subcontractors / Manufacturers
- 6.13 ~~Form Minimum Local Content. Deleted.~~

1

6.1 Form ELI-1: BIDDER INFORMATION FORM

Date: *[insert day, month, year]*
Page *[insert page number]* of *[insert page number]*

[Bidders shall provide the following information:]

Bidder's legal name <i>[insert full name]</i>
In case of a JV, legal name of the representative member and of each member: <i>[insert full name of each member in the JV and specify the representative member]</i>
Bidder's actual or intended country of registration: <i>[insert country of registration]</i>
Bidder's actual or intended year of incorporation: <i>[insert year of incorporation]</i>
Bidder's legal address in country of registration: <i>[insert mailing address]</i>
Bidder's authorized representative information Name: <i>[insert full name]</i> Address: <i>[insert mailing address]</i> Telephone/Fax numbers: <i>[insert telephone/fax numbers, including country and city codes]</i> E-mail address: <i>[insert e-mail address]</i>
1. Attached are copies of original documents of Articles of Incorporation (or equivalent documents of constitution or association), and/or documents of registration of the legal entity named above. 2. Included are the organizational chart, a list of Board of Directors, and the beneficial ownership.

6.2 Form ELI-2: JV MEMBER INFORMATION FORM

Date: *[insert day, month, year]*
Page *[insert page number]* of *[insert page number]*

[The following form is additional to Form ELI-1 and shall be completed to provide information relating to each JV member, in case if the Bidder is a JV. The documents listed /stated as required shall be submitted as attachments hereto.]

Bidder's legal name:

[insert full name]

JV Member's legal name:

[insert full name of Bidder's Party]

Percentage participation in the JV for each JV members:

JV Member's country of registration:

[insert country of registration]

JV Member's year of incorporation:

[insert year of incorporation]

JV Member's legal address in country of registration:

[insert mailing address]

JV Member's authorized representative information

Name: *[insert full name]*

Address: *[insert mailing address]*

Telephone/Fax numbers: *[insert telephone/fax numbers, including country and city codes]*

E-mail address: *[insert E-mail address]*

1. Attached are copies of original documents of Articles of Incorporation (or equivalent documents of constitution or association), and/or documents of registration of the legal entity named above.
2. Included are the organizational chart, a list of Board of Directors, and the beneficial ownership.

6.3 Form CON: HISTORICAL CONTRACT NON-PERFORMANCE AND LITIGATION

[The following table shall be filled in for the Bidder, and for each member if the bidder is a JV]

Date: *[insert day, month, year]*

Bidder's Legal name: *[insert full name]*

JV Member's Legal Name: *[insert full name]*

Page *[insert page number]* of *[insert page number]*

1. History of Non-Performing Contracts:

Non-Performing Contracts			
In accordance with Section III, Evaluation and Qualification Criteria, Sub-Factor 2.2.1, within five (5) years of the bid submission deadline, for the Bidder, any of its joint venture or consortium members, associates, parent company, its affiliates or subsidiaries. <i>[The Bidder shall indicate the applicable wording below by checking the appropriate box.]</i> ☐ contract non-performance did not occur. ☐ contract non-performance occurred as indicated below:			
Year	Non-performed portion of contract	Contract Identification	Total Contract Amount
<i>[insert year]</i>	<i>[insert amount and percentage]</i>	Contract identification: <i>[insert complete contract name, number, and any other identification]</i> Name of the Employer: <i>[insert full name]</i> Address of Employer: <i>[insert mailing address]</i> Telephone/Fax numbers: <i>[insert telephone/fax numbers, including country and city codes]</i> Email address: <i>[insert email address]</i> Reason(s) for non-performance: <i>[indicate main reason(s)]</i>	<i>[insert current value, currency, exchange rate and INR equivalent]</i>

2. Pending Litigation

Pending Litigation				
In accordance with Section III, Evaluation and Qualification criteria, sub factor 2.2.2, <i>[The Bidder shall choose the relevant wording below by checking the appropriate box.]</i> ☐ there is no pending litigation involving the bidder. ☐ there is pending litigation involving the bidder as indicated below:				
Year of dispute	Amount in dispute (currency)	Outcome as Percentage of Net Worth	Contract Identification	Total Contract Amount
<i>[insert year]</i>	<i>[insert amount]</i>	<i>[insert percentage]</i>	Contract identification: <i>[indicate complete contract name, number, and any other identification]</i> Name of the Employer: <i>[insert full name]</i> Address of Employer: <i>[insert mailing address]</i> Telephone / Fax numbers: <i>[insert telephone / fax numbers, including country and city codes]</i> Email address: <i>[insert email address]</i> Party who initiated Litigation: <i>[indicate "Employer" or "Contractor"]</i> Matter in dispute: <i>[indicate main issues in dispute]</i>	<i>[insert current value, currency, exchange rate and INR equivalent]</i>

3. Litigation History

Litigation History		
In accordance with Section III, Evaluation and Qualification criteria, sub factor 2.2.3, <i>[The Bidder shall choose the relevant wording below by checking the appropriate box.]</i> ☐ there are no court orders against the bidder. ☐ there are court orders against the bidder as indicated below:		
Year of award	Contract Identification	Total Contract Amount
<i>[insert year]</i>	Contract identification: <i>[indicate complete contract name, number, and any other identification]</i> Name of the Employer: <i>[insert full name]</i> Address of Employer: <i>[insert mailing address]</i> Telephone/Fax numbers: <i>[insert telephone/fax numbers, including country and city codes]</i> Email address: <i>[insert email address]</i> Matter in dispute: <i>[indicate main issues in dispute]</i> Party who initiated the litigation: <i>[indicate "Employer" or "Contractor"]</i> Abstract of the court order: <i>[state concisely the court order concerning main issues in dispute]</i>	<i>[insert current value, currency, exchange rate and INR equivalent]</i>

6.4 Form FIN-1: FINANCIAL SITUATION

[The following table shall be filled in for the Bidder, and for each member of a JV if the Bidder is a JV. The document listed / stated as required shall be submitted as attachments hereto]

Date: [insert day, month, year]

Bidder's Legal name: [insert full name]

JV Member's Legal Name: [insert full name]

Page [insert page number] of [insert page number]

1. Financial Data

Type of Financial information in (Currency)	Historic information for previous five (5) years (Amount in currency, currency, exchange rate, INR equivalent)				
	Year 1	Year 2	Year 3	Year 4	Year 5
Information from Balance Sheet					
Total Assets (TA)					
Total Liabilities (TL)					
Net Worth (NW)					
Current Assets (CA)					
Current Liabilities (CL)					
Working Capital (WC)					
Information from Income Statement					
Total Revenue (TR)					
Profits Before Taxes (PBT)					
Profits After Taxes (PAT)					

2. Financial Documents

The Bidder and its parties shall provide copies of the financial statements⁽ⁱ⁾ for 5 years indicated in Section III, Evaluation and Qualification Criteria Sub-Factor 2.3.1. The financial statements shall:

- (a) Reflect the financial situation of the legal entity(ies) comprising the Bidder or in case of JV, of each member, and not of the affiliated entities (such as parent company(ies), group companies or subsidiaries) of the Bidder unless they are parties to the Bidder under a JV in accordance with ITB 4.1.
- (b) Be independently audited or certified in accordance with local legislation.
- (c) Be complete, including all notes to the financial statements.
- (d) correspond to accounting periods already completed and audited.

Attached herewith are copies of financial statements for 5 years required above; and complying with the requirements.

Notes for the bidder:

1. If the most recent set of financial statements is for a period earlier than 12 months from the date of bid, the reason for this should be justified.

6.5 Form FIN-2: AVERAGE ANNUAL TURNOVER

[The following table shall be filled in for the Bidder, and for each JV member if the Bidder is a JV]

Date: *[insert day, month, year]*

Bidder's Legal name: *[insert full name]*

JV Member's Legal Name: *[insert full name]*

Page *[insert page number]* of *[insert page number]*

Annual Turnover Data			
Year	Amount and Currency	Exchange rate	INR Equivalent
<i>[indicate year]</i>	<i>[insert amount and indicate currency]</i>	<i>[insert applicable exchange rate]</i>	<i>[insert amount in INR equivalent]</i>
Year 1			
Year 2			
Year 3			
Year 4			
Year 5			
Average Annual Construction Turnover			

Notes for the Bidders:

- Total INR equivalent for all years divided by the total number of years, in accordance with Section III, Evaluation and Qualification Criteria, Sub-Factor 2.3.2 as appropriate.
- Form FIN-2 shall be certified by the Chartered Account (CA).
- Profit and Loss (P&L) statement shall be submitted to verify the Construction Turnover.

6.6 Form FIR -1: Financial Resources

[The following table shall be filled in for the Bidder, and for each JV member if the Bidder is a JV.]

Date: [insert day, month, year]

Bidder's Legal Name: [insert full name]

JV Member's Legal Name: [insert full name]

Page [insert page number] of [insert total number] pages

[Specify proposed sources of financing, such as liquid assets, unencumbered real assets, lines of credit, and other financial means, net of current commitments, available to meet the total construction cash flow demands of the subject contract as specified in Section III, Evaluation and Qualification Criteria, sub-factor 2.3.3 as appropriate.]

Financial Resources		
No.	Source of financing	Amount (INR equivalent)
1		
2		
3		

Notes for the Bidders

1. Sources of financing may include working capital (to be taken from FIN-1), Credit Line (to be substantiated by a letter from the bank issuing the line of credit), etc.

6.7 Form FIR-2: Current Contract Commitments

[The following table shall be filled in for the Bidder, and for each JV member if the Bidder is a JV.]

Date: [insert day, month, year]

Bidder's Legal Name: [insert full name]

JV Member's Legal Name: [insert full name]

Page [insert page number] of [insert total number] page

[The Bidder and each JV member should provide information on their current commitments on all contracts that have been awarded, or for which a Letter of Intent or acceptance has been received, or for contracts approaching completion, but for which an unqualified, full Taking-over Certificate/ Completion Certificate has yet to be issued, in accordance with Section III, Evaluation and Qualification Criteria, Sub-Factor 2.3.3, as appropriate.]

Current Contract Commitments						
No.	Name of Contract	Employer's Mailing Address, Tel, Fax.	Value of Outstanding Work (Current INR equivalent)	Commencement Date	Estimated Completion Date	Average Monthly Invoicing Over Last Six Months [INR/month]
1						
2						
3						
4						

6.8.1 Form EXP-1: GENERAL EXPERIENCE

[The following table shall be filled in for the Bidder, and for each JV member if the Bidder is a JV.]

Date: [insert day, month, year]

Bidder's Legal name: [insert full name]

JV Member's Legal Name: [insert full name]

Page [insert page number] of [insert page number]

[The Bidder shall Identify contracts that demonstrate continuous experience pursuant to Section III, Evaluation and Qualification Criteria, Sub-Factor 2.4.1. and list contracts chronologically, according to their commencement (starting) dates.]

General Construction Experience			
Starting Year	Ending year	Contract Identification	Role of Bidder
[indicate year]	[indicate year]	Contract Name: [insert full name] Brief description of the contract performed by the Bidder: [describe the contract performed briefly] Amount of Contract: (insert amount in currency, mention currency used, exchange rate and INR equivalent) Name of Employer: [insert full name] Address: [insert mailing address]	[insert "Prime Contractor (single entity or JV member)" or "Subcontractor"]

6.9 Form EXP-2: SPECIFIC EXPERIENCE

[The following table shall be filled in by the Bidder, and for each JV member if the Bidder is a JV.]

Date: [insert day, month, year]
Bidder's Legal name: [insert full name]
JV Member's Legal Name: [insert full name]
Page [insert page number] of [insert page number]

[The Bidder shall fill out one (1) form per contract, in accordance with Section III, Evaluation and Qualification Criteria, Sub-Factor 2.4.2(a) to 2.4.2 (d)]

Contract of Similar Size and Nature			
Similar Contract No. [insert number] of [insert number of similar contracts required]	Information		
Contract Identification	[insert contract name and reference identification number, if applicable]		
Award Date	[insert day, month, year; e.g., 15 March, 2015]		
Completion Date	[insert day, month, year; e.g., 15 July, 2017]		
Role in Contract [check in appropriate box]	Prime Contractor		
	Single entity ☐		JV Member ☐
Total Contract Amount	[insert total contract amount and currency(ies)]		INR [insert exchange rate and total contract amount in INR equivalent]
If member in a JV, specify participation in total Contract amount	[insert percentage participation]	[insert total contract amount and currency(ies)]	INR [insert exchange rate and total contract amount in INR equivalent]
	[describe participation in JV and work performed]		
Employer's Name:	[insert full name]		
Address:	[insert mailing address]		
Telephone/fax number	[indicate telephone/fax number, including country and city area codes]		
E-mail:	[insert E-mail address, if available]		
Description of the similarity in accordance with Sub-Factor 2.4.2(a) to 2.4.2 (d) of Section III:	[Fill the respective criteria / rows related to the proposed experience credential]		

Contract of Similar Size and Nature	
Similar Contract No. <i>[insert number] of [insert number of similar contracts required]</i>	Information
1. No. of cars (Metro, LRT, Suburban EMUs, Train sets) manufactured and delivered during last 10 years in accordance with EQC 2.4.2 (a)	<i>[insert quantity and details of cars manufactured and delivered]</i>
2. No. of cars (Metro, LRT, Suburban EMUs, Train sets) with Stainless steel/ Aluminium designed, manufactured and delivered during last 10 years in accordance with EQC 2.4.2 (b)	<i>[insert quantity and details of cars designed, manufactured and delivered]</i>
3. No. of cars comprising stainless steel / steel EMU / MEMU / Metro car manufactured in India for either metro company or Indian Railways	<i>[insert quantity and details of cars manufactured and delivered]</i>
4. No. of metro cars (Stainless steel / Aluminium) assembled in India	<i>[insert quantity and details of cars assembled in India]</i>
5. No. of cars (Metro, LRT, Suburban EMUs, Train sets) supplied to (i) outside the parent company or Group company and (ii) Country other than the country of origin (or) India	<i>[insert quantity and details of cars supplied]</i>
6. No. of cars (Metro, LRT, Suburban EMUs, Train sets) which are in satisfactory revenue operation	<i>[insert quantity and details of cars which are in revenue operation]</i>
7. As stipulated in 2.4.2 (b), performed the train integration as well as interface with other systems like Signaling, Telecom, etc.,	<i>[Insert Yes/No]</i>
Attached herewith are the copies of originals of: (a) abstracts of contract documents, JV Agreements, etc. evidencing that the size and nature of the above-mentioned contract meets the requirements specified in Section III, Evaluation and Qualification Criteria, Sub-Factor 2.4.2(a) to 2.4.2 (d). (b) the end-user certificate(s) (i.e. Taking-over Certificate(s)/ Completion Certificate(s)), evidencing that the above-mentioned contract has been successfully completed.	

6.10.1 Form EXP-2(a): SPECIFIC EXPERIENCE

Whomsoever It may Concern

We, M/s (Name of the Employer) have procured (mentioned the number of cars in both words and numbers) numbers of cars (Metro, LRT, Suburban EMUs, Train sets) from M/s. (Name of the manufacturer) during the period (start date of the contract) and (End date of last car delivery).

The above cars are procured to operate on the line (Specify the network details)

Signature of the Authorized Person

Name of the customer

Name of the Authorized person

Designation of the Authorized person

City

State

Country

Phone number:

E-mail id of Authorized person

NOTE:

The Experience certificates can be submitted in any formats. It is bidder's responsibility to ensure that all the necessary information sought above are captured.

6.10.2 Form EXP-2(b): SPECIFIC EXPERIENCE

Whomsoever It may Concern

We, M/s (Name of the Employer) have procured (mentioned the number of cars in both words and numbers) numbers of cars (Metro, LRT, Suburban EMUs, Train sets) from M/s. (Name of the manufacturer) during the period (start date of the contract) and (End date of last car delivery). The Car body is manufactured with Stainless steel / Aluminium (select anyone). The car body is designed by (name of the designer) and manufactured by (name of the manufacturer).

(OR)

We, M/s (Name of the Employer) have procured (mentioned the number of cars in both words and numbers) numbers of cars (stainless steel / steel EMU / MEMU / Metro car) from M/s. (Name of the manufacturer) during the period (start date of the contract) and (End date of last car delivery). The above cars are manufactured in India at (factory location) for (Name of the Metro or Indian Railways). The car body is designed by (name of the designer) and manufactured by (name of the manufacturer).

Note: If the name of the designer and manufacturer are different, bidder shall submit Form Exp-2(c), otherwise not required.

(OR)

(C.) We, M/s (Name of the Employer) have procured (mentioned the number of cars in both words and numbers) numbers of metro cars from M/s (Name of the manufacturer) during the period (start date of the contract) and (End date of last car delivery). The Car body is manufactured with Stainless steel / Aluminium (select anyone). The cars are assembled at (factory location) in India. The car body is designed by (Name of the designer) and manufactured by (Name of the manufacturer).

Note: If the name of the designer and bidder are different, bidder shall submit Form Exp-2(c) otherwise not required.

Signature of the Authorized Person

Name of the customer

Name of the Authorized person

Designation of the Authorized person

City

State

Country

Phone number:

E-mail id of Authorized person

NOTE:

The Experience certificates can be submitted in any formats. It is bidder's responsibility to ensure that all the necessary information sought above are captured.

6.10.3 Form EXP-2(c): SPECIFIC EXPERIENCE

Whomsoever It may Concern

We, ..., do not have car body design experience. Hence, we do procure/subcontract design from experienced designer or form JV (select anyone) with a company..... having design experience.

Note:

1. A minimum number of cars as stipulated in EQC 2.4.2 (b) **(Metro, LRT, Suburban EMUs, Train sets)** with **stain less steel / Aluminium** must have been manufactured using the design of the proposed Contractor.
2. The bidder shall submit the experience certificate in the form **Exp2(b) para (A)** to validate the experience of designer.

NOTE:

The Experience certificates can be submitted in any formats. It is bidder's responsibility to ensure that all the necessary information sought above are captured.

6.10.4 Form EXP-2(d): SPECIFIC EXPERIENCE

Whomsoever It may Concern

We, M/s (Name of the Employer) have procured (mentioned the number of cars in both words and numbers) numbers of cars (Metro, LRT, Suburban EMUs, Train sets) from M/s. (Name of the manufacturer) during the period (start date of the contract) and (End date of last car delivery).

We also declare that we are neither a parent company nor a group company of the manufacturer.

The cars are manufactured at (place and country of the manufacturing facility) and delivered and operated at (mention the place and country).

Signature of the Authorized Person

Name of the customer

Name of the Authorized person

Designation of the Authorized person

City

State

Country

Phone number:

E-mail id of Authorized person

NOTE:

The Experience certificates can be submitted in any formats. It is bidder's responsibility to ensure that all the necessary information sought above are captured.

6.10.5 Form EXP-2(e): SPECIFIC EXPERIENCE

Whomsoever It may Concern

We, M/s (Name of the Employer) have procured (mentioned the number of cars in both words and numbers) numbers of cars (Metro, LRT, Suburban EMUs, Train sets) from M/s. (Name of the manufacturer) during the period (start date of the contract) and (End date of last car delivery).

(Mentioned the number of cars in both words and numbers) number of cars are in satisfactory revenue operation since (mention date, month, and year)

Signature of the Authorized Person

Name of the customer

Name of the Authorized person

Designation of the Authorized person

City

State

Country

Phone number:

E-mail id of Authorized person

NOTE:

The Experience certificates can be submitted in any formats. It is bidder's responsibility to ensure that all the necessary information sought above are captured.

6.11 Form Manufacturing Facility: Establishment of manufacturing facility in India

Whomsoever It may Concern

We (Name of the Bidder) hereby declare that we will ensure that 100 % of the Ordered quantity in this bid is achieved by establishing / in the established metro cars manufacturing facility of our own, in India to manufacture the Rolling Stock, duly complying to the requirements provided at the Note below.

Note:

1. If the duly filled in Form 6.11 is not submitted, the tenderer becomes ineligible.
2. Single entity shall meet these criteria and submit the Form.
3. If the tenderer is participating as JV or consortium, each member of the JV / consortium shall also meet the criteria.
4. Single Entity or each member of the JV / Consortium shall be eligible to participate in the tender only if registered with competent authority of the Country duly complying with the political and security clearance requirements as per the relevant guidelines of the Government of India issued from time to time.
5. Manufacturing or assembly of cars / trains shall not be subcontracted.

Name of the Bidder

Signature of the Authorized person of the Bidder
Name of the Authorized person

6.12.1 Form Sys-1: Subcontractors / Manufacturers

Whomsoever It may Concern

We, M/s (Name of the Employer) have procured (mentioned the number of cars in both words and numbers) numbers of standard gauge cars (Metro, LRT, Suburban EMUs, Train sets) from M/s. (Name of the manufacturer) during the period (start date of the contract) and (End date of last car delivery).

The cars are fitted with wheel mounted or Axle mounted (select one) Disk brakes or tread brake (select one) bogies. The bogies are designed, manufactured, and commissioned during the period (start date) and (End date) by (Bogie Design and manufacturer name). The cars (mentioned the number of cars in both words and numbers) with these bogies are in service since (DD-MM-YYYY). The performance of these bogies are found satisfactory.

The bogies are manufactured at (Bogie manufacturer place and country) and delivered and used at (Customer place and country)

Signature of the Authorized Person

Name of the customer

Name of the Authorized person

Designation of the Authorized person

City

State

Country

Phone number:

E-mail id of Authorized person

NOTE:

The Experience certificates can be submitted in any formats. It is bidder's responsibility to ensure that all the necessary information sought above are captured.

The sub-system proposed by the Contractor shall be in line with requirements stipulated in Part 2 - ERTS. In case of an alternative variant proposed by the Contractor, that sub-system must be of either equivalent or superior to the requirements stipulated in ERTS.

6.12.2 Form Sys-2: Subcontractors / Manufacturers

Whomsoever It may Concern

We, M/s (Name of the Employer) have procured (mentioned the number of cars in both words and numbers) numbers of standard gauge Metro Railway cars from M/s. (Name of the manufacturer) during the period (start date of the contract) and (End date of last car delivery).

The cars are fitted with Traction converter/ Auxiliary converter/ Traction Motors which is/are designed, manufactured and commissioned during the period (start date) and (End date) by (Traction converter/ Auxiliary converter/ Traction Motors Design and manufacturer name). The cars (mentioned the number of cars in both words and numbers) with these Traction converter/ Auxiliary converter/ Traction Motors are in service since (DD-MM-YYYY). The performance of these Traction converter/ Auxiliary converter/ Traction Motors are found satisfactory.

The Traction converter/ Auxiliary converter/ Traction Motors are manufactured at (Traction converter/ Auxiliary converter/ Traction Motors manufacturer place and country) and delivered and used at (Customer place and country)

Note: If Traction converter/ Auxiliary converter/ Traction Motors suppliers are different then bidder shall submit separate forms for each item.

Signature of the Authorized Person

Name of the customer

Name of the Authorized person

Designation of the Authorized person

City State

Country

Phone number:

E-mail id of Authorized person

NOTE:

The Experience certificates can be submitted in any formats. It is bidder's responsibility to ensure that all the necessary information sought above are captured.

The sub-system proposed by the Contractor shall be in line with requirements stipulated in Part 2 - ERTS. In case of an alternative variant proposed by the Contractor, that sub-system must be of either equivalent or superior to the requirements stipulated in ERTS.

6.12.3 Form Sys-3: Subcontractors / Manufacturers

Whomsoever It may Concern

We, M/s (Name of the Employer) have procured (mentioned the number of cars in both words and numbers) numbers of cars (Metro, LRT, Suburban EMUs, Train sets) from M/s. (Name of the manufacturer) during the period (start date of the contract) and (End date of last car delivery).

The cars are fitted with passenger Doors designed and manufactured by (Passenger Door Design and manufacturer name). The cars (mentioned the number of cars in both words and numbers) with these Doors are in service since (DD-MM-YYYY). The performance of these Doors are found satisfactory.

The Doors are manufactured at (Passenger Door manufacturer place and country) and delivered and used at (Customer place and country)

Signature of the Authorized Person

Name of the customer

Name of the Authorized person

Designation of the Authorized person

City

State

Country

Phone number:

E-mail id of Authorized person

NOTE:

The Experience certificates can be submitted in any formats. It is bidder's responsibility to ensure that all the necessary information sought above are captured.

The sub-system proposed by the Contractor shall be in line with requirements stipulated in Part 2 - ERTS. In case of an alternative variant proposed by the Contractor, that sub-system must be of either equivalent or superior to the requirements stipulated in ERTS.

6.12.4 Form Sys-4: Subcontractors / Manufacturers

Whomsoever It may Concern

We, M/s (Name of the Employer) have procured (mentioned the number of cars in both words and numbers) numbers of cars (Metro, LRT, Suburban EMUs, Train sets) from M/s. (Name of the manufacturer) during the period (start date of the contract) and (End date of last car delivery).

The cars are fitted with Ventilation and Air conditioning (VAC) system designed and manufactured by (VAC Design and manufacturer name). The cars (mentioned the number of cars in both words and numbers) with these VACs are in service since (DD-MM-YYYY). The performance of these VACs are found satisfactory.

The VACs are manufactured at (VAC manufacturer area and country) and delivered and used at (Customer area and country)

Signature of the Authorized Person

Name of the customer

Name of the Authorized person

Designation of the Authorized person

City

State

Country

Phone number:

E-mail id of Authorized person

NOTE:

The Experience certificates can be submitted in any formats. It is bidder's responsibility to ensure that all the necessary information sought above are captured.

The sub-system proposed by the Contractor shall be in line with requirements stipulated in Part 2 - ERTS. In case of an alternative variant proposed by the Contractor, that sub-system must be of either equivalent or superior to the requirements stipulated in ERTS.

6.12.5 Form Sys-5: Subcontractors / Manufacturers

Whomsoever It may Concern

We, M/s (Name of the Employer) have procured (mentioned the number of cars in both words and numbers) numbers of cars (Metro, LRT, Suburban EMUs, Train sets) from M/s. (Name of the manufacturer) during the period (start date of the contract) and (End date of last car delivery).

The cars are fitted with Train control and Monitoring system (TCMS) system designed and manufactured by (TCMS Design and manufacturer name). The cars (mentioned the number of cars in both words and numbers) with TCMS system are in service since (DD-MM-YYYY). The performance of the TCMS system is found satisfactory. The cars are being operated in Unattended Train Operation (UTO) mode.

The TCMS system is developed at (TCMS manufacturer area and country) and delivered and used at (Customer area and country)

Signature of the Authorized Person

Name of the customer

Name of the Authorized person

Designation of the Authorized person

City

State

Country

Phone number:

E-mail id of Authorized person

NOTE:

The Experience certificates can be submitted in any formats. It is bidder's responsibility to ensure that all the necessary information sought above are captured.

The sub-system proposed by the Contractor shall be in line with requirements stipulated in Part 2 - ERTS. In case of an alternative variant proposed by the Contractor, that sub-system must be of either equivalent or superior to the requirements stipulated in ERTS.

6.12.6 Form Sys-6: Subcontractors / Manufacturers

Whomsoever It may Concern

We, M/s (Name of the Employer) have procured (mentioned the number of cars in both words and numbers) numbers of cars (Metro, LRT, Suburban EMUs, Train sets) from M/s. (Name of the manufacturer) during the period (start date of the contract) and (End date of last car delivery).

The cars are fitted with Pneumatic and Brake Equipment (including Air Generation and Treatment unit) system designed and manufactured by (Pneumatic and Brake Equipment Design and manufacturer name). The cars (mentioned the number of cars in both words and numbers) with Pneumatic and Brake Equipment system are in service since (DD-MM-YYYY). The performance of the Pneumatic and Brake Equipment system is found satisfactory.

The Pneumatic and Brake Equipment system is developed at (Pneumatic and Brake Equipment manufacturer area and country) and delivered and used at (Customer area and country)

Signature of the Authorized Person

Name of the customer

Name of the Authorized person

Designation of the Authorized person

City

State

Country

Phone number:

E-mail id of Authorized person

NOTE:

The Experience certificates can be submitted in any formats. It is bidder's responsibility to ensure that all the necessary information sought above are captured.

The sub-system proposed by the Contractor shall be in line with requirements stipulated in Part 2 - ERTS. In case of an alternative variant proposed by the Contractor, that sub-system must be of either equivalent or superior to the requirements stipulated in ERTS.

6.12.7 Form Sys-7: Subcontractors / Manufacturers

Whomsoever It may Concern

We, M/s (Name of the Employer) have procured (mentioned the number of cars in both words and numbers) numbers of cars (Metro, LRT, Suburban EMUs, Train sets) from M/s. (Name of the manufacturer) during the period (start date of the contract) and (End date of last car delivery).

The cars are fitted with Couplers and Draft Gear system designed and manufactured by (Couplers and Draft Gear Design and manufacturer name). The cars (mentioned the number of cars in both words and numbers) with these Couplers and Draft Gear are in service since (DD-MM-YYYY). The performance of these Couplers and Draft Gear are found satisfactory.

The Couplers and Draft Gears are manufactured at (Couplers and Draft Gear manufacturer area and country) and delivered and used at (Customer area and country).

Signature of the Authorized Person

Name of the customer

Name of the Authorized person

Designation of the Authorized person

City

State

Country

Phone number:

E-mail id of Authorized person

NOTE:

The Experience certificates can be submitted in any formats. It is bidder's responsibility to ensure that all the necessary information sought above are captured.

The sub-system proposed by the Contractor shall be in line with requirements stipulated in Part 2 - ERTS. In case of an alternative variant proposed by the Contractor, that sub-system must be of either equivalent or superior to the requirements stipulated in ERTS.

6.12.8 Form Sys-8: Subcontractors / Manufacturers

Whomsoever It may Concern

We, M/s (Name of the Employer) have procured (mentioned the number of cars in both words and numbers) numbers of cars (Metro, LRT, Suburban EMUs, Train sets) from M/s. (Name of the manufacturer) during the period (start date of the contract) and (End date of last car delivery).

The cars are fitted with Communication system designed and manufactured by (Communication system Design and manufacturer name). The cars (mentioned the number of cars in both words and numbers) with this Communication system are in service since (DD-MM-YYYY). The performance of this Communication system is found satisfactory.

The Communication system is developed/manufactured at (Communication system manufacturer area and country) and delivered and used at (Customer area and country)

Signature of the Authorized Person

Name of the customer

Name of the Authorized person

Designation of the Authorized person

City

State

Country

Phone number:

E-mail id of Authorized person

NOTE:

The Experience certificates can be submitted in any formats. It is bidder's responsibility to ensure that all the necessary information sought above are captured.

The sub-system proposed by the Contractor shall be in line with requirements stipulated in Part 2 - ERTS. In case of an alternative variant proposed by the Contractor, that sub-system must be of either equivalent or superior to the requirements stipulated in ERTS.

6.12.9 Form Sys-9: Subcontractors / Manufacturers

Whomsoever It may Concern

We, M/s (Name of the Employer) have procured (mentioned the number of cars in both words and numbers) numbers of cars (Metro, LRT, Suburban EMUs, Train sets) from M/s. (Name of the manufacturer) during the period (start date of the contract) and (End date of last car delivery).

The cars are fitted with Main Transformer designed and manufactured by (Main Transformer Design and manufacturer name). The cars (mentioned the number of cars in both words and numbers) with this Main Transformer are in service since (DD-MM-YYYY). The performance of these Main Transformer is found satisfactory.

The Main Transformer is developed / manufactured at (Main Transformer manufacturer area and country) and delivered and used at (Customer area and country).

Signature of the Authorized Person

Name of the customer

Name of the Authorized person

Designation of the Authorized person

City

State

Country

Phone number:

E-mail id of Authorized person

NOTE:

The Experience certificates can be submitted in any formats. It is bidder's responsibility to ensure that all the necessary information sought above are captured.

The sub-system proposed by the Contractor shall be in line with requirements stipulated in Part 2 - ERTS. In case of an alternative variant proposed by the Contractor, that sub-system must be of either equivalent or superior to the requirements stipulated in ERTS.

6.12.10 Form Sys-10: Subcontractors / Manufacturers

Whomsoever It may Concern

We, M/s (Name of the Employer) have procured (mentioned the number of cars in both words and numbers) numbers of cars (Metro, LRT, Suburban EMUs, Train sets) from M/s. (Name of the manufacturer) during the period (start date of the contract) and (End date of last car delivery).

The cars are fitted with Vacuum Circuit Breaker designed and manufactured by (Vacuum Circuit Breaker Design and manufacturer name). The cars (mentioned the number of cars in both words and numbers) with this Vacuum Circuit Breaker are in service since (DD-MM-YYYY). The performance of this Vacuum Circuit Breaker is found satisfactory.

The VCB is developed / manufactured at (VCB manufacturer area and country) and delivered and used at (Customer area and country)

Signature of the Authorized Person

Name of the customer

Name of the Authorized person

Designation of the Authorized person

City

State

Country

Phone number:

E-mail id of Authorized person

NOTE:

The Experience certificates can be submitted in any formats. It is bidder's responsibility to ensure that all the necessary information sought above are captured.

The sub-system proposed by the Contractor shall be in line with requirements stipulated in Part 2 - ERTS. In case of an alternative variant proposed by the Contractor, that sub-system must be of either equivalent or superior to the requirements stipulated in ERTS.

6.13 Form Minimum Local Content (Applicable only for Class-I local supplier) Deleted

1

Contract No.	ARE05
Name of the Bidder:	-
Minimum Local Content required for this Package: <i>(* Derived on Total Contract Price)</i> <i>[The amounts taken for calculation should exclude all taxes and duties]</i>	Minimum 60 %

No.	Details of Systems, Subsystems, Parts and/or Services	Percentage (%) contribution
1		
2		
3		
4		
5		

6.14 CERTIFICATE CONFIRMING PERSONNEL TO THE WORKS

This is to certify that we, M/s. [Insert name of the company (Single Entity / JV)] have carefully examined all the specified requirements stated in Part 2 - Section VIA Chapter 16, Part 2 - Section VIB Chapter 1 & Part 2 - Section VIC Chapter 1.

We hereby confirm that upon award of the Contract, we shall (prior to commencement of the Works), submit resumes of the Key Staff proposed for deployment; subject to acceptance of the Engineer / Employer. We further commit to ensure that the staff proposed shall be sufficiently qualified and experienced to the extent that they will comply with the requirements of the tender.

6.15 Undertaking on No child labour or bonded labour in Supply Chains

I/We, ... (Name of the bidder), hereby declare that, if awarded with the Tender No.....(Name of work:), no form of child labour or bonded labour will be employed anywhere in the supply chains of the subject contract.

Name of the bidder:

Address of the bidder:

Date and Sign with Firm's seal.

7. FORM FOR SEEKING CLARIFICATION ON BIDDING DOCUMENTS

(Editable Word copy shall also be submitted by e-mail along with the signed PDF copy)

Name of the Bidder:

SI No.	Part / Section No.	Clause No.	Original Bid Condition	Bidder's Query
1				
2				
3				
4				
5				
..				
..				
..				
..				
Continue as required				

8. SAMPLE FORMAT FOR BANKING REFERENCE LIQUIDITY

[To be submitted on the letter head of the Bank with Contact Details, Address, Phone Number, E-mail ID etc.]

BANK CERTIFICATE

This is to certify that M/s is a reputed company with a good financial standing.

If the contract for the work, namely is awarded to the above firm, we shall provide overdraft / credit facilities to the extent of Rs. to meet their working capital requirements for executing the above contract.

Signature: _____

Name of the Bank: _____

Bank Manager: _____

Address of the Bank: _____

Change the text as follows for Joint Venture/Consortium

[This should be given by the JV Members in proportion to their percentage participation]

This is to certify that M/s who has formed a JV / Consortium with M/s And M/s for participating in this Bid, is a reputed company with a good financial standing.

If the contract for the work, namely is awarded to the above joint venture / consortium, we shall provide overdraft/credit facilities to the extent of Rs. to meet their working capital requirements for executing the above contract.

Signature: _____

Name of the Bank: _____

Bank Manager: _____

Address of the Bank: _____

9. UNDERTAKING REGARDING RESTRICTIONS ON PROCUREMENT FROM A BIDDER OF A COUNTRY WHICH SHARES A LAND BORDER WITH INDIA

“We (Include name of Company, Single bidder / JV Member) have read the clause regarding restrictions on procurement from a bidder of a country which shares a land border with India; We certify that our company and the Beneficial ownership of our organisation is not from such a country or, if from such a country, has been registered with the Competent Authority.

We hereby certify that this bidder fulfils all requirements in this regard and is eligible to be considered. [Where applicable, evidence of valid registration by the Competent Authority shall be attached]”.

STAMP & SIGN OF AUTHORIZED SIGNATORY

10. Form of Bid Security (Bank Guarantee)

[Guarantor letterhead or SWIFT identifier code]

Beneficiary: *[insert its name and address]*

Date: *[insert date of issue]*

BID GUARANTEE No.: *[insert guarantee reference number]*

Guarantor: *[insert name and address of place of issue, unless indicated in the letterhead]*

We have been informed that *[insert name of the Bidder, which in the case of a joint venture shall be the name of the joint venture (whether legally constituted or prospective) or the names of all members thereof]* (hereinafter called "the Applicant") has submitted or will submit to the Beneficiary its Bid (hereinafter called "the Bid") for the execution of *[insert description of contract]*.

Furthermore, we understand that, according to the Beneficiary's conditions, Bids must be supported by a bid guarantee.

At the request of the Applicant, we, as Guarantor, hereby irrevocably undertake to pay the Beneficiary any sum or sums not exceeding in total an amount of *[insert amount in words]* (*[insert amount in figures]*) upon receipt by us of the Beneficiary's complying demand, supported by the Beneficiary's statement, whether in the demand itself or a separate signed document accompanying or identifying the demand, stating that either the Applicant:

- (a) has withdrawn its Bid during the period of bid validity set forth in the Applicant's Letters of Technical Bid and Price Bid ("the Bid Validity Period"), or any extension thereto provided by the Applicant;
or
- (b) having been notified of the acceptance of its Bid by the Beneficiary during the Bid Validity Period or any extension thereto provided by the Applicant,
 - (i) has failed to execute the contract agreement, or
 - (ii) has failed to furnish the Performance Security, in accordance with the Instructions to Bidders of the Beneficiary's bidding document.

This guarantee shall expire and be returned to us:

- (a) if the Applicant is the successful Bidder, upon our receipt of copies of the contract agreement signed by the Applicant and the Performance Security issued to the Beneficiary in relation to such contract agreement;
or
- (b) if the Applicant is not the successful Bidder, upon the earlier of
 - (i) our receipt of a copy of the Beneficiary's notification to the Applicant of the results of the bidding process; or
 - (ii) twenty-eight days after the end of the Bid Validity Period.

Consequently, any demand for payment under this guarantee must be received by us at the office indicated above on or before that date.

This guarantee is subject to the Uniform Rules for Demand Guarantees (URDG) 2010 Revision, ICC Publication No. 758.

[signature(s)]

[Note: All italicized text is for use in preparing this form and shall be deleted from the final product]

11. Form POA – Power of Attorney for Signing the BID

1 Know all men by these presents, we (name of the firm and address of the Registered Office) do hereby irrevocably constitute, nominate, appoint and authorize Mr. / Ms. (name), son / daughter / wife of (name) and presently residing at (Address), who is presently employed with us / the Lead Member of our Consortium and holding the position of (Designation), as our true and lawful Attorney (hereinafter referred to as the "Attorney") to do in our name and on our behalf, all such acts, deeds and things as are necessary or required in connection with or incidental to submission of our bid for the award of the license for "~~TENDER FOR DESIGN, MANUFACTURE, SUPPLY, TESTING, COMMISSIONING, TRAINING OF PERSONNEL AND COMPREHENSIVE MAINTENANCE CONTRACT FOR FIFTEEN (15) YEARS OF STANDARD GAUGE METRO ROLLING STOCK (ELECTRICAL MULTIPLE UNITS) TENDER FOR DESIGN, MANUFACTURE, SUPPLY, TESTING, COMMISSIONING OF STANDARD GAUGE METRO ROLLING STOCK (ELECTRICAL MULTIPLE UNITS) AND DEPOT MACHINERY & PLANT AND TRAINING OF PERSONNEL~~" for which proposals are invited by Chennai Metro Rail Limited (CMRL) including but not limited to signing and submission of all Bids and other documents and writings, participate in bidders and other conferences and providing information / responses to Chennai Metro Rail Limited (CMRL), representing us in all matters before Chennai Metro Rail Limited (CMRL) signing and execution of all contracts including the License Agreement and undertakings consequent to acceptance of our Bid and generally dealing with CMRL in all matters in connection with or relating to or arising out of our Bid for the award of License to us and / or till the entering into of the License Agreement with CMRL.

AND

we hereby agree to ratify and confirm and do hereby ratify and confirm all acts, deeds and things done or caused to be done by our said Attorney pursuant to and in exercise of the powers conferred by this Power of Attorney and that all acts, deeds and things done by our said Attorney in exercise of the Powers hereby conferred shall and shall always be deemed to have been done by us.

IN WITNESS WHEREOF WE, _____ THE ABOVE NAMED PRINCIPAL HAVE EXECUTED THIS POWER OF ATTORNEY ON THIS _____ DAY OF _____ 20____

For _____ (Signature, name, designation and address)

Witnesses:

(Notarized)

1.

2.

Accepted

(Signature)
(Name, Title and Address of the Attorney)

Notes:

The mode of execution of the Power of Attorney should be in accordance with the procedure, if any, laid down by the applicable law and the charter documents of the executants(s) and when It is so required; the same should be under common seal affixed in accordance with the required procedure.

The Bidder should submit for verification the extract of the charter documents and documents such as a Board or shareholders' resolution / power of attorney in favour of the person executing this Power of Attorney for the delegation of power hereunder on behalf of the Bidder along with bid document at the time of executing the agreement.

**12. UNDERTAKING REGARDING RESTRICTIONS ON PROCUREMENT FROM A
BIDDER OF A COUNTRY WHICH SHARES A LAND BORDER WITH INDIA AND
ON SUB-CONTRACTING**

“We have read the clause regarding restrictions on procurement from a bidder of a country which shares a land border with India and on sub-contracting to contractors from such countries; We (Include name of Company, Single bidder / JV Member) certify that our company and the Beneficial ownership of our organisation is not from such a country or, if from such a country, has been registered with the Competent Authority and will not subcontract any work to a contractor from such countries unless such contractor is registered with the Competent Authority. Thereby certify that this bidder fulfils all requirements in this regard and is eligible to be considered. [Where applicable, evidence of valid registration by the Competent Authority shall be attached.]”

STAMP & SIGN OF AUTHORIZED SIGNATORY

13.ADDITIONAL CERTIFICATE BY BIDDERS IN THE CASES OF SPECIFIED TOT:

"I have read the clause regarding restrictions on procurement from a bidder having transfer of technology (tot) arrangement. I certify that this bidder does not have any tot arrangement requiring registration with the competent authority."

or

"I have read the clause regarding restrictions on procurement from a bidder having transfer of technology (tot) arrangement. i certify that this bidder has valid registration to participate in this procurement."

STAMP & SIGN OF AUTHORIZED SIGNATORY

14.CERTIFICATE CONFIRMING NO MIDDLEMAN ENGAGEMENT

We _____ (Name of the Bidder (Single Entity or each member in case of a JV/Consortium) hereby declare that no agent, middleman or any intermediary has been, or will be, engaged to provide any services, or any other item or work related to the award and performance of this Contract. We confirm and declare that no agency commission or any payment which may be construed as an agency commission has been, or will be, paid and that the Contract Price will not include any such amount. If the Employer subsequently finds to the contrary, the Employer reserves the right to declare the Bidder as non-compliant and declare any Contract if already awarded to the Bidder to be null and void.

We are fully aware that canvassing or offer of an advantage or any other inducement by any person with a view to influencing acceptance of a Bid will be an offence under laws of India. Such action will result in the rejection of the Bid, in addition to other punitive measures.

STAMP & SIGN OF AUTHORIZED SIGNATORY

1

**15. FORM – UNDERTAKING REGARDING RESTRICTIONS ON PROCUREMENT FROM A
BIDDER OF A COUNTRY WHICH SHARES A LAND BORDER WITH INDIA.**

“We (Include name of Company, Single bidder / JV Member) have read the clause regarding restrictions on procurement from a bidder of a country which shares a land border with India; We certify that our company and the Beneficial ownership of our organization is not from such a country or, if from such a country, has been registered with the Competent Authority.

We hereby certify that (Include name of Company, Single bidder / JV Member) fulfils all requirements in this regard and is eligible to be considered. [Where applicable, evidence of valid registration by the Competent Authority shall be attached]”.

“We (Include name of Company, Single bidder / JV Member) have read the clause regarding restrictions on procurement from a bidder of a country which shares a land border with India and certify that Subcontracting / Subcontractors from such countries are not proposed for this Project.

We (Include name of Company, Single bidder / JV Member) certify that our company and the Beneficial ownership of our organization is not from such a country or, if from such a country, has been registered with the Competent Authority and will not subcontract any work to a contractor from such countries unless such contractor is registered with the Competent Authority. Thereby certify that this bidder fulfils all requirements in this regard and is eligible to be considered. [Where applicable, evidence of valid registration by the Competent Authority shall be attached.]”.

STAMP & SIGN OF AUTHORIZED SIGNATORY



CHENNAI METRO RAIL LIMITED

CHENNAI METRO RAIL PROJECT PHASE 1

Tender No. ARE05

**DESIGN, MANUFACTURE, SUPPLY, TESTING,
COMMISSIONING OF STANDARD GAUGE METRO
ROLLING STOCK (ELECTRICAL MULTIPLE UNITS)
AND DEPOT MACHINERY & PLANT AND TRAINING
OF PERSONNEL.**

**PART 1: BIDDING PROCEDURES
SECTION - V: ELIGIBLE SOURCE COUNTRIES (ESC)**

NOV 2025 APR 2026 JUN 2026

SECTION V – A : ELIGIBLE SOURCE COUNTRIES

(ALL COUNTRIES ARE ELIGIBLE)

SECTION V – B : REQUIREMENTS OF A BIDDER FROM A COUNTRY WHICH SHARES LAND BORDER WITH INDIA

- (i) Any bidder from a country which shares a land border with India will be eligible to bid in this tender only if the bidder is registered with the Competent Authority, specified in Annex-I of Department of Expenditure (DoE), Ministry of Finance (MoF) OM No. F.7/10/2021-PPD dated 23.02.2023 or as updated from time to time.
- (ii) "Bidder" (including the term 'tenderer', 'consultant' or 'service provider' in certain contexts) means any person or firm or company, including any member of a consortium or joint venture (that is an association of several persons, or firms or companies), every artificial juridical person not falling in any of the descriptions of bidders stated hereinbefore, including any agency branch or office controlled by such person, participating in a procurement process.
- (iii) "Bidder from a country which shares a land border with India" for the purpose of this Order means: -
 - (a) An entity incorporated, established or registered in such a country; or
 - (b) A subsidiary of an entity incorporated, established or registered in such a country; or
 - (c) An entity substantially controlled through entities incorporated, established or registered in such a country; or
 - (d) An entity whose beneficial owner is situated in such a country; or
 - (e) An Indian (or other) agent of such an entity; or
 - (f) A natural person who is a citizen of such a country; or
 - (g) A consortium or joint venture where any member of the consortium or joint venture falls under any of the above
- (iv) The beneficial owner for the purpose of (iii) above will be as under:
 1. In case of a company or Limited Liability Partnership, the beneficial owner is the natural person(s), who, whether acting alone or together, or through one or more juridical person, has a controlling ownership interest or who exercises control through other means.

Explanation——

 - (a) "Controlling ownership interest" means ownership of or entitlement to more than twenty-five per cent. of shares or capital or profits of the company;
 - (b) "Control" shall include the right to appoint majority of the directors or to control the management or policy decisions including by virtue of their shareholding or management rights or shareholders agreements or voting agreements;
 2. In case of a partnership firm, the beneficial owner is the natural person(s) who, whether acting alone or together, or through one or more juridical person, has ownership of entitlement to more than fifteen percent of capital or profits of the partnership;
 3. In case of an unincorporated association or body of individuals, the beneficial owner is the natural person(s), who, whether acting alone or together, or through one or more juridical person, has ownership of or entitlement to more than fifteen percent of the property or capital or profits of such association or body of individuals;
 4. Where no natural person is identified under (1) or (2) or (3) above, the beneficial owner is the relevant natural person who holds the position of senior managing official;

5. In case of a trust, the identification of beneficial owner(s) shall include identification of the author of the trust, the trustee, the beneficiaries with fifteen percent or more interest in the trust and any other natural person exercising ultimate effective control over the trust through a chain of control or ownership.
- (v) An Agent is a person employed to do any act for another or to represent another in dealings with third person.
- (vi) The successful bidder shall not be allowed to Subcontract works to any Contractor from a country which shares a land border with India unless such contractor is registered with the Competent Authority.
- (vii) The registration shall be valid at the time of submission of bid and at the time of acceptance of bid.
- (viii) If the bidder was validly registered at the time of acceptance/placement of order, registration shall not be a relevant consideration during contract execution.
- (ix) A bidder is permitted to procure raw material, components, sub-assemblies etc., from the vendors from countries which shares a land border with India. Such vendors will not be required to be registered with the Competent Authority, as it is not regarded as "Subcontracting".
- (x) However, in case a bidder has proposed to supply finished goods procured directly / indirectly from the vendors from the countries sharing land border with India, such vendor will be required to be registered with the Competent Authority.

No.F.7/10/2021-PPD (1)
Government of India
Ministry of Finance
Department of Expenditure
Procurement Policy Division

264-C, North Block, New Delhi.
23.02.2023.

Order (Public Procurement No. 4)

Subject: Restrictions under Rule 144(xi) of the General Financial Rules (GFRs), 2017.

Attention is invited to Order (Public Procurement No. 1) issued vide F.6/18/2019-PPD dated 23.07.2020, Order (Public Procurement No. 2) issued vide F.6/18/2019-PPD dated 23.07.2020, Order (Public Procurement No. 3) issued vide F.6/18/2019-PPD dated 24.07.2020, Office Memorandum (OM) No. F.18/37/2020-PPD dated 08.02.2021, OM No. F.12/1/2021-PPD(Pt.) dated 02.03.2021 and OM No. F.7/10/2021-PPD dated 08.06.2021. In this regard, the following is hereby ordered under Rule 144(xi) (as amended vide OM No. F.7/10/2021-PPD dated 23.02.2023) on the grounds stated therein, in supersession to all of the above mentioned Orders/ clarifications:

Requirement of registration:

2. Any bidder from a country which shares a land border with India will be eligible to bid in any procurement whether of goods, services (including consultancy services and non-consultancy services) or works (including turnkey projects) only if the bidder is registered with the Competent Authority, specified in **Annexure I**.
3. Any bidder (including an Indian bidder) who has a Specified Transfer of Technology (ToT) arrangement with an entity from a country which shares a land border with India will be eligible to bid in any procurement whether of goods, services (including consultancy services and non-consultancy services) or works (including turnkey projects) only if the bidder is registered with the Competent Authority, specified in **Annexure I**.
4. The requirement of registration for cases covered by paragraph 2 above has been applicable since 23.07.2020. The requirement of registration for bidders covered by paragraph 3 above will be applicable for all procurements where tenders are issued/ published after 01.04.2023.
5. In tenders issued after 23.07.2020 or 01.04.2023, as the case may be, the provisions of requirement of registration of bidders and of other relevant provisions of this Order shall be incorporated in the tender conditions.

Applicability:

6. Apart from Ministries/ Departments, attached and subordinate bodies, notwithstanding anything contained in Rule 1 of the GFRs 2017, the Order shall also be applicable

- a) to all Autonomous Bodies;
- b) to all public sector banks and public sector financial institutions;
- c) to all Central Public Sector Enterprises;
- d) to all procurement in Public Private Partnership projects receiving financial support from the Government or public sector enterprises/ undertakings; and
- e) Union Territories, National Capital Territory of Delhi and all agencies/ undertakings thereof.

7. This order will not be applicable for cases falling under **Annexure II**.

Definitions:

8. "*Bidder*" for the purpose of the Order (including the term 'tenderer', 'consultant' 'vendor' or 'service provider' in certain contexts) means any person or firm or company, including any member of a consortium or joint venture (that is an association of several persons, or firms or companies), every artificial juridical person not falling in any of the descriptions of bidders stated hereinbefore, including any agency, branch or office controlled by such person, participating in a procurement process.

9. "*Tender*" for the purpose of the Order will include other forms of procurement, except where the context requires otherwise.

10. "*Transfer of Technology*" means dissemination and transfer of all forms of commercially usable knowledge such as transfer of know-how, skills, technical expertise, designs, processes and procedures, trade secrets, which enables the acquirer of such technology to perform activities using the transferred technology independently. (Matters of interpretation of this term shall be referred to the Registration Committee constituted by the Department for Promotion of Industry and Internal Trade, and the interpretation of the Committee shall be final.)

11. "*Specified Transfer of Technology*" means a transfer of technology in the sectors and/ or technologies, specified in paragraph 15, occurring on or after 23.07.2020.

12. "*Bidder (or entity) from a country which shares a land border with India*" for the purpose of the Order means

- (a) An entity incorporated, established or registered in such a country; or
- (b) A subsidiary of an entity incorporated, established or registered in such a country; or
- (c) An entity substantially controlled through entities incorporated, established or registered in such a country; or
- (d) An entity whose beneficial owner is situated in such a country; or
- (e) An Indian (or other) agent of such an entity; or
- (f) A natural person who is a citizen of such a country; or

- (g) A consortium or joint venture where any member of the consortium or joint venture falls under any of the above

13. *Beneficial owner* for the purposes of Para 12 (d) will be as under:

(i) In case of a company or Limited Liability Partnership, the beneficial owner is the natural person(s), who, whether acting alone or together, or through one or more juridical person(s), has a controlling ownership interest or who exercises control through other means.

Explanation:-

- a. "Controlling ownership interest" means ownership of, or entitlement to, more than twenty-five per cent of shares or capital or profits of the company;
- b. "Control" shall include the right to appoint the majority of the directors or to control the management or policy decisions, including by virtue of their shareholding or management rights or shareholders agreements or voting agreements;

(ii) In case of a partnership firm, the beneficial owner is the natural person(s) who, whether acting alone or together, or through one or more juridical person, has ownership of entitlement to more than fifteen percent of capital or profits of the partnership;

(iii) In case of an unincorporated association or body of individuals, the beneficial owner is the natural person(s), who, whether acting alone or together, or through one or more juridical person, has ownership of or entitlement to more than fifteen percent of the property or capital or profits of such association or body of individuals;

(iv) Where no natural person is identified under (i) or (ii) or (iii) above, the beneficial owner is the relevant natural person who holds the position of senior managing official;

(v) In case of a trust, the identification of beneficial owner(s) shall include identification of the author of the trust, the trustee, the beneficiaries with fifteen percent or more interest in the trust and any other natural person exercising ultimate effective control over the trust through a chain of control or ownership.

14. "*Agent*" for the purpose of the Order is a person employed to do any act for another, or to represent another in dealings with third persons.

[Note:

- i. A person who procures and supplies finished goods from an entity from a country which shares a land border with India will, regardless of the nature of his legal or commercial relationship with the producer of the goods, be deemed to be an Agent for the purpose of this Order.
- ii. However, a bidder who only procures raw material, components etc. from an entity from a country which shares a land border with India and then manufactures or converts them into other goods will not be treated as an Agent.]

Sensitive Sectors/ Technologies (relevant only for the provisions on ToT arrangements):

15. (i) Certain sectors and technologies have been identified as sensitive from the national security point of view. The sectors listed in Schedule I to this Order are considered Category-I sensitive sectors. The sectors listed in Schedule II to this Order are considered Category-II sensitive sectors. The technologies listed in Schedule III are considered sensitive technologies.

(ii) For Category-I sensitive sectors, bidders with ToT arrangement in any technology with an entity from a country which shares a land border with India shall require registration.

(iii) For Category-II sensitive sectors, bidders with ToT arrangement in the sensitive technologies listed in Schedule III, with an entity from a country which shares a land border with India shall require registration.

(iv) In Category-II sensitive sectors, the Secretary (or an officer not below the rank of Joint Secretary to Government of India, so authorized by the Secretary) of the Ministry/ Department of the Government of India is empowered, after due consideration, to waive the requirement of registration for a particular item/ application or a class of items/ applications from the requirement of registration, even if included in Schedule III. The Ministry/ Department concerned shall intimate the Department for Promotion of Industry and Internal Trade (DPIIT) and National Security Council Secretariat (NSCS) of their decision to waive the requirement of registration. Ministries/ Departments of the Government of India are not required to consult the DPIIT/ NSCS before deciding and are only required to intimate the decision to DPIIT/ NSCS. If any point is raised by DPIIT/ NSCS, it should be considered in future procurements; ongoing procurement for which the waiver was granted need not be interrupted or altered.

16. Based on security considerations, a Ministry/ Department in a Category II sensitive sector or other Ministries/ Departments may recommend to DPIIT inclusion of any other technology in the list of sensitive technologies, either generally or for their Ministry/ Department.

Sub-contracting in works contracts

17. In works contracts, including turnkey contracts, contractors shall not be allowed to sub-contract works to any contractor from a country which shares a land border with India unless such contractor is registered with the Competent Authority. The definition of "contractor from a country which shares a land border with India" shall be as in paragraph 12 above. This shall not apply to sub-contracts already awarded on or before 23.07.2020.

[Note: Procurement of raw material, components, etc. does not constitute sub-contracting.]

Certificate regarding compliance

18. An undertaking shall be taken from bidders in the tender documents (**Annexure III**) that the extant guidelines for participation in the tenders (which should include conditions for implementation of this Order) have been complied with. If such certificate given by a bidder whose bid is accepted is found to be false, this would be a ground for debarment and further legal action in accordance with law.

Validity of registration

19. In respect of tenders, registration should be valid at the time of submission of bids and at the time of acceptance of bids. In respect of supply otherwise than by tender, registration should be valid at the time of placement of order. If the bidder was validly registered at the time of acceptance / placement of order, registration shall not be a relevant consideration during contract execution.

Government e-Marketplace (GeM)

20. GeM shall remove non-compliant entities from GeM unless/ until they are registered in accordance with this Order.

Model Clauses/ Certificates

21. Model Clauses and Model Certificates which may be inserted in tenders/ obtained from Bidders are given at Annexure-III. While adhering to the substance of the Order, procuring entities are free to appropriately modify the wording of these clauses based on their past experience, local needs etc.


23/02/2023
(Kanwalpreet)
Director(PPD)

Tel.No. 2309 3811; email: kanwal.irss@gov.in

To

1. Secretaries of all Ministries/ Departments of Government of India for information and necessary action. They are also requested to inform these provisions to all procuring entities.
2. Secretary, Department of Public Enterprises with a request to immediately reiterate these orders in respect to public enterprises.
3. Secretary, Department of Financial Services with a request to immediately reiterate these orders in respect to public sector and public sector financial institutions.
4. Secretary DPIIT with a request to take action as provided under Annexure I.
5. Chief Secretaries/ Administrators of Union Territories/ National Capital Territory of Delhi.
6. CEO/ GeM with a request to ensure implementation of this order on GeM.

List of Category-I Sensitive sectors:

Sr.No.	Sector
(i)	Atomic Energy
(ii)	Broadcasting/ Print and Digital Media
(iii)	Defence
(iv)	Space
(v)	Telecommunications

List of Category-II Sensitive sectors:

Sr.No.	Sector
(i)	Power and Energy (including exploration/ generation/ transmission/ distribution/ pipeline)
(ii)	Banking and Finance including Insurance
(iii)	Civil Aviation
(iv)	Construction of ports and dams & river valley projects
(v)	Electronics and Microelectronics
(vi)	Meteorology and Ocean Observation
(vii)	Mining and extraction (including deep sea projects)
(viii)	Railways
(ix)	Pharmaceuticals & Medical Devices
(x)	Agriculture
(xi)	Health
(xii)	Urban Transportation

List of Sensitive Technologies:

Sr.No.	Sensitive Technologies
(i)	Additive Manufacturing (e.g. 3D Printing)
(ii)	Any equipment having electronic programmable components or autonomous systems (e.g. SCADA systems)
(iii)	Any technology used for uploading and streaming of data including broadcasting, satellite communication etc.
(iv)	Chemical Technologies
(v)	Biotechnologies including Genetic Engineering and Biological Technologies
(vi)	Information and Communication Technologies
(vii)	Software

Competent Authority and Procedure for Registration

- A. The Competent Authority for the purpose of registration under this order shall be/ continue to be the Registration Committee constituted by the Department for Promotion of Industry and Internal Trade (DPIIT)*. [This Committee was already constituted under Order (Public Procurement) No.1].
- B. The Registration Committee shall have the following members*:
- i. An officer, not below the rank of Joint Secretary, designated for this purpose by DPIIT, who shall be the Chairman;
 - ii. Officers (ordinarily not below the rank of Joint Secretary) representing the Ministry of Home Affairs, Ministry of External Affairs, and of those Departments whose sectors are covered by applications under consideration;
 - iii. Any other officer whose presence is deemed necessary by the Chairman of the Committee.
 - iv. With effect from 01.04.2023, an officer (ordinarily not below the rank of Joint Secretary) representing the National Security Council Secretariat.
- C. DPIIT shall lay down the method of application, format etc. for such bidders as covered by the Order.
- D. On receipt of an application seeking registration from a bidder covered by Para 2 and 3 of this order, the Competent Authority shall first seek political and security clearances from the Ministry of External Affairs and Ministry of Home Affairs, as per guidelines issued from time to time. Registration shall not be given unless political and security clearance have both been received.
- E. The Ministry of External Affairs and Ministry of Home Affairs may issue guidelines for internal use regarding the procedure for scrutiny of such applications by them.
- F. The decision of the Competent Authority, to register such bidder may be for all kinds of tenders or for a specified type(s) of goods or services, and may be for a specified or unspecified duration of time, as deemed fit. The decision of the Competent Authority shall be final.
- G. Registration granted by the Competent Authority of the Government of India shall be valid not only for procurement by the Central Government and its bodies specified in para 6 of this order, but also for procurement by State Governments and their agencies/ public enterprises etc. No fresh registration at the State level shall be required.
- H. The Competent Authority is empowered to cancel the registration already granted if it determines that there is sufficient cause. Such cancellation by itself, however, will

not affect the execution of contracts already awarded. Pending cancellation, it may also suspend the registration of a bidder, and the bidder shall not be eligible to bid in any further tenders during the period of suspension.

- I. For national security reasons, the Competent Authority shall not be required to give reasons for rejection/cancellation of registration of a bidder.

[*Note:

(i) In respect of application of the Order to procurement by/ under State Governments, all functions assigned to DPIIT shall be carried out by the State Government concerned through a specific department or authority designated by it. The composition of the Registration Committee shall be as decided by the State Government. However, the requirement of political and security clearance as per para D shall remain and no registration shall be granted without such clearance.

(ii) Registration granted by State Governments shall be valid only for procurement by the State Government and its agencies/ public enterprises etc. and shall not be valid for procurement in other states or by the Government of India and their agencies/ public enterprises etc.]

Special Cases

- A. In projects which receive international funding with the approval of the Department of Economic Affairs (DEA), Ministry of Finance, the procurement guidelines applicable to the project shall normally be followed, notwithstanding anything contained in this order and without reference to the Competent Authority. Exceptions to this shall be decided in consultation with DEA.
- B. This order shall not apply to procurement by Indian missions and by offices of government agencies/ undertakings located outside India.
- C. This order will not apply to bidders (or entities) from those countries (even if sharing a land border with India) to which the Government of India has extended lines of credit or in which the Government of India is engaged in development projects. Updated lists of countries to which lines of credit have been extended or in which development projects are undertaken are given on the website of the Ministry of External Affairs.
- D. Procurement of spare parts and other essential service support like Annual Maintenance Contract (AMC)/ Comprehensive Maintenance Contract (CMC), including consumables for closed systems, from Original Equipment Manufacturers (OEMs) or their authorized agents, shall be exempted from the requirement of registration.

Model Clause/ Certificate/ Undertaking to be inserted in tenders etc.

[While adhering to the substance of the Order, procuring entities and GeM are free to appropriately modify the wording of the clause/ certificate based on their past experience, local needs etc.

The conditions relating to specified ToT (as shown in italics) should be incorporated only in the tenders which attract the restrictions due to specified ToT.]

A. Model Clauses for Tenders (including tenders issued manually or any electronic portal including GeM):

I. Any bidder from a country which shares a land border with India will be eligible to bid in any procurement whether of goods, services (including consultancy services and non-consultancy services) or works (including turnkey projects) only if the bidder is registered with the Competent Authority. *Further, any bidder (including bidder from India) having specified Transfer of Technology (ToT) arrangement with an entity from a country which shares a land border with India, shall also require to be registered with the same competent authority.*

II. "Bidder" (including the term 'tenderer', 'consultant' or 'service provider' in certain contexts) means any person or firm or company, including any member of a consortium or joint venture (that is an association of several persons, or firms or companies), every artificial juridical person not falling in any of the descriptions of bidders stated hereinbefore, including any agency branch or office controlled by such person, participating in a procurement process.

III. "Bidder (or entity) from a country which shares a land border with India" for the purpose of this Order means: -

- (a) An entity incorporated, established or registered in such a country; or
- (b) A subsidiary of an entity incorporated, established or registered in such a country; or
- (c) An entity substantially controlled through entities incorporated, established or registered in such a country; or
- (d) An entity whose beneficial owner is situated in such a country; or
- (e) An Indian (or other) agent of such an entity; or
- (f) A natural person who is a citizen of such a country; or
- (g) A consortium or joint venture where any member of the consortium or joint venture falls under any of the above

IV. The beneficial owner for the purpose of (iii) above will be as under:

1. In case of a company or Limited Liability Partnership, the beneficial owner is the natural person(s), who, whether acting alone or together, or through one or more juridical person, has a controlling ownership interest or who exercises control through other means.

Explanation—

a. "Controlling ownership interest" means ownership of or entitlement to more than twenty-five per cent. of shares or capital or profits of the company;

b. "Control" shall include the right to appoint majority of the directors or to control the management or policy decisions including by virtue of their shareholding or management rights or shareholders agreements or voting agreements;

2. In case of a partnership firm, the beneficial owner is the natural person(s) who, whether acting alone or together, or through one or more juridical person, has ownership of entitlement to more than fifteen percent of capital or profits of the partnership;

3. In case of an unincorporated association or body of individuals, the beneficial owner is the natural person(s), who, whether acting alone or together, or through one or more juridical person, has ownership of or entitlement to more than fifteen percent of the property or capital or profits of such association or body of individuals;

4. Where no natural person is identified under (1) or (2) or (3) above, the beneficial owner is the relevant natural person who holds the position of senior managing official;

5. In case of a trust, the identification of beneficial owner(s) shall include identification of the author of the trust, the trustee, the beneficiaries with fifteen percent or more interest in the trust and any other natural person exercising ultimate effective control over the trust through a chain of control or ownership.

V. An Agent is a person employed to do any act for another, or to represent another in dealings with third person.

VI. [To be inserted in tenders for Works contracts, including Turnkey contracts] The successful bidder shall not be allowed to sub-contract works to any contractor from a country which shares a land border with India unless such contractor is registered with the Competent Authority.

VII. The registration shall be valid at the time of submission of bid and at the time of acceptance of bid.

VIII. If the bidder was validly registered at the time of acceptance / placement of order, registration shall not be a relevant consideration during contract execution

Model Certificate for Tenders:

"I have read the clause regarding restrictions on procurement from a bidder of a country which shares a land border with India; I certify that this bidder is not from such a country or, if from such a country, has been registered with the Competent Authority. I hereby certify that this bidder fulfills all requirements in this regard and is eligible to be considered. [Where applicable, evidence of valid registration by the Competent Authority shall be attached.]"

Model Certificate for Tenders for Works involving possibility of sub-contracting:

"I have read the clause regarding restrictions on procurement from a bidder of a country which shares a land border with India and on sub-contracting to contractors from such countries; I certify that this bidder is not from such a country or, if from such a country, has been registered with the Competent Authority and will not sub-contract any

work to a contractor from such countries unless such contractor is registered with the Competent Authority. I hereby certify that this bidder fulfills all requirements in this regard and is eligible to be considered. [Where applicable, evidence of valid registration by the Competent Authority shall be attached.]"

Model additional certificate by Bidders in the cases of specified ToT:

"I have read the clause regarding restrictions on procurement from a bidder having Transfer of Technology (ToT) arrangement. I certify that this bidder does not have any ToT arrangement requiring registration with the competent authority."

OR

"I have read the clause regarding restrictions on procurement from a bidder having Transfer of Technology (ToT) arrangement. I certify that this bidder has valid registration to participate in this procurement."

B. Model Certificate for GeM (to be taken by the GeM from seller during registration on GeM. GeM should also obtain this certificate from all existing bidders as soon as possible):

"I have read the clause regarding restrictions on procurement from a bidder of a country which shares a land border with India; I certify that this vendor/ bidder is not from such a country and does not have any specified Transfer of Technology (ToT) from such a country or, if from such a country or if having specified ToT from such a country has been registered with the Competent Authority. I hereby certify that this vendor/ bidder fulfills all requirements in this regard and is eligible to be considered for procurement on GeM. [Where applicable, evidence of valid registration by the Competent Authority shall be attached.]"



CHENNAI METRO RAIL LIMITED

CHENNAI METRO RAIL PROJECT PHASE 1

Tender No. ARE05

**DESIGN, MANUFACTURE, SUPPLY, TESTING,
COMMISSIONING OF STANDARD GAUGE METRO
ROLLING STOCK (ELECTRICAL MULTIPLE UNITS)
AND DEPOT MACHINERY & PLANT AND
TRAINING OF PERSONNEL.**

PART 2 : EMPLOYER'S REQUIREMENTS

***SECTION - VIA : EMPLOYER'S REQUIREMENTS
TECHNICAL SPECIFICATIONS (ERTS) –
ROLLING STOCK (RS)***

~~NOV 2025~~ ~~APR 2026~~ JUN 2026



CHENNAI METRO RAIL LIMITED

CHENNAI METRO RAIL PROJECT PHASE 1

Tender No. ARE05

BIDDING DOCUMENTS

PART 1	Bidding Procedures
	Section - I Instructions to Bidders (ITB) Section - II Bid Data Sheet (BDS) Section - III Evaluation and Qualification Criteria (EQC) Section - IV Bidding Forms (BF) Section - V Eligible Source Countries (ESC)
PART 2	Employer's Requirements
	Section – VI A Employer's Requirements Technical Specifications (ERTS) – Rolling Stock (RS). Section – VI B Employer's Requirements Technical Specifications (ERTS) – Depot Machinery & Plant (DM&P)
PART 3	Conditions of Contract and Contract Forms
	Section - VII General Conditions of Contract (GCC) Section - VIII Particular Conditions of Contract (PCC) Section – IX Annex to PCC – Contract Forms (CF)



CHENNAI METRO RAIL LIMITED

CHENNAI METRO RAIL PROJECT PHASE 1

Tender No. ARE05

PART- 2: SECTION VI A – EMPLOYER’S REQUIREMENTS TECHNICAL SPECIFICATION (ERTS) – ROLLING STOCK (RS)

TABLE OF CONTENTS

1.	SYSTEM DESCRIPTION	13
1.1.	CITED REFERENCES	13
1.2.	REFERENCED DOCUMENTS	13
1.3.	GENERAL DESCRIPTION OF SYSTEM	13
1.4.	OPERATIONS.....	17
1.5.	DESCRIPTION OF WORK	18
1.6.	SUSTAINABILITY.....	18
1.7.	CARBON CREDITS.....	18
2.	SYSTEM REQUIREMENTS	19
2.1	NOT USED	19
2.2	GENERAL REQUIREMENTS.....	19
2.3	DESIGN LIFE.....	21
2.4	SERVICE-PROVEN DESIGN	22
2.5	DESIGNS FOR REFURBISHMENT	22
2.6	AESTHETIC APPEARANCE.....	23
2.7	CAR GENERAL CHARACTERISTICS	23
2.8	CLEARANCE REQUIREMENTS.....	25
2.9	WAYSIDE CHARACTERISTICS	25
2.10	TRAINS’ INTER-OPERABILITY REQUIREMENTS	29
2.11	ENVIRONMENTAL CRITERIA.....	29
2.12	WEIGHT CRITERIA	30
2.13	SHOCK AND VIBRATION.....	31
2.14	PERFORMANCE REQUIREMENTS	33
2.15	TRACTION AND BRAKING	37
2.16	CONTROL AND INTERLOCK SIGNALS.....	43
2.17	ACOUSTIC REQUIREMENTS.....	44

2.18	ELECTRICAL NOISE CONTROL REQUIREMENTS	46
2.19	NOT USED	48
2.20	COMPLIANCE MATRIX	48
2.21	DESIGN MANAGEMENT AND CONTROL	49
2.22	SYSTEM INTEGRATION PROCESS	49
2.23	INTERFACE MANAGEMENT	49
2.24	COMMAND RESPONSE TIME	49
2.25	SPECIFIC ENERGY CONSUMPTION	50
2.26	FIRE PERFORMANCE	56
2.27	LIFE CYCLE COST	58
2.28	~~NOT USED~~ UTO OPERATION	59
2.29	FLEET DESIGN FAMILIARITY AND CONSISTENCY	59
3.	VEHICLE BODY	60
3.1	NOT USED	60
3.2	GENERAL	60
3.3	MATERIALS	61
3.4	CARBODY STRUCTURE	62
3.5	INSULATION	69
3.6	INTERIOR FITTINGS	70
3.7	INTERIOR ACCESSORIES	73
3.8	ELDERLY AND DIFFERENTLY ABLED ACCOMMODATIONS	73
3.9	EQUIPMENT ENCLOSURES	74
3.10	INTERCAR CONNECTIONS	74
3.11	EXTERIOR ACCESSORIES	74
3.12	SIGNAGE	75
3.13	CONSTRUCTION CRITERIA	76
3.14	STRESS LEVELS AND DESIGN CALCULATIONS	80
3.15	NATURAL FREQUENCY	87
3.16	MODELS	87
4.	COUPLER AND DRAFT GEAR	88
4.1	NOT USED	88
4.2	GENERAL	88
4.3	COUPLER OPERATION	89
4.4	MECHANICAL COUPLER	90
4.5	DRAFT GEAR	90
4.6	JUMPER CABLES HOSES AND CONDUITS	91
4.7	PNEUMATIC COUPLER	92
4.8	SEMI-PERMANENT COUPLER / INTER-CAR DRAWBAR	92
4.9	FRONT END ELECTRICAL COUPLING	93
5.	OPERATOR'S DESK	94
5.1	NOT USED	94
5.2	GENERAL	94
5.3	OPERATOR'S DESK AREA	95
5.4	OPERATOR'S DRIVING DESK	96
5.5	MASTER CONTROLLER AND RELATED CONTROLS	99
5.6	OPERATOR SAFETY DEVICE	101
5.7	DRIVER DISPLAY UNIT REQUIREMENTS:	101
5.8	WARNING DEVICES	102
5.9	CLOSED CIRCUIT TELEVISION (CCTV)	102
5.10	WINDSHIELD WIPER / WASHER	102
5.11	OTHER EQUIPMENT	102

5.12	TRAIN OPERATOR SEAT	103
5.13	SUN PROTECTION VISORS	103
5.14	CAB VAC	103
5.15	SALOON TO CAB OPERATOR DOOR SALOON TO CAB ACCESS AND PARTITION DOOR	103
5.16	CAB ACCESS DOORS AND CONTROL.....	104
6.	PASSENGER DOORS	106
6.1	NOT USED	106
6.2	GENERAL	106
6.3	DESIGN CRITERIA.....	107
6.4	DOOR OPERATION	109
6.5	DOOR CONTROL	110
6.6	PASSENGERS ACCESS PROTECTION.....	112
6.7	PASSENGERS ALARM AND EMERGENCY SYSTEMS.....	113
6.8	DOOR SYSTEM INTERLOCKS AND BYPASS SWITCHES	115
6.9	EMERGENCY RAMP	116
6.10	DETRAINMENT DOOR DELETED	116
6.11	UTO OPERATION	118
7.	VENTILATION AND AIRCONDITIONING	119
7.1	NOT USED	119
7.2	GENERAL	119
7.3	DESIGN REQUIREMENTS.....	119
7.4	VENTILATION REQUIREMENTS	121
7.5	HEATING REQUIREMENTS	123
7.6	COOLING REQUIREMENTS.....	123
7.7	CONTROLS	124
7.8	REFRIGERANT AND PIPING	126
7.9	CONDENSER AND EVAPORATOR COIL	126
7.10	AIR DUCTS AND DIFFUSERS	127
7.11	AIR FILTERS	127
7.12	EMERGENCY INVERTER.....	127
7.13	EARTH FAULT PROTECTION	128
7.14	DRIVER'S CAB AIR-CONDITIONING	128
7.15	UTO OPERATION	128
8.	LIGHTING SYSTEM	129
8.1	NOT USED	129
8.2	GENERAL	129
8.3	INTERIOR LIGHTING	129
8.4	EXTERIOR LIGHTING	131
8.5	UTO / ATO / RM ATO / UTO INDICATING LIGHT	134
8.6	UTO OPERATION	134
9.	AUXILIARY ELECTRICAL EQUIPMENT	135
9.1	NOT USED	135
9.2	GENERAL	135
9.3	AUXILIARY CONVERTER INVERTER	137
9.4	CIRCUIT REQUIREMENTS.....	139
9.5	EMERGENCY SUPPLY FEEDING.....	143
9.6	BATTERIES AND BATTERY CHARGERS	143
9.7	BATTERY BOX.....	145
9.8	BATTERY ISOLATION.....	146
9.9	EARTHING.....	146

1

9.10	RESCUE OPERATION	146
9.11	UTO OPERATION	147
10.	HIGH VOLTAGE & PROPULSION SYSTEM	148
10.1	NOT USED	148
10.2	GENERAL	148
10.3	HV POWER COLLECTION	149
10.4	HV PROTECTION & DISTRIBUTION	151
10.5	LIGHTNING ARRESTOR	152
10.6	25 KV POTENTIAL TRANSFORMER.....	153
10.7	AC CURRENT TRANSFORMER	153
10.8	MAIN TRANSFORMER	153
10.9	25 KV CABLE WITH HV BUSHING AND T-CONNECTOR	154
10.10	TRACTION EQUIPMENT	155
10.11	POWER CONVERTER- INVERTER.....	155
10.12	PROTECION AND DIAGNOSTICS	158
10.13	TRACTION MOTORS.....	160
10.14	NEUTRAL SECTION DETECTOR	162
10.15	DYNAMIC REGENERATIVE BRAKING SYSTEM	163
10.16	PROTECTION.....	163
10.17	ENERGY MEASUREMENT.....	164
10.18	CONTROL LOGIC AND DIAGNOSTICS	165
10.19	EMI AND EMC	166
10.20	UTO OPERATION	166
11.	BOGIE ASSEMBLY	167
11.1	NOT USED	167
11.2	GENERAL	167
11.3	DESIGN VALIDATION.....	168
11.4	SUSPENSION	169
11.5	DESIGN AND CONSTRUCTION.....	174
11.6	BOGIE FRAME	175
11.7	NOT USED	177
11.8	JOURNAL BEARINGS.....	177
11.9	WHEELS, WHEELSETS, AXLES AND AXLE-BOXES	177
11.10	WHEEL TRUING PROVISIONS	179
11.11	WHEEL FLANGE LUBRICATION (WFL)	179
11.12	OBSTACLE DEFLECTION, DETECTION AND DERAILMENT DETECTION (ODDD) SYSTEM	180
11.13	IDENTIFICATION.....	180
12.	PNEUMATIC AND BRAKE EQUIPMENT	181
12.1	NOT USED	181
12.2	GENERAL	181
12.3	COMPRESSED AIR SYSTEM.....	182
12.4	AIR COMPRESSOR	183
12.5	RESERVOIRS.....	185
12.6	FRICTION BRAKE.....	186
12.7	BRAKE CONTROL UNIT	188
12.8	PARKING BRAKE	189
12.9	PRESSURE GAUGES	190
12.10	TEST POINTS.....	190
12.11	AIR SUSPENSION EQUIPMENT	190
12.12	WHEEL SLIDE PROTECTION	191

1

12.13	ISOLATION OF DEFECTIVE EQUIPMENT	191
12.14	ROLLBACK PROTECTION.....	192
12.15	BRAKE CONTROL DURING TRAIN RESCUE OPERATION.....	192
12.16	FAILURE MANAGEMENT.....	192
12.17	JERK LIMITATION	193
12.18	BRAKE OPERATING TIMING	193
12.19	SIL LEVEL REQUIREMENTS:.....	193
12.20	BRAKE PIPE (BP) CONTROLLED BACK-UP BRAKE SYSTEM	193
12.21	UTO OPERATION	194
13.	COMMUNICATIONS	195
13.1	NOT USED	195
13.2	GENERAL	195
13.3	POWER SUPPLY	196
13.4	COMMUNICATIONS CONTROL HEAD (CCH)	196
13.5	TETRA RADIO SYSTEM	197
13.6	SILENT ALARM.....	197
13.7	PUBLIC INFORMATION SYSTEM.....	197
13.8	AUTOMATIC ANNOUNCEMENTS	201
13.9	OPERATOR'S DESK-TO-DESK COMMUNICATIONS	202
13.10	PASSENGER EMERGENCY COMMUNICATIONS	203
13.11	HEARING LOOP SYSTEM.....	203
13.12	NOT USED	204
13.13	VIDEO SURVEILLANCE SYSTEM (CCTV)	204
13.14	UTO OPERATION	206
14.	TRAIN CONTROL MANAGEMENT SYSTEM (TCMS).....	207
14.0	NOT USED	207
14.1	GENERAL	207
14.2	TCMS ARCHITECTURE.....	209
14.3	DATA ACQUISITION	211
14.4	CONTROL FEATURES	211
14.5	DRIVING CONSOLE INTERFACE.....	213
14.6	SELF-DIAGNOSTIC FEATURES.....	217
14.7	DIAGNOSTIC MONITORING SYSTEM (DMS).....	217
14.8	TROUBLESHOOTING DIRECTORY	219
14.9	MAINTENANCE TOOLS	220
14.10	RECORDING FEATURES.....	222
14.11	REAL TIME REMOTE-DIAGNOSTIC MANAGEMENT SYSTEM (RTR-DMS)	223
14.12	ENERGY CONSUMPTION MEASUREMENTS	227
14.13	~~NOT USED TCMS – OCC / DCC INTERFACE.....~~	~~229~~
14.14	TCMS SYSTEM INTEGRATION TEST LAB.....	229
14.15	ON-BOARD TRACK CONDITION MONITORING AND WARNING SYSTEM	230
15.	SYSTEM SUPPORT	232
15.1	NOT USED	232
15.2	CONTRACTOR'S RESPONSIBILITIES.....	232
15.3	SYSTEM MAINTENANCE PHILOSOPHY	232
15.4	NOT USED	233
15.5	SYSTEM TRAINING PHILOSOPHY	233
15.6	TRAINING PLAN	234
15.7	SUPPLY OF DIAGNOSTIC MAINTENANCE LAPTOPS	235
15.8	OPERATING RULE BOOK	235
15.9	OPERATING PROCEDURES MANUALS	235

15.10	OPERATING AND MAINTENANCE (O&M) MANUALS	236
15.11	OPERATING MANUALS & TECHNICAL DESCRIPTION BY OEM	237
15.12	MAINTENANCE MANUALS	238
15.13	TRAINING DOCUMENTATION	240
15.14	TRAINING DOCUMENT SUBMISSION	241
15.15	TRAINING FACILITIES	241
15.16	REQUIREMENTS OF TRAINING	241
15.17	PARTICULAR SCOPE OF SUPPLY	243
15.18	ENDEMIC FAILURES	243
15.19	OPERATION MANUAL	244
16.	MANAGEMENT PROGRAM	245
16.1	NOT USED	245
16.2	GENERAL	245
16.3	PROJECT MANAGEMENT PLAN	245
16.4	RESOURCING	245
16.5	COMMUNICATIONS	247
16.6	MASTER SCHEDULE	247
16.7	POST-AWARD CONFERENCE	249
16.8	PROGRESS REVIEWS AND REPORTS	250
16.9	SYSTEM INTEGRATION	251
16.10	INDUSTRIAL DESIGN	253
16.11	CONFIGURATION CONTROL	253
16.12	SUBMITTAL REQUIREMENTS AND APPROVAL PROCESS	256
16.13	DESIGN REVIEWS	257
16.14	WEIGHT CONTROL PROGRAM	261
16.15	CAR HISTORY BOOKS	261
16.16	INTERFACE WITH DESIGNATED CONTRACTORS AND OTHERS	262
16.17	PROJECT MANAGEMENT INFORMATION SYSTEM (PMIS)	263
17.	TEST PROGRAM	266
17.0	NOT USED	266
17.1	GENERAL	266
17.2	TEST PROGRAM	266
17.3	TEST PROCEDURES AND REPORTS	267
17.4	TEST CLASSIFICATION	268
17.5	DESIGN CONFORMANCE TESTING	268
17.6	PRODUCTION CONFORMANCE TESTING	281
17.7	CAR STATIC TESTS	283
17.8	POST-SHIPMENT ACCEPTANCE TESTING	285
17.9	INTEGRATED TESTING AND COMMISSIONING:	287
17.10	~~BURN-IN TRIALS / SERVICE TRIALS IN ATO GoA2~~ BURN-IN TRIALS / SERVICE TRIALS IN ATO (GoA2) & UTO (GoA4):	288
17.11	SUBMISSIONS FOR STATATORY APPROVALS:	289
18.	SYSTEMS ASSURANCE	293
18.1	NOT USED	293
18.2	SYSTEM ASSURANCE STANDARDS	293
18.3	SYSTEM ASSURANCE PROGRAM PLAN	293
18.4	SAFETY AND REGULATORY REQUIREMENTS	293
18.5	SYSTEM SAFETY	294
18.6	RELIABILITY PROGRAM	299
18.7	MAINTAINABILITY AND AVAILABILITY	302
18.8	QUALITY ASSURANCE PLAN	306

1

1

18.9	INSPECTIONS	308
18.10	MANUFACTURING PLAN.....	313
18.11	CALIBRATION.....	313
18.12	MANUFACTURING QUALITY RECORDS	313
18.13	SITE AND SITE MANAGEMENT	314
18.14	TRAFFIC, ROAD & APPURTENANCES	316
18.15	STORAGE, PACKING, CRATING AND MARKING	317
18.16	PUBLIC RELATIONS MATTERS AND PROGRESS PHOTOGRAPHS	318
19.	MATERIALS AND WORKMANSHIP	319
19.1	NOT USED.....	319
19.2	GENERAL	319
19.3	UNITS OF MEASURE.....	320
19.4	STORAGE OF MATERIAL	320
19.5	LOW-ALLOY, HIGH TENSILE STRENGTH STRUCTURAL STEEL	320
19.6	STAINLESS STEEL.....	320
19.7	STEEL CASTINGS	321
19.8	RIVET STEEL	321
19.9	HEAT-TREATED ALLOY STEEL	321
19.10	ALUMINIUM.....	322
19.11	NON-METALS	323
19.12	ELASTOMERS	324
19.13	GLASS	324
19.14	FIBERGLASS-REINFORCED PLASTIC.....	325
19.15	THERMOPLASTIC MATERIALS	326
19.16	PLASTIC / COMPOSITE BODY FILLER MATERIAL	327
19.17	NOT USED	327
19.18	SANDWICH PANELS	327
19.19	NEOPRENE FOAM.....	327
19.20	FLOOR COVERING.....	328
19.21	CAULKING AND SEALING.....	328
19.22	ADHESIVES.....	329
19.23	UPHOLSTERY FABRIC	329
19.24	FASTENING TO STRUCTURAL MEMBERS	329
19.25	THREADED FASTENERS.....	330
19.26	RIVETS AND RIVETING.....	331
19.27	CORROSION CONTROL	332
19.28	PAINT AND PRIMER.....	333
19.29	WELDING	334
19.30	BRAZING	337
19.31	SOLDERING	337
19.32	PIPING, TUBING AND PRESSURE VESSELS	337
19.33	BEARINGS AND LUBRICATION.....	339
19.34	THERMAL AND ACOUSTIC INSULATION	340
19.35	WIRING GENERAL REQUIREMENTS	340
19.36	CONDUCTORS.....	341
19.37	APPLICATION AND INSTALLATION.....	342
19.38	WIRE AND CABLE INSULATION.....	342
19.39	GENERAL PURPOSE CABLE AND WIRE	343
19.40	HIGH VOLTAGE POWER CABLES	343
19.41	CABLE CONNECTORS	343
19.42	TERMINALS	344

19.43	HIGH-TEMPERATURE WIRE AND CABLE	344
19.44	COMMUNICATIONS WIRE AND CABLE	344
19.45	UNDERCAR AND ROOF WIRING INSTALLATION	345
19.46	CONDUIT AND CABLE DUCTS REQUIREMENTS	345
19.47	CLEATING	346
19.48	JUNCTION BOXES AND FITTINGS	346
19.49	SPLICING AND TAPING	346
19.50	MOTOR STARTERS (if used)	346
19.51	CIRCUIT PROTECTION	347
19.52	RELAYS AND CONTACTORS	348
19.53	PUSHBUTTON SWITCHES AND INDICATORS	349
19.54	ELECTRONIC COMPONENTS	349
19.55	PRINTED CIRCUIT BOARDS	350
19.56	SEMICONDUCTOR / INTEGRATED CIRCUITS REQUIREMENTS	350
19.57	MICROPROCESSOR-BASED SYSTEM REQUIREMENTS	351
19.58	NOT USED	351
19.59	GROUNDING	351
19.60	WIRE AND TERMINAL MARKING	352
19.61	FLAMMABILITY AND SMOKE EMISSION.....	352
20.	SOFTWARE MANAGEMENT REQUIREMENTS	356
20.1	NOT USED	356
20.2	INTRODUCTION	356
20.3	TRANSPORTATION SYSTEM SOFTWARE	358
20.4	SOFTWARE GENERAL REQUIREMENTS	358
20.5	ORGANISATIONAL REQUIREMENTS	362
20.6	TECHNICAL REQUIREMENTS	362
20.7	DOCUMENTATION TO SUBMIT:	368
	APPENDIX A1: DETAILED SOFTWARE DEVELOPMENT V-CYCLE	369
	Appendix A2: DESCRIPTION OF THE SOFTWARE DEVELOPMENT PHASES	370
21.	ASSET MAINTENANCE MANAGEMENT SYSTEM (AMMS)	374
21.1	GENERAL	374
21.2	SCOPE OF WORK	375
21.3	MAINTENANCE MANAGEMENT SYSTEM.....	376
21.4	OTHER REQUIREMENTS OF AMMS.....	380
21.5	MATERIAL MANAGEMENT SYSTEM.....	383
21.6	REPORTS, ANALYSIS AND KPIS	385
21.7	USER ADMINISTRATION	387
21.8	PROJECT MANAGEMENT	387
21.9	SYSTEM ACCEPTANCE CRITERIA	388
21.10	GO-LIVE.....	389
21.11	TRAINING	390
	APPENDIX A: ABBREVIATIONS.....	391
A.1	GENERAL	391
	APPENDIX B: INTERNATIONAL STANDARDS.....	398
1	GENERAL	398
	Appendix C – INTERFACE.....	415
1	INTRODUCTION	415
2	SIGNALLING & TRAIN CONTROL CONTRACT:	416
3	TELECOMMUNICATION RADIO CONTRACT (TETRA):	455
4	PLATFORM SCREEN DOORS (PSD):	465

1

5	RAILWAY ELECTRIFICATION, POWER SUPPLY CONTRACTORS.....	471
6	TRACK CONTRACTORS.....	476
7	DETAILED DESIGN CONSULTANTS - VIADUCT.....	481
8	DETAILED DESIGN CONSULTANTS - TUNNEL.....	483
9	DETAILED DESIGN CONSULTANTS - UNDERGROUND.....	485
10	DETAILED DESIGN CONSULTANTS - DEPOT.....	487
11	~~NOT USED DEPOT MACHINERY AND PLANT (DM&P) CONTRACTOR.....~~	~~489~~
12	TUNNEL VENTILATION SYSTEM.....	494
13	OTHER DESIGNATED CONTRACTOR.....	496
14	OTHER ROLLING STOCK CONTRACTOR.....	497
	APPENDIX D – GUIDELINES AND DRAWINGS.....	499
	APPENDIX E : SUPPLY OF SPARES & SPECIAL TOOLS.....	500
1.1	GENERAL.....	500
1.2	UNIT EXCHANGE SPARES.....	500
1.3	CONSUMABLE SPARES.....	500
1.4	MANDATORY SPARES.....	501
1.5	RECOMMENDED SPARES.....	502
1.6	OVERHAULING SPARES.....	502
1.7	SPECIAL TOOLS, TESTING AND DIAGNOSTIC EQUIPMENT:.....	502
1.8	SPECIAL JIGS, FIXTURES AND GAUGES.....	503
1.9	MANUFACTURE, DELIVERY AND WARRANTY.....	504
1.10	PURCHASE OF SPARES FROM VENDORS.....	504
1.11	LIST OF SPARES.....	505
	APPENDIX G : DOCUMENTATION & DRAWING REQUIREMENTS.....	506
1.1	INTRODUCTION.....	506
1.2	GENERAL REQUIREMENTS.....	507
1.3	COMPUTER AIDED DESIGN & DRAUGHTING (CADD) STANDARDS.....	508
	APPENDIX H - DELIVERABLES LIST.....	512
1.1	General.....	512
1.2	TABLE - 1: DELIVERABLES MILESTONE.....	513
1.3	TABLE - 2: DELIVERABLES LIST.....	532
	APPENDIX – I: TRAIN WITHDRAWAL SCENARIOS FOR 6 CAR TRAIN.....	554

REVISION HISTORY

R. No	Section	Description
0	ALL	Version published in CPP
1	Section – VI A & Section – VI B	As per Addendum No.1 <u>Section – VI A:</u> 1.1.1, 1.3.2, 1.3.4, 1.3.8, 1.3.9, 1.4.2, 1.4.3, 1.4.4, 1.4.8 (b), 2.2.10, 2.2.11, 2.2.12, 2.2.13, 2.2.25, 2.2.29, 2.7.3.ii., 2.7.3.iii., 2.7.4, 2.9.6, 2.13.1 (e) , 2.14.1 (e) , 2.14.3.5, 2.14.3.6, 2.14.3.9, 2.15.1.3 , 2.15.7.3, 2.15.8.19, 2.15.8.20, 2.15.9.2, 2.15.9.3, 2.15.10.8, 2.15.10.14, 2.16.4.2, 2.16.5.1, 2.16.5.3, 2.16.5.5, 2.21.3, 2.24.2, 2.25.2, 2.25.10(i), 2.25.10 (vii), 2.25.11 (a) (iii), 2.26.1, 2.26.5.2 (a), 2.26.5.2 (d), 2.26.5.2 (i), 2.26.5.4, 2.26.5.7, 2.26.5.8, 2.28, 3.4.3.5, 3.4.3.6, 3.4.3.7, 3.4.3.8, 3.4.9.3.4, 3.4.9.4.6, 3.4.9.4.7, 3.6.1.23 , 3.6.3.6, 3.6.5.1, 3.12.3, 3.14.10.1 (i) & (ii), 3.14.10.2 (a), 4.2, 4.2.1, 4.2.2, 4.2.7, 4.2.8, 4.2.9, 4.2.16, 4.3.2.2, 4.3.2.4, 4.3.3.1, 4.4.2.2, 4.4.3, 4.4.3.1, 4.4.3.2, 4.6.3, 4.6.5, 4.9, 5.2, 5.3.1, 5.3.5, 5.3.6, 5.3.8, 5.4, 5.4.1 (d) (vii), 5.4.1 (d) (ix), 5.4.1 (e) (i), 5.4.1 (e) (xi), 5.4.1 (e) (xv), 5.4.1 (f) (i), 5.4.1 (f) (vii), 5.4.1 (g) (iii), 5.4.1 (g) (vi), 5.4.5, 5.4.6, 5.4.7, 5.5.2, 5.5.3, 5.5.6, 5.5.7 (g) , 5.5.8, 5.5.9, 5.5.13, 5.5.14, 5.6, 5.6.1, 5.6.5, 5.10.5, 5.11.1 (d), 5.12.5, 5.14, 5.15, 5.15.1, 5.16, 6.2.2, 6.2.13, 6.2.14, 6.3.14, 6.4.2, 6.4.3, 6.4.7.2, 6.4.7.4, 6.5.13 (b), 6.5.9 (b), 6.5.17, 6.6.4, 6.6.5, 6.6.6, 6.7.1.2, 6.7.1.6, 6.7.1.8, 6.7.2.3, 6.7.2.8, 6.8.2, 6.8.6, 6.8.9, 6.1, 6.11, 7.4.5.9, 7.4.6.1, 7.4.8.1, 7.4.8.4, 7.4.8.6, 7.6.2 (g), 7.7.1, 7.7.3, 7.7.4, 7.7.16, 7.7.21, 7.12.2, 7.15, 8.3.1.22 , 8.3.1.23, 8.3.2.1, 8.4.1.8, 8.4.1.13, 8.4.1.23, 8.4.1, 8.4.2.1, 8.4.3.3 (ii) (b), 8.4.3.3 (ii) (d), 8.4.4.2 (b), 8.4.4.2 (c), 8.4.4.2 (e), 8.5, 8.6, 9.2.3, 9.2.5, 9.2.13, 9.2.20, 9.3.9, 9.3.12, 9.3.14, 9.4.2, 9.4.5 (e), 9.4.7, 9.4.9 (d) , 9.4.9 (e) , 9.4.9 (f) , 9.4.10, 9.5.4, 9.6.3, 9.6.16, 9.7.1, 9.10.2, 9.11, 10.2.6, 10.2.12, 10.2.23, 10.2.24, 10.3.4, 10.3.5, 10.3.12, 10.3.14, 10.3.15, 10.4.4, 10.5.4, 10.8.9, 10.10.10, 10.11.6, 10.11.10, 10.12.3, 10.12.4, 10.12.5, 10.12.10, 10.14.1, 10.14.3, 10.14.7, 10.15.2.3, 10.16.7, 10.18.1.5, 10.18.3.4, 10.19.2.2, 10.2, 11.2.9, 11.9.2, 11.4.11 (g), 12.4.6, 12.4.12, 12.4.13.8, 12.5.1, 12.6.7, 12.6.8.6, 12.6.8.11, 12.6.8.13, 12.6.9.14, 12.7.8, 12.8.3, 12.8.8, 12.9.2, 12.12.3 f), 12.13.2, 12.14.3, 12.15.5, 12.16.1, 12.21, 13.2.3 f), 13.2.10, 13.4.7, 13.7, 13.7.1.5, 13.7.1.14.7, 13.7.1.15.3, 13.7.1.16.6, 13.7.2.4, 13.7.2.10, 13.8.2, 13.8.5, 13.8.15, 13.8.16.2, 13.8.16.3, 13.10.1, 13.10.2, 13.10.3, 13.10.5, 13.10.9, 13.10.11, 13.10.12, 13.10.13, 13.13.5, 13.13.7, 13.13.8, 13.13.9, 13.14, 14.1.1.5, 14.1.5 (a), 14.1.6, 14.1.7, 14.1.10, 14.2.6, 14.3.1, 14.3.2, 14.3.5, 14.4.4, 14.4.5, 14.4.8, 14.4.9, 14.4.10, 14.5.2, 14.5.2 (t), 14.5.2 (q), 14.5.2 (ff), 14.5.3.2 (b), 14.5.3.4 (a), 14.6.3.2, 14.7.1.3, 14.7.1.4, 14.7.2.1, 14.7.2.3, 14.7.2.4, 14.7.5, 14.7.6, 14.7.8, 14.8.1.1, 14.8.1.2, 14.10.1, 14.10.4.1, 14.10.6.1, 14.11.1, 14.11.2, 14.11.10, 14.12.1.2 (c) , 14.12.2 (b), 14.13, 15.3.5 , 15.3.5, 15.8.6, 15.8.7, 15.9.5, 15.16.4, 15.19.1, 15.19.2, 15.19.5, 16.2.2, 16.3.2 (f), 16.17, 17.5.2.3.3 (a), 17.5.2.8, 17.5.2.9, 17.5.3.6.1, 17.5.4.8.6, 17.5.4.8.8, 17.5.4.8.10, 17.5.4.8.20, 17.5.4.8.22, 17.9.5, 17.9.5 (a), 17.9.5 (d), 17.9.5 (l), 17.9.8, 17.1, 17.10.1, 17.10.2, 17.10.4, 17.10.5, 17.10.7, 17.11.1, 17.11, 18.5.2.1 , 18.6.6.1 Table 18-2, 18.13.2.1, 19.13.3 (i), 19.40.2, 19.52.9, 20.6.5.2, 20.6.6.6, 20.7, 21.1.1, 21.1.3, 21.2.5, 21.2.7, 21.4.55 , 21.9.2 (v) (c) , Appendix C, Appendix D, Appendix H, Appendix – I. <u>Section – VI B:</u> 1.19 - Subcontractors / Manufacturers, 1.1.3, 1.2, 1.19, 1.19, 2.2.1, 2.2.4.1, 2.5.2, 2.5.4.3, 2.5.5.1, 2.12, 2.13, 2.15.2.2, 2.16.2.6 (b).
	Section – VI A & Section – VI B	As per Addendum No.2: <u>Section – VI A:</u> 2.15.8.18, 2.24.3, 3.14.5.6, 9.2.1, 9.3.14, 9.5.1, 10.3.2, 10.3.14, 10.8.2 (c), 13.7.1.16, 14.7.1.3 (d), 17.5.4.4 (c), 17.5.4.5, 17.5.4.6, 17.5.4.7, 17.5.4.8.1, 17.5.4.8.5, 17.5.4.8.11 (a), 17.5.4.8.11 (b), 17.5.4.8.12 (a), 17.5.4.8.15, 17.8.1 (b), 17.8.5, 20.4.6, Appendix C - Chapter 11, Appendix H, Appendix – I.

		<u>Section – VI B:</u> 2.5.2, Table 3-1: DM&P Contractor & RS Contractor, Table 3-3 : DM&P Contractor and E&M/ MEP Contractor
2	Section – VI A	As per Addendum No.3: <u>Section – VI A:</u> 2.2.27, 2.13.3 e) and f), 2.14.2.4, 2.14.2.5, 2.15.4.2, 2.15.9.2, 2.15.9.7, 2.15.9.8, 2.25.11 c) i., 3.2.1.4, 3.4.7.1, 3.6.1.22, 4.4.2.2, 4.4.4.2, 5.2.8, 7.3.2, 7.3.10, 7.3.20, 7.4.1, 9.2.2, 10.11.1, 11.4.10 (e) , 11.4.11 (a) , 11.4.18.1, 11.4.18.3 (c) , 11.4.23 (a), 11.4.23 (b), 11.9.1, 11.11.6, 11.12.4, 12.3.12, 12.5.2, 12.13.6, 13.13.3, 13.13.6, 14.11.1 (b), 14.11.1 (d), 14.11.1 (j), 14.11.10 (b), 14.15, 17.5.2.5 b), 17.5.2.10.9, 17.10.8, 18.6.5.6, 19.32.6, 19.38.12, 19.44.3, 19.55.1, 19.55.2, Appendix C - 2.4.41, 2.9.7, 2.13.2, 6.4.3, Appendix I – S.No. 11

1. SYSTEM DESCRIPTION

1.1. CITED REFERENCES

- 1.1.1. The Contractor shall design, manufacture, and test Rolling Stock using the "INTERNATIONAL STANDARDS" listed in Appendix B. Any deviation from standards mentioned in ERTS must first be approved by CMRL.

Acceptable design standards for this contract are International Standards (UIC), IEC standards, European Standards (EN), British Standards (BS), Japanese Standards (JIS), French Standards, American Standards and Bureau of Indian Standards (BIS). Any other standards the Contractor wishes to substitute must first be confirmed and approved by CMRL. All the standards used shall be latest issued revisions ~~(as on last date of Bid submission).~~

Note: Any other equivalent standards mentioned in Appendix B or additional standards as proposed by the Contractor may be followed subject to approval of CMRL. All the standards used shall be latest issued revisions.

1.2. REFERENCED DOCUMENTS

- 1.2.1. The design and construction of the Electric Multiple Units (EMU) metro rail cars shall comply with the Rights of Persons with Disabilities Act, 2016.
- 1.2.2. The Contractor shall be responsible for ensuring that all materials, documents, and other parts of the Work supplied to the Contractor by subcontractors or other suppliers meets relevant requirements cited for them in these Provisions.
- 1.2.3. The Contractor shall submit to CMRL at the proposal stage a list of standards cited in these Provisions for which the Contractor desires to substitute another equivalent or internationally recognized standard. The decision of CMRL to approve or reject such substitutions shall be final.
- 1.2.4. When assessing acceptability of the Contractor proposed equivalent standard, CMRL will review on a case-by-case basis and will not unreasonably withhold acceptance of any alternative standard that is in general use in the transit agencies or railroads for similar applications that have a successful history of operation.

1.3. GENERAL DESCRIPTION OF SYSTEM

- 1.3.1. The CMRL Metro Phase 1 Project will be approximately 54.1 km long, operating within two corridors i.e.,
- Corridor 1 from Airport to Washermanpet of 23.08 km.
 - Corridor 2 from Chennai Central to St. Thomas Mount of 21.96 km,
 - Corridor 1 Extension from Washermanpet to Wimco Nagar Depot of 9.05 km.
 - The route will be approximately 31 km elevated and 23 km underground.
 - Corridor 1 & Corridor 2 will be extended. Hence, Rolling Stock shall be compatible for such extensions in all aspects (Design, Operations, etc.,)
- 1.3.2. The rake configuration of 6-car Trainsets referred to throughout the tender documents are formed of *DMC + TC + MC + MC + TC + DMC* car configuration in order to achieve 67% propulsion. The rake consists of two units, Unit 1 : *DMC1 + TC1 + MC1 and Unit 2 : *DMC2 + TC2 + MC2. The Trainset shall operate in ~~Grade of Automation 2 (GoA2) / Automatic Train Operation (ATO)~~ Grade of Automation 4 (GoA4) / Unattended Train Operation (UTO).
- 1.3.3. Not used.
- 1.3.4. ~~Underground stations will be~~ are equipped with Full Platform Screen Doors (PSD) and elevated stations will be equipped with half-height Platform Screen Doors (PSD).
- 1.3.5. Each station will be provided with Smart Card / NCMC / QR / Bio-Metric / any latest better

Automatic Fare Collection system with vending machines. The system will operate under a “proof of payment” regime.

1.3.6. The Complete network will be electrified at 25 kV AC 1 ϕ , 50 Hz with auto tensioned Overhead Flexible catenary & contact wire system and overhead rigid catenary system. This overhead catenary system shall be available in elevated, underground, and at-grade system.

1.3.7. Not used.

1.3.8. This specification establishes requirements for the design, development, manufacture, supply, testing, delivery, commissioning and integrated testing of fully furnished modern passenger cars with microprocessor controlled 3 ϕ AC asynchronous motor or latest better motor technology with variable voltage and variable frequency (VVVF) drive Control and suitable for ATO conforming to GoA2 and UTO conforming to GoA4 as specified in IEC 62290 (all parts of latest version), including the training of personnel authorized by CMRL. ~~The trains shall be able to operate in GoA2 GoA4 immediately after commissioning and from the initial stage of passenger operations.~~

Unattended Train Operation (UTO) shall be the predominant mode of train operation. In case if CMRL does not engage UTO for any reason, at any stage of passenger operation or non passenger operation, the Operator will deploy staff to drive the train under ATO or Manual Mode (under ATP). The cars required for the various Lines shall be delivered and commissioned by the Contractor at one or more of Designated Depot(s) as allocated by CMRL.

During the initial phase of the project the trains are planned to be operated in Automatic Train Operation (ATO). The trains shall be able to operate in GoA2 immediately after commissioning and during the initial stage of passenger operations.

Integrated test related to GoA4 mode of operation: Within a period of two years from the date of introduction of 1st Trainset into the revenue operation in GoA2 mode / TOC, the contractor shall complete the integrated tests and trials under the above clause applicable to GoA4 mode of operation under interface with the signalling and PSD contractors to the satisfaction of the Employer.

The at-grade, underground and elevated sections as well as the track at Koyambedu Depot will all have ballast-less track. The cars shall be designed to meet the performance requirement given in clause 2.14 of this specification. The track gauge is 1435 mm.

~~During the initial phase of the project the trains are planned to be operated in Automatic Train Operation (ATO) shall be the predominant mode of train operation. In case if CMRL does not engage ATO for any reason, at any stage of passenger operation or non-passenger operation, the Train Operator will deploy staff to drive the train under Manual Mode (under ATP). After the upgradation made by Signalling Contractor the trains will be operated in GoA3 & GoA4.~~

The System shall also include the following requirements:

- (i) To provide all the documentation and support material associated with the operation and maintenance of the cars as specified in the tender document for all the corridors.
- (ii) Ongoing technical support throughout the Defect Notification Period (DNP).
- (iii) Interfacing with any other Designated the Contractors of CMRL who have any type of interface with this Rolling stock contract.
- (iv) Training of CMRL personnel, operations & maintenance staff, providing the training materials, training kits and demonstration of the system during training.
- (v) Supply and installation of all consumables and materials required for testing, commissioning, maintenance & operation.
- (vi) To provide final drawings, design calculations and other documents including operations and maintenance manuals for review and acceptance by CMRL.
- (vii) To provide supporting information such as 3-D design models, scale models, studies and reports including samples for design development items.
- (viii) Preparation of documents for obtaining approvals by CMRL from the appropriate statutory authorities.

The scope of work includes all items of work which may be required to meet the performance requirements, trouble free and efficient operation of trains and meeting the best international practices even if not specifically mentioned in the specifications.

1.3.9. Localisation:

- 1.3.9.1. To facilitate ease in maintenance and easy availability of spares, the Employer is keen in standardization and the Contractor shall source maximum number of equipment and materials from India which have already been indigenized and used in other Metro Projects. Contractor shall preferably choose their partners in India for manufacturing of such items from the list below:

Table – 1.3.9.1

Sl. No.	Item Description
1	HVAC
2	Ni-Cd Battery
3	Battery Box
4	Axle Bearing
5	Axle Box with earth return brush
6	Gear-drive
7	Air Reservoir
8	All type of Glasses
9	Electrical Panel & Distribution Board
10	Coupler
11	Pantograph with base insulators and its control panel
12	Vacuum Circuit Breaker
13	Bogie Frame
14	Pneumatic Piping – Stainless Steel
15	Stainless Steel Passenger Seats
16	Gangways
17	Stainless Steel- All Type
18	Transformer
19	HV Cable and Surge Arrestor
20	Wheel Flange Lubricator

The items given in Table 1A below are also recommended to be sourced locally to meet the required performance and quality standards as per Tender conditions for ease in maintenance and easy availability of spares during the operations and Maintenance.

Contractor is recommended to choose their partner in India to source all such items that are listed in Table 1A. The Contractor or the respective OEMs (as the case may be) shall arrange granting of unqualified licenses to their chosen Indian partners to manufacture/sell and provide all types of after sales services for such items. In case these items are sourced from the Countries outside India, the Contractor shall have after sale services including manufacturing/sale in India or shall choose an Indian Partner for the same.

During vendor approval stage, the Contractor shall also submit a commitment from the approved vendors that in case of any future procurement action by Employer, they shall quote directly to

Employer.

Contractor to submit comprehensive proposal indicating details of the Indian Partner(s), the place of manufacture/sale in India, work schedule, etc. or alternatively the details of after sales services in India by respective OEMs/Indian Partners for the identified items to be sourced locally, at the time of vendor approval. Maintaining quality standards, ensuring performance requirements and timely delivery shall be the sole responsibility of the contractor.

Contractor to make earnest effort to incorporate such locally sourced items in his train manufacturing schedule at the earliest. The details to be finalized during design/vendor approval stage.

Table 1A: Recommended Items to be sourced locally:

Sl. No.	Item Description
1	Auxiliary Converter Inverter
2	Saloon Door (Door Leaf and Door Operating Mechanism without Electronic Controller)
3	Luminaries (Saloon Light)
4	LED Head Light
5	Entire Pneumatic Brake System except Brake Electronics and Air Supply System
6	Radial Arm
7	Brake Blocks
8	Consumables: Lubricants, Sealants, Oils, Greases, etc.
9	Traction Motor
10	Traction Converter Inverter
11	Bogie Damper
12	Wiper Assembly

Table 1B: Recommended items for further Indigenization:

Sl. No.	Description of Items
1	Floor cover
2	Floor Board
3	Brake Electronics
4	Auxiliary Motors
5	Bearings (other than Axle Bearings)
6	Primary & Secondary springs
7	PCBs used in different equipment.
8	Public Address (P/A) / Public Information System (PIS)
9	CCTV System
10	Electronic Door Control Unit (EDCU)

1.4. OPERATIONS

- 1.4.1. CMRL plans to operate 365 days a year, from approximately 4.00 Hrs to 00.00 Hrs Monday through Sunday during the complete fleet operation conditions.
- 1 1.4.2. Rakes will operate in revenue service in as 6 car trainsets. ~~initially and shall be increased to 6 car trainsets later in case of increased passenger patronage.~~ Under normal operating conditions, trains may be coupled and uncoupled during maintenance and in rescue modes.
- 1.4.3. ~~During the initial phase of the operational requirement, rakes have to be operated in GoA2 (ATO) / GoA1 (ATP). However, the Phase 1 project is planned for the upgradation of the Signalling System to GoA3 & GoA4 operations.~~
- 1 Based on operational requirement, rakes may have to be operated in GoA2 mode with driver / in GoA3 mode with attendant / in GoA4 (UTO). However, the rakes are planned with operations in GoA2 (ATO) during the initial passenger service and subsequently in GoA4 (UTO).
- 1.4.4. The maximum allowable operating speed of the vehicles shall be 80 kmph. The maximum design speed of the train shall be 90 kmph. Minimum headway shall be ~~120 seconds~~ 90 seconds to satisfy normal peak ridership in UTO. ~~However, Rolling Stock contractor shall ensure that when the upgradation of the Signalling System to GoA3 & GoA4 system the minimum headway shall be 90 seconds to satisfy normal peak ridership.~~ However, Minimum headway shall be 120 seconds to satisfy normal peak ridership during the initial stage of passenger operations in GoA2 (ATO).
- 1 1.4.5. During the complete fleet operation conditions of this project, the trains may travel an average of 1,50,000 km per year.
- Operating Schedule Speed : The minimum average Round-trip Operating Schedule Speed shall be 34 kmph.
- Declared Schedule Speed (DSSP) : The Contractor shall propose DSSP values (in Kmph) for each load condition during the design stage. DSSP values for load conditions up to AW3 shall be greater than or equal to 34 kmph and shall meet the requirements defined in Clause 2.14.1.
- 1.4.6. The rakes shall include ventilation and air conditioning systems, rake's one emergency door on each car on each side and shall be appropriately labelled as an emergency exit. The vehicles shall also include on-board CCTV cameras and external CCTV cameras for security and emergency doorways monitoring, etc.
- 1.4.7. The corridor-1 and corridor-2 are currently under passenger revenue operation. The Contractor shall plan, coordinate, and execute all activities of the Works so as to avoid any interference with the existing train operations and the Employer's ongoing maintenance activities within the section. The Employer's Operations & Maintenance (O&M) activities shall be given preference at all times, and the Contractor shall adjust its work schedule and methodology as required by the Employer.
- 1.4.8. The operating modes are defined as follows:
- a) Normal Mode: The train shall achieve the required Operating Schedule Speed whilst driving under normal Tractive / Braking Effort characteristics with a minimum 8% of coasting and keep to timetable factoring the defined dwell times (excluding turnaround time at terminal stations). Brake blending shall utilise regenerative braking to the most extent possible. Normal mode will be used when trains are running on time and the timetable can be maintained.
 - b) All-out Mode: Shall be the same as normal mode except that there shall be no coasting in order to exceed the Operating Schedule Speed. All-out mode will be used to make up time when trains are running late.
- 1 When the train is in UTO / ATO mode, the train will get appropriate commands from Signalling system.

1.5. DESCRIPTION OF WORK

- 1.5.1. This specified work includes the Design, Development, Manufacture, Supply, Delivery, Testing & Commissioning, Integrated testing, Training of operating & maintenance staff of CMRL of modern Metro passenger cars and Depot Machinery & Plant.
- 1.5.2. The Scope also covers supply of spares, special tools, testing and diagnostics equipment, jigs and fixture etc., for maintenance, repair and overhaul of cars.
- 1.5.3. The trains shall initially be operated in 'GoA1 & GoA2', and subsequently in 'GoA3 & GoA4' mode of operation conforming to Grade of Automation-GoA4 as specified in IEC62290 all parts (latest version).

1.6. SUSTAINABILITY

- 1.6.1. The Contractor shall apply the highest standards for application of sustainability (with proven design) in the design and construction of the trains to effect overall life-cycle cost savings and environmental benefits. Life-cycle analysis shall be conducted and used for rationalizing all sustainability inputs. Sustainability consideration will provide heavy emphasis on delivering energy efficiency of system and subsystems, energy conservation and regenerative braking, potential and kinetic energy conservation systems and light weightiness to effect reduced traction power energy consumption.

1.7. CARBON CREDITS

- 1.7.1. The Contractor shall assist CMRL in obtaining Carbon Credits by providing necessary documentation to support the amount of power / energy saved by utilizing regenerative braking and other energy efficiency features used in train.

2. SYSTEM REQUIREMENTS

2.1 NOT USED

2.2 GENERAL REQUIREMENTS

- 2.2.1 This chapter establishes the performance, environmental, and design criteria for the Trainset. Included are dimensional, environmental, weight, ride quality, performance, acoustical, and electrical noise requirements, etc.
- 2.2.2 This rake as constructed, manufactured, assembled, and delivered shall fully conform to all provisions of those requirements unless otherwise specified in these provisions and shall be furnished with components, materials, equipment, and systems that comply fully with those requirements.
- 2.2.3 The Contractor shall provide for each car an on-board emergency equipment list. The Contractor shall propose a suitable enclosure and mounting location for such equipment for CMRL approval.
- 2.2.4 Any one car of each 6 car Trainset shall be exclusively dedicated for lady passengers. The design related amenities for this car shall be finalized during design stage.
- 2.2.5 The Contractor shall install passenger emergency instructions in each car with additional spare supply of adequate signage to CMRL. The Contractor shall submit a proposal detailing the appearance and location of each passenger emergency information sign or decal for CMRL approval.
- 2.2.6 One wheelchair parking area shall be available in each driver car of the 6 car Trainset. At least four seats shall be available for the elderly and differently abled passengers in each car.
- 2.2.7 The rake shall consist of a 6 car Trainset from initial revenue operation.
- 2.2.8 The rake shall be a high-floor design, with level boarding from platforms. Wheelchair and mobility-impaired boarding shall not require the use of bridging or lifting devices. The horizontal gap between the passenger door thresholds and platform edge and vertical gap between the passenger door thresholds and platform edge details are mentioned in SOD (Clause 2.7.1). In no cases (including the worst operating conditions) shall the top surface of the horizontal threshold of the car be lower than the top edge of the platform.
- 2.2.9 Trainsets shall be operated bi-directionally and shall have equal performance in either direction. The details of the emergency operator desk details explained in chapter 5.
- 1 2.2.10 The Contractor is advised that full platform screen doors (PSD) ~~will be~~ are installed on all platforms of underground stations and Half height Platform Screen Doors (PSD) ~~will be installed in Elevated Stations~~. The Contractor shall coordinate with Designated Contractor to provide the necessary interface information to the PSD Contractor for the proper working design, installation and operation of the PSDs. Additional information is provided in clause 6.2.4
- 2.2.11 Prototype Train Program
- Following the successful completion of all design review activities the Contractor shall begin production of a Prototype Train, which shall consist of the manufacture of two Diving Motor Cars, two Trailer Cars and two Motor Cars, which will make up a 6 car trainset. Upon delivery, these 6 cars shall then constitute the Prototype Train. The Prototype Train shall be considered a "proof of design" first article after being exercised in test and simulated revenue service, and the adequacy of all aspects of the design and manufacturing activities have been substantiated. The Prototype Train program shall be conducted in three phases:
- (i) Phase 1 - The first 6 car trainset shall precede all other cars in production and shall be considered the Prototype Train. Components and cars shall be tested according to the requirements in Chapter 17, as applicable. Components and cars shall also be offered for First Article Inspection as specified in Chapter 17 at the supplier's facility or the Contractor's facility. All adjustments and/or changes required shall be completed prior to shipment to CMRL's facility.

- (ii) Phase 2 - Upon arrival at CMRL premises, the Prototype cars shall be on-site qualification tested for required functional characteristics as per Chapter 17.

1

- (iii) Phase 3 - When the on-site delivery testing requirements have been satisfied, the ~~three~~ six Prototype cars shall be united to form a Prototype Train. The Prototype Train shall then undergo operational testing as required in Chapter 17 followed by proof of performance testing as 6 car trainset. This shall include all specified system interface testing on CMRL's property.

Any adjustments / changes found necessary during the Prototype Train program are properly documented and incorporated into the following production cars configuration at no additional charge, unless approved by the CMRL. It is intended that except where otherwise approved or required by CMRL, the Prototype Cars' manufacturing quality level after the completion of all required modifications shall be the standard for all following cars.

- 2.2.12 Automatic coupler with ~~mechanical and pneumatic head~~ mechanical, pneumatic and electrical head shall be provided at the front end of each DMC cab. For the intermittent coupling, semi-permanent couplers shall be provided between the cars. Both automatic and semi-permanent couplers shall comply the requirements specified in Chapter 04. Semi-permanent mechanical, pneumatic and jumper cables shall be used between the DMC & TC, TC & MC and MC & MC for the 6 car consist configuration shown below.

1

6 car rake: *DMC + TC + MC + MC + TC + DMC* (67% Traction power)

Notes:

- The symbol * denotes a ~~semi-automatic coupler~~ fully automatic coupler (with electrical head).
- The symbol + denotes a semi-permanent coupler.
- DMC denotes Driving Motor Car
- TC denotes Trailer car (with pantographs)
- MC denotes Motor Car

1

- 2.2.13 Cars shall be equipped to operate normally as a single rake. Trainsets shall be equipped for emergency towing operation ~~without any manual intervention for coupling or any purpose~~.

- 2.2.14 The rake shall be designed and manufactured to operate successfully within the environments of CMRL's dedicated right-of-way.

- 2.2.15 The saloon of each car shall have a total of eight (8) Dynamic Route Map Display (DRMD) screens. Displays shall be provided above the doors, facing towards the Centre line of the car. These shall show direction of travel, current location of the rake and next station, and any other important information in Tamil and English. Additionally, six (6) displays per Car shall be provided for advertisement purposes.

- 2.2.16 The cars shall include a Public Address System, Interior and Exterior Passenger Information Displays, Cab-to-Cab Communications, Passenger Emergency Intercoms, Diagnostic Monitoring System, Event Recorder, Video Surveillance and CCTV, as described in Chapter 13.

- 2.2.17 Environmental conditions for the equipment on board the cars shall conform to EN 50125-1.

- 2.2.18 The cars shall be air-conditioned with two identical roof-mounted air-conditioning units in each car, as described in Chapter 7.

- 2.2.19 Electronic equipment shall be designed, constructed and tested in accordance with EN 50155.

- 2.2.20 When fully mated, the connectors for internal use (i.e., fitted within the car body) shall achieve a seal rated to at least IP53 in accordance with IEC 60529 if the sealing is not provided by the cabinet or similar. Connectors fitted externally to the Car body shall achieve a seal rated to at least IP65.

- 2.2.21 It shall be demonstrated that all electronic equipment shall be immune to surge and transients typically expected in the Rolling Stock environment in accordance with EN 50155.

- 2.2.22 The main electrical protection of the Traction Power Supply to each car shall comply with the requirements of IEC 60077. The inductors used shall comply with the requirements of IEC 60310

(2004) or latest.

2.2.23 The complete brake system shall be of similar performance to UIC 544-1, EN 13452-1 and EN 13452-2.

2.2.24 Rolling stock and all its sub-systems functions must meet all the criteria defined in Chapter 14.

2.2.25 The Contractor shall identify and implement any design and/or interface Works required to ensure the ARE01 Rolling Stock fleet achieves the following objectives for interoperability:-

- a) The fleet shall serve all two (2) corridors of the CMRL Phase-1 network and Phase-1 extension.
- b) Be capable of running in mixed traffic operational diagrams; alongside of additional fleet variants of Passenger Rolling Stock (ARE01) as well as maintenance vehicles of CMRL Phase-1 and Phase-1 extension.
- c) Have limited cross-compatibility with other passenger Rolling Stock fleets (ARE01) to the extent that is defined by the technical requirements elsewhere in this Contract (E.g. emergency train rescue requirements).
- d) Complies with any other interoperability requirements identified during the course of coordinated interface Works with other Designated Contractors (as defined in Appendix-C) or as may be required to ensure the safe operation of the railway.

2.2.26 The Contractor shall comply with all the Statutory requirements and guidelines related with Research Designs & Standards Organisation (RDSO), Ministry of Railways (MoR), Commissioner of Metro Railway Safety (CMRS), Ministry of Housing and Urban Affairs (MoHUA) or any other bodies related to the sanction and operation of metro Rolling Stock.

2.2.27 All electrical and electronic components shall comply with the EMC and EMI requirements of EN 50121 (all parts), IEEE 16, EN 50500, EN 55011 and IEC 61000 standards or other equivalent international standards. The requirements of EMC EMI requirements referred in clause 10.19 & clause 2.18 of the Rolling Stock shall be met.

2.2.28 Fire properties of the materials used shall comply with EN 45545 part 1 to part 7 latest editions (Category 4-A, Hazard level HL3) as a minimum or better international standard applicable for similar Metro applications. Requirements of clause 2.26 shall be met. Material requirements of all sub systems of train shall be compliant with the requirements of Chapter 19.

2.2.29 With prior approval of employer, the Contractor shall appoint an independent experienced international consultant who shall carryout validation and certification of the design of proposed Rolling Stock and design of signalling system on conformity with Automatic level of GoA-4 within a period of two years from the date of introduction of 1st Trainset into the revenue operation in GoA2 mode / TOC. The cost of appointing such consultant by Contractor shall be quoted by the Contractor in Price Centre RS-A: "Preliminaries, General Requirements, Design of Rolling Stock, and Provision of 3D Virtual models" under BF 4.4.1, item RS-A8.

2.3 DESIGN LIFE

2.3.1 The car body structure, bogie structure, seat frames, and equipment boxes shall be designed for a service life of 35 years minimum in the Chennai environment (as defined in the specification), based on an average annual operating distance of 150,000 km per rake without requiring structural repair or replacement for any reason other than collision damage, vandalism, natural disasters, or misuse.

2.3.2 All other equipment shall be designed for a minimum service life of 18 years subject to routine maintenance, overhaul, or replacement. Major subassemblies and/or LRU's requiring overhaul or replacement to meet the requirements of this Chapter shall be identified at Preliminary Design Review (PDR), Pre-Final Design Review (PFDR) and Final Design Review (FDR).

2.3.3 Unless agreed otherwise by CMRL, the rakes shall utilize sub-assemblies that minimize the life-cycle costs of the car. If requested by CMRL, the Contractor shall submit a cost-benefit analysis for review.

2.4 SERVICE-PROVEN DESIGN

- 2.4.1 The car body shall conform to EN 12663:2000 or any other standard as applicable to Cars of an urban rail transport system Category P-III.

Car, system and subsystem designs shall be service proven. CMRL will evaluate the applicability of "service proven" according to the risk associated with each particular design. In general, "service proven" shall mean the system, subsystem, equipment or components, etc. which shall comply with requirement's specified in Part 1 - Section III : Evaluation and Qualification Criteria of the contract document.

- 2.4.2 To establish a design's service-proven history, the Contractor shall submit as part of the proposal specific details of the application history. The Contractor is free to propose design improvements; provided the service proven design basis is substantially unchanged.

Proposed changes to the design or method of manufacture must be supported by reasonable justifications such as resolution of obsolescence, meeting specific CMRL technical requirements or for the improvement of product reliability.

Submitted change proposals must specify the reason for the proposed changes and be supported by evidence to demonstrate the risk of adversely effecting operation and performance is mitigated.

For such service proven designs, the Contractor shall produce for CMRL's review and approval test documents from the other systems/projects for which the Contractor is providing the proven design application.

- 2.4.3 Evidence documenting service proven design shall be furnished as part of the proposal for the following systems / Sub-contractors and components:

- a) Car body Structure
- b) Coupler and Draft Gear
- c) Traction converter inverter system
- d) Traction Motors
- e) Drive Gear Units and couplings
- f) Pneumatic and Brakes Control system
- g) Door system and Controls
- h) VAC System
- i) Bogies
- j) Wheels and Axles
- k) Auxiliary converter inverter system and Battery Charger
- l) TCMS & Event Recorder
- m) Batteries
- n) All High Voltage equipment's
- o) Audio visual Passenger Information System and CCTV

- 2.4.4 CMRL may waive some requirements for detailed design review and design conformance testing when service-proven equipment is provided. In general, the decision to waive design and test requirements will be based on CMRL's understanding of the historical success of the equipment applications.

2.5 DESIGNS FOR REFURBISHMENT

- 2.5.1 The passenger rake shall be designed to simplify future overhaul and refurbishment, including repair and replacement of all systems and their constituent parts. Removal and replacement of system equipment shall be possible without causing damage to other systems or to the car body.

- 2.5.2 It shall be possible to easily separate and move a car for the purposes of repair, overhaul, or refurbishment, with electrical connections having quick-disconnect connectors. Pneumatic connections between the cars shall use flexible hoses and quick disconnects.
- 2.5.3 Interior panels and equipment shall be of a modular design suitable for future refurbishment.

2.6 AESTHETIC APPEARANCE

- 2.6.1 The rake's exterior design shall present a smooth, sleek, and attractive appearance. A purely functional layout is not sufficient. Body side bi-parting doors shall be compliant with Chapter 6.
- 2.6.2 To the greatest extent possible, consistent with regulatory requirements, safety, satisfactory performance and maintainability, equipment shall be hidden from sight.
- 2.6.3 Cover panels shall be readily removable and/or hinged for maintenance access. Hinged panels shall be provided with a means for locking in the open position. Equipment cases shall consist of a dust and damp protecting enclosure manufactured with sealing rating of IP 65 in accordance with EN 60529.
- 2.6.4 The interior design and layout of the rake shall provide an attractive appearance. The interior design shall enable the rake to be easily maintained in a clean state. The exterior and interior of the cars must be designed and equipped to aesthetically accommodate and display public advertisements, as a means for the CMRL to derive revenue for offsetting operating cost.
- 2.6.5 The Contractor shall propose arrangements for Line route maps, complete network maps and advertisement holders in the saloon that are unobtrusive and easy to maintain.

2.7 CAR GENERAL CHARACTERISTICS

- 2.7.1 Not used.
- 2.7.2 Not used.
- 2.7.3 Passenger Capacity
- (i) The following data and assumptions shall be used by the Contractor for all normal and degraded performance requirements and calculations. For a 6 car rake composition, minimum seating and standing capacity shall comply with EN 15663 and below requirements:
 - (ii) For a Driving Motor Car, there shall be a 1 Wheelchair provision and minimum of ~~44~~ 42 seats longitudinally arranged along each side of the interior of the car. Seat shall be standard type bench seats with no individual / single seat mouldings. The typical width of the passenger seat spacing shall be 450 mm and the depth, including leg room (as per EN 15663), shall be 670 mm. The remaining floor space shall maximize standing room for passengers for each of the loading conditions described in Chapter 2.12.2.
 - (iii) For Trailer cars & Motor cars, there shall be a minimum of 50 seats longitudinally arranged along each side of the car. Seat shall be standard type bench seats with no individual / single seat mouldings. The proposed width, height, depth, and leg room (as per EN 15663) of the seats shall be optimised to ensure maximum standing room for passengers for each of the loading conditions described in Chapter 2.12.2. The proposed design shall be subjected to CMRL approval.

	DM car	T car	M car
Seats	42 46	50	50 48
Wheelchair	-	-	1
Standees (AW3 condition)	Without Partition - 210 With Partition - 201 213	207 208	207 208

	DM car	T car	M car
Standeers (AW4 condition)	Without Partition - 280 With Partition - 268 284	276 278	276 278
Total capacity (6 car) AW3 condition	Without Partition - { (42+210) + (50+207) + (50+207) } x 2 = 1532 passengers With Partition - { (42+201) + (50+207) + (50+207) } x 2 = 1514 passengers + 1 Driver ~~{ (46+213) + (50+208) + (48+1+208) } x 2 = 1548 passengers + 1 Driver~~		
Total capacity (6-car) AW4 condition	Without Partition - { (42+280) + (50+276) + (50+276) } x 2 = 1948 passengers With Partition - { (42+268) + (50+276) + (50+276) } x 2 = 1924 passengers + 1 Driver ~~{ (46+1+284) + (50+278) + (48+1+278) } x 2 = 1970 passengers + 1 Driver~~		

Note: Wheelchair area is considered as standing area.

- 2.7.4 The general dimensions of the rake are indicated in Table 2-1. Tolerances for these dimensions shall be approved by CMRL.

Table 2-1: Car Dimensions

Dimension	Values
Length of car over coupler faces	Driving Motor Car (DMC) : 22,350 mm Trailer Car (TC) & Motor Car (MC) : 21,850 mm
Height of car, overall	Compatible with the dynamic gauge specified in Appendix D. (4048 mm with pantograph in lock-down position)
Width of car, overall	2900 mm
Wheel dimensions: New wheel diameter Wheel wear limit	860 mm 80 mm (on diameter)
Height of car floor above top of rail at end door threshold	1,130 mm (maximum) 1,100 mm (minimum)
Spacing between bogie centrelines	14,850 ± 250 mm
Dynamic outline	Rake shall not exceed the dimensions shown in Appendix D – SOD.

- 2.7.5 Seats shall be arranged longitudinally to maximize the number of standing Seats shall be provided for handicapped persons as described in clause 3.8.

- 2.7.6 Vertical and horizontal handrails shall be provided at the doorways on either side way. The layout and design shall be submitted for CMRL's approval. Details of stanchions and Handrails requirements are in clause 3.6.3.
- 2.7.7 The Contractor shall submit a seating conceptual layout with the technical proposal that offers the best trade-off between passenger seating capacity, standing and circulation space.

2.8 CLEARANCE REQUIREMENTS

- 2.8.1 The Kinematic Envelope of the Car shall be in accordance with Schedule of Dimensions in Appendix D. The Contractor's calculations of the static and kinematic envelope of the vehicle shall be calculated in accordance with UIC 505 and/or equivalent International Standard. The vehicle and attached equipment shall be designed to operate within the Kinematic Envelope shown in Appendix D, under all worst conditions of speed, passenger load, sway, roll, side play, wear, including wheel and rail wear and failures other than structural failures on level tangent track. The method and details of the calculations shall be submitted for the approval of CMRL as a separate design submission.
- 2.8.2 The clearance envelope is limited through stations by the station platform. The Contractor shall assess the reduced car clearance envelope present through stations. Interference with station platform due to lateral and vertical displacements and all conditions of passenger load, sway, roll, side play, wear of wheel, and rail and a single point failure shall be included in the assessment.
- 2.8.3 The Contractor shall submit for approval design configuration drawings showing the static and kinematic clearance envelope for the cars, indicating compliance with clause 2.7 and 2.8
- 2.8.4 The Contractor shall perform tests as specified in Chapter 17 to demonstrate compliance with the static and kinematic clearance requirements.
- 2.8.5 The Contractor shall ensure that the cars conform to the latest version of Schedule of Dimension (SOD) without any addition cost to CMRL.

2.9 WAYSIDE CHARACTERISTICS

- 2.9.1 The Rolling Stock shall fulfil the conditions as per UIC 512 for smooth operation.
- 2.9.2 The provisions on the following pages provide the basic track and wayside limitations under which the rake shall operate in revenue passenger service. The Contractor shall be responsible for submission of any additional data for design clearance and certification by the Commissioner for Metro Railway Safety (CMRS). All interface data interchange is described in Appendix C, Interfaces.
- 2.9.3 Station Platforms: All underground stations will be air conditioned. The station platform edges will be equipped with Platform Screen Doors. The major dimensions of the station platform edge are given in SOD.
- 2.9.4 Track (Design Values): The cars shall be designed to negotiate all track conditions found on the CMRL system. The design geometry of the track is as defined in the Appendix D (Schedule of Dimensions) and Appendix D (Alignments and Profiles).
- 2.9.5 Track Maintenance
The tolerances within which the main track will be maintained is provided in the Schedule of Dimensions in Appendix D.
- (i) Table 2-2 contains information on the track design values.
 - (ii) Table 2-3 provides information on the track structure parameter.
 - (iii) Table 2-4 provides information on the track tolerances and
 - (iv) Table 2-5 provides information on the platform interfaces.

Table 2-2: Track Design Values

Dimension	Maximum	Minimum
Track gauge	1,435 mm (nominal)	
Horizontal curve radius: Mainline		
a) Under Ground Sections	-----	200 m
b) Elevated and Surface Sections	-----	120 m
c) Depot and Sidings at Stations	-----	100 m
Minimum radius of vertical curve	1,500 m	
Cant deficiency	85 mm	-----
Cant	110 mm	-----
Cant gradient	-----	1 in 440
Gradient		
At station	0.25 % (1 in 400)	-----
At turnout	2.5 % (1 in 40)	-----
Other sections in Mainline	4 % (1 in 25)	
Depot	Level	
Rate of grade change	-----	1 in 440
Rail type: CWR	60E 1 Profile as per IRS T 12 – 2009 (With Latest Amendments / Correction Slips) canted at 1 in 20	
Platform curve	1,000 m	

2.9.6 Track characteristics

- a) The Track Structure Parameters for At-grade, Elevated and Underground sections are set out in Table 2.3.

Table No 2-3: Track Structure Parameters

Description	Elevated and At-grade sections	Underground sections
Track Laying Gauge	1435 mm ± 2 mm	
Rail Type		
Main Line	UIC 60E 1 Head hardened as per IRS T 12 – 2009 With All Amendments / Correction Slips. (1080 Not used. as per latest draft no more 1080)	
Depot	UIC 60E 1 (880 Grade) as per IRS T 12 – 2009 With All latest Amendments / Correction Slips.	
Rail Profile	UIC 60 E1 Profile	

1

Description	Elevated and At-grade sections	Underground sections
Inclination Of Rail	1 in 20	
Main line Rail Seat spacing	Nominal 650 mm $\pm$ 5 mm	
Depot Sleeper Spacing	650 mm $\pm$ 5 mm; Inspection Lines 1000 mm	
Ballast Cushion		
Designated Depot(s)	Ballast less Track in Koyambedu Depot & Wimco Nagar Depot	
Rail Panel Lengths	Continuous welded rails	
Minimum Radius of Curvature	Depot – 100 m Main line – At grade & elevated – 120 m	200 m
Minimum Turn Out Radius. Main Line	140 m	
Minimum Turn Out Depot	1 in 7 R 140	
Minimum Turn Out Main line	1 in 5 R 100	
Maximum Permissible Cant Gradient	1 in 440	
Turn-out Speed : Turn-out (Main line)	1 in 9 R 300=36 kmph ; 1 in 9 R 190=29 kmph 1 in 7 R 190=29 kmph ; 1 in 7 R 140= 25 kmph 1 in 5 R 100=15 kmph	
Maximum Gradient (Main Line)	4 % Including Grade Compensation.	
Minimum vertical curve radius crest	1500 m	
Maximum track axle load (AW4)	16 tons	
Widening of track Gauge on curves	Up to 9 mm	
Structural gauge and passing clearance in straight line, in curves, in open air grade, in tunnel	As per SOD of CMRL Refer to Appendix D of this document for typical Sections	
Tunnel Profile	As per SOD of CMRL Drawings showing section of cut and cover and bored tunnel in the Underground sections and details of various equipment's/cables etc located therein are mentioned in are enclosed in Appendix D	
Line profile	The drawings showing the line profiles of all corridors are enclosed in Appendix D of this document:	

- b) The Track tolerances for At-grade, Elevated and Underground sections are set out in Table 2.4. Final track tolerances will be confirmed by CMRL during the preliminary design of the vehicle.

Table 2-4Track Tolerances:

Description	Ballasted	Ballast-less (DFF)
Laying Tolerance of Vertical Alignment measured by 10m chord (Designed level)	± 4 mm	± 4 mm
Alignment (Laying) (Base 10m)	± 5 mm	(± 4 mm for 20m chord as per CMRL maintenance manual)
Cross Level Laying Tolerance (Designed)	± 3 mm	±2 mm
Twist (Other than transition curve)	1 mm / 250 mm	Target value not to exceed 3 mm over 3 m; isolated locations up to 5 mm over 3 m; Threshold value for speed restrictions 10 mm over 3 m.
Cross Level Difference (Maintenance)	15 mm	10 mm
Gauge measured at a point 14mm below crown of rail (laying) (with respect to 1435 mm)	± 6 mm	Target value ± 6 mm Threshold value for speed restrictions + 20 mm / - 10 mm
Unevenness (Maintenance) – 3, m chord	3, m chord: 15 mm	Target value not to exceed 6 mm; isolated locations up to 10 mm; Threshold value for speed restrictions 15 mm.
Alignment (Maintenance) (Base 7.5m)	15 mm	Target value not to exceed 5 mm; isolated locations up to 10 mm; Threshold value for speed restrictions 15 mm.
Gauge variation maintenance (sleeper to sleeper)	± 6 mm	(± 6 mm as per CMRL maintenance manual)
Gauge (Maintenance) – Tangent track (with respect to 1435 mm)	- 10 mm to + 20 mm	Target value ± 6 mm Threshold value for speed restrictions +20 mm / - 10 mm
Gauge (Maintenance) - >500m radius (with respect to 1435 mm)	+ 20 mm / - 10 mm over widened gauge	+ 20 mm / - 10 mm over widened gauge
Gauge (Maintenance) - <500m radius (with respect to 1435 mm)	+ 20 mm / - 10 mm	+ 20 mm / - 10 mm over widened gauge
Gauge Face Wear	8 mm	8 mm

- c) Platform interfaces are set out in Table 2.5

Table 2-5: Platform interfaces:

Particulars	Measurements
Length	135 m (6 cars)
Width: Island type	8.0 to 12.0 m
Width: Side type	4.0 to 6.0 m
Ballasted Track	1090 mm $\pm$ 5 mm (Height above Top of Rail level)
Ballast-less Track	1080 mm $\pm$ 5 mm (Height above Top of Rail level)
Distance between track centre and platform edge	In underground: 1510 mm - 1515 mm In Elevated & At grade: 1515 mm – 1520 mm
Minimum horizontal curvature at platform	1000 m
Structural gauge and passing clearance in platform	Refer to Appendix D of this document

2.10 TRAINS' INTER-OPERABILITY REQUIREMENTS

- 2.10.1 Metro passenger trains of this contract shall be designed for operation in all corridors of CMRL Phase 1 network.
- 2.10.2 Trains shall be operated in Corridor 1 and Corridor 2 and also in their inter-corridor operations through service loops between the corridors.
- 2.10.3 Trains shall be fully capable of being stabled and maintained at all Designated Depot(s) of the CMRL Phase 1 network. Hence all the related interface with various depot machines and track systems suggested in Appendix C – Section 6, Section 10, Section 11 shall be achieved.
- 2.10.4 Trains shall be compatible with combined operation with other type of trains in CMRL Phase 1 network. Hence all the related interface with other Rolling stock systems suggested in Appendix C & Section 14 shall be achieved.
- 2.10.5 All the requirements of Interface suggested in Appendix C shall be taken care during the design of the Rolling stock.

2.11 ENVIRONMENTAL CRITERIA

- 2.11.1 Environmental conditions for the on-board equipment shall conform to EN 50125-1. The rake shall be capable of being operated, stored, and maintained at specified performance levels within the environmental conditions of the Chennai area as shown in Table 2-6.

Note: The details mentioned above are tentative and it shall be RS Contractor responsibility to confirm these values from relevant resources.

Table 2-6: Environmental Conditions of Chennai Area

Condition	Maximum	Minimum
Climate	Tropical Wet, Dry, and humid	
Ambient temperature	45°C	16 °C

Condition	Maximum	Minimum
Monsoons	October through December	
Rainfall	1,333 mm average annual. (Very heavy / continuous with heavy lightning discharges).	
Relative humidity	100 % saturation during rainy season which may be as long as 3 ~ 4 months. Other times, 82 % humidity.	
Atmosphere during hot season	Extremely dusty	
Maximum wind speed	130 kmph	
SO ₂ level in atmosphere	5 ~ 40 micro g / m ³	
NO _x level in atmosphere	10 ~ 40 micro g / m ³	
Respiratory Suspended Particles Matter in atmosphere (RSPM)	45 ~ 100 micro g / m ³	
Total Suspended Particles Matter in atmosphere (TSPM)	150 ~ 320 micro g / m ³	
Altitude	Sea Level	
Conditions in stations	All underground stations will be A/C. Above ground stations will have A/C for certain designated rooms only.	

The temperature of stationary rake exposed to sun for long periods may go as high as 75°C. The equipment shall not be adversely affected in any way due to exposure to such high temperatures.

- 2.11.2 As the Chennai Metro lines will have elevated and underground portions, there may be sudden change in the ambient temperature to Rolling Stock. The equipment shall be designed to take care of such thermal shocks.
- 2.11.3 The Traction Equipment mounted on the under-frame shall be designed to permit propulsion of the train at 10 kmph through water up to a depth of 75 mm above rail level (with maximum allowable wheel and rail wear). Traction equipment shall be made splash proof in accordance with International Standards.
- 2.11.4 The rakes shall be continuously exposed to highly corrosive, salty atmosphere along with industrial pollutants.
- 2.11.5 With maximum allowable wheel and rail wear, the rake must be able to operate successfully under the above conditions with no entry of moisture or other contaminants into any compartment, component, or device that could cause equipment on the rake to malfunction or be damaged; that could increase maintenance requirements; or that could cause premature wear or failure.
- 2.11.6 The Water used in Chennai for washing is likely to have a high level of dissolved matter which may aid corrosion.

2.12 WEIGHT CRITERIA

The distribution of equipment on a particular car shall be arranged to maintain an even weight balance and shall be tested in accordance with IEC 61133 to the extent that it applies to electric multiple units.

- 2.12.1 Each passenger weight shall be assumed to be 65 kg.
- 2.12.2 For design and performance purposes, the weight of each car of a rake shall be as defined below. Alternatively, the weight of each car of a rake may be taken as that defined in the UIC standards subject to prior approval by CMRL for the particular application.

- a) AW0 : Empty rake operating weight, ready to run.
 - b) AW1 : One Driver + Fully seated passenger load, plus AW0.
 - c) AW2 : Normal load rake weight at 4 passengers / m² plus AW1.
 - d) AW3 : Crush load car weight at 6 passengers / m², plus AW1.
 - e) AW4 : Exceptional Crush Load weight at 8 passengers / m², plus AW1.
 - f) AW5 : Car Structure design load at 10 passengers / m², plus AW1.
- 2.12.3 The rake shall not exceed an axle loading of 16 tonnes under AW4 conditions. The measured load per axle shall not exceed as mentioned in ERTS – RS (clause 11.9.23).
- 2.12.4 CMRL prefers a rake design that minimizes weight while maintaining the required structural strength.
- 2.12.5 The Contractor shall submit a car weight distribution report that will detail the weights of all major subassemblies. The report shall include the weight distribution on each bogie and on each axle. Weight targets and actual measurements shall be clearly identified.

2.13 SHOCK AND VIBRATION

2.13.1 Component Design Criteria

- a) All car equipment shall be designed to operate without damage or degradation of performance when subjected to vibration and shocks encountered during normal service.
- b) Equipment design and mounting arrangements shall be based on the specific location of the equipment on the rake and shall take into account the influence of adjacent components as well as the effect of normal car operation. It shall be the car supplier's responsibility to assure that the operating environments specified below are not exceeded.
- c) The Contractor shall ensure that equipment will withstand all normally occurring random shock and vibration magnitudes transmitted through the car axles and suspension, and present at the support points for each piece of equipment.
- d) The mounting of under-body equipment shall be designed to ensure that breakage or loss of any of the mounting arrangement shall not cause the under-body equipment to fall on to the track.
- e) Under-body equipment shall not be supported by bolts under tension unless otherwise approved by the CMRL. Or mounting arrangements shall ensure that under no circumstances the equipment would fall on track during operation, by providing U shaped safety brackets with secondary protection of fall proof safety SS ropes.

1

The locking of all nuts, bolts and fixings shall be of a positive form, which prevents mechanical rotation of the nut relative to the bolt, irrespective of the source of the vibration. The use of chemical thread locking compounds such as Loctite or equivalent shall not be considered sufficient for positive locking.

- f) All mechanical, electrical and electronic equipment fitted to the rake shall operate without damage or suffer any reduction in reliability when subjected to the shock and vibration occurring in normal service for the Service Life of the equipment.
- g) To demonstrate compliance with this requirement, each equipment shall have been subjected to a series of shock and vibration tests, or simulations, representing the real environment. In the case of a proven design component/equipment which has been previously tested, the car builder may submit the previous test results for CMRL review and approval, and not have to re-conduct the shock and vibration test.
- h) Where acceptable results from prior testing are not available for any item of equipment, tests shall be performed in accordance with IEC 61373 or EN 12663.
- i) The equipment design and mounting arrangements for testing shall be based on specific mounting locations on the rake and shall consider the influence of adjacent components when mounted in-situ.

- j) In cases where components are mounted in a partially sprung environment, the Contractor shall be responsible for defining the environment to avoid failure of the components.

2.13.2 Vibration Generation

- a) The vibration of traction motors shall be assessed using the methodology contained in IEC 60349 and shall not exceed the limits defined in IEC 60034-14. Following ISO 2631-4 standards, vibration frequencies shall be outside of the maximal sensibility range.
- b) For a stationary car, equipment and auxiliaries mounted at any position on the car or bogie shall not cause vibration on any portion of the car floor, side-walls, ceiling panels, stanchions, handholds, seat frames, doors, electrical cabinets and their panels, windows, any passenger seating or holding components in excess of 2.0 mm peak-to-peak amplitude for the frequency range from 1.4 Hz to 20 Hz, and in excess of 0.8 mm per second peak vibration velocity for the frequency range above 20 Hz.

All equipment's, sub-assemblies and components listed above shall be capable of withstanding shock and vibrations of the Rolling Stock satisfactorily such that they do not fail prematurely on this account earlier to the designed life. To establish this requirement, all of equipment's, sub-assemblies and components shall be subjected to shock and vibration testing as per standards mentioned above.

2.13.3 Ride Quality and Passenger Comfort (Stability Analysis)

- a) All cars in the rake shall be dynamically stable throughout the maximum design speed range of 90 kmph. This ride performance shall be achieved under all Loading Conditions, when travelling throughout the range of operating speeds and cant deficiencies prevailing in normal passenger service for the Service Life of all suspension components. The Contractor shall submit a ride performance stability analysis.
- b) The bogie stability tests shall be carried out in accordance with the requirements of UIC 518.
- c) The rake vertical, lateral and longitudinal ride quality shall be to a level that is comfortable for both seated and standing passengers.
- d) The ride quality measurements shall be carried out in accordance with the requirements of ISO 2631-4. The frequency weighting filters shall however be replaced by the filters related to the Sperling index definition.

- e) ~~The Sperling ride index of the rake at 80 kmph shall not exceed 2.5 in both vertical and horizontal directions in inflated condition of secondary suspension and 3.0 in deflated condition for both vertical and horizontal directions.~~

The new Rolling Stock on the existing track shall satisfy the following maximum values.

- 1a) Maximum Sperling ride index of the rake for both vertical & lateral modes in Inflated conditions = 2.5
- 1b) Maximum Sperling ride index of the rake for both vertical & lateral modes in Deflated conditions = 3.0
- 2) Maximum value of vertical acceleration = 0.27 g
- 3) Maximum value of lateral acceleration = 0.27 g
- 4) Maximum $\Delta Q/Q = 0.5$
- 5) The accelerations and spring displacements should decay within 2 to 3 cycles
- 6) There should be no hunting tendency noticeable up to the maximum speed of 90 kmph.

- f) ~~The oscillation trials shall be conducted with tare and fully loaded cars in both inflated and deflated conditions up to maximum design speed of 90 kmph starting from 40 kmph in the incremental order of 10 kmph for inflated condition and up to 80 kmph for deflated conditions.~~

The Oscillation Trials are to be conducted with tare and fully loaded vehicles, in both inflated and deflated conditions up to maximum designed speed starting from 40 kmph in the incremental order of 10 kmph; up to 90 kmph for inflated conditions.

The Sperling ride index of the rake at 80 kmph shall not exceed 2.5 in both vertical and horizontal directions in inflated condition of secondary suspension.

As far as operation with deflated springs are concerned, trials will be conducted up to the speed where the above (e) maximum level of parameters are experienced, and based upon the results, the maximum speed of operation with deflated springs will be decided.

- g) Any vibration emitted by the rake, caused by the operation of any equipment or machines (compressor set, blowers, electromagnetic equipment, circuit breakers, motors etc.) shall not be a source of discomfort to the passengers or the Driver.

2.14 PERFORMANCE REQUIREMENTS

2.14.1 General

The acceleration and braking requirements given below are minimums for actual performance with new wheels on level track in still air. Performance shall be verified by empty car acceptance tests done on all cars, as well as loaded car engineering tests done on the first rake. Design calculations shall be based on the Davis Formulae for rolling resistance (in both elevated and under-ground) or approved equivalent for a configuration with new wheels.

To facilitate testing, equivalent performance criteria shall be developed, for approval by CMRL. While the specified acceleration and service braking rates are desired and are believed by CMRL to be based upon capabilities of existing apparatus designs, alternate rates may be proposed in the Technical Proposal if the benefits of the revised rates can be documented.

The balancing speed for 6 car rakes on level tangent track under AW4 conditions in still air shall be a minimum of 80 kmph and the maximum motor, gear unit and bogie safe speed, with minimum wheel diameter, shall be a minimum of 90 kmph. Each car shall be capable of continuously operating in service at all sustained speeds up to 80 kmph, with repeated acceleration and braking, without degradation or damage to any part of the car.

- a) The Contractor shall submit performance calculations for propulsion and braking system duty cycles simulations to demonstrate the capability for both normal operation and rescue operations using the following input data. The Contractor's design shall comply with the supply voltages and quality of voltage specified in the requirements of IEC 60850. The general particulars of 25 KV, 50 HZ, Single Phase AC Traction Power Supply System shall be as follows:

Normal voltage	25 KV
Normal variation in voltage	19 ~ 27.5 KV
Occasional maximum voltage (Cut off)	30 KV
Occasional minimum voltage	17.5 KV
Cut off voltage	16 KV
Voltage for guaranteed performance	22.5 KV
Frequency variation	47 ~ 52 Hz

In the event that the Traction Power Supply voltage is reduced to less than 16.5 KV the current drawn from the Traction Power Supply shall not increase and the traction performance shall diminish gradually with restricted power.

- b) The power control system(s) shall ensure that when oscillation (or momentary fluctuations) of line voltage occur; there shall be no instability or damage caused to any train systems (in accordance with IEC 60850).
- c) The traction equipment shall be able to accept intermittent Traction Power Supply voltage without any damage.
- d) The proportion of motored axles per rake shall be in accordance with the requirements of clause 2.2.12. The car-builder is required to meet the minimum requirements of acceleration and deceleration.
- e) The Trainset shall be capable of sustaining a maximum operating speed of 80 kmph with ATP / ATO / UTO and maximum design speed of 90 kmph on track curves as per the Schedule of Dimension.

Maximum equivalent response time taken into account for the calculations is for service and emergency braking shall be compliant with EN 13452-1

The following performance requirements shall be achievable with any degree of wheel wear including rail adhesion level no greater than 20%, any track conditions within the design criteria, any passenger Loading Condition (up to AW4) on level tangent track:

Table 2-7: Rolling Stock Design Performance Requirements

Item	values
Minimum Design Average Acceleration rate for fully loaded (seating plus standees @ 8 passengers / m2) train on level tangent track shall be as under: 0 kmph to 40 kmph 0 kmph to 60 kmph 0 kmph to 80 kmph	1.0 m/s ² 0.6 m/s ² 0.3 m/s ²
Minimum Operational Average Acceleration rate for (seating plus standees @ 6 passengers / m2) loaded train on level tangent track shall be as under: 0 kmph to 35 kmph 0 kmph to 60 kmph 0 kmph to 80 kmph	1.20 m/s ² 0.65 m/s ² 0.35 m/s ²
Minimum Average Service braking rate from 80 kmph to standstill for fully loaded (seating plus standees @ 8 passengers / m2) train on level tangent track	1.0 m/s ²
Minimum Average Service braking rate from 80 kmph to standstill for - (seating plus standees @ 6 passengers / m2) train on level tangent track	1.1 m/s ²
Minimum Average Emergency braking rate from 80 kmph to 0 kmph for fully loaded train on level tangent track	1.3 m/s ²
Jerk rate (Maximum)	0.75 m/s ³

- f) Rake resistance curves shall comply with international standards.
- g) The Contractor shall provide a computer simulation of a round trip journey stating the actual Rolling Stock characteristics used and incorporating the above data where appropriate to predict the round-trip time and the power consumption of the rake. This shall be done as part of the Performance and Failure Management Analysis.
- h) The Contractor shall also submit the speed time and tractive effort characteristic curves of AW4 loaded rake under the specified voltage and wheel conditions between the various stations in various corridors and also with the following
 - i) Inter-station running time for each corridor, each way
 - j) Actual schedule speed with a dwell time as mentioned in the attached alignment drawings and Schedule of Dimensions (SOD).
 - k) Percentage coasting achieved in terms of time and distance, if any.
 - l) Total traction energy consumed
 - m) Total auxiliary energy consumed
 - n) Total regenerative energy fed back into the system
 - o) Total regenerative energy generated at the Converter-Inverter level
 - p) Total regenerative energy used in Auxiliary loads in the train during 'Braking' duration

- q) Total energy input at the Pantograph during ‘No Braking’ durations
- r) Total energy input at the Pantograph during ‘Braking’ durations
- s) Line current plots
- t) Net energy consumption; and
- u) RMS current loading

Table 2-8: Proforma for submission of simulation results Line 1 & Line 2

Sl. No.	Station	Run Time (Sec.)					Energy Consumption (kwh)				
		P	C	B	D	Total (3~6)	P	C	B	D	Total (8~11)
1	2	3	4	5	6	7	8	9	10	11	12
Corridor 1											
	Airport to Meenambakkam										
	Meenambakkam Stop										
	Meenambakkam to OTA										
											
	Wimco Nagar Depot										
Corridor 2											
	Central Metro to Egmore Metro										
	Egmore Metro stop										
	Egmore Metro to Nehru Park										
											
	St. Thomas Mount Metro										
Inter Corridor Operation											

Note : P means “Powering”, C means “Coasting / Neutral”, B means “Braking” and D means “Dwell Time”.

- v) Trainset performance calculations shall be based on half worn wheels except where otherwise stated. Wheel diameter shall be taken as 860 mm. Maximum wheel wear limit shall be 80 mm (on diameter) and Half worn wheels shall be 40 mm (on diameter). However, for reference purpose the Contractor shall also submit the calculations for New Wheels and Fully worn wheels.
- w) The Contractor shall also furnish the inter-station running time for a fully loaded rake (AW4 loading) for each way.
- x) The round-trip running time, under All-out Mode, for AW3 loaded train condition for 6 car trainset with one motor coach cut-out, shall not be more than the scheduled round trip time as declared by the Contractor vide clause 1.4.5. In such case the operation may be high TE mode. Under such operation conditions the temperature rise of the propulsion equipment shall not exceed the respective thermal ratings and the train shall be able to start and move on a UP gradient of 4 %.
- y) The Contractor should also furnish the inter-station running time for a fully loaded (AW4) train & AW3 train, under emergency conditions of running, for each Line, each way for 6 car train with 50% motors cut out. The train shall be able to start and move on a UP gradient of 4%.

- z) The continuous thermal rating of the traction system shall meet all the conditions of normal working. During emergency conditions operation (Clause 2.14.1.Y), the rake starting after a continuous working, thermal rating should not be exceeded for continuous working, in each Line.
- aa) The Contractor shall handover one complete set of software(s) package and associated hardware employed by him for the above studies including assessment of energy conservation modes (Clause 2.14.1.Y) along with the requisite documentation, during design stage to CMRL. The software shall simulate Run Time performance of the train under varied loads, route profiles, headway, inter-station distances, train resistance, Train formation and Tractive Effort & Braking Effort characteristics, evaluation of energy conservation modes etc. The software shall not be restrictive to the above and shall be for general application with provision for CMRL to select parameters. Nominated staff shall be fully trained and made fully conversant by the Contractor for this purpose. The handed over set shall be fully functional during the contract period and post warranty period & shall require no inputs or facilities whatsoever from CMRL.

2.14.2 Traction Performance

The overall energy consumption of the rakes shall be minimized commensurate with the use of advanced technology.

- 2.14.2.1 During a conventional train rescue operation (E.g. release of both parking and service brakes is achieved on the failed train) a healthy assisting train (in AW4 load condition) shall be capable of rescuing a failed train (also in AW4 load condition). The coupled AW4~AW4 consists shall be capable of starting and accelerating up a worst-case gradient of 4 % and be able to reach a speed of 20 kmph in restricted manual mode. This is to enable the defective rake to be removed from service.

- 2.14.2.2 During the rescue operation of a train with a burst MR pipe; a healthy assisting train (in AW0 load condition) shall be capable of rescuing a failed train (in AW4 load condition). The coupled AW0 ~ AW4 consists shall be capable of starting and accelerating up a worst case gradient of 4% and be able to reach a speed of 20 kmph in restricted manual mode.

This coupled rake of healthy and defective consists shall be able to ascend any combination of gradient and/or curve as may be necessary to reach the next station to allow passengers to deboard. The healthy train shall thereafter be able to push or pull the defective train (with its load now reduced to AW0) over a distance of up to 10km in order to reach the nearest pocket rack or siding track.

To facilitate recovery of failed trainsets back to the Depot during non-revenue hours, an AW0 healthy consist shall also be capable of recovering an AW0 failed train from any point of the Phase I network to the Designated Depot(s). The Contractor shall demonstrate that this can be accomplished this without exceeding any thermal limits.

- 2.14.2.3 The design of the traction control system and the associated traction motors shall ensure that in the event of an inverter (plus associated control equipment) or bogie failure, at AW4 condition, the rake shall continue to operate as far as its scheduled destination without incurring a delay of greater than Five (5) minutes.

- 2.14.2.4 Means shall be provided to isolate locally each set of traction equipment in the rake. In case of failure of One Motor car, only that Motor coach bogie shall be isolated in bogie control propulsion system and in case of failure of One Motor car, only that Motor coach car shall be isolated in car control propulsion system. In either case and still the rake shall be capable of continuing to-work until the peak period is over-operate in passenger service operation

- 2.14.2.5 One serviceable AW4 loaded 6-car train with one motor car inoperative/cut out shall be capable of pushing a AW4 loaded defective 6-car train respectively without parking brakes applied, on all Lines including a section of 4% up gradient up to the next station. Thereafter, the healthy train shall, after all the passengers have been de-trained at the station, continue to push the defective train up to the terminal station. There shall be no equipment damage or degradation, while maintaining safe operation. Train shall be also able to start and move on a up gradient of 4% on above condition including the conditions specified in ERTS clause 2.14.1 (x) and (y).

The defective and healthy train can either be new or existing rolling stock or vice versa.

2.14.3 Braking Performance

- 2.14.3.1 The Contractor shall submit design calculations for the safe braking distances and Emergency braking distances for both dry and wet conditions as per UIC 544-1, EN 14531-1, EN 13452-1 & EN 13452 -2 and design basis for wet condition.
- 2.14.3.2 For a normal operation of service brake (nominal 1 m/s^2) on level track from maximum speed, the rake shall brake to a standstill from 80km/h in 247m (+0, -10%) under any Loading Conditions up to AW4. The Contractor shall demonstrate by providing calculations of the minimum adhesion level, required to achieve the stopping distance. Upon receipt of signal to Brake Control Unit, the application of service brake time should be less than 300 msec.
- 2.14.3.3 For an emergency brake application in good adhesion conditions (i.e. dry uncontaminated wheel rail interface) on level track from maximum speed, the rake shall brake to a standstill from 80 kmph within a distance of 223 m under any Loading Conditions up to AW4. The minimum average emergency brake rate following any single point failure shall not be less than 1.3 m/s^2
- 2.14.3.4 Not used
- 2.14.3.5 A consistent stopping accuracy of within $\pm 300 \text{ mm}$ of the stopping position for ~~99.50 % of station stops and $\pm 500 \text{ mm}$ of the stopping position for~~ 99.98 % of station stops for normal station stops when controlled from the ATO / UTO. ~~Stopping accuracy information shall be recorded in TCMS. Information shall be recorded in TCMS. The electrical dynamic braking facility in the train shall be made available and upto zero kmph speed of the train, so as to achieve smooth and accurate stopping of the train. The design of such electrical braking shall be proposed at the design stage for verification by CMRL.~~
- 2.14.3.6 The parking brakes shall be capable of holding a stationary rake in the AW4 Loading Condition on the worst gradient of the Main Line (4 %) in the worst wind conditions stated in Table 2-6 for an unlimited time. A visual indicator shall be provided in the Operator's Desk / ~~RSC consoles of OCC, BCC & DCCs~~ to alert the driver of rake movement with the parking brakes engaged.
- 2.14.3.7 During a rescue scenario, the service brakes of the rescuing rake shall be capable of holding itself and the coupled defective rake, under any combination of loading conditions (from AW0 to AW4 Loading), on the worst combination of gradient and the worst wind conditions as stated in Table 2-6.
- 2.14.3.8 The pneumatic brakes shall be controlled on a per-bogie basis. Measures shall be taken to prevent a brake fault on one bogie from affecting brake equipment on the other bogie.
- 2.14.3.9 The brake control system shall be capable of providing accurate repeatable brake levels and shall be compatible with the requirements of the ~~ATO~~ ATO (GoA2) & UTO (GoA4) system.
- 2.14.3.10 Under push-out conditions with no brakes on the defective rake, the brake system shall be capable of stopping the coupled rakes at the next station to detrain all passengers and then permit the empty rakes to continue to the terminal station without further scheduled stopping. (However, the emergency brake application on both rakes shall still be possible).

2.15 TRACTION AND BRAKING

2.15.1 Rake State and Mode Selection

- 2.15.1.1 A master control switch shall be provided in each Operator's Desk to determine the state and mode of the rake. The master control design (modes of operation, Traction Braking control, removal of Key, etc.,) shall be confirmed and agreed with Signalling Contractor.
- 2.15.1.2 The master control switch shall include a mode selector switch to select the mode of operation of the rake.
- 2.15.1.3 The master control switch shall include an integral two position electronic or mechanical switch (i.e., 'Lock' and 'Unlock') to energize the Master Controller. The master control selection shall be interlocked with the mode selector switch to ensure that sign-off / switch-off and removal of the master control key can only be achieved when the mode switch is in the "Off" and "GoA4" position. The Event Recorder shall record all events associated with the start-up and authorization for the

Operator.

- 2.15.1.4 The controlling cab shall be the cab in which the mode selector switch is set first (in any mode other than an “Off”). The rake shall become fully operational within 5 seconds when a controlling cab, which was previously in “Standby” mode, has been activated. Refer Chapter 5.
- 2.15.1.5 Interlocking shall be provided between the Rake Control Consoles at each end of a rake to ensure that no more than one Rake Control Console shall be active at any one time.
- 2.15.1.6 The mode selector switch shall include sufficient switch positions to enable the following driving modes to be selected. (Ref. Chapter 5)
- 2.15.1.7 Selection of different modes, from the mode selector switch, shall not incorporate any undefined states.
- 2.15.1.8 Permitted mode changes that require a change in direction shall only be possible when the rake is proved to be stationary. Attempts to change direction when the rake is in motion shall activate the emergency brake.
- 2.15.1.9 A traction brake controller shall be provided, to manually drive the rake using a facility to select motoring, coasting, service and emergency braking.
- 2.15.1.10 The traction brake controller shall consist of a movable handle with a set of positions corresponding to combinations of control functions that shall be transmitted to the traction and braking systems throughout the rake namely (Ref. Clause 5.5 for Master controller and related controls for detailed explanation):
 - a) a region where ‘Motoring’ only is demanded.
 - b) a ‘Coasting’ position - this position shall have a detent.
 - c) a region where ‘Service Braking’ only is demanded; and
 - d) a position where ‘Emergency Brake’ is demanded shall have a detent.
- 2.15.1.11 All positions of the traction brake controller shall be visually identified. When in the motoring position, the control handle / lever shall be spring biased towards the coasting position when unattended.
- 2.15.1.12 The traction brake controller as well as providing the manual driving inputs to the traction and braking system shall also provide the signals to the safety proving system.
- 2.15.1.13 Movement of the handle / lever shall provide both the operating demand for motoring, service braking, coasting and emergency brake and also an associated proportional rate for motoring and service braking.
- 2.15.1.14 A Driver’s Safety Device (DSD) shall be provided as an integral part of the traction brake controller’s handle / lever.
- 2.15.1.15 The design of the DSD shall ensure that it is impossible to use any easily available object to override the safety features.
- 2.15.1.16 DSD functions of Phase 1 to be added.

2.15.2 Traction and Braking Control Equipment

- 2.15.2.1 Traction and braking control systems shall be provided which shall be designed to ensure a high utilization of available adhesion under all wheel / rail conditions.
- 2.15.2.2 The traction and braking system and associated equipment shall be fully integrated with control circuits, diagnostic and monitoring facilities, load-weighing and wheel-slip and slide systems. The integration shall be designed to minimize the time required to test the equipment and to diagnose faults.
- 2.15.2.3 The electronics required for the control, diagnostics and monitoring facilities shall be designed and constructed in accordance with the requirements of IEC 60571.
- 2.15.2.4 Traction control equipment shall incorporate measurement of energy consumption for traction, energy consumption for auxiliaries, regenerated energy and total net energy consumption.
- 2.15.2.5 Braking should be provided on all cars and must be continuous and Automatic throughout the

rake. Continuous Automatic brakes should inhibit traction power when applied.

2.15.3 Traction Motors

- 2.15.3.1 The rake shall be propelled by 3 ϕ AC asynchronous traction motors or permanent magnet motors or any better proven design, suitable for the proposed converter / inverter operation shall be offered. The motors shall be designed, manufactured and tested in full accordance with the requirements of IEC 60349 and IEC 61377 where applicable.
- 2.15.3.2 Not used.
- 2.15.3.3 Each motor design shall utilize standard roller bearings for Railway applications.
- 2.15.3.4 A separate motor shall be provided in association with each axle of a motor car, which shall be mounted on the bogie frame with its rotor shaft parallel to the axle.
- 2.15.3.5 The mounting arrangement of the traction motor shall be designed with a secondary mounting arrangement to prevent the motor from dropping onto the track should the primary mounting arrangement become disconnected.
- 2.15.3.6 All components shall have been already proven in previous railway service in similar operating and environmental conditions in accordance with Chapter 2.4. and Chapter 2.11.
- 2.15.3.7 The traction motors and associated drive system shall be suitable for all normal and emergency duties, without damage or deterioration of either the motor or its connections that may lead to subsequent premature failure.
- 2.15.3.8 The traction motors shall be designed for a life of thirty-five (35) years with no need for major overhaul before 1.2 million Kms.
- 2.15.3.9 All lubricant for gear and pinion shall have an Indian equivalent and be commercially available.

2.15.4 Traction Equipment

- 2.15.4.1 The traction equipment shall be arranged so that the tractive and braking effort of the rake is dependent on the load.
- 2.15.4.2 The main traction equipment of motor cars for 67% powering arrangement shall include ~~two (2) independent power circuits for bogie control~~. one(1) power circuit / two (2) independent power circuits for car control propulsion/bogie control propulsion respectively.
- 2.15.4.3 The main traction equipment shall utilize IGBT or any other latest metro rail proven technology based VVVF control providing total traction and regenerative braking control.
- 2.15.4.4 It shall be possible to isolate locally each set of traction equipment in the rake.
- 2.15.4.5 The types of power semi-conductors used shall have had extensive use and proven experience in traction applications. The circuit breakers, contactors and conventional electromagnetic components used shall comply with the requirements of IEC 60077. The inductors used shall comply with the requirements of IEC 60310.
- 2.15.4.6 The vacuum circuit breaker shall be capable of safely interrupting the maximum possible fault load current. Except for the fuses required for the current collection equipment, the use of fuses in the power circuit shall not be permitted.
- 2.15.4.7 Over temperature monitoring and alarms shall be incorporated into Power Converter Inverter and Traction motors.
- 2.15.4.8 The service life of the traction equipment shall be at least 35 years.

2.15.5 Dynamic Brake

- 2.15.5.1 The dynamic brake shall take priority over the friction brake to utilize the regenerative energy function to the maximum degree possible and reduce wear on the friction brakes.
- 2.15.5.2 At low speed, a blend of dynamic braking and friction braking shall be used to stop the rake. During the blending process, a consistent overall braking effort with a seamless transition between the various types of brake shall be achieved.
- 2.15.5.3 The regenerative braking shall not cause the Traction Power Supply voltage to exceed the maximum operating voltage.

2.15.5.4 Should the Traction Power Supply system become totally or partially non-receptive then friction braking shall be applied without any noticeable change in brake effort. The design of the operating voltage, when it may become partially or completely non-receptive, shall be proposed by the designer.

2.15.5.5 The dynamic brake equipment shall be capable of withstanding any surge and transient voltages without damage or failure and without affecting the operation of the rake.

2.15.6 Friction Brake

2.15.6.1 A friction brake shall be provided which shall function as the ultimate braking system on the rakes, acting as a back-up to dynamic braking during normal service braking and as the primary braking system during emergency stops and while the rakes are parked.

2.15.6.2 The friction braking shall be Electro-pneumatic and shall be fully rated to meet the full braking performance and shall be capable of sustaining the continuous full emergency braking requirement.

2.15.6.3 The friction brake system shall be proven and capable of achieving all performance requirements without the aid of electric regenerative braking for a Round trip.

2.15.7 Parking Brakes

2.15.7.1 Spring applied; pneumatic release parking brakes shall be provided which shall be applied automatically in the event of loss of the main compressed air supply. The parking brake shall be capable of holding AW4 Loaded rake on the worst-case gradient incline (4%) in the worst anticipated wind condition for an unlimited time, and a 4% grade in the depot under AW0 loading condition.

2.15.7.2 The parking brake release air supply shall be derived directly from main reservoir but via a separate air pipe than the friction brake.

1 2.15.7.3 The parking brakes shall be capable of being applied or released from TCMS / OCC when the compressed air supply is present, or manually released, from the saloon when no compressed air is present.

2.15.7.4 The parking brakes shall be applied automatically once the power in the cab is turned off (Master Controller "OFF" Mode).

2.15.7.5 Automatic release of the parking brake shall be possible only after building up the normal air pressure.

2.15.7.6 The design shall be such that the parking brakes will take effect prior to fade off holding brake and shall ensure that the combined brake effect of the pneumatic brake and parking brake is never less than the full brake effort of the parking brake alone.

2.15.8 Traction and Braking Control

2.15.8.1 All rake control circuits essential to the operation of the rake's traction and braking equipment shall have service proven operation.

2.15.8.2 The use of diodes shall be avoided where possible and shall only be accepted where no alternative proposal can be established.

2.15.8.3 The feeds and inputs shall be duplicated and shall be used to control traction and braking equipment to ensure that no single point failure or event causes all the rake's traction and/or braking equipment to fail. No single point failure or event shall prevent the emergency brake system from being applied.

2.15.8.4 Where duplication or redundancy is used in safety related equipment, failure of any one component shall not be permitted to remain undetected if a failure of a second component could result in a hazardous situation.

2.15.8.5 In the event of a failure that results in a conflict between a brake demand and motor demand, or a conflict between direction signals, i.e. forward or reverse, the individual traction equipment shall initiate coasting.

2.15.8.6 The specified level of demand received by all the traction equipment on the rake shall be identical.

The tractive effort / braking effort output from the traction equipment shall be according to the level of demand received over the normal working range of the control signal.

- 2.15.8.7 In the event of an abnormal level of demand (i.e. outside the normal working range), or loss of signal, a default traction effort / braking effort shall be generated, which is equal to the maximum service braking effort under the AW4 Loading Condition).
- 2.15.8.8 If the auxiliary control voltage should vary outside the normal operating limits, the equipment shall not operate incorrectly or be damaged, should operate in degraded mode or shut down safely. The equipment operation shall restart immediately the auxiliary control voltage returns within limits.
- 2.15.8.9 The control of the brake systems shall be carried out independently on each bogie so that a fault in one bogie brake system or its control power supply shall affect that bogie only.
- 2.15.8.10 Software contained within the traction and braking equipment shall be capable of modification to alter the rake performance and capabilities.
- 2.15.8.11 Pneumatic brake control shall be designed to operate a single rake and two coupled rakes in case of push / pull recovery.
- 2.15.8.12 Interlocking shall be provided to ensure that a direction change is inhibited while the rake is in motion.
- 2.15.8.13 In the event of an occurrence of an interlock open circuiting, the effect shall not cause an unsafe condition to arise. Such an occurrence of a single open circuit interlock failure shall not disable both motoring and braking.
- 2.15.8.14 The traction equipment shall not operate unless a direction signal, consisting of either a forward or reverse demand and a motoring demand signal are received, as well as not receiving a braking demand signal.
- 2.15.8.15 The complete brake system shall be of similar performance to UIC 544-1, EN 13452-1 and EN 13452-2.
- 2.15.8.16 The dynamic braking equipment shall not operate unless a direction signal and a braking demand signal are received, as well as receiving a signal representing the level of demand. In the event of loss of the direction signal, the brake system shall revert to friction only.
- 2.15.8.17 Changes in the level of brake demand shall result in an appropriate and corresponding change in brake retardation.
- 1 2.15.8.18 The signal representing the braking demand level, transmitted by the brake control system, shall be of a resolution fine enough to enable the **ATO UTO** to operate satisfactorily and shall be coordinated with the **ATO UTO** design requirements.
- 1 2.15.8.19 The brake control system shall be capable of receiving inputs from the combined traction brake controller in the controlling cab and also the signal for the level of brake demand from the **ATO UTO** system.
- 1 2.15.8.20 A mechanism shall be provided to **remotely** isolate, from TCMS / OCC only the failed brake equipment on that rake.
- 2.15.8.21 A rollback protection feature shall be provided; when a train is at standstill there shall be sufficient retention of brakes (holding brake) such that the train does not roll back on a 4% gradient. The brake application shall be retained while traction power is applied, and the train takes forward movement. Specific provision shall be made in the software to ensure that the train safely starts on the 4% gradient.
- 2.15.8.22 An emergency brake control system shall be provided by two independent Hard-Wired circuits that shall demand an emergency brake application on all cars unless the status of all the rake's integral safety devices are proved to be safe. No electronic circuit components shall be directly coupled to this circuit.
- 2.15.8.23 In the event of an emergency brake application, the emergency brakes shall remain applied until the rake comes to a complete stop.
- 2.15.8.24 Emergency brakes shall be released only when the rake is proven to be in a "safe condition."

- 2.15.8.25 If a door opens when a rake is in motion, an emergency brake shall apply to bring the rake to a standstill.
- 2.15.8.26 The local auxiliary supply required for each car's emergency brake system shall be independent to that required for the service brake control.

2.15.9 Wheel Slip and Slide Protection System (WSP)

- 2.15.9.1 Traction and brake control systems shall be required to offer a highly efficient utilization of the available adhesion under all rail conditions. Requirements of clause 10.12 and clause 17.5.4.8.6 shall be met.

2.15.9.2 ~~A system shall be provided to detect and control wheel slip / slide on all axles and detect slip at axle level with control at bogie level, to ensure that any reduction in requested tractive effort or brake retardation during wheel spin/slide is kept to a minimum.~~ A system shall be provided to detect and control wheel slide on all axles. Detection of slip at axle level with control at bogie or at car level for bogie/car control propulsion respectively, to ensure that any reduction in requested tractive effort or brake retardation during wheel spin/slide is kept to a minimum.

- 2.15.9.3 The system shall be designed to be Fail Safe to ensure that any failure of the system shall not render it ineffective for friction brake control. If a failure of the slide protection system occurs while braking, the system shall not reduce the level of braking below the commanded level for more than ~~Ten (10)~~ Three (3) seconds. Alternatively, the Contractor must demonstrate fail safe proven design to CMRL.

- 2.15.9.4 The detection thresholds shall be commensurate with controlling the wheel-sets at or close to the peak of the variable friction-slip curves and the avoidance of wheel slip.

- 2.15.9.5 The wheel slip / slide protection equipment provided shall be operable in all traction and braking modes and under all varying Car passenger load, adhesion and speed combinations.

- 2.15.9.6 If wheel slide is detected then brake effort shall be smoothly ramped down and smoothly reapplied as soon as wheel slide has been corrected, to prevent any damage to the wheel sets, traction motors and transmissions, during the slide.

- 2.15.9.7 The correction of slide by the pneumatic brakes system shall act independently on a per axle basis. Whereas, dynamic braking shall correct slide a per bogie basis ~~for bogie control propulsion system or per car basis for car control propulsion system~~. The overall blended brakes system shall be fully adaptive to optimise braking in varying adhesion conditions.

- 2.15.9.8 Wheel spin on any individual axle must always be detected. However, correction of wheel spin need only be applied at a whole bogie level ~~for bogie control propulsion system and correction of wheel spin need to be applied at a whole car level for car control propulsion system~~. When wheel spin is corrected, traction power shall be gradually increased to meet performance requirements.

2.15.10 Brake Control Unit (BCU)

- 2.15.10.1 BCU and an associated electro-pneumatic (EP) brake unit shall be installed on each car. The system shall provide independent brake control for each bogie.
- 2.15.10.2 BCU shall be of a failsafe design such that a fatal error shall result in an emergency brake application.
- 2.15.10.3 Notwithstanding the requirement for brake control to be failsafe; system redundancy shall be sufficient to always ensure that a single point of failure can never result in an immobilized trainset due to the loss of EP brake control preventing the release of service brakes.
- 2.15.10.4 On receipt of a brake demand, the service brake shall be applied at the correct and corresponding level having regard to the car weight (from information provided by the pneumatic suspension system).
- 2.15.10.5 When a change in braking effort is demanded, the BCU shall control the rate of change in accordance with the specified levels of jerk and response times.
- 2.15.10.6 The train and brake control shall maximize the use of the dynamic brake at all times by interfacing with the traction system. Any shortfall in the effort provided by the dynamic brake shall be achieved using the friction brake.

2.15.10.7 Not used.

1 2.15.10.8 The BCU shall contain fault diagnostic facilities, which record all the relevant fault information and status of the equipment at the instant of failure to facilitate maintenance. A comprehensive set of indications & fault records shall be available on the BCU to display major faults which shall also be transmitted to TCMS / the RSC consoles of OCC, BCC & DCCs.

2.15.10.9 The fault indications shall be electrically latched when the faults are detected and shall illuminate whenever the supply to the electronics is switched on. The information contained within the fault log shall be stored on non-volatile memory.

2.15.10.10 The associated EP brake unit shall be of the energize-to-release type during Emergency Brake and energize-to-apply for other friction brakes and shall contain all the pneumatic items necessary to control all applications and release of the friction service brakes and emergency brakes on that car.

2.15.10.11 The emergency brake control valves shall be independent of the service brake control valves and shall be controlled directly from the emergency brake rake control lines.

2.15.10.12 The mechanism of brake force / Car weight adjustment employed shall ensure a full proportional adjustment is achieved through the braking range between Tare Loading Condition (AW0) and Exceptional Crush Loading Condition (AW4).

2.15.10.13 The method by which the passenger load-sensing signal is processed shall be arranged to ensure that absence of a load-sensing signal, for any reason, shall result in a brake force being applied corresponding to AW3 Loading Condition on that car.

1 2.15.10.14 The rake braking system shall be fully compatible with ATQ UTO system.

2.16 CONTROL AND INTERLOCK SIGNALS

2.16.1 Control and interlock signals, where required, shall be capable of providing sufficient signal strength such that a rake is able to tow a disabled rake.

2.16.2 If propulsion and braking train lines ever appear in an abnormal combination, the most restrictive signal shall govern. The implementation of these signals shall be fail-safe so that all failures tend toward a more restrictive mode.

2.16.3 Selection of propulsion or braking modes shall be a direct result of the master controller position. The signal shall follow fail-safe principles of using higher-level signals for the propulsion mode and lower-level signals or zero (loss of signal) to request braking. Alternative proven designs may be considered but will be subject to CMRL approval.

2.16.4 Direction Control

2.16.4.1 Direction signals shall be a pair of train lines, energized individually to determine the direction of operation. Energizing or not energizing both train lines at the same time shall inhibit propulsion.

1 2.16.4.2 Direction signals shall originate remotely from OCC, BCC & DCC in case of UTO mode of operation. And in Non UTO mode, direction signals shall originate from TCMS / Master Controller.

2.16.4.3 During reverse operation, car speed shall be limited to 3 kmph.

2.16.5 Emergency Brake Control

1 2.16.5.1 Activation of the console emergency stop pushbutton, movement of the master controller to the emergency brake position, or the control of the ATQ UTO, shall command emergency braking.

2.16.5.2 Emergency brake train line command signals, activated from the console mounted emergency stop pushbutton, shall override jerk-limit to directly apply friction brakes as required.

1 2.16.5.3 Emergency brake train line command signals, activated by placing the master controller into its emergency brake position or the control of the ATQ UTO, shall override jerk-limit control but shall maintain the slide-control function of the braking systems.

2.16.5.4 Separation of the train lined electric functions shall cause an emergency brake application on all cars in the rake.

- 2.16.5.5 The emergency brake command shall be normally energized. When de-energized, this signal shall call for an irretrievable friction brake emergency stop to zero speed, with the following propulsion and braking system response:
- Propulsion system shall go into coast immediately.
 - Emergency friction braking shall be applied immediately.
 - The spin / slide system for the dynamic brake shall be disabled when the command is initiated by the Operator's Emergency Pushbutton available on the Operator's Emergency Driver desk or RSC consoles of OCC, BCC & DCCs in case of ATO UTO mode of operation.

1

2.17 ACOUSTIC REQUIREMENTS

2.17.1 General

The Car design shall ensure that noise generated by Car motion and also from the mounted equipment is minimised. The noise transmission to both the external and internal environments shall not exceed the levels specified below. Unless otherwise specified, all measurements shall be made in accordance with ISO 1683, EN ISO 3381:2005 & EN ISO 3095:2005

- 2.17.1.1 This section contains the general requirements for maximum allowable sound levels in passenger spaces including Operator's Desk, and at the wayside. The Contractor shall submit for approval a plan and analysis to show how the requirements of this section will be met.
- 2.17.1.2 The Contractor shall devote particular attention to the design of the rake and equipment to obtain quiet operation and shall ensure that the noise criteria specified herein are not exceeded.
- 2.17.1.3 Enclosures, baffles, seals, acoustical absorption, and body panels with adequate sound transmission loss, vibration isolators, or other appropriate methods shall be incorporated into the car design to attenuate noise and vibration generated by wheels, rails, motors, and all elements and equipment, and to ensure that the limitations on interior and wayside noise are not exceeded. The Contractor shall select the optimal design to meet the noise requirements, subject to CMRL's approval.
- 2.17.1.4 All equipment shall be designed to eliminate rattling and resonance at all speeds up to 10% above maximum normal operating speed by the use of damping, gaskets, resilient mounts, or similar methods.
- 2.17.1.5 In general, the noise-control features of the equipment shall last for the useful life of the car.
- 2.17.1.6 Designs based upon ISO 3095 (external) and ISO 3381 (internal), as well as, ANSI S1.4 / IEC 61672-2 : 2013, ANSI S1.6, ANSI S1.11 and ANSI S1.13 will be acceptable

2.17.2 Definitions

2.17.2.1 Measurements:

All overall noise levels shall be measured in terms of dBA. Unless otherwise indicated, "slow" meter response time shall be used. Where frequency analysis is required, it should be made at least in 1/3-octave bands according to EN ISO 266. The measurement system shall be calibrated before and after measurements.

2.17.2.2 Environment:

Noise criteria specified herein for a stationary car are based on measurements taken in an essentially free-field environment, such as outdoors away from any reflective surfaces other than track upon which the rake is parked.

The test site should be such that free sound propagation exists. The ground needs to be flat, the area around the microphones shall be free from reflecting objects. The area between the vehicle and the microphone shall be as free as possible from sound absorbing matter (tall vegetation, other tracks) or reflective covering (water). Measurements require a wind speed below 5 m/s and no rain. The track shall be dry, the level gradient shall be less than 3:1000 and the radius of curvature shall be larger than 1000 m for speeds below 70kmph and 3000 m for speeds above 70 kmph. The noise levels below assume that the test track fulfils the roughness and decay

requirements on a reference track for pass-by noise according to A.1.4 in TSI (Official Journal of the European Union 8.2.2006, Commission Decision 2006 / 66 / EC). These requirements are normally fulfilled by a newly ground UIC60 rail on ballast less track or equivalent. Testing can still be performed on a non-compliant track by recalculating the noise levels to account for the additional noise contribution from the track.

2.17.2.3 *Pure Tone or Narrow Band*: Assessment of tonality:

Tonality shall be assessed according to ISO 1996-2 Annex D. This means that a 1/3-octave band is considered tonal if the level of this band exceeds the average levels of the two adjacent bands with more than 15 dB for frequencies up to 125 Hz, 8 dB between 160 Hz and 400 Hz or 5 dB for frequencies above 400 Hz.

2.17.3 **Interior and Exterior Noise Control and Criteria**

2.17.3.1 Not used

2.17.3.2 Not used

2.17.3.3 The noise limits in Table 2-9 shall not be exceeded when testing according to ISO 3381

2.17.3.4 Measurements of interior noise levels shall be taken in a fully equipped car. It shall be unloaded or unoccupied except for the train crew. Doors and windows shall be kept closed.

Table 2.9 Interior Noise Levels (L_{pAeq} , 20 Seconds)

Location (Section)	Interior Noise Measurements in Maximum dBA			
	Stationary		Running (75KMPH)	
	Elevated & at grade	Under ground	Elevated & At grade	Under ground
All cars passenger saloon location including Emergency Operator desk	68	75	75	82

Where:

- During Stationary condition, the specified limits shall be met with all auxiliary equipment loads operating simultaneously and shall be considered during test for noise measurement.
 - For running conditions the specified limits at specified speeds shall be met (including during acceleration and deceleration) with all equipment operating simultaneously.
 - All measurements to be made along the car centreline 1400mm above the floor and not less than 600mm from the end of the vehicle.
- 2.17.3.5 Exterior Noise Levels for elevated (measured in two track section) and at-grade sections shall not be more than those specified in table 2.10.

Table 2.10 Exterior Noise Levels (L_{pAeq} , 20 Seconds):

Maximum Level of Exterior Noise in dBA @ 7.5 m from centre of track on either sides	
Stationary	Running (75Kmph)
67	82

Where :

- Exterior Noise level measurement to be done at a location 7.5 m horizontally from the track centre line on a horizontal plane passing through the axle centre line at any point along the length of the vehicle on either side.
- During Stationary condition the specified limits shall be met with all auxiliary equipment operating simultaneously at maximum capacity.
- For running conditions the specified limits shall be met for the entire speed range up to 75kmph (including acceleration and deceleration) with all equipment operating simultaneously

- 2.17.3.6 Noise levels obtained in underground tunnels and platforms shall be measured by the Contractor under the same conditions (as far as possible). These shall be submitted to the Project Manager for reference purposes.
- 2.17.3.7 Standards ISO 3095 for external noise and ISO 3381 for internal noise should be followed.
- 2.17.3.8 Standard for vibration ISO 2631-1:1997, ISO 2631-4:2001 shall be followed. All equipment, auxiliaries mounted at any position on the car shall have below mentioned criteria:
- 2.0 mm peak to peak vibration amplitude – frequency range from 1.4 Hz to 20 Hz
 - 0.8 mm per second peak vibration velocity – frequency range above 20Hz
- 2.17.3.9 Door Operation Noise produced by simultaneous operation of all saloon doors on one side of the car shall not exceed 75 dBA during the sliding operation and 78 dBA for the locking / unlocking, measured on the fast meter scale. This should be measured at all points in the car 300 mm from the doors and 1000 mm above the floor during train stationary condition.
- 2.17.4 **Wayside Noise Control and Criteria**
- 2.17.4.1 The noise limits in table 2-11 shall not be exceeded when testing according to ISO 3095 on a reference track according to above.
- 2.17.4.2 Microphones shall be placed 1.2 m above top of rail.

Table 2-11: Maximum Wayside Noise Levels

Condition	Maximum Level of Exterior Noise in dBA @7.5m from centre of track on either side
All systems operating simultaneously, including air conditioning and propulsion cooling system, rake stationary	67 dBA at 7.5 m
Each auxiliary system operating alone, car stationary	65 dBA at 7.5 m
Rake at any speed from 0 kmph to 75 kmph, including maximum acceleration, maximum deceleration, maximum full-service brake with all auxiliaries operating under normal conditions	82 dBA at 7.5 m

2.18 ELECTRICAL NOISE CONTROL REQUIREMENTS

- 2.18.1 To help avoid undesirable effects upon external equipment, or upon other installations along the right-of-way, caused by onboard car systems, the electromagnetic emission limits specified herein shall not be exceeded.
- 2.18.1.1 The Contractor shall comply with the requirements of the international standards EN 50121 part 1 to part 5 : 2003 and related standards and the IEC 61000 series, or equivalent standards. EMC considerations shall be incorporated in the Contractor's procedures for functional safety and engineering verification.
- 2.18.1.2 Each item of Rake mounted equipment shall be tested in accordance with the Contractor's EMC Test Plan which shall be based on the requirements of the relevant part of EN 50121 and the results shall be submitted for approval of CMRL.
- 2.18.2 Meeting these emission limit requirements is the first level of defining the interface between the rake and its intended environment. The Contractor shall be responsible for reducing emission limits, if necessary, to prevent interference with any existing railway or non-railway systems, and shall work jointly with CMRL and others designated by CMRL to ensure compatibility between the car and any CMRL equipment and with the operating environment.

- 2.18.3 The Contractor shall employ design techniques, construction methods, and whatever apparatus is required to prevent interference caused by internal sources from affecting the proper operation of the car and external systems.
- 2.18.4 In addition to coordinating frequencies, EMC levels, and susceptibility levels, the Contractor shall provide the necessary on-board grounding, balancing, filtering, shielding, modulating techniques, and isolation to maintain signal-to-noise ratios within clearly workable limits and to reduce the undesirable effect of interference.
- 2.18.5 Electrostatic and magnetic electrical shielding methods shall be employed to minimize the effect of stray signals and transient voltages on cables. Power and signal cables shall be physically separated where practicable and shall be shielded where necessary. Suppression devices shall be employed on relay and magnet-valve circuits to protect low-voltage circuits from relay transients.
- 2.18.6 Components and functional circuits shall be grouped according to their similar sensitivities to electrical interference and power supply needs and grouped to reduce the effects of voltage drops in ground circuits. Power and return leads shall be routed in the same Cable duct or harness. Suppression devices shall be used on power supply leads where necessary to suppress interference at the inputs to sensitive circuits.
- 2.18.7 Train lines shall be located and arranged to minimize voltage induction due to propulsion and auxiliary power.
- 2.18.8 Any harmonic currents produced by the rake in the running rail shall not interfere with the normal operation of the signalling system, including cab signalling.
- 2.18.9 **Radiated Emission Limits**
- 2.18.9.1 Rolling stock shall comply with following or equivalent Standards: EN 50121 part 1 to part 4.
- 2.18.9.2 Each item of Rake mounted equipment shall be tested in accordance with the Contractor's EMC Test Plan which shall be based on the requirements of the relevant part of EN 50121 and the results shall be submitted for approval of the CMRL.
- 2.18.9.3 The maximum levels of radiated EMI of any individual item of rake mounted equipment shall not exceed the levels specified in EN 50121-3-2. The emissions of the rake shall not exceed the levels specified in EN 50121-3-1. These limits shall apply under all normal conditions.
- 2.18.10 **Conductive Emission Limits**
- 2.18.10.1 All electrical and electronic equipment on board the Rolling Stock shall not exceed the conducted interference levels as defined in EN 50121-3. These limits shall apply under all normal conditions.
- 2.18.11 **Susceptibility of Rake borne Equipment**
- 2.18.11.1 All electrical and electronic equipment on board the Rolling Stock shall be immune to any radiated electromagnetic energy produced by other pieces of Rolling Stock equipment and external sources as required by EN 50121-3.
- 2.18.11.2 The mounting of sensitive equipment in the vicinity of the mounted rake radio antennas shall be avoided.
- 2.18.12 **Electrostatic Discharge**
- 2.18.12.1 Any equipment sensitive to electrostatic discharge likely to be touched by personnel shall be protected against electrostatic discharge. Equipment shall be tested to 3 kV with contact discharge, as defined in EN 50121-3.
- 2.18.12.2 These criteria shall be a part of the electromagnetic compatibility (EMC) control plan, as defined in this Chapter and Chapter 17.
- 2.18.13 **Audio Frequency Interference**
- 2.18.13.1 It is essential that rake emissions do not interfere with the proper operation of power frequency (PF) track circuits, or cab signals. Therefore, design techniques and construction methods shall be employed that ensure suppression of any interference emissions.

- 2.18.13.2 In addition, since equipment boxes and cabling will be removed, inspected, and/or replaced on a routine basis, the equipment shall be designed to ensure proper sealing of boxes, cables, etc., during routine maintenance procedures.

2.18.14 Control and Test Plans

- 2.18.14.1 The Contractor shall submit for approval an EMC control plan, addressing complete rake and rake system requirements, before purchase specifications are issued for any car borne apparatus.
- 2.18.14.2 The plan shall ensure that proper emphasis will be placed on the control of interference, interface design from the earliest stages of rake design. The EMC control and test plans shall describe the Contractor's approach to ensure that the specified EMC requirements are met.
- 2.18.14.3 At a minimum, the Contractor's EMC control plan shall include the following:
- a) General design and mitigation techniques to be applied to the complete rake and all car systems.
 - b) Analysis of the susceptibilities of car systems and the standards and criteria to be applied to system designs.
 - c) Analysis of wayside and non-railroad susceptibilities applicable to rake design, as well as overall EMC emission requirements as defined herein.
 - d) Requirements for emission limits for one complete rake, including all car systems.
- 2.18.14.4 The following design requirements shall be included in the EMC control plan:
- a) To contain EMC emissions wherever possible, the suppression of transients shall be at the source of the transient.
 - b) All magnet valves relay and contactor coils, and other inductive devices shall have transient suppression. The absence of suppression for performance reasons will require approval.
 - c) The number of suppression devices shall be kept to a minimum.
 - d) Equipment design, wiring techniques, and enclosures shall shield equipment from any effects resulting from the operation of a hand-held transceiver.
 - e) Equipment design, wiring techniques, and enclosures shall shield equipment from any effects resulting from the operation of cellular telephones, including when cellular telephones are operated within the rake or on the passenger platforms.
 - f) Equipment design, wiring techniques, and enclosures shall shield systems to prevent the rake and its systems from causing undesired effects to external equipment and systems, with particular emphasis being placed on safe operation with the wayside signal and communications systems. The Contractor shall ensure that this program confirms that operational sensitivities of the wayside signal and communications systems, and interference free operation, are within design parameters.
- 2.18.14.5 The EMC test plan shall address how the susceptibility and emission limits will be verified.
- 2.18.14.6 The Contractor shall conduct EMC tests in accordance with an internationally recognized standard, and Chapter 17.
- 2.18.14.7 CMRL approval of the EMC control and test plans does not relieve the Contractor from the requirement to provide equipment that functions safely and properly in the transit environment.

2.19 NOT USED

2.20 COMPLIANCE MATRIX

- 2.20.1 The Contractor shall develop and maintain a compliance matrix demonstrating how all Technical Provisions are validated and complied with. The compliance matrix shall clearly identify how compliance is achieved and refer to the related written proofs and with their revisions. That compliance matrix shall be dispatched to CMRL for information on a regular basis to be agreed upon between the Parties (basically, every month) until agreement of compliance for all clauses by CMRL. CMRL reserves the right of access to any of those written proofs.

2.21 DESIGN MANAGEMENT AND CONTROL

- 2.21.1 To ensure that the requirements of this Technical Specification are met, the Contractor shall establish and maintain documented procedures using ISO 9001 to control and verify the design of the train and all its sub-systems. These procedures shall be subject to review and approval by CMRL. The Contractor shall have complete responsibility for the correctness of design and its compliance with the specification.
- 2.21.2 The Contractor shall establish and maintain a systematic, documented, comprehensive, and verifiable system integration process throughout the execution of the Contract. This process shall ensure that interfaces and interaction between cars, infrastructure, subsystems, software, and operating and maintenance requirements have been identified and engineered to function together as a system.
- 2.21.3 Demonstration of contract compliance and traceability against all contractual technical and functional requirements using a formal requirements management and traceability tool. For tools that are compatible with IBM Rational DOORS latest version or equivalent, electronic copies of the database shall be submitted to the Employer / Engineer with every design submission, starting from the beginning of the System Design phase until the end of the project for the Employers / Engineers information. For tools that are equivalent to IBM Rational DOORS proposed by the contractor, approval of the Employer / Engineer shall be obtained. The complete setup including the hardware and software, license, etc. proposed and approved by the Employer / Engineer shall be handed over to CMRL for use starting from the beginning of the System Design phase until the end of the project. The hardware, software and license shall be latest versions and the license shall be on Employer name.

1

2.22 SYSTEM INTEGRATION PROCESS

- 2.22.1 The Contractor shall systematically identify and formally document all design, manufacturing and operational interfaces between equipment within the train, and between the train and external systems, facilities, operations and the environment likely to affect or be affected by the train.
- 2.22.2 A mechanism and assigned project responsibility for interface management and control shall be provided, such that every identified interface has a defined resolution process that can be monitored.
- 2.22.3 The Contractor shall define methods to confirm compatibility between train consist sub-systems and carrying out integration tests at different stages of the design and interface management process to demonstrate that all sub-systems functions perform properly, both individually and as part of the complete train.
- 2.22.4 The Contractor shall ensure that performance, availability and safety requirements are addressed in the design process and that the reliability and maintainability of all sub-systems will enable the service performance to be met. The system integration process shall be capable of audit by CMRL.

2.23 INTERFACE MANAGEMENT

- 2.23.1 The Contractor shall submit to CMRL for review an Interface Management Plan (IMP) and Detail Interface Document with each Designated Contractor, in accordance with the Interface requirement of Appendix C which defines how the Contractor shall systematically identify and document technical interfaces.

2.24 COMMAND RESPONSE TIME

- 2.24.1 Command Response Time includes response to modulation within a mode (powering, coasting & braking) and transition from one mode to another, including emergency brake.
- 2.24.2 Modulation within a mode shall be jerk limited. The command response time (combined response time for electrical equipment response, electronic equipment response, network response and

1

software response times) within a mode shall not exceed 300 m sec. This shall be applicable for all ~~ATO and ATP~~ UTO and Non-UTO modes of operation.

2.24.3 Mode change dead time for transition from one mode to adjacent mode (motoring to coasting, coasting to braking, braking to coasting and coasting to motoring) shall not exceed 500 ms, exclusive of jerk limiting. This shall be the applicable for all ~~ATO and ATP~~ UTO and Non-UTO modes of operation.

1

2.24.4 The command response time shall be measured from the time the change is initiated until the acceleration or deceleration transitions to 10% of the requested change.

2.24.5 The achieved command response time as per above shall be submitted during pre-final design stage.

2.25 SPECIFIC ENERGY CONSUMPTION

2.25.1 The Contractor shall note that 'SPECIFIC ENERGY CONSUMPTION (SEC)' shall be verified in any one corridor of Phase 1 (which can be selected by the Contractor) under conditions detailed hereafter in this clause shall not exceed 50 Wh / GTKM (watt hours per gross tonne kilometre), referred to as SECs. The Contractor shall submit detailed simulation results for all corridors of Phase 1 during the Pre-Final Design stage.

1

2.25.2 This Specific Energy Consumption shall be total of two components viz. SEC for 6 car train (with VAC switched off) i.e. 'SEC_P' value and SEC of VAC for 6 car train i.e. 'SEC_H' value and ~~'SEC_{AUX}' value of Auxiliary load.~~ These ~~three~~ two values shall be declared by the Contractor (SEC_{P-declared} + SEC_{H-declared} ~~+ SEC_{AUX-declared}~~) during Preliminary Design stage and the same shall be validated in pre-final design stage and verified in combine testing and mainline testing. The total declared SEC value i.e. SEC_{declared} for 6 car train as declared by the Contractor i.e. SEC_{P-declared} + SEC_{H-declared} shall not exceed the SEC_s i.e. 50 Wh/GTKM as mentioned above.

The Contractor shall note that no adjustments shall be permitted on the 'SEC' values obtained during validation. Changes to SEC_{P-A} (Achieved value of SEC_P) and SEC_{H-A} (Achieved value of SEC_H) will be permissible on account of any of the following:

- (i) Increase in length of the network in any corridors by up to 5% of the total length of the section including change in alignment (horizontal curve, vertical curve, etc.,).
- (ii) Increase in number of stations by 2 (two) stations in each Corridor.
- (iii) Any changes in station locations with consequent changes in inter station distances / rationalization of curves & gradients.

2.25.3 The Contractor shall also note that irrespective of any tolerances specified in any relevant international Standards or relevant other engineering documents of other metros or in the submitted bid documents, with respect to the measured or SEC values, no tolerance / margin shall be considered applicable in this case.

2.25.4 In the event of measured SEC exceeding 50 Wh/GTKM, the Contractor shall carry out rectification / modification work on the train, within a reasonable time as agreed with CMRL (not beyond DNP completion) to achieve 50 Wh/GTKM. In case the Contractor fails to achieve 50 Wh/GTKM, the Bank Guarantee related to Project Performance Security will be held.

2.25.5 The Contractor shall note that 'no-bonus' is payable for achieving specific energy consumption figures better than specified ones.

2.25.6 The estimated specific energy consumption figures will be submitted by the Contractor along with the bid for each section based on the train resistance formula, curve resistance formula and track profile in the 'normal mode' of train operation. The Contractor shall also furnish the break-up of the estimated specific energy consumption as follows:

- (i) Specific energy consumption in traction.
- (ii) Specific energy regenerated and fed back to the system.
- (iii) Specific energy consumption of each auxiliary power unit.

- (iv) Specific energy consumption of each VAC unit.
- 2.25.7 Verification of the estimated energy consumption with full auxiliary load of the unit and AW4 loading will be carried out:
 Speed-current characteristic and torque current characteristic data will be acquired from the type test of combined propulsion equipment and traction motor. Performance data on measured basis i.e. weight of the car, efficiency of propulsion and auxiliary subsystem / equipment and validated train resistance formula, along with the above data shall be used for simulation with the computer program for energy consumption.
- 2.25.8 The verification of the declared energy consumption and regeneration shall be done during combined system test. Any reduction of either component of energy as above shall be corrected at the test bed till the declared values are achieved. The Contractor shall carryout demonstration tests to establish achievement of the declared Specific Energy Consumption figures. If the actual specific energy consumption exceeds the estimated specific energy consumption quoted by the Contractor by more than 3%, the Contractor shall carry out rectification work on the train, within a reasonable time as agreed with CMRL.
- 2.25.9 The Contractor shall also furnish the following information:
- Quality specification of the regenerated energy including its harmonic analysis.
 - Efficiency of each auxiliary power consumption point.
- 2.25.10 **Components of Specific Energy Consumption (SEC):**
- SEC for a 6 car train with VAC switched off ('SEC_p')**
 - The 'SEC_p' value as declared by the Contractor i.e., SEC_{p-declared} shall be validated under Combined Test Bed and Field Trial conditions:
 - For Combined Test Bed: Round Trip Time (RTT) corresponding to Declared Schedule Speed (DSSP) (RTT_{DSSP}), in Phase 1 network for Corridor 1 & 2.
 - For Field Trial: Actual Round Trip in main line (Corridor 1 & 2) under ATO / UTO operation including twice Turnaround time at terminal station to reach the same point from where the journey started.

Note: The train may be required to run for approximately 500 meters at each terminal station for turnaround. In case the actual run during turnaround is more than 500 m but the overall increase in the length of the network is within 5% of the total length of the section, no adjustments of the SEC values shall be permissible.
 - Dwell time at each intermediate station shall be 30 seconds (including door opening and closing time).
 - Total Turnaround time at each Terminal station including Dwell time shall be 3 minutes.
 - Loading conditions:
 - For Combined test bed: AW3 loading condition.
 - For Field Trial: AW3 loading condition.
 - The Train operation under Normal mode as per the Guaranteed "Declared Schedule Speed (DSSP)" in Kmph for a round trip in Corridor 1 & Corridor 2.
 - For Combined test bed: The Contractor shall indicate the total runtime and the Guaranteed "Declared Schedule Speed (DSSP)" in Kmph for a round trip in Corridor 1 & 2 under the following condition.
 - Train loaded: AW3
 - Mode of operation: NORMAL MODE (ATP/ATO)
 - Acceleration rates: Equal to or better than rates specified in the performance table 2-7.
 - Average service brake rate from maximum speed to standstill shall be equal to or better than the specified brake rate in the performance table 2-7 above

1

- Round Trip in main line (Corridor 1 & 2) including twice Turnaround time at terminal station so as to reach the same point from where the journey started
 - Dwell time at each station shall be 30 secs (including door opening and closing time)
 - Total Turnaround time at each Terminal station including Dwell time shall be 3 minutes
 - The Contractor shall indicate total time for the round trip as round trip time i.e., RTT_{DSSP} .
- vii. For Field Trial: NORMAL ATO / UTO mode (refer Clauses Part-2, Section VI A, Appendix C, Clause 2.3.4 & 2.3.6 as decided by CMRL during design stage shall be considered. The decision of CMRL shall be final and binding.
- viii. During the run and during the reversal at Terminal stations, full auxiliary load with all auxiliaries functioning at full load at unity duty cycle shall be in operation. However, VAC shall be switched off during this run and one air compressor shall be working.
- The Contractor shall submit the Average Equivalent Auxiliary load (D_{Aux}) in kW at pantograph level for a round trip detailed above. The Contractor shall also consider the D_{Aux} value while declaring the value of $SEC_{P-declared}$ during Preliminary design stage. (D_{Aux}) calculations shall consider the following factors:
- Operation of all auxiliary loads (including doors opening and closing at stations / terminals) as noted above
 - Efficiency of auxiliary converter-inverter.
 - Cable losses in the cables between Main Transformer and auxiliary converter-inverter.
 - Efficiency curve of Main Transformer (auxiliary winding) during the dwell time and during the run.
- And shall follow these assumptions:
- Shall include the Load of one main air compressor and one air dryer
 - Shall not include VAC and associated control loads
 - The battery charger load shall be considered as only 25 % of the rated load.
- ix. In support of the declared SEC value ' $SEC_{p-declared}$ ' during Preliminary design stage, the Contractor shall submit the calculations, ratings and technical data sheet comprising of but not limited to:
- Complete simulation report (including run curve simulation, input data and assumptions made). The simulation report in excel format shall include the details of the distance travelled, train speed, acceleration or deceleration achieved, electric effort (tractive or regenerative), mechanical effort and motion resistance at an interval of 250 msec. during the run.
 - Traction motor voltage, current and DC link voltage at different speeds during powering and braking. Values shall be submitted in Excel format for speed increment of one tenth of kmph.
 - Tractive Effort and Braking Effort values for powering and regeneration shall be submitted in Excel format for speed increment of one tenth of kmph.
 - Efficiency values of Main transformer, Traction Motor, Converter Inverter, gear drive and auxiliary converter-inverter shall be submitted in Excel format for speed increment of one tenth of kmph.

b) SEC of VAC for a 6 car train (Say ' SEC_H ' Wh/GTKM)

Specific Energy Consumption for functioning of VACs of a 6 car train – (' SEC_H ') as declared by the Contractor i.e. $SEC_{H-declared}$ shall be validated by conducting a test on one car under following conditions in a climatic chamber:

- i. Round Trip Time (RTT) corresponding to Declared Schedule Speed (DSSP) (RTT_{DSSP}), in Phase 1 network for Corridor 1 & 2 as mentioned in clause 2.25.10.a.vi. shall be considered.

- ii. Dwell time at each intermediate station shall be 30 seconds (including door opening and closing time).
- iii. The train operation and the run time between stations corresponding to DSSP as per clause 2.25.10.a.vi. shall be considered for testing during validation.
- iv. Inside car temperature shall be maintained at 25°C and relative humidity of 65%. The Contractor to note that the car inside temperature before opening of the saloon doors at each station shall be within 25°C.
- v. Ambient (summer) conditions to be maintained outside the car. Ambient temperature, humidity and air speed of outside car shall be monitored as per EN 14750-2. Energy Consumption test shall be conducted at an air speed of 5 kmph.
- vi. Loading Condition: Heat load of AW3 numbers of persons as per EN 14750-1, throughout the round trip including the terminal turnaround time.
- vii. Doors opening and closing as per scheduled to and fro run on the route.
- viii. For terminal stations, 2 times opening as well as closing of doors shall be considered.
- ix. The Contractor shall submit the efficiency value of Auxiliary Converter-Inverter and calculation sheets during pre-final design stage:
 - Cable losses between Auxiliary Converter-Inverter and VAC with size and length of cables.
 - Efficiency curve of Auxiliary Converter-Inverter.
 - Cable loss between Auxiliary Converter-Inverter and main transformer.
 - Efficiency curves of Main Transformer during run, turnaround and during dwell time.

The energy measured on one car (CMRL will inform type of car during design stage) in the climatic chamber will be multiplied by six (6) to determine the energy consumption by VACs of a 6 car train in climatic chamber (SEC_{H-CC}). Energy loss on account of items listed above 2.25.10.b.ix. shall then be added to the measured value above i.e., SEC_{H-CC} to determine the value of SEC_H i.e., ' SEC_{H-A} '.

2.25.11 Validation of Specific Energy Consumption:

The validation of the declared values $SEC_{P-declared}$ and $SEC_{H-declared}$ shall be done as described below. However, the conclusion of validation shall be done in totality after the Contractor has established the compliance of specified Specific Energy Consumption i.e., SECS value.

a) Validation of " $SEC_{P-declared}$ ":

Validation of ' $SEC_{P-declared}$ ' under conditions noted above shall be carried out by the following methods undertaken in two stages:

- i. Validation on COMBINED TEST BED (Stage-1):
 - The test protocol shall be prepared in detail and approved by CMRL before commencement of the test. The "Combined Test Bed" shall comprise of equipment (E.g., Main Transformer, Converter Inverter, Traction Motor and Auxiliary Converter-Inverter etc) that is supplied by the same OEM and of the same configuration as the final design. Type test results including efficiency curves at different loads for Main Transformer, Gear Case, Converter Inverter and Auxiliary Converter-Inverter shall be considered for finalizing the test protocol.

For measurement, Current Transformer and Potential Transformer of accuracy class 0.1 or better as in IEC 61869 shall be used. Energy meter of accuracy 0.15% or better shall be used.
 - The declared auxiliary load (D_{Aux}) multiplied by the total round-trip time (corresponding to DSSP as per clause 2.25.10.a.vi) shall be added to the measured value while calculating specific energy consumption in the combined test bed set up. This value shall be the $SECP-A$ -Stage 1.
- ii. Validation during Field Trial (Stage-2):

1

The value of 'SEC_{P-declared}' shall also be validated on the actual mainline as stated in Clause 2.25.10.a.vii. This measured value during field trial shall be the SEC_{P-A-Stage 2}.

- iii. The Contractor shall note that, to determine compliance of the total specified 'SECS' value, the actual values determined on "Combined Test Bed" (2.25.11.a.i) as well as the actual measured value in the line run test-round trip under ~~UTOATO~~/ATO mode of operation (2.25.11.a.ii) shall be considered.
- iv. To determine compliance, the highest of the determined Specific Energy Consumption values on the combined test bed i.e., SEC_{P-A-Stage 1} and measured value in actual line test i.e., SEC_{P-A-Stage 2} shall prevail. The higher of the two values (SEC_{P-A-Stage 1} and SEC_{P-A-Stage 2}) shall be considered as SEC_{P-A} (Achieved SECP).
- v. Combined Test Bed test for validation of 'SECP-declared' shall be conducted and concluded during pre-final design stage and before dispatch of the prototype train set.

b) Validation of "SEC_{H-declared}":

- i. Before conducting Specific Energy Consumption test, the car level type test of the VAC system should have been completed and the VAC & Air duct system should have been found suitable.
 - ii. Validation of 'SEC_{H-declared}' value shall be done in a climatic chamber as per conditions specified in clause 2.25.10.b.
 - iii. To determine compliance with the declared specific energy consumption value for VAC i.e., 'SEC_{H-declared}', the Contractor shall carry out test on a single car (CMRL will inform type of car during design stage) in the climatic chamber.
 - iv. Suitable necessary arrangements shall be made for providing almost evenly distributed sensible heat and humidity load inside the car with the help of thin film resistors, other heating devices and humidifiers for simulating the specified passenger heat loads and other heat loads. Heaters and humidifiers will be placed such that real life like situation is created.
 - v. Doors shall be opened and closed as detailed for a round trip and passenger load throughout the Round Trip (including terminal detention) shall be AW3.
 - vi. Detailed instrumentation of the VAC, car interior and exterior, and the climate chamber shall be done to monitor if the specifications and standards specified criteria are not getting violated at any time in during the test.
 - vii. The Contractor shall note that the 'SEC_{H-declared}' value validation test shall be carried out only after ensuring compliance of "Air Flow" and "Cooling Capacity test" exactly in line with the relevant standards and specifications of this tender.
 - viii. Energy Consumption for VACs for the car under test shall be multiplied by the number of cars in a train (i.e., 6 cars) to determine the Energy Consumption of VACs for one train ("SEC_H" Wh/GTKM).
- c) Based on the achieved value of SEC i.e. SEC_A [SEC_{P-A} + SEC_{H-A}], after conclusion of the validation of SEC_S, if the Contractor is unable to validate and establish compliance of total Specific Energy Consumption value i.e. SEC_S to the entire satisfaction of CMRL, the Contractor shall carry out necessary modifications (hardware and/or software) in the Rolling stock to achieve the specified Specific Energy Consumption value (SEC_S) and re-validate the same. In such cases, the revalidation will be again carried out after modifications as per clause '2.25.11.a' and '2.25.11.b' above including Air Flow Test & Cooling Capacity Test of VACs.

The Contractor shall note that the achieved values i.e., 'SEC_{P-A}' and 'SEC_{H-A}' shall be considered up to one tenth of the unit with the one tenth component rounded up to the next value. For example:

- If the achieved value of 'SEC_P' on combined test bed and/or during field trial is 26.11 Wh/GTKM, the value would be considered as 26.1 Wh/GTKM.
- If the achieved value of 'SEC_H' is 16.89 Wh/ GTKM, then value would be considered as 16.9 Wh/GTKM.

For validation, the energy measured with external energy meter during field trials shall prevail. The Contractor shall submit calibration certificate for the energy meters used for measurement from an independent laboratory and such certificate shall not be more than 3 months old.

i. Measurements to be made for:

Sl. No.	Description	Symbol
1.	Energy Consumption input at pantograph during 'Non-braking' (Traction & Coasting)	E_{231}
2.	Energy consumption at input of APS (Auxiliary Converter-Inverter) during 'Non-braking'	E_{221}
3.	Energy consumption at Converter-Inverter unit during 'non-braking'	E_{211}
4.	Energy consumption input at pantograph during 'Braking'	E_{131}
5.	Energy exported during 'Braking' at pantograph	E_{132}
6.	Energy Consumption at APS (Auxiliary Converter-Inverter) from Line during 'Braking'	E_{121}
7.	Regenerated Energy for input of APS (Auxiliary Converter-Inverter) during 'Braking'	E_{122}
8.	Regenerated Energy at Converter-Inverter input during 'Braking'	E_{112}

Traction Energy Consumption = $E_{211} - E_{112}$

Auxiliary Energy Consumption = $E_{221} + E_{121} + E_{122}$

Total Input (E_{IN}) = $E_{231} + E_{131}$

Regeneration Output (E_{OP}) = E_{132} Net Input = $E_{231} + E_{131} - E_{132}$

Notations are explained below:

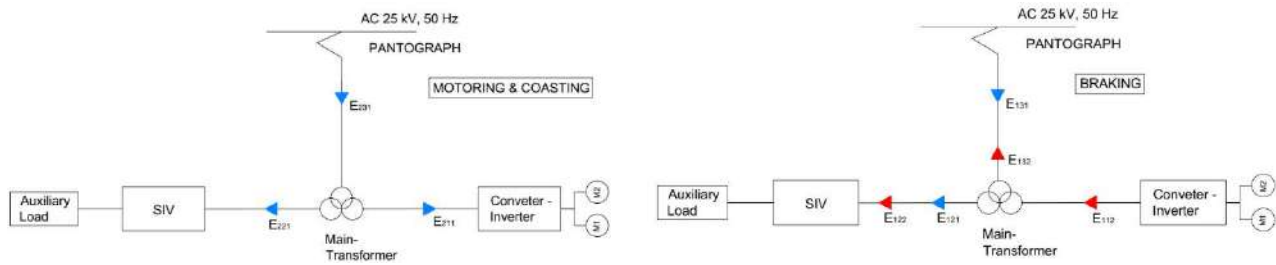
E_{xyz} Where, x specifies the mode of operation

y specifies the equipment under consideration

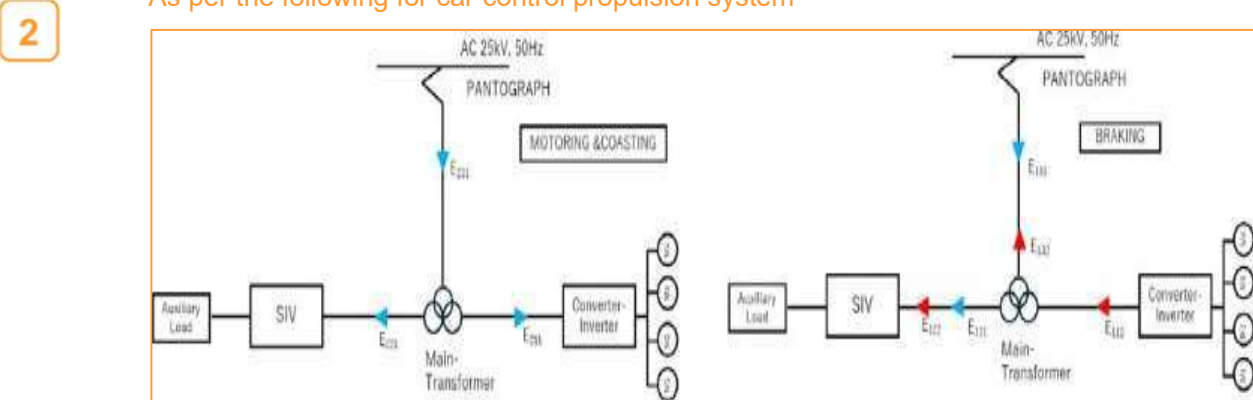
z specifies whether the energy consumed from line or energy regenerated

Subscript	Value	Description
x	1	Braking mode
	2	Non-Braking mode
y	1	Converter-Inverter unit
	2	APS (Auxiliary Converter- Inverter)
	3	Pantograph
z	1	Energy consumed from line
	2	Energy regenerated

The above parameters may be visualized in the following diagrams for understanding only:



As per the following for car control propulsion system



2.26 FIRE PERFORMANCE

2.26.1 General

- (i) The car interior shall have resistance to fire and conform to EN 45545 (Part 1 to Part 7), Category 4-A, Hazard level HL3 and BS 6853 Code of practice for fire precautions in the design and construction of passenger carrying rakes or any other approved international standards.
- (ii) Each train shall be designed to minimize the risk of a fire starting, as far as practically possible.
- (iii) Materials used in the construction of each train shall be selected to reduce to the maximum extent practical the heat release rate, heat load, propensity to ignite, rate of flame spread, smoke emission and toxicity of combustion gases.
- (iv) The train shall be designed to prevent fire propagation through the use of fire barriers in the floor, and in walls at the sides and ends and fire-resistant equipment housings. The flammable materials will be tested according to EN45545-2 requirements. The vehicle floor shall provide a fire barrier of 30 minutes duration tested in accordance with EN45545 Part 1 to Part 7 (Category 4-A, Hazard level HL3) latest editions or better equivalent standard.
- (v) The design and the materials used in the cars shall conform to fire safety requirements of EN45545 Part 1 to Part 7 (Category 4-A, Hazard level HL3) latest editions or better international standards for similar metro operations, subject to the acceptance of CMRL.
- (vi) The Contractor shall submit a plan to CMRL for review which shall describe the process that will be used to systematically identify and eliminate fire hazards, to avoid the use of combustible materials whenever practical and to reduce to the extent practical the energy content and heat release rates of the combustible material that are used.
- (vii) The plan shall include the Standards to be followed and the tests to be completed and shall be submitted for review by CMRL.
- (viii) The Contractor shall provide an Aerosol-based automatic fire suppression system for all electrical

panels located in the saloon area. The fire suppression system shall be suitable for protection of electrical equipment and shall comply with applicable international fire safety standards for railway Rolling Stock.

1

- (ix) The Contractor shall submit Fire Safety Certification and Safety Integrity Level (SIL) certification for the fire safety system applicable to the complete train. The certificates shall be issued by the employer approved independent third-party certification body.

2.26.2 Material used in the cars shall meet the Flammability, Smoke Emission and Toxicity requirements of the chosen Specification and shall comply to latest standard.

2.26.3 The Contractor shall minimize the total fire load of potentially flammable materials on a vehicle as far as is practicable, but in any case, it shall not exceed above floor level: 28,000 MJ and below floor level: 28,000 MJ. However, the Contractor shall confirm to EN 45545 as per Category 4-A, HL 3 requirements.

2.26.4 The Contractor shall furnish the relevant data, fire load calculations, certifications etc. of the items considered in fire load calculations separately for Above & Below the floor level. The calculations and validation shall conform to the standard adopted by the Contractor for fire strategy.

2.26.4.1 In case of occurrence of fire in the train, the details shall be sent as an audio-visual alarm to the TCMS and RSC consoles of OCC, BCC & DCCs. The details shall display the actual location of the incident.

2.26.4.2 The Contractor shall prepare a Fire Safety Design Report for review and acceptance by CMRL. This shall be submitted during PFDR stage and shall be further revised and updated in FDR stage. Both the design as well as materials used in the cars shall conform to fire safety requirements of EN 45545 Part 1 to Part 7 (Category 4-A, Hazard level HL3) or later edition if superseded.

If the Contractor proposes any equivalent international standard; it must be applicable to Underground Metro operations and cover the scenario of front-end evacuation. Acceptance of an alternative standard shall be subject to CMRL approval. The Contractor shall also engage an internationally reputed agency for the audit and certification of their fire safety design report. Certification from the agency shall be submitted to CMRL.

2.26.5 Smoke & Heat detection system

2.26.5.1 The fire detection system shall be able to detect any fire originating inside the cars, and also detect smoke coming inside cars emanating from outside including emergency driver desk and all electrical cabinets. The focus is on protection of passengers and staff in Rolling Stock. The objective shall be to detect incipient fires in an early stage to warn Train Operator / OCC. A fire event shall be detected early during the development phase; the affected area shall be located exactly by identifying which sensor(s) is actuated and further system's actions shall be activated without any delay. The fire / smoke detection system shall meet ARGE (German standard), or any other acceptable international fire standards, requirements. The correct functioning of the fire detection system shall be demonstrated by tests. Ventilation shall be provided depending on whether the fire / smoke has been detected inside or outside of the passenger saloon area.

2.26.5.2 System Design Requirements shall consider the following aspects in the design but not limited to:

- a) Proven methodology in metro railways application shall be used for the fire detection system shall consist of dual smoke and heat detectors (multi-sensors) or individual heat & smoke detector in passenger area (6 to 8 nos./sets per car may be provided), Linear Heat Detectors (LHD) in all technical cabinet areas (cabinet/ enclosures / cubicles), Heat Detectors in fire prone equipment, integrated with Fire Detection & Control Unit (FDCU). The FDCU shall interface with TCMS in a redundant manner. The interface of the system shall be suitably ensured with the overall system integration and **GoA2 GoA4** requirements.
- b) All events (alarms, faults etc.) shall be recorded in TCMS and shall be retrievable for analysing any issue.
- c) The system shall provide a dynamic two detector dependency (smoke and/or heat) in the

1

passenger areas along with provision of drift compensation in order to decrease the risk of false, or unwanted alarm.

1

- d) Alarm hooter / Beacons shall be provided in train at a suitable location **as well as in and RSC consoles of OCC, BCC & DCCs**. The Contractor shall provide necessary diagnostic tools (software's, hardware's etc.) in order to identify failures immediately. The details shall display the actual location of the incident.
- e) Complete system should be SIL2 compliant. Any change in SIL level shall be subject to the hazard analysis and acceptance or otherwise of the same by the CMRL whose decision shall be final and binding. The system shall be designed and tested for polluted environmental condition of Chennai. Any failure / maloperation on account of environmental conditions is not acceptable.
- f) Quick detection; EN54 shall be complied for validation.
- g) Positioning and number of detectors shall consider size and design of passenger saloon, VAC design and other operational aspects like door opening at stations etc. ARGE guidelines for fire detection in Rolling Stock application or similar shall be used for real scale smoke test to certify the layout of smoke detection system.
- h) Robust design to avoid false alarm.
- i) Complying to GoA2 & GoA4 requirements
- j) The relevant requirements in EN45545, EN 50533, EN50126 & EN50128 shall be complied.

1

2.26.5.3 Fire Detectors (Smoke & Heat Detectors) for passenger area:

Minimum 6~8 nos. of Smoke & Heat detectors (multi-sensors) or 6~8 pairs of individual heat & smoke detectors shall be installed in passenger area of each car. The sensitivity and response of smoke / heat detectors shall fulfil the requirements of ARGE guidelines. The actuating temperature of heat detector shall be settable according to the international norms and standards.

2.26.5.4 Linear Heat Detectors (LHD) / Multi Detectors (Heat + Smoke) for Enclosures / Cubicles:

1

A linear heat detector / **better solutions like Multi detector (Heat + Smoke)**, suitable for Rolling Stock applications shall be provided in all Enclosures / cubicles for review and approval by CMRL. The linear heat detector is to be actuated in case of any fire / overheating in the electrical cabinets. LHD system shall also be provided in Underframe and Roof Enclosures / cabinets as mentioned in different chapters of this document. However, final decision on use of LHD / Heat detector in Underframe Electrical enclosures will be taken during design stage.

2.26.5.5 Provision for bypassing any faulty / malfunctioning detector is required and the proposal shall be made during PFDR stage for review and approval by CMRL.

2.26.5.6 The number of smoke / heat detectors, LHD and their exact location may vary and shall be finalized during design stage.

1

2.26.5.7 Functioning Controlling, Monitoring, Reset of smoke and heat detection system shall be integrated with the TCMS **and the same shall be available in OCC/BCC/DCC**.

1

2.26.5.8 Provision shall be available to avoid false alarm and bypass the fire detection control unit though TCMS / OCC in UTO / Non UTO modes of Operations. ~~in ATO / ATP / Non-Signalling modes of Operations.~~

2.26.6 Fire Extinguisher

2.26.6.1 Each car in train shall be provided with minimum two numbers of suitable type fire extinguishers at appropriate locations in each car. Additionally, one fire extinguisher shall be provided near emergency operator desk. These shall be in a niche so as not to cause injury to people. Details of the equipment and location shall be submitted to CMRL for approval.

2.26.6.2 In case of emergency, the fire extinguisher should be easily removable by the passenger. Break open type cover is not acceptable.

2.27 LIFE CYCLE COST

- 2.27.1 The Contractor shall develop a life cycle cost plan in accordance with IEC 60300-3-3 with an aim to minimize the overall life cycle cost whilst meeting the safety, quality, availability, maintainability, and reliability requirement of this particular specification.
- 2.27.2 The LCC shall include the capital cost, cost of operation (including energy consumption), maintenance (both material and labour), depreciation, refurbishment, inflation etc. Per unit energy consumption cost may be considered as INR 8.50.

2.28 NOT USED UTO OPERATION

- 2.28.1 The design of Rolling stock, all its sub-systems and its relevant components in train shall support for the UTO / GoA4 in the CMRL Phase 1 & Phase 1 extension network defined in Chapter 1. Trains shall be operated in GoA2 / ATO mode during the initial stage of commissioning and revenue operations and in GoA4 / UTO subsequently. Hence all the feed-backs, information and train controls which are available on TCMS screen shall also be available in OCC (operational control Centre) and DCC (Depot Control Centre) for smooth operation of passenger service.

1

2.29 FLEET DESIGN FAMILIARITY AND CONSISTENCY

- 2.29.1 Unless otherwise specified in this Employer Requirements, the Contractor shall ensure that interior aesthetics, configuration and colour schemes shall as far as reasonably practicable follow similar concepts to those that have already been adopted on earlier introduced Chennai Phase 1 fleets.
- 2.29.2 To ease the challenge of upholding Operator familiarity with multiple fleet types; the Contractor shall apply best endeavours to ensure the layout of Human Machine Interface (HMI) and Communications Control Head (CCH) are broadly similar to earlier introduced Chennai Phase I fleets.

3. VEHICLE BODY

3.1 NOT USED

3.2 GENERAL

- 3.2.1 The most up-to-date, proven design and manufacturing techniques, as presently used in the railway car industry shall be employed, to produce a minimum weight, monologue structure which shall ensure fitness for the intended purpose.
- 3.2.1.1 If an off-the shelf proven design is used for the carbody structure, and the Contactor can prove its adequacy in meeting the requirements of these Specifications, CMRL will consider accepting such design as adequately complying with the requirements of the specification. Structural elements or structural systems of the overall carbody structure will be considered for approval on a case-by-case basis.
- 3.2.1.2 The Contractor shall demonstrate in the design of the body structure the philosophy with respect to the following factors:
- Ease of repair.
 - Thermal and acoustic insulation.
 - Aerodynamics; for benefits of energy efficiency
 - Sealing against the ingress of water and dirt.
 - Strength of materials; and light weight, for benefits of reduced power consumption and overall energy efficiency
 - use of high recycled material content and low toxicity materials
 - Corrosion resistance and ease of external washing and cleaning
 - Ability to withstand repeated washing with water having high dissolved content.
- 3.2.1.3 Outside contour of the coach shall be such that entire surface of sidewalls, roof and skirt can be cleaned spotlessly by an Automatic coach washing plant.
- 3.2.1.4 The car structure material shall be Stainless Steel or Aluminium. Stainless steel shall conform to ASTM A666 / EN 10088-2 / JIS G4305 or equivalent. Aluminium shall conform to ALCOA Specification / EN 755-2 / EN 485-2 or Equivalent International standards Covering Use of Aluminium in Passenger Carrying Railroad Vehicles Aluminium Association Aluminium Standards and Data. The end under frame may be constructed of low alloy high tensile strength (LAHT) structural steel complying with EN 10025-2 / EN 10025-5 / JIS G3114 or equivalent to satisfy the strength requirements.
- 3.2.1.5 Finished corrosion resistance Stainless steel or Aluminium should be aesthetically applied for an exterior finish that will reduce the need for maintenance.
- 3.2.2 Features important to passenger safety and comfort and to operational requirements on CMRL's system must govern the car body design. These features include, but are not limited to:
- Safety concerns, such as overall car body strength in conformance with EN 12663:2000 or any other standard as applicable to Coaches of an urban rail transport system Category P-III.
 - Passenger interface features and human factors, such as overall styling and aesthetics, large window sizes and adequate lighting, threshold heights, door and aisle widths, seat width and comfort, handrail locations, rainwater diversion, climate control, rights of persons with disabilities act 2016 requirements, noise transmission, and ride quality.
 - Operation and maintenance concerns, such as durability, corrosion resistance, clearances, lifting points, equipment access (including access to mounting points), ease of repair and cleaning, and appropriate allowances for wear and deterioration such that the design life is achieved.
- 3.2.3 Shrouds shall be designed such that free access is provided to any equipment located directly behind the coverings.

- 3.2.4 Not used.
- 3.2.5 The environmental operating conditions of Chennai, India, as defined in Chapter 2 shall not cause undue degradation or loss of performance to the car.
- 3.2.6 Sufficient clearance shall be provided between the carbody and any wayside objects in accordance with the Static and Kinematic Outline diagrams provided in the attached Schedule of Dimensions. The Contractor shall be responsible for ensuring that the car will operate within this outline under any and all worst-case operating conditions as defined in Chapter 2.
- 3.2.7 Design of carbody shall be such that sealants are not used as a primary protection for ingress of rainwater. The cars shall be completely watertight, without using any sealing compound. If considered unavoidable, only weld-through sealants shall be provided. The external sealants shall not be exposed to direct sunlight. The life of the sealant shall be at least 12 years. Detailed literature / catalogues shall be submitted to the CMRL and approval obtained prior to undertaking manufacture of car body. Water tightness shall comply with clause 17.6.13. Metallic conduit, tubing, piping, and fittings shall not require replacement for the design life of the car. Additionally, the car body shall be designed with safety margins commonly used in the railroad industry or as detailed in this Specification.
- 3.2.8 The car structure shall have a fatigue life in accordance with EN 12663. The Contractor shall demonstrate that the car body-shell is capable of remaining free from fatigue failures over the specified Service Life.
- 3.2.9 The design of the carbody and of interior and exterior details shall be approved by CMRL following the design review process.
- 3.2.10 Structural requirements for rail vehicle structures shall be design and tested conforming with GM RT 2100, UIC 566, EN 12663-1.
- 3.2.11 Carbody and its sub-assemblies shall be manufactured conforming to NF F31-101 tolerance class B or ISO 13920 or any other International Standard.
- 3.2.12 The fire resistance requirements and testing methods for fire barriers for railway vehicles shall conforming to EN 45545-3. Vehicle's all Fire barrier requirements shall be validated by test conforming to EN 45545-3 and witnessed by CMRL.

3.3 MATERIALS

- 3.3.1 The Coach body shall be Stainless Steel or Aluminium. Where dissimilar materials are used, measures shall be provided to mitigate corrosion in the body due to electrolytic action, fatigue resistance, emergency egress openings, resistance to projectiles, crashworthiness, protection against trip and slipping hazards, car to car gap protection, protection against pinch points of any kind, and fire resistance as required by either NFPA 130, BS 6853, EN 45545 or the Japanese Fire Standards, and Chapter 19.
- 3.3.2 The exterior and interior colour schemes and interior arrangements of the car shall be developed by the Contractor, in consultation with CMRL, as part of the industrial design process (ref. clause 16.10) and shall be submitted for approval.
- 3.3.3 Generally, paint will be allowed for the end underframe only for stainless steel coaches. The Contractor must obtain CMRL approval prior to using paint on any other surfaces.
- 3.3.4 The stainless steel or aluminium material surface finish / texture shall be subject to approval by the CMRL; regardless of whether it is applied by machine or hand. The finish and finish texture shall also conform to ASTM A480 / EN 10088-2 / JIS G4305 or relevant standard: Finish of stainless steel sheets and strip.
- 3.3.5 For all areas of the carbody and/or interior that are visible to passengers (at platform level in the case of the exterior the car) a minimum of three (03) proposals with samples of different types of material surface finish for each surface of vehicle interior and exterior shall be submitted to CMRL for review and selection.
- 3.3.6 All welds on car exterior and interior (including spots weld marks) shall be passivated with an

acceptable procedure to protect against any visible rusting/chemical deposits / blackening etc Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems shall be done as per ASTM A380 or equivalent. Procedure shall be submitted for CMRL's approval before ninety (90) days start of car manufacturing.

- 3.3.7 Non-stainless steel surfaces below the floor of the carbody shall be primed with epoxy coating and then finish painted with approved polyurethane paint of minimum 60 micron.

3.4 CARBODY STRUCTURE

3.4.1 Underframe

- 3.4.1.1 The underframe is the primary load bearing structure of the car and typically includes coupler anchors, side sills, floor beams, and end underframe structure (draft sill and end sill).

3.4.1.2 End Underframe

- 3.4.1.2.1 The end underframe structure shall be capable of transferring loads generated from passenger loading, couplers, and equipment under normal service conditions without permanent deformation.

- 3.4.1.2.2 The end underframe structure shall also be capable of supporting vertical loads resulting from jacking the car at the anti-climbers, coupler and other locations required for re-railing.

- 3.4.1.2.3 Distribution and absorption of the collision loads generated during the scenarios noted in clause 3.14.10.2 to primary underframe structure shall also govern the end underframe design.

- 3.4.1.2.4 The loads mentioned in clause 11.5.1(d) and end underframe structural requirements as per EN 12663-1 including buffers loads shall be validated during carbody structural test.

3.4.1.3 Collision Structure

- 3.4.1.3.1 The cab ends of the car shall have a collision structure that may include, but is not limited to, full-height corner posts, collision posts, structural shelf, and sheeting. The stress analysis for the collision posts and corner posts shall be submitted for approval. An analysis demonstrating that all joints comply with fatigue load requirements shall also be submitted for approval.

- 3.4.1.3.2 Limiting of car penetration and distribution of load to energy-absorption zones shall be the governing parameters for design of the anti-telescoping structure, that maximizes the survivability of the passenger in the event of a collision.

3.4.1.4 Underfloor Equipment

- 3.4.1.4.1 All Underfloor piping shall be Seamless Stainless Pipe and Conduits shall be HDPE or equivalent.

- 3.4.1.4.2 Equipment mounted to the underframe of the car shall conform to the spatial limits shown in Appendix D, Schedule of Dimensions.

- 3.4.1.4.3 The carbody and attached equipment shall be designed to provide necessary clearances for the bogie and bogie profiles. Under normal conditions, the design must allow for 40 mm minimum clearance between carbody mounted parts and all bogie mounted parts, including wiring, hoses, cable, wheels and chains, under the worst combination of wear, except for any stops attached to the carbody for limiting bogie movement or for bogie lifting during maintenance. Worst case conditions may result from horizontal and vertical curves, track super elevation, worn wheels, maximum passenger load, roll, yaw, lateral motion, and suspension system failures.

- 3.4.1.4.4 Components vital to system operations, wiring, conduit, tubing or hoses shall be mounted in a manner that will guard against impact from projectiles, especially in the vicinity of the bogies.

- 3.4.1.4.5 The failure of one equipment support point shall not cause the equipment to violate the kinematic envelope.

- 3.4.1.4.6 The equipment shall be mounted in accordance to IEC 61133 and the Contractor shall comply clause 11.9.23 regarding weight distribution.

- 3.4.1.4.7 All equipment boxes and covers shall be made of stainless steel or Aluminium such that the boxes, covers and anti-corrosive coating above them shall last for the life of the Car body, i.e. for 35 years. The RS Contractor shall also provide a declaration for the same during the design stage.

3.4.1.5 Hoisting and Jacking

- 3.4.1.5.1 The carbody shall be designed such that the car can be jacked and hoisted for re-railing or bogie removal. There shall be no permanent deformation of the underframe when kept on the jacking pads with all underfloor equipment installed, for a period of 15 days.
- 3.4.1.5.2 Jacking pads shall be provided on the underframe and shall be designed to preclude the jack from slipping.
- 3.4.1.5.3 Lifting lugs capable of being used to right an overturned car shall be provided. The lugs shall be designed with a factor of safety of at least 2.
- 3.4.1.5.4 Where practical, lifting points shall be masked or styled to match the car aesthetics, but must be readily accessible with simple hand tools.
- 3.4.1.5.5 Hoisting lugs and jacking pads shall be capable of supporting, without permanent deformation, 2 times the appropriate proportion of vertical load from an AW0 car, including bogies, plus 10% of this load applied horizontally in any direction.
- 3.4.1.5.6 The worst reasonable case of uneven jacking, such as might occur with one jack lower than the others or hoisting by opposite lifting lugs, shall not cause any stress to exceed the yield strength of the carbody structure, nor any failure, loss of water tightness or disconnection of attached equipment such as panelling or windows.
- 3.4.1.5.7 Stress analysis shall be provided to prove all jacking and hoisting requirements are satisfied.
- 3.4.1.5.8 The Contractor shall provide one (1) trainset quantity of any special devices required to hoist or jack the car.

3.4.2 Side Walls

- 3.4.2.1 Connections between all structural elements in the sidewalls shall be done such that optimum strength values are achieved without forgoing aesthetics. Visible bolts, or rivets, on the side are prohibited.
- 3.4.2.2 Sound metalworking practices shall be employed such that undulations, mismatched seams, and warping are avoided.
- 3.4.2.3 The side structure (including sheeting) shall be capable of sustaining loads from car washing equipment, without permanent deformation.

3.4.3 Cab Ends (Operator's Desk)

- 3.4.3.1 The cab ends shall be designed and constructed to meet the requirements as specified in Chapter 5. Unless otherwise approved, the cab enclosure shall be constructed of the same materials used throughout the structure.
- 3.4.3.2 Suitable framing may be used to support or reinforce the enclosure. The enclosure shall be contoured to provide a profile with a modern, aerodynamic appearance that is aesthetically pleasing (ref. clause 2.6).
- 3.4.3.3 If a "plug-in" cab enclosure is used, the watertight seal between the main carbody and cab shell shall last for a minimum of 12 years under the loading and environmental conditions identified in these Technical Provisions. Joints formed primarily with caulking or sealant shall not be used.
- 3.4.3.4 The Contractor shall submit design data for proposed cab end (Operator's Desk) configurations for review and approval.

1 3.4.3.5 Cab layout and facilities shall be designed to meet all possible modes of operation including ATO / ATP UTO / Non UTO, Manual Driving in main line / depots / stabling yards etc.

1 3.4.3.6 Cab layout shall be designed in such a way that it allows the passenger to move freely from one cab to another cab end without any obstruction during the GoA3 / GoA4 mode of operation. In such case, Cab layout shall have necessary seating for accommodating passengers.

3.4.3.7 UTO shall be the predominant mode of train operation. In case of emergency, a train operator will be on-board to drive the train under ATO or Manual Mode (under ATP).

1 3.4.3.8 During UTO operation the driving console shall be concealed by an aesthetically matching cover (with car interiors). The cover shall have sufficient structural strength, vandalism proof, compatible

with fire performance and suitably locked and secured. During the non UTO operation only authorized personnel can open the cover which shall be recorded and transmitted to the OCC.

3.4.4 Roof

- 3.4.4.1 The roof structure, including the sheathing, shall be capable of sustaining, without permanent deformation, loads from car-washing equipment and concentrated loads of 1,112 N over 0.05 m² area, as might be applied by a maintenance technician carrying tools during equipment repairs.
- 3.4.4.2 In the vicinity of roof-mounted equipment where maintenance personnel will stand, the roof shall support a concentrated load of 120 kg spaced every 750 mm without permanent deformation.
- 3.4.4.3 The structure shall be capable of sustaining any loads resulting from equipment loading, operating loads, and collision loads as defined in these Provisions.
- 3.4.4.4 Appropriate decals shall be provided by the Contractor and be applied to the car exterior, including CMRL logos, train identification numbering, graphics or styling decals, and any markings required by the Rights of persons with disabilities act 2016. Decals and application locations shall be submitted for approval.
- 3.4.4.5 Roof design shall be such that there shall be no possibility of water stagnation at any part of the roof in stationary condition of car. Special attention shall be given to the design and strength of roof structure in pantograph mounting area. Multiple operations of pantograph throughout the lifetime of vehicle shall not cause the mounting roof to sag such that water accumulation takes place in that area. The Contractor shall submit the design provision taken in consideration to address this specific issue.
- 3.4.4.6 All Roof equipment boxes and covers shall be made of stainless steel for stainless steel car body and shall be made of Aluminium for Aluminium car body.

3.4.5 Roof-Mounted Equipment

- 3.4.5.1 All control and power cables shall be terminated within enclosures or junction boxes.
- 3.4.5.2 Cables and Pipes Entries Seal:
Cable entry shall be by means of watertight sealing glands. To prevent entry and ensure fool proof protection against water, dust, humidity, insulation damage / failure, fire, vibrations, temperature variations, pull tension, noise as well as rodents etc. and increasing life of cable / equipment, all the cables and pipe transits in all cars including rooftop shall be sealed with a suitable EPDM (Ethylene Propylene Diene Monomer) based cable and pipe sealing system. Sealing and Protection application area shall be identified and got approved from CMRL during design stage. Suitable cable transit system with EPDM should be used for holding/ retention of running power cables and control cables, HT cables at underframe
- 3.4.5.3 Glands, box covers, and cable terminations shall provide for cable replacement without the removal of lugs, terminals, or connectors from the wires.
- 3.4.5.4 High velocity air exiting from any ventilation equipment shall be directed away from the roof, so as not to disturb dirt and debris.
- 3.4.5.5 Exhaust air from equipment shall not be directed to the air intake of other equipment.
- 3.4.5.6 The requirement of clause 3.4.4.1 regarding loading shall apply to all roof-mounted equipment areas that are capable of being walked upon.
- 3.4.5.7 VAC units shall be mounted at each end of the car roof, housed in suitable watertight wells in the car roof structure. The wells shall be provided with adequate, double sealed connections to the main conditioned air ducting, electrical supply and condensate drains. Conditioned air shall be fed into thermally insulated ducting. The design of duct shall distribute air evenly throughout the length of the car. In the event of the failure of one VAC unit conditioned air shall be made available throughout the length of car including driving cab in DM car. The design of the duct shall comply with the requirements laid down in Chapter 7.
- 3.4.5.8 Suitable arrangement shall be provided for conditioned air in the Operator's Desk area as well as in the front / rear cubicles. The temperature shall be same as achieved in the saloon.
- 3.4.5.9 Suitable arrangement shall be provided to drain out the condensate water from the lowest point

of the VAC unit. Service life of the drain holes shall be minimum 35 years. The drain arrangement shall be robust and of adequate size, shall be designed to prevent choking and shall be easy to clean and design shall be finalised during Pre-Final Design Stage. Under no circumstances, the condensed water shall spill inside the saloon or on the platform.

3.4.6 Gangways

- 3.4.6.1 An open split type of double skin gangway shall be provided between the ends of inter-connecting cars. Gangway doors are not desired. Gangway shall be design and tested conforming to the requirements of EN 16286-1 & EN 16286-2.
- 3.4.6.2 The gangway shall have a minimum throughway height of 1900 mm and a width of 1400 mm. Carbody end wall flatness shall be less than 1.5 mm per each 500 mm conform to the requirements of EN 16286-1 for gangway mounting surface and including outside mounting surface.
- 3.4.6.3 The centre line of the gangway shall be coincide with the centre line of the cars.
- 3.4.6.4 The gangway floor shall have a resilient, durable non-slip surface.
- 3.4.6.5 Any bonding between the floor covering and the gangway tread-plate shall remain effective under all operating conditions, throughout the life of the gangway. If not, the Contractor must specify the parts which will need to be replaced due the wear. In the event of movement between floor sheets, provision shall be made to take up any abrasion wear. The elements of the gangway shall give a service life of minimum fifteen years except those susceptible to wear & deterioration.
- 3.4.6.6 The gangway internal sides and ceiling shall where possible be lined with hard smooth surfaces, which shall, as far as possible, match those of the saloon interior.
- 3.4.6.7 The gangway shall form a sealed enclosure, free from draughts and ingress of dust, water and external noise. The location of drain holes in the frame shall be such that water does not fall and corrode the junction box or coupler beneath.
- 3.4.6.8 The gangway shall provide a safe passageway, free from protrusions, finger traps and tripping hazards, for passengers under all operating conditions. The interior design of the gangway shall be fitted with smooth and aesthetically pleasing panelling.
- 3.4.6.9 The gangway floor shall be at the same height as the Car floor and, with the exception of the tread plate, there shall be no steps or ramps within the throughway.
- 3.4.6.10 The gangway shall maintain its performance and remain stable over the full range of relative Car movements encountered in normal operation. The design of the floor shall be such that the relative movement between adjacent vehicle ends does not cause sliding floor plates to lift in such a way as could cause injury, in particular to sandal-clad or bare feet.
- 3.4.6.11 The gangway shall incorporate longitudinal resilience to allow for coupler movement during minor collisions, in order to minimise damage.
- 3.4.6.12 The gangway and the Car structure, to which it is attached, shall withstand all operating loads without permanent deformation or damage.
- 3.4.6.13 There shall be no sliding movements between any mating surfaces of adjacent gangways including gangway panels.
- 3.4.6.14 Split or one-piece gangways shall be designed to ensure that the requirements for coupling and uncoupling are not affected.
- 3.4.6.15 Any split or one-piece gangway location and/or clamping device shall be easily and quickly operable without the aid of any tools.
- 3.4.6.16 It shall be clearly obvious from viewing at ground level that the gangway has been correctly coupled.
- 3.4.6.17 If splittable gangways are used, the gangway splitting arrangement shall be at the middle of the gangway, to ensure that each gangway half is identical and interchangeable, irrespective of the orientation of the Car.
- 3.4.6.18 The gangway shall be provided with sufficient thermal and acoustic insulation to ensure that the

overall air conditioning performance and noise performance of the train are achieved.

- 3.4.6.19 Gangway side wall shall be designed in such a way that it shall prevent getting damaged or cracked during all operating conditions of Rolling Stock as defined in Chapter 2. Gangway side wall design shall be submitted for CMRL review and approval.
- 3.4.6.20 The gangway structure shall lock securely at top and bottom. Locking and unlocking shall be by manual means with single operation levers one each for gathering and latching functionalities. The levers shall not be easily accessible to commuters.
- 3.4.6.21 Gangway Strength:
The gangway floor shall be designed to meet the same strength requirements as the rest of car floor.
The gangway shall withstand without permanent deformation the following loads:
- A differential pressure between inside and outside of the gangway of $\pm 2.5 \text{ kN / m}^2$.
 - A concentrated perpendicular load, acting from within the gangway as per EN 16286 part 1 shall be applied on the surface of the side walls.
 - Gangway lifting mechanism shall have sufficient strength to bear its weight throughout the lifetime of the gangway.
 - There shall be no sagging in the gangway under desired operating conditions throughout the lifetime of the gangway.
- 3.4.6.22 The floor through the inter-car gangway shall be maintained (as far as reasonably practicable) at the same height as the rest of the car floor. At no point shall the height difference exceed 20 mm. Changes in height shall be ramped so as to eliminate any trip hazard to passengers.
- 3.4.6.23 Vertical gaps between the hinged moving tread-plates of the inter-car gangway and the general floor level of the car shall not exceed 5 mm. A means shall be provided to minimise wear of the floor by the sliding action of each moving tread plate. The wear pads provided for this purpose shall have a robust design which prevents risk of detachment from the assembly and it shall be possible to replace the wear pad during scheduled maintenance.
- 3.4.6.24 To protect the vehicle interior from inclement weather, dusty environment, high wind condition etc, when stabled and decoupled temporary gangway end covers shall be provided. The covers shall be sufficiently robust to provide good protection, but sufficiently light weight to permit fitting and removal by one person. The covers shall be lockable in position. For a quantity of sixteen (16) such covers shall be provided and are deemed to have been included in the Contract price.

3.4.7 Flooring

- 2 3.4.7.1 Flooring shall remain non-slip and not present a hazard to passengers when wet. The Minimum thickness of floor structure shall be 80 mm.
- 3.4.7.2 The transition between saloon floor, cab floor and gangway vestibule between cars shall be smooth and free from steps and unduly steep gradients, which would impede the flow of passengers between cars.
- 3.4.7.3 The non-skid floor structure shall be floating floor type comprising of aluminium honeycomb sandwiched type or Composite floor boards or any other service proven material such that no repairs or replacement to the floor structure is required throughout the codal life of car-shell, i.e. 35 years. The material of the floor structure shall be subject to CMRL's prior approval. Floor covering shall achieve low noise level inside the cars and shall be of less weight.
- 3.4.7.4 The floor installation shall be continuous over the complete area of the saloon without floor traps, gaps, or holes. Either coving sections shall be provided between all floor and vertical sections or the floor coving should extend up into the side wall lining. At all door openings, the floor shall make a weather-tight connection. No opening in the sub-floor is permitted.
- 3.4.7.5 The floor covering shall have a proven record of successful use in comparable railway applications; a service life of not less than 18 years shall be provided. Adhesion between floorboard and floor covering shall be appropriate and shall last for the lifetime of floor covering.

There shall be no cases of floor covering peeling off from floorboard and the Contractor shall guarantee the same.

- 3.4.7.6 It shall be feasible to replace all, or sections of the floor covering and coving during the life of the train if necessary. The floor design shall allow the floor covering to be removed without damage to the floor sub-structure.
- 3.4.7.7 The floor, and its mounting structure, shall be designed to withstand any loads that may be applied over 35 years in normal operation of metro train. Floor shall resist to a load of AW5 (650 kg / m²) and to a stamping effort of 35 daN on a surface of 25 mm².
- 3.4.7.8 Floor covering material shall be laid with the minimum number of joints. Floor all be so arranged to ensure that the bend radius required at the plinth base does not coincide with a joint in the covering that will affect the visual continuity between the plinth and floor. Where joints occur, they shall not coincide with those of the floorboards. Joints shall be sealed against the ingress of dirt, moisture and water. Any sealant used shall be coloured to match the background colour of the floor covering.
- 3.4.7.9 The total floor structure shall provide an effective fire barrier for a minimum of 30 minutes as per BS 6853, or equivalent.
- 3.4.7.10 The sub-floor shall be insulated for anti-drumming and noise suppression.
- 3.4.7.11 Floor covering shall show no significant signs of wear, abrasion test results shall be submitted.
- 3.4.7.12 Flooring shall remain colour fast under the following BS 1006:1990 conditions (like Light, Shampoo, Dry cleaning, Water spotting, Acid spotting, Alkali spotting, Rubbing, etc.,). Flooring with minimum colour fastness according to EN ISO 4892-2 is also acceptable.
- 3.4.7.13 Flooring shall be easily cleaned with the minimum of effort using readily available cleaning agents meeting the requirements.
- 3.4.7.14 Flooring shall not require glazing, polishing or any other post-production refinishing in short intervals to maintain its finish; the cleaning procedure shall be submitted.
- 3.4.7.15 Flooring shall suit regular cleaning schedules and during service and shall not appear dirty between scheduled cleaning.
- 3.4.7.16 The flooring shall not be damaged or discoloured by materials usually encountered in depot or service use.
- 3.4.7.17 The flooring shall have high abrasion resistance as per ISO-4649 and shall be compliant with relevant EN / ISO standards.
- 3.4.7.18 Specific attention shall be paid to the design of complete floor system to eliminate floor swelling / bulging or floor contraction for the lifetime of the vehicle. Same shall be guaranteed by the Contractor.
- 3.4.7.19 The floor covering shall be anti-slip, waterproofed and sealed, non-skid, resistant to wear and staining shall not trap dust, and shall be easily cleaned using conventional floor cleaning machines / methods and media. The Contractor shall propose suitable cleaning machines and liquid (with suitable local equivalent) and demonstrate the cleaning procedure to the satisfaction of CMRL and without any damage to flooring on long term basis. The floor covering shall meet the requirements of EN45545 part 1 to part 7 Latest editions in respect of fire, smoke and toxicity. The Contractor shall ensure even, uniform and gapless joints.

3.4.8 Thresholds

- 3.4.8.1 Door thresholds shall be provided at all side and end doors. Door thresholds shall be designed and constructed to prevent the entry of water between the threshold and door, including entry of water when the car is subject to the horizontal spray jets of the car washing facility.
- 3.4.8.2 The height of the side door threshold shall be 3.2 mm maximum above the top surface of the finished floor, with a maximum slope toward the outside of the car of 25 mm in 305 mm.
- 3.4.8.3 The door threshold may extend beyond the nominal car width at floor height by not more than 38 mm. Beyond the doorway, on both sides of the doorway, the extension strip shall gradually slope towards the sidewall to form a horizontal ramp. The threshold extension shall be designed,

constructed and installed to shear off if impacting any wayside structures without causing additional damage to the car structure.

- 3.4.8.4 CMRL may request the Contractor to provide a segmented rubber gap filler at the outer edge of the threshold to reduce the horizontal train to platform gap. The depth of the gap filler (if required) shall be finalised during preliminary design stage. If it is requested, it shall be provided by the Contractor at no additional cost to CMRL.

3.4.9 Windows (Body Side And Door Windows)

3.4.9.1 Body side windows

- 3.4.9.1.1 All glazing shall be of toughened glass and shall comply with DIN 52306 (impact strength) and EN 1288 (bending strength). Structural requirements for rail vehicle structures shall be design and tested conforming with GM RT 2100, UIC 566, EN 12663-1.
- 3.4.9.1.2 The body-side windows shall be designed to minimise solar gain and provide a level of thermal insulation consistent with the requirements of the air conditioning system.
- 3.4.9.1.3 All body-side windows shall be sealed to prevent the ingress of draughts, water and foreign matter.
- 3.4.9.1.4 Body-side windows shall comprise two panes of glass with outer laminated glass and inner non-shattering toughened glass separated by an air gap hermetically sealed against ingress of moisture and internal misting.
- 3.4.9.1.5 Replacement of glazing or window fixtures shall be achieved with the minimum of disturbance to the rest of the car.
- 3.4.9.1.6 All glazing materials shall meet the requirements of clause 19.13.
- 3.4.9.1.7 The glazing design and replacement procedure shall be submitted for approval.
- 3.4.9.1.8 Alternative approaches and standards will be considered but must be submitted, along with service history data, for approval.
- 3.4.9.1.9 The number of different window glass shapes shall be minimized.
- 3.4.9.1.10 Body side windows shall have a neutral tint to complement the car styling. Tinting is to be selected to optimize the light to solar gain ratio.
- 3.4.9.1.11 Body side windows shall be large enough to allow clear visibility to the outside surroundings as viewed by seated passengers.

3.4.9.2 Door Windows

- 3.4.9.2.1 All door windows shall be sealed to prevent the ingress of draughts, water and foreign matter. Structural requirements for rail vehicle structures shall be design and tested conforming with GM/RT2100, UIC 566, EN 12663-1.
- 3.4.9.2.2 Door windows shall be designed to minimize solar gain and provide a level of thermal insulation consistent with the requirements of the air conditioning system.
- 3.4.9.2.3 Door windows shall comprise two panes of toughened non-shattering glass separated by an air gap hermetically sealed against ingress of moisture and internal misting.
- 3.4.9.2.4 Replacement of door window glass shall be possible without removal of door leaf.

3.4.9.3 Cab window

- 3.4.9.3.1 The cabs shall have watertight look-out glasses on both lateral sides of each Operator's Desk area; look-out glasses shall be of the same construction as the body side windows. The minimum size of the look-out glass shall be 800 mm x 450 mm and locations of the cab side look-out glasses shall be approved by CMRL.
- 3.4.9.3.2 From the cab side window, the standing operator shall be capable of seeing 1 m tall human standing 610 mm from the sides.
- 3.4.9.3.3 Cab side window assembly shall be integrated with the car design.

- 3.4.9.3.4 ~~the contractor shall ensure that during GoA2 or GoA1 or Degraded mode of operation, the Train Operator shall have the access to open the lookout glass. During GoA3 or GoA4 operation, the~~

~~lookout glass shall be manually locked.~~

The contractor shall ensure that the Train Operator shall have the access to open the lookout glass.

1

Once the commissioning of trains in UTO (GoA4) mode of operation is completed, the lookout glass shall be permanently locked in a manner that preserves the aesthetic integrity of the train, without any degradation in visual or functional standards.

3.4.9.4 Windshield glazing

3.4.9.4.1 The windshield design shall be single piece design with glazing and shall be clear in colour. The glazing material shall be laminated glass and it shall comply to IS 2553 or any International Standard. Structural requirements for rail vehicle structures shall be design, tested and conform with GM RT 2100, UIC 566, EN 12663-1, UIC 651, EN 15152.

3.4.9.4.2 Visible glare or reflections on the windshield, including reflections from interior lighting during night operation, shall be minimized. Glasses shall have high visible light transmission and low UV transmission.

3.4.9.4.3 Windshields shall be replaceable from the outside of the car.

3.4.9.4.4 Not used.

3.4.9.4.5 Water sprinklers shall be provided above the windshield and shall cover complete windshield.

1

3.4.9.4.6 All the windshields shall have electrically operated wiper system with water spray. The windshield wipers shall withstand air pressure equivalent to 90 kmph of two trains running in the opposite direction inside a tunnel.

1

3.4.9.4.7 The wiper systems shall be operated Manually and also through TCMS / OCC.

3.5 INSULATION

3.5.1 The Contractor shall provide thermal and acoustic insulation on the passenger car as required, to meet the interior noise and air-comfort performance requirements of these Technical Provisions (ref. clause 19.34).

3.5.2 Thermal Insulation

3.5.2.1 Thermal insulation shall be installed against the inboard surface of the car's ceiling and sidewall exterior carbody structure.

3.5.2.2 Thermal insulation shall not mould, rot, or sustain vermin. Fibres, where used, shall be bonded together with a (i.e., thermosetting phenolic resin). It shall not corrode any metals or "shake down" under car vibration. It shall neither have odour nor be capable of absorbing odours.

3.5.2.3 Overall carbody heat transfer shall not exceed 80 kJ / hr / °C / m of car length and shall be verified through testing as specified in Chapter 17.

3.5.2.4 Thermal breaks shall be provided in locations where it is necessary to interrupt an all-metal path between the interior of the carbody and the outside of the carbody skin.

3.5.2.5 The thermal insulation shall also meet the smoke, flammability and toxicity requirements of clause 19.61.

3.5.2.6 The body side and roof outer skin shall have a suitable thickness of approved acoustic and thermal insulating material bonded to their interior surfaces.

3.5.3 Acoustical Insulation

3.5.3.1 The car shell structure shall be provided with a vibration and sound-damping material applied to inner surfaces, including subflooring, car ends, roof, and side frames. Alternative "service proven" vibration and sound-damping designs may be proposed for CMRL's approval.

3.5.3.2 The acoustic insulation shall meet the smoke and flammability requirements of clause 19.61.

3.6 INTERIOR FITTINGS

3.6.1 General

- 3.6.1.1 All interior fittings and surfaces shall be designed, constructed and installed to meet or exceed standard industry requirements and shall be approved by CMRL. Structural requirements for rail vehicle structures shall be designed and tested conforming with GM/RT2100, UIC 566, EN 12663-1.
- 3.6.1.2 The interior of the passenger car shall be pleasing in appearance, shall have a design which minimizes the number of components, and shall be free of sharp corners or edges to preclude the possibility of injury.
- 3.6.1.3 Design emphasis shall be placed on integration of components, maintainability, passenger and maintainer safety, aesthetics, and cleanability. Surfaces requiring paint are not permitted.
- 3.6.1.4 All materials shall be resistant to graffiti and shall be readily cleanable with standard cleaning materials and solutions.
- 3.6.1.5 Linings and structure shall be assembled in a manner that eliminates any possibility of squeaking once installed.
- 3.6.1.6 Anti-squeak tape shall be used between linings and any structure to which they are attached or with which they come in contact.
- 3.6.1.7 Visible interior fasteners shall be minimized and shall be tamper-proof.
- 3.6.1.8 To the maximum extent possible all interior fasteners of the same diameter shall utilize the same tool for installation and removal.
- 3.6.1.9 All interior fittings shall be designed to allow for simple interior refurbishment at car half-life.
- 3.6.1.10 Data on and samples of all intended interior materials, and samples of the colours of the interior parts that influence the overall impression the most (i.e., walls, roof, seats, floor) shall be submitted for CMRL approval. The data shall include certification that the requirements in respect to toxicity, flammability and smoke emission are complied with.
- 3.6.1.11 The mounting shall be designed to accommodate the dynamics of car movement without transmitting stress to the liners.
- 3.6.1.12 Where linings cover apparatus requiring maintenance, they shall be fastened with captive, tamperproof machine screws, designed to allow ready access for removal and replacement of apparatus.
- 3.6.1.13 The interior linings and mouldings shall be free of undulations exceeding 1.5 mm.
- 3.6.1.14 The design and layout of interior linings shall minimize the size and number of seams and mouldings.
- 3.6.1.15 Edges and corners of linings and panels shall have adequate radii to facilitate cleaning.
- 3.6.1.16 Window masks, if any, shall be sloped to eliminate dirt collection and liquid pooling.
- 3.6.1.17 All joints shall be supported and covered with mouldings in accordance with these provisions.
- 3.6.1.18 The colours of mouldings on all exposed surfaces shall be coordinated with the colours of the other materials in the car.
- 3.6.1.19 Suitable separate 15A and 5A socket with suitable protection device shall be provided in the cab and console at both ends of all cars for charging emergency light, use of cleaning machines etc. Sockets shall be concealed and not be visible for passengers.
- 3.6.1.20 Nominal clear height inside the car between floor and roof ceiling shall be between 2050 mm ~ 2150 mm with mounting tolerance of ± 5 mm for nominal clear height, additionally conforming to gaps and flush tolerances.
- 3.6.1.21 All internal panel surfaces shall be smooth finished with modern low flammability, low smoke emission, anti-graffiti, and low toxicity materials. All internal panels shall be resistant to graffiti, scuffing, vandalism, and cleaning agents (properties of cleaning agent shall comply with the Anti-Graffiti Protection Standard NFF 31-112). The colour shall not fade or discolour with time or

change due to rubbing. Rounded corners or covings shall be provided wherever mutually perpendicular flat plane surfaces abut. Metal sticking strips with radiused coving are required on all exposed vertical surfaces above floor level.

- 2 3.6.1.22 All internal panels (side panels, ceiling panels, end-ceiling panels, inspection cover panels, door coving panels, ceiling coving panels, etc) shall be of Ceramic coated aluminium material with proven record in Metro / EMU application. Coating system shall be proposed by the Contractor shall be proven and conform to the requirements in clause 3.6.1.21, subjected to CMRL approval. Flatness of Aluminium side panels shall be controlled within 0.5 mm per 1m length.

The Contractor shall ensure adequate measure have been taken to prevent and mitigate the risk of bi-metallic corrosion and rattling. Suitable damping and Insulation shall also be provided to reduce noise and thermal conductivity especially at metal-to-metal contact points.

Minimum thickness of ceramic coating on aluminium panel: 50 µm (front), 20 µm (back)

- 1 3.6.1.23 The number of joints on all interior panels shall be minimised. The location of joints shall be carefully selected such that they are minimally visible throughout the entire vehicle including saloon interior. Where side panel joints cannot be eliminated, ~~only one joint~~ not more than two joints behind the saloon seat shall be permitted. No later than pre-final design stage, proposals for all internal panels shall be submitted to CMRL for approval. CMRL's decision on the design selection shall be final and binding on the Contractor.

The number of joints on all interior panels shall be minimised. The location of joints shall be carefully selected such that they are minimally visible throughout the entire vehicle including saloon interior. Where side panel joints cannot be eliminated, not more than two joints behind the saloon seat shall be permitted. No later than pre-final design stage, proposals for all internal panels shall be submitted to CMRL for approval. CMRL's decision on the design selection shall be final and binding on the Contractor.

- 3.6.1.24 No later than pre-final design stage, the Contractor shall also submit details of processes and raw materials used in manufacturing of different panels. The submission shall include but not be limited to details covering arrangements for side panels, Operator's Desk, ceiling panels, end-ceiling panels, inspection cover panels, door coving panels, ceiling coving panels etc. CMRL's decision on design selection shall be final and binding.
- 3.6.1.25 The Contractor shall submit 200 mm x 250 mm minimum three (3) samples of each proposed material, indicating material finishes for CMRLs review and approval.
- 3.6.1.26 As far as reasonably practicable, fastening devices, hinges, fixings and securing screws shall not be visible from within the saloon.
- 3.6.1.27 Gaps in vehicle interior shall be minimized. Gaps that are visible to passengers shall be maintained in the range of 1mm (min) to 2mm (max) to ensure they are flush and uniform with the panel edges. Concealed gaps shall be 1.5 mm ~ 3 mm.
- 3.6.1.28 Also Gaps in interior panels and covers may be infilled by lap joint assemblies / Gap hider and suitable damping material to be provided in between to reduce noise and vibration.
- 3.6.1.29 Openable covers shall be suitably cushioned to ensure rigid and positive locking without the possibility of play in locking mechanism.

3.6.2 Equipment Lockers and Access Panels

- 3.6.2.1 Lockers shall be made from a rigid, durable, scratch-resistant material.
- 3.6.2.2 All lockers shall be provided with key locks to ensure security in accordance with clause 3.7.1. Access panels shall be hinged and shall incorporate safety chains to prevent injury when the panels are let down.
- 3.6.2.3 A conceptual drawing shall be submitted for CMRL review and approval that depicts the intended envelopes and location of each locker.
- 3.6.2.4 The installation of equipment in under seat boxes shall be avoided and in exceptional cases shall be provided with specific approval of CMRL. Electronic equipment or batteries shall not be installed beneath seats.

3.6.2.5 Equipment lockers and access panels covers shall be provided with secure locking devices.

3.6.3 Stanchions and Handrails

3.6.3.1 Stanchions and handrails shall be provided to aid passengers when boarding, moving throughout the car, or standing throughout their journey. Structural requirements for rail vehicle structures shall be design and tested conforming with GM/RT2100, UIC 566, EN 12663-1.

3.6.3.2 Stanchions shall not be placed where they will obstruct passenger flow through the side doors. Stanchions shall be arranged in two rows. They shall be placed in longitudinal rows. Stanchions shall not be placed in the centre isle of the passenger compartments. Stanchions in the middle may be replaced by handrails.

3.6.3.3 Stanchions and handrails shall be stainless steel.

3.6.3.4 Vertical stanchions shall be capable of sustaining a horizontal load of 2,224 N applied midway between supports, and in any direction, without permanent deformation. Horizontal handrails shall be capable of sustaining a vertical load of 2,224 N applied at any angle from vertical to 45 degrees, located midway between support, and at any position around the perimeter of the handrail without permanent deformation. Alternatively, vertical stanchions may comply with UIC 566 and EN 12663 or approved equal. An analysis demonstrating compliance with these requirements shall be provided.

3.6.3.5 Stanchions and handrails shall be between 32 mm and 38 mm in diameter unless otherwise approved and shall have a minimum of 38 mm knuckle clearance from the nearest adjacent surface.

3.6.3.6 **1** Spring loaded passenger strap hangers or grab straps shall be stainless steel incorporated into the interior car design. Two Three longitudinal rows or three of grab straps rail with spring loaded strap hangers / grab handles shall be installed. ~~subject to CMRL's approval~~. The layout and style shall be submitted to CMRL for approval.

3.6.3.7 The completely assembled grab handles shall be subjected to "pull off test" to measure the maximum load they can withstand. A minimum load of 2500 N shall be achieved. The fully assembled grab handle shall be subjected to an endurance test with the following basic conditions. A) Load: 35 kg vertical b) Cycles: 300,000 cycles minimum c) Bending Angle: $\pm 45^\circ$ degrees d) Frequency: Each cycle to consist of movement of the handle from one extreme to another extreme and back within one second. Any other test considered essential for the grab handle test to be included in the test plan

3.6.3.8 Grab rails shall be so designed that they don't hinder passengers view through CCTV.

3.6.4 Not Used

3.6.5 Seats

1 3.6.5.1 Longitudinal banks of bucket flat type anti slip finish stainless steel seats shall be provided along the body-side between the doorway draught screens. The Contractor shall provide as much seating space as possible between the side doors. The seat layout should be such that it will not obstruct the flow of passengers during rush hours while boarding or detraining. Draught screen shall be provided at each door and shall be an integral part of the stanchions at the doorways. Bump support / Lumber support arrangement shall be at suitable locations as decided by CMRL.

3.6.5.2 The Contractor shall submit interior seating conceptual layouts that offer the best trade-off between seating capacity and interior standing and circulation space (as defined in clause 2.7.3).

3.6.5.3 The Contractor shall submit the conceptual and detailed drawings of intended seat and seat insert design.

3.6.5.4 5% of the seats of the rake shall be designated for disabled persons.

3.6.5.5 The seats shall conform to EN 15663. An adequate level of comfort, good appearance as well as scuff and vandal resistance shall be ensured. The proposed width, height, depth, and leg room of the seats shall be optimised to ensure maximum standing room. The proposed design shall be subjected to CMRL approval.

3.6.5.6 Armrests between seat places shall not be used.

- 3.6.5.7 The seat surface shall be easily cleaned and shall be made from stainless steel.
- 3.6.5.8 Each bank of seats shall be mounted on a totally enclosed plinth, capable of carrying an evenly distributed load equivalent to the number of seated passengers per seat bank times the weight of a passenger times a load factor of two (2) without damage or permanent deformation.
- 3.6.5.9 Banks of seats in similar situations in a car shall be interchangeable.
- 3.6.5.10 The seats and their mountings shall be capable of withstanding the loads arising in service conditions. The seats shall be designed to have a service life compatible with the car. Structural requirements for rail vehicle structures shall be design and tested conforming with GM/RT2100, UIC 566, EN 12663-1.
- 3.6.5.11 The Contractor shall submit interior seating conceptual layouts to show that the maximum amount of standing capacity will be achieved.
- 3.6.5.12 The conceptual seating arrangements shall include different grouping configurations, flip-up arrangements, and flexible interchangeability.
- 3.6.5.13 Seat mountings shall maximize access for ease of floor cleaning.
- 3.6.5.14 Construction
 - 3.6.5.14.1 The seat construction and its attachments to the carbody shall withstand the loads to be expected in transit operation.
 - 3.6.5.14.2 Seats shall be supported by the wall structure. Each passenger seat frame and its support shall be constructed as an integrated unit. Seat attachment shall permit easy replacement of the seat.
 - 3.6.5.14.3 Seats shall meet the requirements of UIC 564-2 or equivalent.
- 3.6.5.15 Materials
 - 3.6.5.15.1 Seat back pans shall be sufficiently rigid to resist deformation as the result of passenger abuse. They shall be attached to the seat shells in an approved manner and shall not rattle or drum.
 - 3.6.5.15.2 Seat framing may be stainless steel or Aluminium with a satin or Anodized finish. Frame members shall be joined together using proper welding technique. Any seat frame tubing shall have the ends plugged to prevent the entry of vermin.
 - 3.6.5.15.3 The use of manufacturer's logos or markings that will be visible to passengers shall be avoided or used with approval of CMRL.
 - 3.6.5.15.4 Behaviour of seats at static, fatigue, vibrations, impact stress shall be design, tested as per NFF 31-119 and indentation test shall be design, tested as per ISO 2439. The indentation hardness shall be similar to industry standards. The indentation hardness and depth shall be measured first be tested initially and then at 80,000 cycle intervals.
 - 3.6.5.15.5 The natural frequency of the seat system (including seated passengers, each weighing 65 kg) shall be greater than 1.4 times the natural frequency of the carbody natural bending frequency.

3.7 INTERIOR ACCESSORIES

- 3.7.1 Keys shall be supplied to provide access to all locks on the car, as follows.
 - 3.7.1.1 Master controller Key: This key shall enable the operation of master controller. Six numbers of such key shall be provided for each train set.
 - 3.7.1.2 Universal Key: This key shall allow operation and maintenance personnel to access the car through operation of door key switches, equipment boxes, panels, enclosures in under frame, roof and saloon area. Eighteen numbers of such key shall be provided for each train set.

3.8 ELDERLY AND DIFFERENTLY ABLED ACCOMMODATIONS

- 3.8.1 Access to the cars for persons with disabilities, including wheelchair users, shall be provided through the side doors and shall conform to UIC 565-3.
- 3.8.2 One wheelchair parking area shall be available in each DM car. At least four seats shall be

available for the elderly and differently abled passengers in each car.

- 3.8.3 Seats shall be provided for differently abled persons as described in the clause 3.6.5.
- 3.8.4 The designated areas for wheelchair parking shall be located adjacent to an accessible entrance and shall be compliant with all IDA (Rights of persons with disabilities act 2016) requirements.
- 3.8.5 Fold-down seats may be provided for use in these areas when they are not occupied by a wheelchair or stroller.
- 3.8.6 Wheelchair users must be able to exit the car from any wheelchair parking position through either of at least two accessible doors (on the same side of the train).

3.9 EQUIPMENT ENCLOSURES

- 3.9.1 Equipment supports and associated structure shall be designed to sustain the loads defined in clause 3.14.6.7 with no permanent deformation, when applied at the centre of gravity of the equipment.
- 3.9.2 Equipment shall not separate from the car under the collision scenarios defined in clause 3.14.10.2.
- 3.9.3 Unless explicitly approved, equipment shall not be supported by bolts in tension or shear. Equipment supported by vibration isolators shall have safety straps which prevents equipment from dropping into the clearance envelope or falling from the roof.
- 3.9.4 All Equipment enclosures shall be watertight and shall have covers, which allow unrestricted access to internal components. Ventilation / drain hole(s) shall be provided to allow air circulation or water drainage but shall not allow vermin to enter the enclosure. All Equipment enclosures shall be same material used for car body.
- 3.9.5 Equipment wells, if used, shall be capable of sustaining carbody and equipment loads, and shall be watertight to any interior compartment. Wells shall have proper drainage. Special attention shall be paid to ensure wells are corrosion resistant.
- 3.9.6 Not used.
- 3.9.7 Any roof-mounted equipment surfaces that can be walked on shall be covered with an anti-slip coating or surface that will not trap or retain water.
- 3.9.8 Suitable shields or enclosures must be provided for all equipment to isolate potential ignition sources from combustible materials and to control fire and smoke propagation.
- 3.9.9 Interior Equipment: Equipment location and enclosure construction shall protect the equipment from dirt, conductive dust, and spilled liquids, including corrosive cleaning fluids.

3.10 INTERCAR CONNECTIONS

- 3.10.1 Strength Requirements
 - 3.10.1.1 The semi-permanently coupled cars connection shall be capable of transmitting the peak carloads, including the loads generated under the collision scenarios noted in clause 3.14.10.2, without permanent deformation.
 - 3.10.1.2 The inter-car connection shall be designed with anti-telescoping and anti-climbing features such that cars remain aligned under collision loading. It shall be a proven design.
- 3.10.2 Performance
 - 3.10.2.1 The inter-car connection shall connect the cars through a joint that provide support and allow the cars to negotiate all horizontal, vertical, and spiral curves on CMRL's track without damage, interference, or undue loading.

3.11 EXTERIOR ACCESSORIES

- 3.11.1 Air exhaust or intake openings shall be covered by grilles that are attached and locked. Grilles

shall resist water entry and projectiles and shall be made of corrosion-resistant material.

3.11.2 Grilles visible to passengers shall be decorative to coordinate with the exterior styling and colour scheme and shall be subject to CMRL for approval.

3.11.3 Grilles mounted in the plane of the roof shall resist water entry without adversely affecting airflow. Warning notices shall denote roof grilles as a surface not to be stepped on unless the grille is designed to carry the loads detailed in clause 3.4.4.2.

3.11.4 A proven air exhaust system in Metro / EMU application to be proposed by the Contractor. An exit path to exhaust air shall be provided through openings located in vehicle interior such that openings are not visible to the passengers and proposed opening shall be vermin proof. The proposal shall be subject to CMRL approval.

3.11.5 Rain Drainage

3.11.5.1 The roof of the car shall be designed to prevent water from cascading down the side of the car, especially over door openings and cab windows during the maximum rainfall rate specified in clause 2.11.

3.11.5.2 The design of the drainage system shall prevent a surge of water from flowing off the roof when the car accelerates or decelerates. Any drainage tubing shall be properly sized, shall have minimal joints, be designed to prevent clogging, and shall not be located near electrical components. Joints in drainage tubing shall be positively sealed and shall not leak should backflow occur. Mounting of these gutters shall ensure that water shall not leak inside the train during any operational condition.

3.11.5.3 The design of the drainage system shall be aesthetically pleasing and shall blend with the overall appearance of the car.

3.11.5.4 The Contractor shall ensure adequate water drainage from the roof, such that no water shall be discharged into the vicinity of the passenger doorways. The water shall not accumulate in the rain gutters and shall be easily discharged through adequate sized pipes at levels below the floor level and sufficiently away from the track. Hose/Rubber fittings are not preferred in the discharge pipe and Stainless steel pipe fittings shall be preferred. In case, rubber pipe connections are unavoidable due to tolerance clearance issues, they can be used only at one location provided the life of rubber used shall be more than 12 years and suitable window arrangement on the carbody for its replacement shall be available.

3.11.5.5 The rain gutter shall be so mounted on the car body such that there is no possibility of water seepage from gutter on the body at any circumstances and gutter design is subjected to CMRL approval.

3.11.6 Pulling and Tie-Down Points

3.11.6.1 The car body shall be provided with suitable pulling and tie-down points to be used by CMRL for the repairing and straightening of collision-damaged structure. These may also be used to restrain a car for over-the-road transport.

3.11.7 Graphics

3.11.7.1 Rake and car number and location information shall be agreed upon with CMRL. Number locations shall include at least each body section interior, including passenger and cab areas, and each body section exterior.

3.11.7.2 Samples of passenger assistance and general information signage shall be furnished for CMRL's approval.

3.11.7.3 All graphics shall be compliant with the rights of persons with disabilities act 2016.

3.12 SIGNAGE

3.12.1 Exterior signage

3.12.1.1 The exterior of passenger Cars shall be equipped as a minimum with signs for the following and shall be consistent with the style of signage defined in the performance specification for Graphics

and Signage.

Signage above floor level shall include:

- i. individual Car numbers.
- ii. Passenger saloon emergency door releases; and
- iii. wheelchair location.

Signage below floor level shall include:

- i. equipment modules.
- ii. parking brake release handles.
- iii. brake isolating cocks.
- iv. lifting and jacking points.
- v. high voltage warnings.
- vi. traction supply isolation switches.
- vii. filler cap locations; and
- viii. battery isolation switches

3.12.2 Interior Signage:

These will include:

- i. Emergency escape route
- ii. Location of alarm system
- iii. Location of emergency communication facility

Signage for the train driving cab front end shall include:

- i. Chennai Metro Rail Limited symbol
- ii. digital cab head-code (Train Number Sign).

3.12.3 The Contractor shall submit all the signage's and stickers/logo including under frame for CMRL review and approval. All interior /exterior stickers/ signages strips / logo etc used in any location shall conform to BS EN 5499 part 5 & 6 or international norms and must be in use in more than 3 different metros worldwide. The safety related signages shall be fluorescent / [photo-luminescent](#). The signage used for marking wheelchair shall be placed on floor as per the standard signage. The Adhesion value of the signages after 24 hours of application shall be 560-600 gm / cm. The Contractor shall prepare detail plan for signages, and stickers / labels as followed in the metros worldwide for CMRL's approval. The signage's for emergencies shall be fluorescent / [photo-luminescent](#) types. Signages, and stickers/ labels shall have better fire, smoke, and toxicity characteristics.

1

3.13 CONSTRUCTION CRITERIA

- 3.13.1 Carbody structure shall generally be assembled by welding or using huck-bolting technology.
- 3.13.2 All connections shall be designed such that they develop the full strength of the weakest member. Fillet welds shall not be utilized to transmit primary loads.
- 3.13.3 Procedures, tooling & fixtures shall be used to ensure all carbody shells are of uniform construction and configuration.
- 3.13.4 The end underframe structure shall be designed to absorb the maximum of collision energy possible through controlled progressive buckling, plastic deformation, and energy-absorption devices. Controlled failure as part collision energy absorption shall begin at the ends of the car and progress towards the coupler anchor or bolster (if used). For survival zone during collision scenario, the requirements of EN15227 Section 6.3 may be applied, or an equivalent analysis if approved by CMRL.
- 3.13.5 Care shall be taken in the design against brittle fracture of all structural connections. The

connection of the end underframe structure, collision posts, corner posts, structural shelf and other end structure, shall be designed such that the connections can resist loads to the ultimate shear and tensile strength of the weakest member.

- 3.13.6 To the greatest extent possible, structural elements intended for collision energy absorption shall be designed such that repairs, or replacement are as simple as possible. Unitized energy absorption elements, if used, that are not part of the main structure shall be capable of being replaced with standard tools.
- 3.13.7 Each collision post shall be located at a lateral position approximately equal to one third the width of the underframe as measured from the nearest corner of the underframe. The Contractor may propose an alternative service proven design in lieu of collision posts for energy absorption.
- 3.13.8 The collision posts and corner posts shall be designed to have continuous cross sections from the floor structure to the roof, excluding shear reinforcements.
- 3.13.9 The lower and upper connections of the collision posts, corner posts, and any shear reinforcements shall be built into the structure by connecting to the top and bottom plates or flanges of the end structure and roof structure. Welding used for these connections shall be full penetration in accordance with AWS/EN.
- 3.13.10 Shear reinforcements, if used, shall have a ultimate shear strength equal to the loads specified in clause 3.14.1 and shall be of continuous cross section for a distance of 450 mm up from the underframe connection then taper to a point at least 750 mm above the connection.
- 3.13.11 For a welded construction, the camber on coach body under fully loaded condition (AW4) shall be such that the structure shall not sag below the horizontal plane throughout the vehicle's 35 years life. Alternatively, the shells fabricated with modular elements, the coach shall be built with a suitable camber under tare condition. It shall be ensured that the downward deflection of the coach in fully loaded condition (AW4) shall not sag below the horizontal plane throughout the vehicle's 35 years life to ensure proper operation of doors under all loading conditions. Detailed calculations shall be submitted by the Contractor for the expected deflection to confirm that the deflection is within permissible limits under all conditions throughout the life of the coach. Tests for stresses etc. as well as other tests as per relevant standard for the method of construction deployed shall be carried out under specified loads.

During design phase the Contractor shall simulate the carbody camber for a fully assembled car in both AW0 and AW4 load condition, in order to determine the optimal positive camber required to ensure the 35 year design life of the train. Calculations shall be validated by data obtained from previous projects (in service for more than 10 years) and shall be submitted to CMRL for approval before the start of prototype train manufacturing.

A factory validation test shall also be undertaken to verify the simulations / calculations and ensure that the camber remains in range in loaded / unloaded conditions. The vertical deflection of the car body structure, up to the fully loaded condition, shall not hinder the normal operation of the passenger doors.

The car body, and any equipment mounted on / beneath or within it shall be designed to withstand the fatigue loads that the car body structure will encounter over a period of 35 years in service, in accordance with the criteria described herein. The fatigue life assessment of body structure shall be carried out using recognized techniques and shall be submitted by the Contractor for review and approval by CMRL.

- 3.13.12 All equipment, mountings and fasteners of components shall withstand the forces and impacts as specified EN 12663 without any part of the equipment becoming detached and without any permanent deformation to carbody.
- 3.13.13 Alternative "Proven Designs" with regard to carbody structure will be considered as long as the structure meets other design requirements of EN 12663.
- 3.13.14 The car side wall, roof and under frame material shall be manufactured from high tensile austenitic stainless steel with carbon content not more than 0.03% (ASTM A666 / EN 10088-2 / JIS G4305

or equivalent standard). Highly stressed components such as head-stock, may be manufactured with low alloy high tensile strength (LAHT) structural steel preferable conforming with EN 10025/ JIS G3114 or equivalent international standards.

Alternatively, if an aluminium car shell is offered the Contractor shall propose different combination of Aluminium alloy to fully meet all the strength and load conditions as in Employer Requirements Technical Specification, for approval by CMRL.

Aluminium materials used for carbody extrusions will be of the 6000 series alloy. Extrusions for structural parts will mostly be made from 6005A (AlMgSi0.7), 6082 (AlMgSi1) may be chosen for extrusions in areas with increased strength requirements. Heat treatment will be defined according to strength requirements. Non-structural parts with low stress levels will be made from 6060 (AlMgSi0.5).

Table: Designation of Materials for Car Body Structure

Part of the Carbody –	Material
Underframe	
Solebar	EN AW 6005A-T6 or EN AW 6082-T6
Floor extrusion profiles	EN AW 6005A-T6
Bolster	EN AW 6005A-T6 or EN AW 6082-T6
Coupling Mountings	EN AW 6005A-T6 or EN AW 6082-T6
Underframe Ends	EN AW 6005A-T6 or EN AW 6082-T6
Roof	
Cantrail	EN AW 6005A-T6 or EN AW 6082-T6
Roof Extrusion profiles	EN AW 6005A-T6 or EN AW 6082-T6
AC tray sheets	EN AW 6005A-T6 or EN AW 6082-T6
Side Wall	
Door pillar	EN AW 6005A-T6
Side wall extrusion profiles	EN AW 6005A-T6
End Wall	
End wall extrusion profiles	EN AW 6005A-T6
End wall sheets	EN AW 6005A-T6

For some minor parts the materials EN AW 5083-H111 (sheet) or similar material can be chosen taking into account the respective strength requirements.

3.13.15 The Contractor shall show his offers are based upon their proven designs and experience. In the case of assemblies where metal parts with differing electrochemical dissolution potentials in water can be in contact, all necessary measures shall be taken to prevent the occurrence of galvanic corrosion.

3.13.16 Link between Coupling Mechanism and Car Structure

3.13.16.1 The coupler attachments shall be designed and constructed to meet or exceed the requirements of EN 12663 for Category P-III.

3.13.17 Bogie Connections

- 3.13.17.1 The Contractor shall submit the proposed method for the carbody connection to the bogies for approval. In addition, the bogies shall be capable of being raised off the tracks vertically with the car, without permanent deformation or damage to drive or suspension components, through supports designed to sustain the weight of a fully equipped bogie. The Contractor shall indicate the minimum safety factor used, taking account of the yield stress for all support members.

3.13.18 Anti-climber

- 3.13.18.1 Anti-climbers shall be attached to the headstock at each end-car and shall include a minimum of three ribs. In the event of a collision, the anti-climbers on one end-car shall mate with the anti-climbers on the adjacent end-car to prevent one car climbing above another. Anti-climbing within a train shall be prevented by anti-climbers or couplers.
- 3.13.18.2 The train's front & rear anti-climbers shall be compatible to anti-climbers used in trains of other Rolling stock contracts of the CMRL phase 1 project. The RS Contractor shall interface with other Rolling stock Contractors of CMRL Phase 1 for the same.

3.13.19 Structural Shelf

- 3.13.19.1 A structural shelf shall be provided at the cab-end of the car, which spans between the two corner posts, in front of the collision posts.
- 3.13.19.2 The shelf shall be capable of resisting a horizontal inward load as specified in the appropriate standards at any location with no permanent deformation of the carbody structure.

3.13.20 Car Finishes – Aesthetics

- 3.13.20.1 Modern lightweight integrally structured rail passenger cars are required, using modular construction techniques for major components, such as roof, sides, floor and end modules.
- Full details of the technique / technology employed for joining the modular elements of shells shall be furnished, along with details of quantity and service records including inspection check sheets, test reports of vehicles assembled using such techniques.
- 3.13.20.2 The car body shall be designed and constructed for a service life of at least 35 years of normal usage without major rebuilding, strengthening and repair. Same shall be proven with the help of the type test or simulation.
- 3.13.20.3 The appearance of the car exterior shall have a modern and aesthetically pleasing profile. Significant emphasis must be placed on the style of the car exterior as the metro passes through some of the most important parts of the city.
- The stainless steel finish shall not require paint for protection. However, CMRL may at its sole discretion opt for partial or complete painting in case of Aluminium carbody. The painting scheme for an aluminium carbody design shall be submitted by the Contractor for review and approval by CMRL.
- Excessive surface undulations shall not be permitted; to the extent that the Contractor must achieve a finish that is commensurate with industry best practices. Undulations on brightly polished / unpainted surfaces shall not be easily visible to the naked eye. Surface undulation/variation shall not exceed 1.5 mm in any one square meter area, to ensure that the exterior stainless steel or aluminium appearance is smooth. Smoothing shall be achieved without the use of filler, painting or other similar materials.
- The Contractor may propose alternative specifications for an improved aesthetic appearance to CMRL for review no later than at preliminary design stage.
- 3.13.20.4 Main requirements for aesthetic are:
- a) modern look and must symbolize a modern transport means engaged toward in the future,
 - b) rapid and robust appearance, two requirements which influence the shapes, the dynamic behaviour and reliability,

- c) nice, curvy and non-aggressive shape respecting the surrounding environment and contributing to the quality of life,
 - d) accessible and protective at the same time, opened on the outside life with an impression of transparency, but protecting from the outside aggression,
 - e) comfortable, offering an impression of quietude to the passengers, by a tidy soundproofing, a relaxing brightness, soft and rounded shapes and a choice of suitable interior colours.
- 3.13.20.5 The Contractor shall propose aesthetic solutions each minimum five (05) the following but not limited to: colours of car saloon interior & exterior, themes & design of cab front mask, cab interior & driver desk, Livery pattern design of car interior & exterior, car interior colour & harmony of car interiors (not limited to interior panels, doors, door pillars, draught screen, ceiling, grab poles, grab rails, grab handles, seats, windows, floor cover, lights, diffusers, covers etc.). These shall be part of submission for CMRL approval.
- 3.13.20.6 The Contractor shall submit his proposals in the form of drawings, renderings, isometric sketches, photographs, artist's impressions to convey the overall aesthetic appearance and image of his design.
- 3.13.20.7 The CMRL logo (to be advised after contract award) shall be applied on both sides of the car and also at the both ends. The car number shall be applied on both sides of each car at both ends, both externally and internally to be easily visible to maintenance personnel.
- 3.13.20.8 The exterior style of the car shall be subject to the CMRL's acceptance. The final front and rear end design, colour scheme shall be agreed upon during the preliminary design review of the cars.
- 3.13.20.9 Proposals for measures that will maintain the original appearance of the car exterior and interior from undue deterioration, staining or streaking, including appropriate chemical cleaners shall be submitted. The cleaning and washing procedure shall be submitted to reinstate train's original appearance.

3.14 STRESS LEVELS AND DESIGN CALCULATIONS

3.14.1 Strength Requirements

- 3.14.1.1 The mechanical strength of the car body structure shall comply with the requirements of EN 12663 for Category P-III cars except for the compressive loads which shall be 1200 kN applied at the end of the carbody at the centre line of the coupler and shall be compatible in respect of crashworthiness as per EN 15227. The strength of the car body at other points shall comply with EN 12663. The tensile force shall be considered in the same ratio as the compressive force in EN 12663.
- 3.14.1.2 The Car structure shall be designed and constructed to withstand to AW5 conditions.
- 3.14.1.3 The methods used to substantiate the design load cases shall be submitted for review.
- 3.14.1.4 The Car structure shall have a fatigue life in accordance with EN 12663.
- 3.14.1.5 The Contractor shall demonstrate that the Car body-shell is capable of remaining free from fatigue failures over the specified Service Life.
- 3.14.1.6 The car shall, as a minimum, meet the load requirements specified below.

3.14.2 Roof Skin Structure

- 3.14.2.1 The roof skin structure in those areas where maintenance personnel are required to work shall be non-slip and sufficiently strong to support, vertical downloads of up to 2 person at 120 kg spaced 750 mm without permanent deformation.
- 3.14.2.2 The roof, including any protective coating, shall not suffer any damage due to roof pressure that may be imposed by the Car washer.

3.14.3 Side Structure:

- 3.14.3.1 The car side structure shall comply with the requirements of EN 12663 for Category P-III cars.

3.14.4 Hoisting and Jacking Loads:

- 3.14.4.1 The car with or without bogies shall be capable of being hoisted or jacked at designated carbody and truck locations without permanent deformation, buckling, or loss of watertightness in carbody seams and joints, in order to facilitate routine maintenance operations, emergency lifting, or re-railing. Deformation at the door openings shall not affect the door operations.

3.14.5 **Car End Design**

- 3.14.5.1 The cab framework, together with panels although not windscreens shall prevent penetration of a sharp cornered hollow steel cube sides 70 mm ~ 75 mm and of uniform thickness with a mass of 0.9 kg, projected corner-first at a speed of 160 kmph.

- 3.14.5.2 The Car ends shall be designed in a manner that allows the absorption of collision energy in a progressive manner as follows. Collision Buffers may be proposed for the front end of the Driver cars in addition to the mechanical and semi-permanent couplers as a means of absorbing crash energy. Car end including cab end, collision buffers structural strength requirements shall conform with Table 7 & Table 8 of EN 12663-1 and shall be validated by test.

- 3.14.5.3 A suitable proven energy absorption feature with associated collapse features shall be incorporated into the coupler draft gear. The coupler shall sustain no permanent damage for the below scenarios:

- a) When 6-car trainset loaded to AW2 loaded condition travelling at up to 10 kmph, colliding with a stationary AW2 loaded condition 6-car trainset with maximum parking brakes applied condition.
- b) When 6-car trainset loaded to AW2 loaded condition travelling at up to 10 kmph, colliding with a stationary AW2 loaded condition 6-car trainset with unbraked condition.

Energy shall all be absorbed within the recoverable stroke of the coupler resilient element and the motions of the Cars involved shall be stopped with no structural damage to any Car.

- 3.14.5.4 At closing speeds of 10 kmph to 25 kmph, the coupler shall absorb the additional energy within its sacrificial elements (loading condition as mentioned in EN 15227). The couplers shall progressively collapse bringing into play the anti-climb protection which shall remain fully engaged and operational under the action of vertical shear loads (upwards and downwards) equivalent to half the Crush Loading Condition Car weight. For survival zone during collision scenario, the requirements of EN15227 Section 6.3 shall apply, or an equivalent analysis, if approved by CMRL.

- 3.14.5.5 At a closing speed in excess of 25 kmph, the energy of impact of a car (loading condition as mentioned in EN 15227) shall be absorbed initially as described above and then by appropriate measures, e.g., deformation and/or absorber concept, up to a speed advised by the Contractor.

- 3.14.5.6 The Contractor shall submit a detailed technical analysis to derive predicted values for the following criteria for collision of trainset according to the scenarios stated below:

(a) **Scenarios:**

- (i) When 6-car trainset loaded to AW2 loaded condition colliding with a stationary AW2 loaded condition 6-car trainset with maximum parking brakes applied condition.
- (ii) When 6-car trainset loaded to AW2 loaded condition colliding with a stationary AW2 loaded condition 6-car trainset with unbraked condition.
- (iii) When existing 4-car trainset loaded to AW2 loaded condition colliding with a stationary AW2 loaded condition 6-car trainset with maximum parking brakes applied condition.
- (iv) When existing 4-car trainset loaded to AW2 loaded condition colliding with a stationary AW2 loaded condition 6-car trainset with unbraked condition.

1

(b) **Criteria:**

- i. The maximum collision speed at which there is no structural damage to the car body and the coupler.
- ii. The minimum collision speed at which the coupler energy absorption device fails.
- iii. The minimum speed at which actual structural damage commences.
- iv. The maximum speed at which the cab structural collapse features deform completely, without damage to the main car body structure.

- 3.14.5.7 The Contractor shall demonstrate this performance can be achieved through results of actual tests or a computer simulation verified previously by actual tests.
- 3.14.6 **Stress Analysis**
- 3.14.6.1 The Contractor shall perform and submit a stress analysis report of the carbody structure and equipment supports for equipment weighing over 150 Kg prior to commencing manufacture of any carbody structural parts.
- 3.14.6.2 Stress analyses for supports for items weighing less than 150 Kg may be requested for review at the discretion of CMRL.
- 3.14.6.3 The approved stress analysis report shall be a prerequisite for approval of the structural test procedures required by this Specification and shall be used as an aid in determining strain gauge locations.
- 3.14.6.4 The initial stress analysis requires some assumptions as to configuration and weights; also manufacturing and other considerations may require some design changes. As these changes are made, the stress analysis shall be revised and submitted for CMRL review. The final submitted and approved stress analysis shall be for the car as built.
- 3.14.6.5 Critical connections that cannot be adequately analysed shall be prototyped and tested to show their efficacy.
- 3.14.6.6 The elastic stability of plates, webs and flanges shall be calculated for members subject to compression and shear. The variation in the stainless steel or aluminium compression modulus with stress shall be considered in calculating compressive stability of stainless steel or aluminium members.
- 3.14.6.7 The mounting fasteners and support structures for equipment weighing more than 68 kg shall be analysed using design loads specified in the applicable standards.
- 3.14.6.8 For any portion of the proposed design that is based on a service-proven car, the Contractor may provide data from previous tests, historical data from operations, or stress analyses as required to satisfy the corresponding portion of these requirements.
- 3.14.6.9 The Contractor shall carry out a stress analysis of the car body (including torsion mode) as well as for important structural components that affect safety or availability, using the Finite Element Method. Separate analyses shall be demonstrated and submitted for car bodies having different basic structures. The analysis shall demonstrate that all static and fatigue strength requirements of the car body and equipment mounting are met.
- 3.14.6.10 Calculations of the moments of inertia of the car body about its longitudinal and transverse axes shall be furnished, together with those of the car body bending frequency.
- 3.14.7 **Stress Analysis Report**
- 3.14.7.1 If a cited reference is not readily available to CMRL, the Contractor shall provide the reference or copies of the pertinent pages. In addition to the pages that show the cited formula or data, the pages that show the development and interpretation of the formula or data must be included.
- 3.14.7.2 The stress analysis report shall include, at a minimum:
- a) Table of Contents.
 - b) Wherever a formula or equation is used, it must first be stated algebraically with all terms defined and the values of these terms stated, before substitution and calculations are performed.
 - c) All quantities wherever given must have their units given with them.
 - d) References for all formulas, calculation procedures, buckling coefficients, material strengths, fatigue strengths, and other physical and mechanical properties cited where these items appear in the stress analysis.
 - e) Each page numbered, dated, and initialled by the analyst. In the event of a revision, the revision letter shall be included with revision date and initial of the analyst.
 - f) A structural diagram (layout) of the carbody (including sheathing) showing all member locations and shapes and indicating the material and thickness of each. Methods of joining shall be defined.

- g) Diagrams displaying, for each load case, externally applied loads to the carbody and points of support.
- h) Diagrams displaying the FEA element numbers and node numbers divided into two sets: Set A shall show the beam elements with the beam elements and nodes numbered. Set B shall show the plate elements with the plate elements and nodes numbered. These drawings shall be approximately to scale, dimension, and sufficiently clear that every node and element number can be read.
- i) An analysis showing compliance with each design load and condition.
- j) Detailed calculations of stresses with Margins of Safety (MS) in all structural framing members and sheathing, with a summary of the results. Locations where the MS is less than 0.20 shall be shown in a table along with the design or operating conditions (loads) that cause the stresses.

Particular reference in the stress analysis shall be made but not limited to:

- side sill
- body sills
- end sill
- anti-climber
- draft sills
- coupler supports
- side frame rails
- side frame posts
- doorway framing supports
- transverse and longitudinal sections at doorways
- body bolster (if used)
- floor and floor beams
- collision posts
- corner posts
- structural shelf
- roof structure
- equipment hangers
- connections between structural elements
- front windshield enclosure frame

The windows and front windshield frame with seal shall be capable of withstanding the air pressure resulting from two passing trains traveling at 80 kmph in opposite directions and simulating entry and exit of train in tunnel. The windows and front windshield frame with seal shall be validated by test conforming UIC 566 / GM/RT2100 or equivalent.

- k) A tabulation or diagram of calculated deflections of the carbody under full vertical loading and under combined vertical and compression loads specified in Chapter 3.
- l) Analysis of all critical and highly loaded connections showing the joint stronger than the weakest member being joined.
- m) An analysis of the strength of the connection of the bogie to the carbody, including calculated vertical and horizontal connection capacities.
- n) Analyses of the carbody structure under the torsional loading resulting from diagonal jacking described in Chapter 17, and under torsional loadings resulting from anticipated normal

operations.

- o) A tabulation of the Contractor's selection of allowable fatigue stresses, with sources, and assumed applied fatigue stress ranges for structural members that are critical in fatigue.
- p) A table showing the engineering properties of each material, and each grade and temper of the material, used for the car structure. This table shall include the material specification, yield strength, ultimate strength, elongation, and Young's modulus for tension, compression, and shear. These values shall be the minimum values shown in the material specifications for the grade and heat treatment of the material applied. Materials, grades and tempers not used in the carbody construction shall not be included in the tables.
- q) Table(s) showing the minimum strength and fatigue strength of single and multiple spot welds. Values shall be given for each material, temper, weld size, and thickness combination. The source of this data must be provided.

3.14.7.3 If tests are conducted to provide the necessary data, the entire test report shall be submitted. This report shall show the test procedure, raw data as well as reduced data, and summary.

3.14.8 **Finite Element Analysis (FEA)**

3.14.8.1 The stress analysis shall include a finite element analysis (FEA) of the complete carbody. The FEA shall be a recognized computer program such as Nastran, Ansys, Algor Supersap, Hyper Works or any advanced soft tools.

3.14.8.2 The Contractor shall prepare and submit to CMRL a report on the finite element model prior to performing the analysis. The element grid, all assumptions, and a complete printed copy of the input file which includes input data, such as loads, boundary conditions, area properties and material properties, shall be included as part of the preliminary submittal and again as part of the complete analysis. A key to all symbols and colours shall be included. Boundary reaction forces of the shell at AW0 are to be included.

3.14.8.3 The input and output of the FEA shall be included in the FEA.

3.14.8.4 Colour plots shall be made showing the original and deflected shape of the car under all loading conditions. Colour contour plots shall be made showing the directional stresses in the car or any portion of the car under all loading conditions. All plots (drawings) shall show the maximum and minimum values and all values which are greater than 80% of the specified maximum value.

3.14.8.5 Submittal of the input file is required with the model and shall be included as part of the preliminary submittal, and again as part of the complete analysis. Criteria for final approval of the stress analysis shall include the Contractor's submittal of the fully configured input data files as required by this paragraph.

3.14.8.6 Tables shall be prepared comparing the stresses computed in the analysis with stresses computed from the strain gauge readings of the structural tests of ERTS 17. These tables shall be prepared for each test. A minimum of 100 strain gauges shall be used for comparison in each table. The tables shall be annotated to explain differences between the predicted and test values. Analysis and test results shall agree within 15% for at least 80% of the strain gauges and none less accurate than 30%. These tables shall be submitted with the test report as per ERTS 17.

3.14.9 **Crashworthiness**

The carbody structure shall be designed according to European standard EN 12663 category PIII and crash scenarios defined in EN 15227 (Category CII), or as described below.

The end of each car shall have two corner posts, two collision posts and an anti-climbing device. In lieu of corner posts and collision posts the Contractor may propose a service proven collision buffer system that meets the requirements of EN 15227. For crash scenarios (loading condition as mentioned in EN 15227).

3.14.9.1 The car structure shall be designed to sustain collisions with other cars, without unnecessary risk of injury to passengers.

3.14.9.2 The end structure shall be designed to absorb energy during a collision such that the risk of a collapsed structure penetrating the passenger compartment is minimized.

CMRL prefers that the carbody design follows international standards for Crash Energy Management (CEM). Proposers must address this issue as part of the Technical Proposal. A comparable crash energy management analysis will be considered by CMRL.

- 3.14.9.3 The car ends shall be designed to prevent overriding and telescoping of the car into any passenger area in the event of a collision. The anti-telescoping structure shall include elements such as corner posts, collision posts, and anti-climbers.
- 3.14.9.4 The end underframe equipment shall be configured such that end-structure crushing during a collision is not hindered by equipment or associated supports. Anti-climbers shall engage under all track geometry and possible car-to-car head-on collision scenarios.
- 3.14.9.5 The resistance to car crushing shall increase as the collapse distance increases. Controlled failure as part collision energy absorption shall begin at the ends of the car and progress towards the coupler anchors in the case of extreme overload.
- 3.14.9.6 Particular concern is about the driving car front structure, which is required to protect the passengers, and vital control and communications equipment in the event of a collision. The Front part of the driving car is to be used as an emergency escape route from driving car to track. The Contractor shall design the driving vehicle and its cab structure in such a manner as to fulfil the requirements of EN 15227.

The Contractor shall submit the proposal for structural arrangement of driving car front and sides, and the manner in which members tie-in with the under frame and roof structure.

3.14.10 **Crashworthiness Analysis**

- 3.14.10.1 A crash energy absorption (“large deflection”) analysis of the car shall be made and submitted to assess the energy absorbing properties of the structure. The Contractors shall submit a detailed report showing all the results of the analysis for CMRL’s review and approval.

Crashworthiness analysis shall be conformed for all train configuration mentioned this contract and in clause 2.2.12.

This analysis is required to show that the car crushes in from the end and does not affect the occupied volume. The analysis shall be based on the following scenarios:

- (i) one 6-car train (loading condition as mentioned in EN 15227), traveling at 25 kmph, impacts another 6-car train similarly AW2 loaded Condition, which is standing still with friction brakes applied on level, tangent track so that the anti-climbing mechanisms engage.
- (ii) one 6-car train (loading condition as mentioned in EN 15227), traveling at 25 kmph, impacts another 6-car train similarly AW2 loaded Condition, which is standing still with unbraked on level, tangent track so that the anti-climbing mechanisms engage.
- (iii) one 6-car train (loading condition as mentioned in EN 15227), traveling at 25 kmph, impacts another existing 4-car train similarly AW2 loaded Condition, which is standing still with friction brakes applied on level, tangent track so that the anti-climbing mechanisms engage.
- (iv) one 6-car train (loading condition as mentioned in EN 15227), traveling at 25 kmph, impacts another existing 4-car train similarly AW2 loaded Condition, which is standing still with unbraked on level, tangent track so that the anti-climbing mechanisms engage.

The analysis shall include the following calculations:

- Compression load developed by the longitudinal frame members designed for crushing,
- Buckling strength of the longitudinal members under the calculated compressive load,
- The progressive buckling and bending of the carbody end structure,
- The accumulation of energy during crushing, i.e., force versus distance,
- Show that mounted equipment and structural members other than those designed for energy absorption shall not provide any portion of, nor interfere with, the crushing.

This report shall include the same information as required in the Stress Analysis Report described in clause 3.14.7. Compression tests shall be performed on the various structural elements to show the energy absorbed by the element during crushing. If the Contractor’s Finite Element Modelling

and corresponding stress analysis have previously been proven out (confirmed and approved) through actual testing on a previous project, then a physical crash test (whether elemental or dynamic) is not required to be repeated as long as the same methodology and modelling is applied for this analysis. If the Contractor does not have a previous experience and an approved model, stress analysis and test verification from a prior project then a compression test will be required. The test(s) mentioned is for the sacrificial elements only. The crush test means the quasi-static large deformation test only since the passenger compartment must not be affected or deformed in any way. A dynamic crash test is not required.

- 3.14.10.2 For the purposes of design of the crashworthiness components, the following collision scenario and crashworthiness criteria may apply, or those which comply with the cited international standards:

Crashworthiness analysis shall be conformed for all train configuration mentioned this contract and in clause 2.2.12.

a. **Collision Scenario:**

- i. One 6-car trainset (loading condition as mentioned in EN 15227) on level tangent track and moving at velocity V, impacts a similar, 6-car trainset loaded to AW2 stationary trainset which has all friction brake systems applied.
- ii. One 6-car trainset (loading condition as mentioned in EN 15227) on level tangent track and moving at velocity V, impacts a similar, 6-car trainset loaded to AW2 stationary trainset which is unbraked.
- iii. One 6-car trainset (loading condition as mentioned in EN 15227) on level tangent track and moving at velocity V, impacts another, existing 4-car trainset loaded to AW2 stationary trainset which has all friction brake systems applied.
- iv. One 6-car trainset (loading condition as mentioned in EN 15227) on level tangent track and moving at velocity V, impacts another, existing 4-car trainset loaded to AW2 stationary trainset which is unbraked.

b. **Crashworthiness Criteria:**

The Contractor shall submit predicted values for the following in respect of AW2 loading condition. The Contractor shall submit a detailed technical proposal and analysis to specify the following in respect of the AW2 loaded vehicle collision scenario defined above in clause 3.14.10.2 a:

- (i) The maximum collision speed at which there is no structural damage to the car body and the coupler.
- (ii) The minimum collision speed at which the coupler energy absorption device fails.
- (iii) The minimum speed at which actual structural damage commences.
- (iv) The maximum speed at which the cab structural collapse features deform completely, without damage to the main car body structure.

- 3.14.10.3 At a minimum, the Contractor shall demonstrate by test that the main collision energy absorption elements of the structure achieve the desired characteristics. The test results shall be correlated with the analyses within an accuracy to be agreed upon with CMRL. A report showing the results of the collision scenarios shall be submitted to CMRL for review and approval.

- 3.14.10.4 Prior to beginning the crashworthiness analysis, the Contractor shall provide a Crashworthiness Analysis Approach and Test Plan, that details the approach the Contractor will use to demonstrate compliance with clause 3.14.9

- 3.14.10.5 Electrical equipment and wiring shall be configured in a manner that precludes any electrical shock hazard to passengers, operators, or rescue personnel for the collision scenarios defined in clause 3.14.10.2. Compressed air systems and associated lines for these shall be configured to minimize the possibility of rupture and fire for the collision scenario in clause 3.14.10.2

3.15 NATURAL FREQUENCY

- 3.15.1 The natural frequency of the complete car shall be fully de-coupled from all potentially damaging excitation frequencies such as those from bogies, track and equipment. The natural frequency of the first body bending mode shall be at least 1.5 times that of the bounce frequency of the bogie frame and primary suspension system, unless the Contractor proves through testing, or by comparison of existing test data, that resonance will not occur under any operating conditions and that the ride quality requirements of Chapter 2 are met. This requirement shall be met at all car speeds, up to and including maximum design speed, and all occupancy levels.

3.16 MODELS

3.16.1 3D Virtual Models:

A fully rendered suite of accurately scaled 3-dimensional images shall be produced to demonstrate the virtual mock-up. A 3D motion video of a full scale model of the Trains shall also be developed. The video shall include the artistic impression of the Trains travelling through the section.

The Contractor shall arrange the necessary Software and complete set of Hardware including laptop for viewing the 3D Virtual Model. The initial version of the 3D virtual model, 2D images of virtual model and 3D motion video shall be submitted to the CMRL within 36 weeks of the date for Commencement of the Works. The Contractor shall submit three (03) virtual models to CMRL for review and approval. The Contractor shall incorporate comments of CMRL into virtual mock-up in two formal reviews and submit the final one.

The Contractor shall develop and arrange at least three (03) 3D digital mock-up reviews of proposal for CMRL's review and approval.

3.16.2 Physical scale model:

The Contractor shall prepare and handover to CMRL, one scale model of approximately 1:20 size stainless steel (non-working) 6 car train configuration, duly equipped with representative track, OCS, interior-exterior furnishings, internal illumination, headlight, marker light and flasher light, display boards, pedestal and casings. All lights in the model shall be functional. Suitable stand (duly approved by the CMRL) shall be provided with the model. The same shall be delivered along with the delivery of the Pilot train. Sample of the model shall be approved from CMRL.

In addition to the above, five numbers of reduced scale models (non-working) with 1:100 size shall also be provided within three months from the delivery of the Pilot train in depot. Sample of the model shall be approved from CMRL.

4. COUPLER AND DRAFT GEAR

4.1 NOT USED

4.2 GENERAL

- 4.2.1 A single 6 car consist shall be formed of two sets of Driving Motor Cars, two sets of trailer cars and two sets of Motor cars (DMC + TC + MC + MC + TC + DMC).

1

CMRL shall operate both existing 4-car (DMC+TC+TC+DMC) and 6-car rake formations during revenue service in the same corridor.

Hence, the coupler design shall comply with rescue requirements of the 6-car formation with 4-car and the vice versa.

- 4.2.2 Each front and rear ends of a 6 car consist shall be equipped with semi-automatic mechanical couplers of symmetrical, slack-free type and with pneumatic head & electrical head complying with auxiliary power requirements specified in clause 9.10 coupling for push-pull rescue operations.

1

- 4.2.3 Intermediate cars shall be coupled with semi-permanent couplers.

- 4.2.4 Automatic isolation and shutoff of train-lined air shall be provided during normal coupling and uncoupling operations. It shall also be possible to isolate or shut off the train-lined air manually at both ends of each car, from a position that is accessible from both track and platform level. The same function shall be performed from the Operator Console and also be interfaced with TCMS.

- 4.2.5 All hardware shall be made of corrosion-proof materials or shall be protected from corrosion.

- 4.2.6 The Contractor shall propose the optimum coupler configuration considering that the 6 car rakes will remain semi-permanently coupled within single rake in normal operations and for maintenance purposes.

- 4.2.7 The design of the front-end semi-automatic coupler shall permit Automatic mechanical-only coupling (e.g., a reduced coupling mode without simultaneous electrical and pneumatic coupling) to facilitate the rescue operation of prevent the event that a failed train rake; without causing electrical and/or pneumatic fault that may be transmitted to migrate to the assisting rake.

1

- 4.2.8 To meet emergency requirements of clearing a disabled train by a healthy train, the couplers of ARE05 trainsets shall be totally compatible for providing safe mechanical and pneumatic coupling with electrical jumper cable (only for rescue operation) with ARE01 trainsets.

1

- 4.2.9 As trains shall operate in ~~ATO mode (GoA2)~~ UTO mode (GoA4), the Contractor shall design the couplers in such a way that regardless of whether a train is in normal operating mode or in a degraded mode of operation no manual intervention at coupler shall be required to couple / uncouple the defective train with healthy train (and vice-versa). This condition shall be met throughout the complete alignment of CMRL Phase 1 & Phase 1 extension.

1

- 4.2.10 The Rolling Stock Contractor shall share the details of couplers and anti-climbers with related interface Contractors of the CMRL Phase 1 project.

- 4.2.11 Trains procured under this tender will ply along with the existing trains of CMRL Phase 1. In order to meet the coupling and rescuing of a disabled train by a healthy train, the couplers in the proposed train shall be fully compatible with existing train's coupler for effecting safe mechanical and pneumatic coupling. Height and tolerance of the coupler shall be same as existing trains and in the same alignment of the under-frame structure.

- 4.2.12 All electrical and electronic components shall comply with the EMC and EMI requirements of EN 50121 (all parts), IEEE 16, EN 55011 and IEC 61000-4 standards or other equivalent international standards. The requirements of EMC EMI requirements referred in clause 10.19 & clause 2.18 of the Rolling Stock shall be met.

4.2.13 Fire properties of the materials used shall comply with EN 45545 part 1 to part 7 latest editions (Category 4-A, Hazard level HL3) as a minimum or better international standard applicable for similar Metro applications. Requirements of clause 2.26 shall be met.

4.2.14 Material requirements of all sub systems of train shall be compliant with the requirements of Chapter 19.

1

4.2.15 The Contractor shall submit a simulation analysis report demonstrating the behavior of the coupler under collision conditions at the specified collision speed. The report shall include structural analysis, failure modes, and impact on train safety to demonstrate compliance with the applicable crashworthiness and safety requirements.

1

4.2.16 The train's front & rear end automatic couplers shall be used for coupling / uncoupling and for rescue operation with trains of other Rolling stock contracts of the CMRL phase 1 & phase 1 extension. The Contractor shall interface with other Rolling Stock Contractors of CMRL Phase 1 & Phase 1 extension for the same.

4.3 COUPLER OPERATION

4.3.1 General

4.3.1.1 The coupler system shall permit rakes of 6 car loaded at AW4 to operate over all segments and track configurations of the complete alignment of CMRL phase 1 during recovery operations of disabled rakes, without permanent deformation to the cars, couplers or inter-car drawbars (if used).

4.3.1.2 The coupler and drawbar shall be designed and constructed to permit coupled cars to negotiate all horizontal and vertical curves specified in Chapter 2, including operations with maximum mismatch between cars due to spring deflection, wheel wear, suspension failure and track irregularities. Under no conditions shall the drawbars or couplers interfere with bogie parts, wheels, cables or other equipment. This applies even while operating as a rescue rake in coupled condition.

4.3.2 Coupling / Uncoupling

4.3.2.1 The operation of the mechanical coupling in the front and rear end semi-automatic couplers of the rake shall be completely automatic when coupling and un-coupling.

1

4.3.2.2 With one uncoupling command from ~~the active cab adjacent to the coupler~~ Operator's Desk, it shall enable sequential dis-engagement of electrical head, pneumatic head and mechanical head uncoupling. Uncoupling shall be possible only when the rake is stationary.

4.3.2.3 Mechanical coupling at speeds up to 3.2 kmph shall be possible from any cab to any adjacent cab (i.e., no "handed" couplers are permitted) without experiencing damage to any of the components. Higher allowable coupler speeds will be preferred. Mechanical coupling shall be possible even on curves and gradients.

1

4.3.2.4 ~~Not used.~~ In front-end automatic coupling operation, the Contractor shall ensure that the operation of the electrical head coupling occurs only after effective and successful engagement of both mechanical and pneumatic coupling between rakes. There shall always be manual command provision from Operator's Console or from TCMS to allow or not the engagement of electrical heads between rakes after effective and successful mechanical & pneumatic coupling.

4.3.2.5 Adequate earthing and grounding provisions shall be available between the cars when in Coupled condition. These earthing and grounding between cars shall be easily able to be disconnected during un-coupling between cars.

4.3.3 Manual Operation

1

4.3.3.1 Devices / controls shall be provided inside the train to manually operate (hard wired) from Operator's desk ~~Console~~ and soft signal from TCMS for the functions such as electrical head retrieval, electrical head isolation, pneumatic uncoupling and mechanical uncoupling of the rake from another rake.

- 4.3.3.2 When uncoupled and without lubrication, the drawbar and coupler assemblies shall move laterally when a force of not more than 75 lbs. (333.6 N) is applied laterally to the face of the coupler head.
- 4.3.3.3 Provision shall be made for disconnecting the jumper connections only, without mechanical uncoupling.

4.4 MECHANICAL COUPLER

4.4.1 Strength

- 4.4.1.1 The coupler system shall be able to withstand a buff load or draft load equal to the rake weight, as well as loads due to pushing or towing as defined in clause 4.3.1.1 without permanent deformation. The coupler system load characteristics shall be coordinated with car crashworthiness requirements.
- 4.4.1.2 Coupler is to be Service-proven design and all components shall withstand the all vertical and horizontal loads, under normal and extreme operating conditions.

4.4.2 Gathering Range

- 4.4.2.1 The minimum gathering range of the mechanical coupler shall be ± 75 mm in both horizontally and vertically.
- 4.4.2.2 The Contractor shall prove CMRL that automatic coupling between two rakes (mechanical, pneumatic and electrical) shall be possible ~~from either one side of the train~~ without any manual intervention ~~and the other side with manual intervention~~ in the ruling curve (sharpest curve), ruling gradient (sharpest gradient) in mainline as well in depot (for all GoA2 & GoA4 operation network) based on the alignment drawing provided by CMRL.

4.4.3 Centering

- 4.4.3.1 The coupler shall have a self-centering device that retains the unconnected coupler head within its gathering range, to enable automatic coupling upon buffing two cars together.
- 4.4.3.2 The self-centering device shall include an override, to allow manual movement of the coupler for coupling at track locations outside the gathering range of the coupler.
- 4.4.3.3 The centring device shall prevent the coupler from swinging transversely when it is not coupled.

4.4.4 Vertical Support

- 4.4.4.1 The coupler shall be supported at the draft gear in the vertical direction to maintain nominal height above top of rail.
- 4.4.4.2 The supporting device shall provide a suitable means for vertical / angular height adjustment of the coupler head ~~to compensate for wheel wear, operating levels of the primary suspension, failure of air suspension and coupler assembly wear.~~

4.4.5 Anchorage

- 4.4.5.1 The anchorage and its attachment to the car underframe shall be designed and constructed to withstand any loads that can be transmitted to them by the coupler.

4.4.6 Wear

- 4.4.6.1 Shims, replaceable bushings, wear plates, or other means of compensating for wear shall be installed at locations of high wear.
- 4.4.6.2 Parts requiring lubrication should be avoided. The use of parts requiring lubrication must be approved by CMRL. If the use of such parts is approved, they shall require lubrication no more than once every 37,500 km and/or consistent with the recommended maintenance process.

4.5 DRAFT GEAR

- 4.5.1 The coupler shall provide cushioning that is effective in both buff and draft.
- 4.5.2 Energy Absorption Feature

- 4.5.2.1 Energy absorption and automatic release capability shall be provided, compatible with the specified crashworthiness requirements.
- 4.5.2.2 The coupler system and mountings shall be capable of withstanding all forces caused by coupling a rake with AW4 loading and traveling at 3.2 kmph, with another stationary 6 car and 6-car rake consist loaded at AW4, without automatic release or permanent deformation of coupler system. In this scenario, the stationary consist shall be considered to have parking brakes applied. Higher allowed coupling speeds will be preferred.
- 4.5.2.3 Any permanent deformation to or automatic release of the coupler shall be visibly detectable from trackside.
- 4.5.2.4 The energy absorption feature and anti-climber travel shall be coordinated to optimize coupler energy absorption, while ensuring that the anti-climbers engage prior to the end of the energy absorption feature travel. The minimum travel length capability of the energy absorption feature shall be 150 mm.
- 4.5.2.5 Following automatic release, the coupler shall be retained so that it does not separate completely from the carbody nor shall it protrude into the track bed or penetrate the car floor.
- 4.5.2.6 The released coupler or any of its components shall not prevent the anti-climbers from engaging fully. An automatically released coupler assembly shall be capable of being fully restored to serviceable condition with-in 2 man-hours.
- 4.5.2.7 The Contractor shall submit a description and calculations for the energy absorption release feature.

4.6 JUMPER CABLES HOSES AND CONDUITS

- 4.6.1 During the rescue operation of a defective train loaded with passengers, the healthy train shall ensure simultaneous brake application in both healthy and defective train. The design shall be proposed during preliminary design stage. This requirement also applies to rescue operation of Rolling Stock under this contract to/from existing CMRL Phase 1 fleet.
- 4.6.2 The Contractor shall submit a procedure describing all modes of coupling & un-coupling operations covering all scenarios of a train rescue operation described in this section.
- 1 4.6.3 When uncoupled, the front & rear end ~~semi~~-automatic coupler shall be arranged so that pneumatic connections shall be automatically protected from the ingress of water, dust, fire and extraneous foreign matter.
- 4.6.4 The connecting hoses of front & rear end automatic coupler shall be placed with adequate spacing between the adjacent train components, adjacent cables / conduits / hoses to prevent chafing during train operating and coupling / un-coupling conditions.

- 4.6.5 Jumper cables shall be used for all electrical connections, trainlines and communication lines wherever intermediate car(s) of the rake are semi-permanently coupled. Separate conduits / pathways shall be provided for HV power cables, auxiliary power cables, battery voltage supply cables and train-line control circuit wiring. ~~Jumper cables for electrical connections, shall be used for train to train coupling between 6-car rake and existing 4-car rake for coupling & rescue operation.~~

~~Jumper cables shall be used between and at end of coaches having semi-automatic and semi-permanent couplers and have a separate coupler for power, auxiliary power and control circuits.~~

1 Electrical end connections ~~between intermediate cars~~ shall be semi-permanent by means of jumpers or jumping cables. ~~However, the jumper cables for train-to-train coupling shall be designed to allow coupling and uncoupling operations to be carried out from the platform or walkway, without the need to access the track.~~ Uncoupling or re-coupling shall not damage these connections. It shall not be necessary to give preventative maintenance attention to these connections between vehicle overhauls. Electrical connections between cars shall be provided manually. Pneumatic continuity will be done by means of flexible hoses or through the semi-permanent coupler.

- 4.6.6 Uncoupling or re-coupling of jumper cables shall not damage or degrade the integrity of the connections. Preventative maintenance interventions shall not be required in between major overhauls of the trainset. Pneumatic pipes shall be provided will be done by means of flexible hoses or through the semi-permanent coupler.
- 4.6.7 The connecting hoses, jumper cables and other electrical conduits between cars shall be secured with cleats, glands etc to ensure adequate spacing between the adjacent train components, adjacent cables / conduits / hoses to prevent chafing during train operating including coupling / un-coupling operations.
- 4.6.8 The ingress points for all jumper cables, conduits, pneumatic hoses, etc., between the underframe and body interior shall be effectively sealed for ingress of water, dust and fire.
- 4.6.9 The Contractor shall submit for CMRL approval the dynamic motion and design suitability analysis for all the electrical and pneumatic connections in between cars & in-between rakes including all conditions of flexing applications during operation. This arrangement shall show the clamping arrangement meeting the requirements of clause 4.6
- 4.6.10 Sufficient clearance shall be maintained for all Jumper cables, hoses and conduits considering the full wheel wear diameter, operating levels of the primary suspension and failure of air suspension.
- 4.6.11 An allocation of at least 10% of spare wires (with connected terminals) shall be provided for each usage category. Usage categories shall include but not be limited to audio, Ethernet, trainlines, various train networks, other serial & parallel communications as well as all types of car lines and/or trainlines; which exist in all jumper cables and/or conduits. It shall be possible for CMRL to utilize the allocation of spare cables without impacting other functionalities of the train at a later stage.

4.7 PNEUMATIC COUPLER

- 4.7.1 An automatic pneumatic coupler shall be provided as part of the mechanical coupling mechanism. The pneumatic coupler shall be capable of making all connections necessary for rake-lining the main reservoirs and emergency brake applications in a rake.
- 4.7.2 The pneumatic coupler shall connect automatically upon mechanical coupling, and disconnect and seal the air-line automatically upon mechanical uncoupling.
- 4.7.3 Each coupler shall include cut-out cocks for manual pneumatic isolation. The location of the cut-out cocks shall allow access to operate from both the exterior of the train (at platform level) as well the interior (near the Operator's Desk).

4.8 SEMI-PERMANENT COUPLER / INTER-CAR DRAWBAR

- 4.8.1 **Mechanical Connection:**
 - 4.8.1.1 A drawbar shall mechanically connect between the Motor car and Trailer car. The draw bar shall provide cushioning in both buff and draft.
 - 4.8.1.2 The drawbar system shall be able to withstand a buff load or draft load equal to the rake weight, as well as loads due to pushing or towing as defined in clause 4.3.1.1, without permanent deformation. The drawbar anchorage load characteristics shall be designed and constructed in compliance with international standards. The Contractor shall submit to CMRL a description of the drawbar system and calculations showing compliance with the requirements of these Provisions.
 - 4.8.1.3 In collisions, the drawbar shall allow the anti-climbers to fully engage and shall be guided so as to not penetrate into the car floor, nor into the track bed.
- 4.8.2 **Electrical and Pneumatic Connection:**
 - 4.8.2.1 Electrical connections between the cars of a rake shall use highly flexible multi-conductor cables conforming to relevant international standards with quick-disconnect connectors on both ends.

- 4.8.2.2 If hoses are used for air connections, they shall be equipped with quick disconnects on both ends. The hoses shall be provided with mistake proofing connectors distinguishing between various types of hoses in-order to prevent wrong connections.

4.9 FRONT END ELECTRICAL COUPLING

- 4.9.1 During the automatic coupling of two trains with electrical head in engaged condition, it shall be possible for the assisting train to rescue the Faulty train with both the trains in switched ON condition.

1

- 4.9.2 Automatic electrical protection shall be available in circuits of each train to prevent any short circuiting, sparks, spike / dip in voltage / current during the electrical coupling & un-coupling of two trains. In any case of automatic electrical coupling & Un-coupling between two trains, there shall not be any damage to any component of the trains coupled.
- 4.9.3 In case of an electrical failure on a defective train (or in the case of coupling with a train from a different Chennai Phase-1 fleet); it shall be possible to electrically couple with only essential control and power feed circuits active (E.g. non-essential circuits shall be isolated to avoid migration of the electrical defect to the healthy train).
- 4.9.4 The Contractor shall interface with other concerned Contractors to identify the essential control and power feed circuits to be made compatible for the rolling stock fleet(s) and meet the requirements defined in the Brakes Chapter. The design shall be proposed during preliminary design stage.
- 4.9.5 In the case of an unresolvable electrical failure (E.g. it is present on the essential circuits) it shall still be possible to mechanically and pneumatically couple the two train consists in rescue mode with the electrical head operation inhibited.
- 4.9.6 The Contractor shall submit a procedure describing all modes of coupling & un-coupling operations covering all scenarios of a train rescue operation described in this section.
- 4.9.7 When uncoupled, the front & rear end automatic coupler shall be arranged so that electrical contacts and pneumatic connections shall be automatically protected from the ingress of water, dust, fire and extraneous foreign matter.
- 4.9.8 The connecting hoses and electrical conduits of front & rear end automatic coupler shall be placed with adequate spacing between the adjacent train components, adjacent cables / conduits / hoses to prevent chafing during train operating and coupling / un-coupling conditions.
- 4.9.9 The Connectors and closing mechanism of the Auto-coupler Electrical Heads shall be rated for at least IP 55 in accordance with EN 60529.

5. OPERATOR'S DESK

5.1 NOT USED

5.2 GENERAL

- ~~5.2.1 An Operator's Desk shall be provided inside both the extreme ends of the train. This Operator's Desk shall be suitable for operation of train in ATO / ATP and other degraded modes of operation.~~
- ~~5.2.2 Both sides of the cab shall be provided with a single leaf door (hinged or sliding) to permit access from station platforms and from track level.~~
- ~~5.2.3 The cab shall be ventilated from bleed off from the saloon air conditioning and be free from external draughts and ingress of dirt, water and noise. The Driving position shall be in the centre of the Cab.~~
- ~~5.2.4 The train operator's seat shall be cushioned, non-slippery, ergonomically designed using non-flammable materials and filling. The seat shall be foldable and adequate measures shall be taken to ensure that it is opened only by the train operator.~~
- ~~5.2.5 In DM Car from the face of the coupler, the Operator desk shall not exceed 2000 mm.~~
- ~~5.2.6 During GoA4 & GoA3 operation, the Operator's Desk shall be concealed by aesthetically matching covers (material, colour, and texture matching with car interiors). The covers shall have sufficient structural strength, be vandalism proof, compatible with fire performance standards and suitably locked & secured. During the non UTO operation, only authorized personnel shall be able to open the covers and operate the train~~

- 5.2.1 An Operator's Desk shall be provided inside both the extreme ends of the train. This operator's desk shall be suitable for operation of train in GoA1, GoA2, GoA3, GoA4 (UTO) and other degraded modes. The Driving position shall be in the centre of the Cab. The Operator's Desk and the train controls shall be suitably designed on the centre area of the train ends and shall meet all the requirements of Chapter 5.

- 5.2.2 During GoA4 & GoA3 operation, the Operator's Desk shall be concealed by aesthetically matching covers (material, colour, and texture matching with car interiors). The covers shall have sufficient structural strength, be vandalism proof, compatible with fire performance standards and suitably locked & secured. During the non UTO operation, only authorized personnel shall be able to open the covers and operate the train which shall be recorded as an event and shall be transmitted to the RSC consoles of OCC, BCC and DCC. Refer to clause 3.4.3.8 for compliance.

- 5.2.3 The cab end area including the operator's desk region shall be part of passenger saloon area during UTO mode of operation. Ventilation shall therefore be achieved from the same VAC system as the saloon.

The cab area shall be ventilated from bleed off from the saloon air conditioning and be free from external draughts and ingress of dirt, water and noise in compliance to UIC 651, GMRT 2100, EN 14750, EN 45545 (all parts) or equivalent.

- 5.2.4 UTO / GoA4 shall be the predominant mode of train operations. In case CMRL does not engage UTO for any reason during any stage of operation, the train operator / train attendant shall be onboard to operate the train under GoA3, ATO or Manual Mode (under ATP) or under Restricted Manual Mode or any other degraded mode required for rescue operation or depot shunting. Based on operational requirement, the rakes are planned with operations in GoA2 (ATO) during the initial passenger service and subsequently in GoA4 (UTO).

- 5.2.5 The Operator's Desk' System shall function in accordance with all the criteria defined in Chapter 14.

- 5.2.6 The covers of the Operator's Desk shall be able to slide inside the panel cabinets, shall not cause any infringement or vibration or disturbance to the train operator or passengers during non-UTO modes and degraded modes of train operations.

- 5.2.7 Deleted

- 5.2.8 The Operator's Desk layout shall confirm to UIC 651 or GMRT 2100 and its facilities shall be designed for train operation in GoA4 and shall also meet all the existing modes of operation including all UTO & Non-UTO, degraded modes, rescue mode, Manual Driving in main-line / depots / stabling yards, shunting lines and during testing & commissioning.
- 5.2.9 All the panels of operator's desk shall be mounted such that, there shall be easy access to the internal equipment. There shall not be requirement to remove any rigid mountings to access any equipment inside the operator's desk.
- 5.2.10 Not used.
- 5.2.11 All electrical and electronic components shall comply with the EMC and EMI requirements of EN 50121 (all parts), IEEE 16, EN 55011 and IEC 61000-4 standards or other equivalent international standards. The requirements of EMC EMI requirements referred in clause 10.19 & 2.18 of the Rolling Stock shall be met.
- 5.2.12 Fire properties of the materials used shall comply with EN 45545 part 1 to part 7 latest editions (Category 4-A, Hazard level HL3) as a minimum or better international standard applicable for similar Metro applications. Requirements of clause 2.26 shall be met.
- 5.2.13 Material requirements of all sub systems of train shall be compliant with the requirements of Chapter 19.
- 5.2.14 Not used.
- 5.2.15 The design of Operator's desk and its relevant components in train shall support for the UTO / GoA4 and trains shall be operated in GoA2 / ATO during the initial stage of commissioning and revenue operations and in GoA4 / UTO subsequently. Hence all the feed-backs, information and train controls which are available on TCMS screen shall also be available in OCC (operational control Centre) and DCC (Depot Control Centre) for smooth operation of passenger service.
- 5.2.16 An emergency train operator's seat shall be provided in the Operator's desk area, the seat shall be cushioned, non-slippery, ergonomically designed using non flammable materials and filling. The seat shall be foldable and adequate measures shall be taken to ensure that it is opened only by the train operator.
- 5.2.17 In DM Car from the face of the coupler, the Operator desk shall not exceed 2000 mm.

5.3 OPERATOR'S DESK AREA

- 5.3.1 The design of the Operator's Desk area shall be based on a proven design of GoA2 GoA4 operating trains and, as a minimum, shall meet the following objectives:
- a) be aesthetically pleasing.
 - b) be safe & comfortable for the train operator for continuous train operation in both standing & seating condition.
 - ~~c) provide efficient and safe detainment facilities.~~
 - c) be easy to clean and maintain the panels.
- 5.3.2 The design of the Master Controller location in the Operator's Desk shall take into consideration that 90% of operators are likely to be right-handed.
- 5.3.3 The Operator's seating area, standing area and control arrangements shall permit the operator to carry out train operation tasks from both seating & standing position.
- 5.3.4 Brush finished grab rails / handrails shall be provided at appropriate (more than one location) locations in the Operator's Desk area for operating the train in continuous standing & seating condition.
- 5.3.5 The design shall allow clear external line of sight to ensure that full range of operators can achieve the expected vision requirements as mentioned below. Operator's Desk controls location shall be designed such that when the train operator is operating the train in Non-ATO Non-UTO modes, the below exterior components shall be visible from the wind shield in front of the Operator's Desk during standing & seating condition:

- a) Way side Signals & signalling information.
- b) OHE mast numbers, OHE contact wire, catenary, and other wayside OHE equipment.
- c) Way side Emergency information boards
- d) Track, turn-outs, points, crossovers.
- e) Station Platforms
- f) Platform screen doors
- g) Opposite trains
- h) Neutral section OHE components
- i) Train Coupling and Uncoupling activity
- j) clear vision within the Depots, ramps & mainline.

The Contractor shall submit the Design to enable proper external view for Train operator as per clause 5.3.5

1 5.3.6 ~~Not used.~~ Egress of passengers during de-boarding and in rescue operations shall be from emergency passenger door as specified in clause 6.9 and clause 3.4.

5.3.7 All edges and corners of the Operator's Desk shall be designed to preclude injury to the operator. The Operator's Desk components and panels shall not have any sharp corners or edges.

1 5.3.8 Train operator shall be provided with sufficient moving place inside Operator's Desk area to operate the train in all ~~non-ATO non-UTO~~ modes in standing & seating condition. Train operator shall be able to control & view complete Operator's Desk controls, all passenger & OCC communication systems, coupling / uncoupling functions, control train movement in traction & braking, etc. while seating & standing from one location itself.

5.3.9 The Windscreen shall be constructed of toughened, laminated safety glass, and shall comply with the requirements of IS 2553 (Part 1 and 2), ECE Regulation-43, EN 15152, and UIC 566. The inner and outer surfaces of the windscreens shall be scratch resistant. This design shall comply with Chapter 3.

5.3.10 There shall be watertight look-out glasses on both lateral sides of each Operator's Desk area to enable the train operator to observe the station platforms stoppages, passengers' movement during door open/close operations, etc. This design shall comply with requirements of Chapter 3.

5.4 OPERATOR'S DRIVING DESK

5.4.1 The design of Operator Driving desk shall comply to UIC 564-2 and but not limited to the below mentioned categories of equipment and controls:

a) meet the following objectives:

- i. Visibility.
- ii. Be aesthetically pleasing.
- iii. Be comfortable for the operator.
- iv. Be able to withstand daily wear and tear.
- v. Interfaces with passengers.
- vi. Interfaces with the operational staff.
- vii. Fast exit of the driver in case of emergency.
- viii. Allow for efficient, safe and stress-reducing execution of operating tasks.
- ix. Provide efficient and safe detainment facilities.
- x. Be easy to clean and maintain.
- xi. All edges and corners shall be designed to preclude injury to the operator.

b) TCMS Display Console or Train Operator's Display Console Or Driver Display Unit – Also to refer to clause 14.5.

c) Communications Control Head

d) Indicators and Indicator buttons

- i. ALL Door Close
- ii. VCB Open / Close indication
- iii. Parking brake Applied / Released indication.
- iv. Emergency Brake Applied / Released indication.
- v. Dead-Man Apply / Release indication.
- vi. Smoke mode activation alarm
- vii. Any other indications, alarms felt necessary by the Contractor for ~~ATO and non-ATO~~ UTO and non-UTO operations.
- viii. Indication during Obstacle deflection as defined in clause 11.12.
- ix. UTO mode, ATO mode, ROS mode, Line Voltage, Occupied Cab, Smoke detected, Fire detected, etc.,
- x. Fault indicator for CI, APS, VAC, Saloon Door, VCB trip, Brakes, Main Transformer, etc.,

e) Control buttons

- i. UTO, ATO Start controls.
- ii. Passenger door Open / Close pushbuttons
- iii. Push-button Control to over-ride door opening in case of non-availability of Door open authorization from Signalling system in stations.
- iv. Two emergency brake stop pushbuttons at different locations which are accessible to train operator from his/her designated standing location.
- v. Couple and Uncouple controls for front end automatic couplers.
- vi. VCB (Vacuum Circuit Breaker) Open / Close controls,
- vii. Windshield wiper controls
- viii. train wash controls in wash mode
- ix. Train operator's desk lighting control
- x. warning horn (High and low decibel horns) controls
- xi. Any other control buttons felt necessary by the Contractor for ~~ATO and non-ATO~~ UTO and non-UTO operations.
- xii. Any other control buttons required for interface with other systems of CMRL.
- xiii. Cab to Cab communication, PEI acknowledgement, public address controls
- xiv. Cut off of battery control powers of the train.
- xv. ~~Unlock Command to the both Detrainment Doors Deleted~~
- xvi. Train On / OFF control
- xvii. Head light Control
- xviii. Lamp test
- xix. Pantograph Up / Down control

f) Selector switches / Isolation switches / By-pass switches

A series of Selector / isolating / By-pass switches shall be provided in each Operator's Desk to ensure that the following systems, as a minimum, can be manually isolated by the operator:

- i. UTO / ATO / ATP activation, isolation
- ii. Door Proving Loop bypass

- iii. Service Brake Loop bypass
- iv. Emergency brake loop bypass
- v. Pantograph Selector
- vi. Holding Brake release

1

- vii. Any Other Selector / Isolation / By-pass switches felt necessary by the Contractor for ~~ATO~~ and ~~non-ATO~~ UTO and non-UTO operations.
- viii. emergency egress switches
- ix. miniature circuit breakers (MCB's) operation

The isolating switches shall be sealed with a breakable seal and incorporate a visually clear mechanical or illuminated indication visible in the panel when each switch is in the "Isolated" position.

Once the seal has been broken, replacement of the seal shall not be achievable by the operator.

g) Other Provisions on Operator's Desk

- i. traction brake controller (also called Master Controller or Driving Control Head);
- ii. master controller key switch,
- iii. mode selector switch – shall be designed to be operated in all the modes of ~~ATO and Non-ATO~~ UTO and Non-UTO modes suggested by STC Contractor during the Interface design stage.
- iv. provisions of remote downloading of train logs for all systems of Rolling Stock
- v. provisions for single location upload of software for all sub-systems of Rolling Stock through hardwire means.
- vi. Any other functions felt necessary by Contractor for ~~ATO and Non-ATO~~ UTO and Non-UTO operations.
- vii. An emergency equipment cupboard shall be provided at suitable location in the Operator's Desk area and shall be equipped with first Aid box, safety equipment including fire extinguishers (minimum 5 Kg capacity) etc.
- viii. Suitable 15A and 5A socket with independent protection device shall be provided inside the Operator's Desk and at both ends of the car for charging emergency equipment, use of cleaning machines etc.

Design and layout of emergency operator's driving desk shall be proposed by the Contractor for approval by CMRL. Emergency controls and the controls requiring frequent / close monitoring by the operator should be located within easy reach of the train operator.

5.4.2 The lights of the Operator's Desk shall be LED type and shall illuminate in both active and inactive Operator's Desk area of the train. The use of panel lights other than LEDs is acceptable for only instrument backlighting.

5.4.3 Sufficient Hard-Wired fault indicators shall be provided to facilitate fault identification and appropriate recovery action as defined in RTR-DMS system defined in clause 14.11 & 14.13.

5.4.4 Contractor shall use the best international practices for cable routing of all the Rolling stock equipment & interface equipment inside the Operator's Desk and for wiring between Operator's Desks of train.

5.4.5 RS Contractor shall design the Operator's Desk with due consideration of all other signalling and telecommunication equipment required for train operation in various ~~ATO and non-ATO~~ UTO and non-UTO modes. Suitable space for equipment, its ventilation requirements, cable routing provisions, power supply etc., shall be interfaced with Signalling & telecommunications Contractors. RS Contractor shall interface with signalling & telecommunication Contractors about the details of interface equipment to be installed in Operator's Desk.

1

5.4.6 Spring loaded protective caps with sealing shall be provided for the following push buttons :

1

- a. Door Opening Push Button
- b. Permissive Door Release button
- c. Any other Safety- critical push buttons.

1

RS Contractor shall propose the methodology of train automatic preparation from shut down condition during UTO mode, the methodology to proceed to mainline operation directly from yard / parked condition during UTO mode.

5.4.7 Train shall be capable of automatic preparation in UTO mode from RSC console of OCC, BCC & DCC without any attendant / operator inside the train when train is parked in depot / mainline.

1

5.5 MASTER CONTROLLER AND RELATED CONTROLS

5.5.1 A master controller key switch shall be provided in each Operator's Desk. It shall be used to switch on / switch off the train and initialize / switch-off the systems of train.

5.5.2 A mode selector switch shall be provided to select the mode of operation of the train.

The functionality of the master controller and mode selector switch are detailed below. The Contractor may propose any suitable better arrangement / operation of modes and switches during design review for CMRL approval. Details on master controller design, Mode selector switch, Master control key switch and other interlocks between them during ~~ATO, Non-ATO~~ UTO, Non-UTO and all degraded modes of operation shall be proposed to CMRL for approval.

A traction brake controller or Master Controller Handle shall be provided, as a means to manually drive the train using a facility to select motoring, coasting, service braking and emergency braking. The master controller shall be of 'Fore and Aft' type or better type. It shall incorporate a driver's safety device "dead man" control. Master controller handle shall be operated in a smooth manner with minimum friction.

The master controller positions proposed by the Contractor may be as follows. These positions range shall be suitably visually indicated on the panel. With the set of below positions corresponding to combinations of control functions, shall be transmitted to the traction and braking systems throughout the train namely:

MODE	FUNCTION
POWER / TRACTION	Continuous Control between minimum and maximum tractive effort
COASTING	A notched position without traction and without braking.
BRAKE	Continuous control between minimum service braking to full-service brake with the full-service brake position as a notch
EB	Emergency brake (Notched position)

Movement of the handle / lever shall provide operating demand for motoring, service braking, coasting & emergency brake. It shall also provide an associated proportional rate for motoring and service braking.

5.5.3 The master control key switch shall be electrically & mechanically interlocked with the mode selector switch to ensure that removal of the master control key can only be achieved when the mode switch is in the "Off" and "GoA4" position.

1

5.5.4 The controlling Operator's Desk shall be the operator desk in which the mode selector switch is set in any other mode than an "Off".

5.5.5 The train shall become fully operational within 5 seconds when a controlling operator desk, which was previously in "Standby" mode, has been activated.

5.5.6 Interlocking shall be provided to ensure that if more than one controlling Operator's Desk has been selected, the Operator's Desk initially selected takes priority and ensure that the second controlling Operator's Desk position shall be ignored by all sub-systems. This control shall be provided in all modes of operation including **ATO/ATP UTO** mode.

5.5.7 The below modes shall be required as minimum for train operation. Any additional positions shall be proposed by the Contractor.

- a) **OFF:** In this state the master control key shall be removable and the auxiliary supplies on the train shall be switched off with only the train permanent loads on the battery remaining.
- b) **REVERSE:** The train shall be capable of being driven manually in the reverse direction but shall be limited to a maximum permitted speed of 3 kmph.
- c) **STANDBY :** Removal of the key and Powering shall not be possible in this mode. Brake shall be applied, and motoring will not be available. All auxiliary power shall be ON and selected train subsystems; including lighting, air conditioning and emergency or safety loads (as defined in clause 9.4) shall be available. Selected control functions shall be available at the Operator's Desk, including Passenger Door Control.
- d) **FORWARD – RESTRICTED MANUAL (RM) MODE:** In this mode, ATP shall limit the speed of the train to 25kmph. This mode shall also allow train movement when the ATP Cut-Out (By-pass) Mode has been activated. In this scenario, the speed supervision shall be provided by TCMS. The speed limit shall be selectable to either 25 kmph (for Depot movements) and 40 kmph (for Mainline movements). TCMS shall supervise the applicable speed and automatically cut-off the traction / apply full-service brake when exceeded.
- e) **GoA1 (ATP) Mode:** In this mode, the Train shall be capable of Manual operation under the control and protection of the ATP. All passenger door controls and other passenger facilities (such as communication, lighting, air conditioning etc) shall be available. The maximum permitted speed shall be controlled by the ATP system.
- f) **GoA2 (ATO) Mode:** In this mode, the Train shall be capable of Automatic operation under the control of the ATO. All passenger door controls and other passenger facilities (such as communication, lighting, air conditioning etc) shall be available. The maximum permitted speed shall be controlled by the ATO system.
- g) **GoA3 (DTO) / GoA4 (UTO) Mode:** Since both these modes are fully driverless operation, they shall share a single mode position (ATO mode) on the mode selector switch of the master controller. The master controller key shall be removable in this mode.

Note: A separate rotary switch (accessible without opening the Operator's Desk cover) shall be provided to register the presence of a train attendant with OCC, BCC & DCCs. The position of this switch provides the demarcation between DTO and UTO modes.

Modes mentioned here are indicative. RS Contractor shall interface with STC Contractor as per Appendix C requirements and shall adopt required number of modes in train considering all modes of operation.

5.5.8 **Not Used. Sleep Mode:** ATC may initiate automatic train sleep function when trains are not required to be operated in mainline or in depots. Whenever sleep command is initiated by Train Operator / OCC / DCC, TCMS shall shutdown the relevant equipment except for control supply to necessary equipment.

5.5.9 **Wash Mode:** shall be provided for train coupling and passing of the train through a wash plant. Wash mode shall enforce a max speed of 3.2 kmph in a Forward direction. It shall be available at all locations of the alignment, regardless of the presence of gradients or curved track. **Wash Mode** shall activate automatically when the train is in UTO mode, and a route is set to pass through the train wash plant.

An illuminated push-button shall also be provided, to allow the same speed supervision to be applied when the train is driven manually in "Forward – RESTRICTED MANUAL (RM) MODE". Selection of this mode shall only be available when the train is at zero speed. TCMS and the

traction system shall regulate tractive effort to enforce the permitted speed and limit train vibrations. TCMS will also display WASH MODE on the DDU.

- 5.5.10 Each switching position shall have a detent and shall be clearly identifiable. The mode changing in mode selector switch shall be possible only when the Master Controller Handle is in Full-Service Brake position and train is in static switched on position.
- 5.5.11 Selection of different modes, from the mode selector switch, shall not incorporate any undefined states.
- 5.5.12 Permitted mode changes that require a change in direction shall only be possible when the train is proved to be stationary by the Signalling system or by the traction equipment in the event of a signalling system failure. Attempts to change direction when the train is in motion shall activate irrevocable emergency brake.
- 1 5.5.13 It shall not be possible to directly select ~~ATO~~ UTO mode and Forward position from the "Reverse" position, or vice versa, without previously selecting all the other modes.
- 1 5.5.14 ~~Not Used.~~ Master controller handle shall be designed to operate in UTO / GoA4 and ATO / GoA2 trains. RS Contractor shall interface with signalling Contractor to identify the suitable resting slot position in Master Controller during which train shall operate in ATO, DTO and UTO modes. The operator safety devices of master controller shall not infringe with train operations during ATO, GoA3 and GoA4 conditions.

5.6 OPERATOR SAFETY DEVICE

- 1 5.6.1 A dead man's device feature shall be an integral part of the traction brake controller's handle / lever. This device shall protect the train in the event of the operator being incapacitated, whilst driving in a manual-operating mode (Forward, Reverse, Coupling / Wash / Rescue, ~~APT~~ ATP or any manual modes below ATO). It shall be designed in a manner to provide a high degree of redundancy.
- 5.6.2 The design of the dead man's device shall be an integral part of the traction brake controller and shall ensure that it is impossible to use any easily available object to override the safety features.
- 5.6.3 Release of the dead man safety device for a preset value of time, except that when the traction brake controller handle is placed in the full-service braking or emergency braking position, shall stop the train by activating the emergency brake in all manual operating modes below ATO.
- 5.6.4 Following an emergency brake application initiated by the dead man's device, release of the emergency brake shall require the action of Manual / Signalling system controlled releasing and re-setting of the brake.
- 1 5.6.5 The Dead man's device shall identify ~~ATO mode of the various Grades of Automation (GoA1, GoA2, GoA3 and GoA4)~~ and shall not be activated in ATO, DTO and UTO modes of operation.
- 1 5.6.6 Provision shall be made for sealing the Deadman Bypass Switch. The arrangement shall ensure to prevent, un-intentional operation of Deadman Bypass Switch and to operate only with the authorization of OCC.

5.7 DRIVER DISPLAY UNIT REQUIREMENTS:

- 5.7.1 The Display Units (TCMS DDU, CCTV DDU, Signalling Contractor DDU, CCH, etc.,) shall be located such that it is suitable for continual reference and actuation by Train operator, without discomfort or fatigue while operating in continuous standing & seating condition.
- 5.7.2 This Display Units (TCMS DDU, CCTV DDU, Signalling Contractor DDU, CCH, etc.,) shall be clearly visible to the Operator in standing & seating positions, from bright sunshine to darkness, without developing a brightness level that interferes with the Operator's vision.

5.8 WARNING DEVICES

- 5.8.1 Each Operator's Desk shall be provided with an electrical warning horn or electrically operated pneumatic horn with both high decibel and low decibel features.
- 5.8.2 The warning horn shall operate from the train's Low voltage power supply and shall maintain its performance over the full range of LV voltage as defined in Clause 9.4.
In addition to high decibel level, electric horn shall also have a low decibel level in order to minimize noise pollution during night time movements in the Yard. The minimum and maximum levels of dBA for both high and low decibel horns shall be submitted for review and approval by CMRL.
- 5.8.3 The horn shall produce a loud warning tone when activated by means of a pushbutton located on the Operator's Desk.
- 5.8.4 The technical parameters like tone, frequency, sound intensity level of the warning horn shall be in accordance with the requirements of UIC 644. The horn shall not generate noise exceeding 90 dBA inside the Operator's Desk with all train doors closed condition.

5.9 CLOSED CIRCUIT TELEVISION (CCTV)

- 5.9.1 CCTV display screen (CCTV DDU) and Communication Control Head (CCH) shall be provided in the Operator's Desk as defined in clause 13.4 to view the live footages of interior saloon and exterior cameras of train. The related control electronics and associated power supply shall also be installed in Operator's Desk.
- 5.9.2 All the exterior and interior surveillance cameras shall function continuously in day and night times in all operating locations and timings of CMRL service operation. Suitable latest camera technology and latest network technology shall be proposed by the Contractor. The requirements of clause 13.13 shall be adhered.

5.10 WINDSHIELD WIPER / WASHER

- 5.10.1 Externally mounted windscreen wiper / washer units shall be provided, which shall accommodate intermittent operation in addition to a minimum of three fixed speeds (Slow mode, High mode & Wash mode). The wipers shall sweep the largest possible arc and clear a windscreen area that shall enable the operator to meet all his external vision requirements.
- 5.10.2 The wipers shall not obstruct the operator's vision when the wiper is in parked position. The wipers shall provide efficient operation at all train speeds and environmental conditions.
- 5.10.3 The washer reservoir shall have a capacity of twenty (20) litres, refillable from the exterior of the car at track level and station platform levels. There shall be adequate suitable water filter accessible from exterior of the car.
- 5.10.4 The electrical and mechanical working mechanism of the Wiper operation shall be reliable.
- 5.10.5 All front wind-shields shall have electrically operated wiper system with water spray. The wind shield wipers shall withstand air pressures equivalent to 90 kmph of two trains which are running in opposite directions. Wiper system shall also be operated from TCMS and RSC consoles of OCC, BCC & DCCs.
- 5.10.6 All the components of wiper, water tank, their controls and their related components shall be reliable in all operating conditions.

5.11 OTHER EQUIPMENT

- 5.11.1 An external visual destination indicator display shall be provided, mounted on the exterior sides of the front mask and rear mask as specified in clause 13.7. This shall normally be controlled automatically but it shall also be possible for the operator to control manually. Requirements of External Displays shall be provided as follows:

- a) The display shall be capable of displaying in Tamil and English language consecutively.
- b) The display shall include illuminated bright characters on a black background.
- c) The external front display shall be designed to ensure that any extraneous light from the display shall not disseminate into the Operator's Desk area.
- 1 d) The display shall only be activated from the active controlling operator's desk, from OCC and from DCC. This display shall default be a blank display when the train is shutdown or incorrect information is detected.
- e) The minimum viewing distance over which all the characters shall be visible, legible and glare free under all types of external conditions shall be 50 meters.

5.12 TRAIN OPERATOR SEAT

- 5.12.1 The Train Operator's seat shall be backwall mounted, cushioned, non-slippery, ergonomically designed with back / lumbar support using non-flammable materials and filling, fully adjustable in the longitudinal / vertical directions and seat height adjustment shall be spring assisted. The complete seat assembly shall meet the flammability and smoke emission and toxicity as per EN 45545 part 1 to part 7 (Hazard level HL3). The contractor shall propose a detailed arrangement and seat adjustment during the Pre-final design stage.
- 5.12.2 Assistant seat shall also be provided in each Operator cab. The seat back may be made integral with the back wall. The seat squab shall be arranged to flip up, when weight is removed from it, providing a narrow lateral passageway between the centre of the cab and the side door.
- 5.12.3 Adjustable footrest shall be provided for train operator. The seat and footrest shall be harmonized and shall be suitable for anthropology of Indians to ensure comfortable seating for Train operator.
- 5.12.4 The seat shall be highest quality, heavy duty, long life, trouble free, maintenance free and easily cleaned (contain no dirt traps) and will have free space at front. The seat position shall be located and positioned so that at the operator's eye level there will no obstructions from cab console equipment and full view across the front screen.
- 5.12.5 ~~When the train is upgraded to GoA3 / GoA4 mode of operation, the Train operator seat shall be re-designed such that the train operator's seat be foldable. Adequate measures shall be taken to ensure that it is opened only by the train operator.~~

1 Once the commissioning of trains in UTO (GoA4) mode of operation is completed, the train operator seat shall be permanently removed in a manner that preserves the aesthetic integrity of the train, without any degradation in visual or functional standards. Foldable emergency train operator's seat will be available for the operation of trains for rescue, testing, etc.

5.13 SUN PROTECTION VISORS

- 5.13.1 Sun Protection visors shall be provided to avoid the dazzling by sunbeam from the front and sides of the cab. This device shall be adjustable from the operator cab and the field of vision shall not be reduced.

5.14 CAB VAC

- 1 5.14.1 Cab / Cab area VAC shall be ventilated by providing bleeding arrangement from the saloon air conditioning and be free from noise.

5.15 ~~SALOON TO CAB OPERATOR DOOR~~ SALOON TO CAB ACCESS AND PARTITION DOOR

- 5.15.1 ~~The rear side of the operator's desk shall be fitted with a door to provide access to the saloon area.~~

1

The saloon to cab partition door shall include a security lock, operable from the passenger side by means of the door access key. The partition door shall enable the operator to exit the cab safely and rapidly by hinging the door into the cab. The mechanism to partition open the door shall be achieved by means of a keyless quick release lever on the cab side of the partition door, which shall operate correctly, irrespective of the door being locked or unlocked. The clear door opening shall be min 650 mm $\pm$ 50mm wide.

The cab partition between the cab and saloon area shall be of a modular and detachable design, capable of being fully dismantled from its mounting to support UTO (Unattended Train Operation) mode of operation. The Contractor shall ensure that the design, removal method, and reinstallation process comply with all applicable operational, safety, and maintainability requirements. Suitably designed door between the saloon and the cab to permit access to the passenger saloon shall be provided. Detailed procedure for the same shall be submitted to CMRL for approval. ~~The Contractor shall ensure that this arrangement is easily removed during operation mode conversion from GoA2 to GoA3 or GoA4. The clear door opening shall be min 650 mm $\pm$ 50mm wide.~~

1

Once the commissioning of trains in UTO (GoA4) mode of operation is completed, the saloon to cab access and partition door shall be permanently removed in a manner that preserves the aesthetic integrity of the train, without any degradation in visual or functional standards.

- 5.15.2 In normal operation, opening the door from the saloon shall require the use of a special key and opening the door from the cab shall not require any key.
- 5.15.3 The door shall not get jammed due to pressure exerted by passengers or distorted due to minor mishaps.
- 5.15.4 The finish of the door shall harmonize with that of the cab and the passenger saloon.
- 5.15.5 The locking mechanism shall only use heavy duty locks, simple levers and actuating arms with proven record in metro applications.
- 5.15.6 The door shall not be possible to be bolted, wedged or other locked from either side of the door to prevent opening.
- 5.15.7 A visual and audible alarm shall be activated in the event that the saloon to cab door in the unoccupied cab is opened.
- 5.15.8 The Open / Close and Lock / Unlock status of the saloon to cab door shall also be used to provide the status to TCMS and also to actuate the cab lights in the unoccupied cab is opened. Provision of two limit switch parallel to each other shall be installed. The details shall be furnished during PFDR stage.
- 5.15.9 The assembly of the saloon to cab door shall not use any fasteners directly to FRP material.

5.16 CAB ACCESS DOORS AND CONTROL

1

- 5.16.1 Non-powered cab door (hinged / sliding) shall be provided on both sides of each cab / operator's desk to enable operator cab / operator's desk access from station platforms and from track level.
- 5.16.2 Each cab door shall include external recessed handhold(s), to be located to enable the door to be opened from a standing position at both track and station platform levels.
- 5.16.3 The cab doors shall not infringe the Kinematic Envelope under any condition and shall be designed to avoid door jamming in the event of a rake collision.
- 5.16.4 An external / internal device shall be provided to enable the operator to manually release, open and lock the cab door, as well as close and secure the door.
- 5.16.5 The device to open, close and lock the door shall be capable of operation from both track and station platform levels.
- 5.16.6 The cab doors shall be provided with monitoring interlocks incorporated in a circuit to prove that the doors are closed.

- 5.16.7 The monitoring of the non-controlling cab doors shall be integrated with the monitoring of the passenger doors.
- 5.16.8 Once the commissioning of trains in UTO (GoA4) mode of operation is completed, the cab doors shall be permanently locked in a manner that preserves the aesthetic integrity of the cab, without any degradation in visual or functional standards.

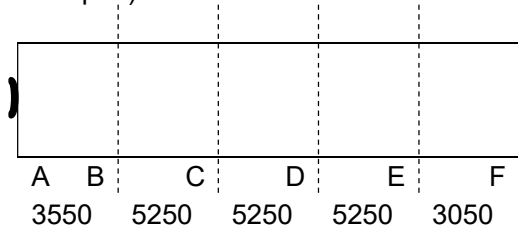
6. PASSENGER DOORS

6.1 NOT USED

6.2 GENERAL

- 6.2.1 Each Coach shall have Eight (8) electrically powered, exterior sliding type or plug type bi-parting doors Four (4) on each body side, conforming to EN 14752. The free passing through height of open doors shall be 1900 mm minimum. The minimum door passage width shall be 1400 mm. The doors shall enable short stopping dwell times.
- 6.2.2 The two door panels at each passenger doorway shall be synchronously controlled with Anti-drag Feature and shall provide a door clear opening width of equal spacing of not less than 1400 mm. Since Full Height platform screen doors (PSD) are installed on all platforms of underground stations and Half height Platform Screen Doors (PSD) will be installed in Elevated Stations will be used at all stations with full height PSDs in underground stations, the location, inter-door distance & size of the door panels are important for the PSD equipment supplier. The Contractor shall coordinate with PSD Contractor as part of interface.
- 6.2.3 Trains procured under ARE05 tender will ply along with the existing trains of CMRL Phase 1. In order to meet the door pitch, the proposed train shall be totally compatible with existing trains for free flow of passengers. A tentative layout for DM car, T car & M car is shown below for easy reference (all dimensions are in mm). The Contractor shall submit the door layout design for approval of CMRL.

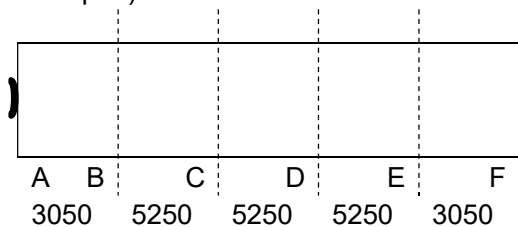
DM car (22,350mm Distance over Coupler)



A~B & E~F is distance between the Coupler Head to the Centre Line of the Door.

B~C, C~D & D~E is Door Pitch.

T / M car (21,850mm Distance over Coupler)



A~B & E~F is distance between the Coupler Head to the Centre Line of the Door.

B~C, C~D & D~E is Door Pitch.

- 6.2.4 The Contractor is advised that Full height Platform Screen Doors (PSD) is installed on all Under ground stations and CMRL is planning to install Half height Platform Screen Doors (PSD) in Elevated Stations. The Contractor shall coordinate with Other Designated Contractors to provide the necessary interface information data for the separate PSD contracts including, ATP / ATO signals to coordinate for the opening and closing of PSDs & train doors, station dwell times, door opening and closing announcements, signals for "Train Arriving" and Train Leaving" announcements, and all signals necessary for the proper design, interface, interface and operation of the PSDs with Rolling stock operation.
- 6.2.5 The reliability and intrinsic safety of the doors of metro rakes are of paramount importance. One door failure often has the effect of disrupting the service, and usually by more than a two-minute delay. It is of the utmost importance therefore that the door scheme should be designed with

necessary safeguards against potential failure. The door operation shall remain reliable under all operating conditions from AW0 to AW4 loadings.

- 6.2.6 No door system operation or single defect or failure of any part of any door system shall produce a situation capable of causing injury to any passenger / maintenance staff.
- 6.2.7 Door guides and supports shall be mounted within the section of doorway protected by the door seals and other suitable means from inside and outside ensuring that no ingress of dust, debris, water or any other foreign matter likely to result in excessive wear or incorrect operation of the door equipment. The cleaning of the door guides shall be able to be done with the general tools and shall not require any special tools for cleaning. The proposed design for sealing of the guides shall be got approved from CMRL during design stage.
- 6.2.8 Limit switches used shall be of high reliability and with IP 65 protection. Life of the limit switches shall be at least 15 years. The Contactor shall furnish details during Pre-Final Design Stage.
- 6.2.9 Passenger Doors System's functions has to meet the all the criteria defined in Chapter 14.
- 6.2.10 All electrical and electronic components shall comply with the EMC and EMI requirements of EN 50121 (all parts), IEEE 16, EN 55011 and IEC 61000-4 standards or other equivalent international standards. The requirements of EMC EMI requirements referred in clause 10.19 & 2.18 of the Rolling Stock shall be met.
- 6.2.11 Fire properties of the materials used shall comply with EN 45545 part 1 to part 7 latest editions (Category 4-A, Hazard level HL3) as a minimum or better international standard applicable for similar Metro applications. Requirements of clause 2.26 shall be met.
- 6.2.12 Material requirements of all sub systems of train shall be compliant with the requirements of Chapter 19.
- 1 ~~6.2.13 The Contractor shall provide Passenger Door button or Local Door Control button in compliance with EN 14752 (Cl. 4.3.1). This button function (On, Off, Reset, Isolation, etc.,) shall be fully controlled by TCMS. Deleted.~~
- 1 6.2.14 Provision shall be available for the operator to board the train from the track level (in elevated, tunnels and in at-grade sections of CMRL Phase 1 and Phase 1 Extension) and able to lock & unlock at-least two opposite saloon doors on each end car of the rake using operator's key. Necessary handrail and ladder arrangement shall be included at these positions in the design of the train. The location of the ladder and handrail shall be proposed to CMRL for approval.

6.3 DESIGN CRITERIA

- 6.3.1 The construction and mounting arrangement of the door system shall be sufficient to prevent deformation or damage when subjected to a load equivalent to load that could occur on AW4 Loading condition of Rake.
- 6.3.2 The construction shall ensure that the complete door system is sealed against the ingress of draughts, water, dust and noise from all sides of the door system.
- 6.3.3 The door leaf edges shall be designed to ensure that when the doors are closed, they shall form a weather tight seal extending the full height of the passenger door.
- 6.3.4 Seals shall be effective under all operating conditions from AW0 to AW4 Loading condition and shall be particularly resistant to atmospheric and chemical deterioration and to vandalism. Life of the seals shall not be less than 10 years.
- 6.3.5 The closing force of the passenger doors shall be in accordance with EN14752.
- 6.3.6 To open an unlatched passenger door when no power supply is available, the force exerted by a person within the car or standing at track level shall be in accordance with EN 14752.
- 6.3.7 During all door operations and under all power supply conditions, door movements shall be smooth, controlled, and devoid of jerks or any violent motion. The Contractor shall supply Service proven motor drive for Door operation.
- 6.3.8 Doors shall not slam after removal of an obstruction or when the power supply is lost, removed,

or interrupted.

- 6.3.9 All passenger door components and systems, including all rollers, racks gears and pinions which are not intended for passenger use or access, shall be adequately protected against passenger intrusion and be vandal resistant at all times, particularly during the passenger door operating cycle.
- 6.3.10 In the closed position the sealing shall ensure that the doors do not permit draughts, dirt, or water to enter the car either in service or when undergoing washing operations or during any monsoon rainfall conditions of Chennai.
- 6.3.11 Not Used.
- 6.3.12 The operation of the doors and all associated equipment shall not be impaired during the lifetime of the doors by normal or abnormal operating conditions.
- 6.3.13 The door controller unit shall be of a proven design, shall be equipped with self-diagnostic functions and shall communicate with TCMS as per requirements of Chapter 14.
- 6.3.14 It shall be possible for CMRL to modify or change the door system parameters, modify or change open-close logic of the door circuits and implement the same as required by CMRL based on their operational and maintenance requirements. ~~Full access to the software for the purpose above shall be provided.~~ Parameters that are to be changed for Operation and Maintenance requirements shall be available for modification by CMRL. Any hardware software tool required for this purpose shall also be provided. The documentation including but not restricted to flow charts (for complete software), signal flows, and interpretation of signal etc. shall be provided. CMRL personnel shall be fully trained and made fully conversant by the Contractor for this purpose.
- 6.3.15 Passenger Door Opening and Closing Times
- Opening and closing time of the passenger doors shall be adjustable in the range of 1.5 to 4.5 seconds.
 - The end of the closing stroke (say 100 mm per doorway) shall be damped or cushioned to reduce impact and minimize possible injury to passengers.
 - All doors on the rake shall fully open within 2.0 to 2.5 seconds from initiation of the open-door command.
 - All doors on the rake shall fully close within 2.5 to 3.5 seconds from the initiation of the “Close Door” command.
 - Once any specific door(s) is/are completely opened after persistent obstacle detection, the system shall have provision of re-closing only the obstruction detected door(s) alone without opening other closed doors.
- 6.3.16 Similar finish material as adopted for Coach Sidewall shall be used for Door leaf construction. Joints and edges of door window and complete door leaf shall be thoroughly sealed against ingress of moisture. The composition of door leaf shall be of any latest technology which meet the below requirements:
- Minimum replacement Lifetime of 35 years
 - Better Noise attenuation while operating in tunnels and in elevated sections to meet the criteria of clause 2.17.
 - Fire compatibility requirements as per EN 45545 – HL 3 category and meet the requirements of clause 2.26.
- 6.3.17 There shall not be any drain holes on the floor sides that allow any exterior noise, vermin, water, and dust from exterior of the saloon under frame to saloon during door close condition.
- 6.3.18 Each door leaf shall have a glass window meeting the requirements of clause 3.4.9. Replacement of door glass window shall be possible without removal / detachment of door leaf from the train.
- 6.3.19 No single point failures in door system shall immobilize the train under any circumstances. Sufficient redundancies shall be provided by the Contractor in the design.

1

- 6.3.20 Single point uploading of software and single point downloading of fault data per train shall be ensured for all the Door control units in the rake. The requirements of clause 14.11 shall be met.
- 6.3.21 Real time remote downloading of logs for door system shall be available as per clause 14.11 and 14.13.
- 6.3.22 A microprocessor-based saloon Door Controller Unit (DCU) shall control each pair of saloon door leaves and shall be an integral part of door control assembly. The door controller unit of a proven design shall be equipped with self-diagnostic functions and shall communicate with TCMS on all the events, faults, and variables of the door system. Power supply to DCUs shall be in such a loop that redundancy can be ensured in case of breakage / disconnection of any one power / network wire. The Contractor shall ensure that the system shall not be affected in single point failure. Details shall be submitted for review of CMRL.
- 6.3.23 The door position measurement and detection shall be accurate and real time measurement of the distance moved by each leaf. Details shall be discussed and finalized during design stage. All door close and all door latching shall be independently monitored through two separate independent circuits. All door closing function and all door latching functions shall be separately monitored at the train level.
- 6.3.24 Door System shall be SIL 2 compliant at train level for all the safety related functions including the following:
- Complete system (both Hardware & Software)
 - Door unlocking when train not at standstill,
 - Door opening at standstill on platform side,
 - Train departure with an open door,
- The Contractor shall submit relevant details for SIL levels for above. The SIL levels as above shall be validated and shall ensure that the train shall not move from a station unless Train doors & PSD are closed and latched unless intentionally permitted by the concerned operator or OCC controller or DCC controller. Details shall be worked out during design stage. The details certified for SIL 2 rating shall also be verified for CMRL satisfaction during the type testing.
- 6.3.25 Door Operation Noise produced by simultaneous operation of all saloon doors on one side of the car shall not exceed 75 dBA during the sliding operation and 78 dBA for the locking & unlocking conditions, measured on the fast meter scale. This should be measured at all points in the car 300 mm from the doors and 1000 mm above the floor.

6.4 DOOR OPERATION

- 6.4.1 Each passenger door shall have two stable states:
- door open
 - door closed and latched.
- 6.4.2 In the door open state, the passenger door shall fully open to allow free passenger movement in & out of the car but shall be capable of being closed and latched by the operator in ~~non-ATO~~ non-UTO operations and by the signalling system in ATO UTO operations.
- 6.4.3 In the door closed and latched state, the passenger door shall be proved closed (detection of the physical position of the passenger door) and proved latched (detection of the mechanical latching device), to the rake operator as well as the rake control system, to the RSC consoles of OCC, BCC & DCCs.
- 6.4.4 The Contractor shall ensure that the passenger doors are not affected by lateral or longitudinal displacement by normal wear of any part of the passenger door in service. Wear and/or damage as a result of the lateral or longitudinal movement of the doors shall be repaired and/or replaced by the Contractor at its own expense.
- 6.4.5 The device to detect and prove that passenger doors are fully closed and latched shall be capable of detecting any obstruction causing a minimum gap of 10 mm per doorway and prevent the door

proving indication from being achieved, in accordance with EN-14752. This detection obstacle function shall be achievable for a minimum gap of 10 mm per doorway all along the height of the door.

6.4.6 Crew Switches:

- 6.4.6.1 Crew Switch to open and close coach side doors electrically shall be provided as per below requirement: One door location per each interior side of the car (total two numbers in each car interior) One door location per each exterior side of the car (total two numbers in each car exterior). The exterior crew switches shall be accessible from both track level and from platform level.
- 6.4.6.2 The Operator's keys and maintenance keys shall activate these crew switches.
- 6.4.6.3 Crew switches shall be provided at doorways. Exterior crew switches shall be waterproof. The identification details on the crew switches shall be properly engraved on its surface to withstand regular train cleaning.
- 6.4.6.4 Both interior and exterior switches shall be enclosed to blend with both interior and exterior finishes.
- 6.4.6.5 The Contractor shall submit for approval a proposal that details the recommended locations of crew switches.
- 6.4.6.6 The crew switch functions shall always operate, unless the car battery is discharged or disconnected.
- 6.4.6.7 The location of exterior crew switches (2 numbers in each car) shall be decided during interface with PSD Contractor and same shall be submitted for CMRL approval.

6.4.7 Door System Indicators:

- 6.4.7.1 Door Closed and Opened Indicators shall be provided on the Operator's Desk.
- 1 6.4.7.2 The door closed interlock described in this Chapter shall provide signals for door open / closed indicators in the Operator's Desk and to the TCMS DDU, OCC, BCC & DCCs.
- 6.4.7.3 Each doorway shall be provided with exterior & interior door open LED indicators. Each car shall be provided with external Car indication lamp on each car lateral side. The functionality of individual door's exterior & interior door open LED indicators & external Car indication lamps shall be complied as per the requirements of clause 8.4.3 and 8.4.4. The Contractor shall present the design for CMRL approval during design review.
- 1 6.4.7.4 Door open / closed status shall be communicated to the train Operator through indicator buttons & TCMS DDU. It shall also be displayed remotely in RSC consoles of OCC, BCC & DCCs. It shall be able to identify malfunctioning doors individually on the train's DDU and in RSC consoles of OCC, BCC & DCCs as defined in clause 14.11 & 14.13.
- 6.4.7.5 Doors Out of Service Indicators shall be provided on the car interior and exterior that denote that the door panel(s) of a cut-out door operator is (are) out of service (as defined in clause 8.4.4). These shall be integrated with the car's aesthetic styling. The type, style, and location of these indicators shall be submitted for approval.

6.5 DOOR CONTROL

- 6.5.1 Doors shall be electrically operated from 110V DC supply through train line wire. The door system shall continue to operate correctly with the car battery voltage supply range between 77~132VDC as specified in EN 50155. The passenger door control system shall ensure the safe operation of the passenger doors on the rake and shall be classified as a Safety Critical system and shall meet the requirements mentioned below.
- 6.5.2 The operator shall have full use of all passenger door controls in the Driver desk. These controls shall be activated when the master control switch is not in the "OFF" position and when the auxiliary supplies are available.
- 6.5.3 The train operator shall be provided with the following passenger door controls at each Operator's

Desk and shall be ergonomically located to facilitate door open operation:

- a) One “Right Door Open” illuminating-cum-control pushbutton.
- b) One “Left Door Open” illuminating-cum-control pushbutton.

Illumination of the “Door Open” pushbuttons shall indicate that the specific train side door opening enable signal from the Signalling system is available.

6.5.4 The train operator shall be provided with the following passenger door controls per each Operator’s Desk and shall be ergonomically located to facilitate door close operation.

- a) One “Right Door Close” illuminating-cum-control pushbutton,
- b) One “Left Door Close” illuminating-cum-control pushbutton.

6.5.5 The illumination of the “Door Close” pushbuttons shall indicate that all the passenger doors per train side are proved closed and mechanically latched.

6.5.6 Passenger door control circuits shall have two circuits specific to each side of the car. One circuit shall monitor closing & opening of all doors per each side of the car. Another circuit shall monitor Locking & Un-locking of all doors per each side of car. Both Door control circuits of each train side shall be designed to be totally independent from each other and shall be independent from both door control circuits of opposite side of train, ensuring that failure of any door control circuit on one train side shall not affect the door operation on other train side.

6.5.7 All pushbuttons shall be connected in the circuit to ensure that no single false feed or earth fault can activate the passenger doors without the action of the operator or without signalling system authorization, even though all the prerequisite parameters are available.

6.5.8 Passenger door control circuit shall employ Hard Wired feed and return rake control wires. The feed and return rake door open control wires, on every car, shall be electrically bonded together at all times unless a legitimate door open signal is activated.

6.5.9 To change the state of the passenger doors on the rake from “Closed and Latched” to “Open”, the following actions shall be required:

- a) the rake shall be proved stationary, by the signalling system or the traction equipment in the event of an signalling system failure, and with the brakes applied.
- b) the correct commands are received from the signalling system or Rolling Stock system, including the correct side [authorisation](#) for the passenger doors to be opened.
- c) Door opening commands are received from the signalling system or Rolling Stock system for opening only on the platform side of the rake.

6.5.10 In “Automatic” mode, the door open command shall be activated automatically, provided the above clause 6.5.9 requirements have been achieved. A switch shall be provided, preferably at the side of the driving console. In ATO mode, the Automatic door open command may be overridden by operating this switch. Operation of this switch shall be monitored by TCMS.

6.5.11 In a manual driving mode, the operator shall be required to depress the “Door Open” illuminated pushbuttons, which correspond to the correct station platform side. The lamps shall only be illuminated when the signalling system permits the door open controls to function.

6.5.12 The door control commands shall be as follows.

- a) Doors open – provided that the prerequisite parameters of clause 6.5.9 are available, the operation of door opening shall be performed automatically. All the passenger doors on the corresponding train side shall synchronously open. All passenger doors on the opposite side at the rake shall remain “Closed and Latched”.
- b) Doors closed – the passenger doors shall be capable of being closed without the prerequisite parameters of clause 6.5.9 being available. The operation of the “Door Close” pushbutton shall broadcast an audible warning in each car’s saloon, signifying that the passenger doors shall subsequently close. After a pre-set time, adjustable between 0 and 5 seconds, following the finish of the audible warning, the control system shall synchronously “Close and Latch” all the passenger doors on the corresponding side. The location of the audible warning devices within

1

and outside the saloons and the output sound pressure levels shall be such that they are clearly audible by passengers in the rake and passengers standing on the platforms. It shall be possible for CMRL to adjust the type of door warning alarm tone based on passenger feedback.

6.5.13 A visual indication of the door's status, by means of the "Door Close" illuminated pushbuttons, shall be provided to the rake operator. The indicators shall be available at all times and shall be controlled by means of a monitoring circuit that illuminates the lamps when all the following conditions are detected:

- a) all the passenger doors are closed and mechanically latched.
- b) ~~both the Detrainment doors are closed and latched. Deleted.~~
- c) None of the passenger door emergency release devices are activated.

6.5.14 The monitoring circuit shall be designed to incorporate a Hard-Wired rake control feed and return loop, supplied from the controlling Operator's Desk only and check the continuity of all door detection devices. The circuit shall provide a "circuit validity" indication on the Operator's Desk and an associated exterior indication on each side of each car as per clause 8.4.3.

6.5.15 The monitoring circuit shall also be interlocked with the driving controls, to ensure that the loss of continuity of door monitoring circuit shall inhibit motoring and apply a full-service brake once the rake has proved to be stationary.

6.5.16 The door operating mechanism shall be housed within the saloon above the doorway lintels. The design shall provide ease of access for maintenance. The complete mechanism shall be modular and mounted on a rigid frame so that it can be adjusted in situ for alignment and be removed as an integral unit from the car. The entire door mounting hardware and door actuation hardware must be readily accessible for adjustment and removal. The Contractor shall submit a detailed door operating function matrix for CMRL's review and approval.

6.5.17 The opening and closing of doors shall be possible from an operative driving console in train, ~~from RSC consoles of OCC, BCC & DCCs.~~ However, during ~~ATO~~ UTO GoA4 mode of operation, all the door controls shall be controlled automatically by Signaling system. The door controls shall be located on Operator's Desk, suitably located on side end position between the end door & front end. This control Push Buttons shall be suitably encapsulated during ~~GoA2~~ GoA4. The location shall be proposed by the Contractor and subject to approval from CMRL.

6.6 PASSENGERS ACCESS PROTECTION

6.6.1 An obstacle detection system shall be capable of detecting an obstruction as specified in Chapter 6.4.5.

6.6.2 If a passenger door whilst closing should be obstructed by an object, then the door movement shall pause to enable removal of the obstacle, then another attempt to re-close will follow. The passenger door shall attempt to re-close 3 times, which shall be adjustable. After each attempt a partial 50 to 200 mm reopening of each door leaf shall be carried out before next attempt.

6.6.3 In the event that the passenger door fails to close following the three attempts, further door movement shall cease on the offending passenger door and door will remain in full open position. Once such a passenger door has stopped movement, following this condition, further door closure shall require another activation of the corresponding "Door Close" command without the necessity to re-open & close all other doors of train.

6.6.4 Door closed, latched and obstruction sensing information shall be sent from each car in the rake to TCMS ~~DDU, RSC consoles of OCC, BCC & DCCs.~~

6.6.5 The type and frequency of obstruction sensing information and failure reports to be sent to the TCMS, ~~OCC & DCC will be determined during design review.~~

6.6.6 ~~All the Passenger Doors shall have the Static and Dynamic Anti-Drag system (ADS) to detect the passenger or object trapped by the Train Doors. The ADS shall detect thinnest possible objects and clothing, handkerchiefs, belts, etc. as per EN 14752:2025 and latest. The system shall function in all directions against doors and car body and comply for all requirements of EN~~

14752:2025 and latest. The contractor shall submit detailed documentation for the Anti-drag system function and its methodology for static and dynamic drag detection for the CMRL approval.

6.7 PASSENGERS ALARM AND EMERGENCY SYSTEMS

6.7.1 Passengers alarm

6.7.1.1 Two locations on each side of the coach, total four numbers per car, (locations to be determined during design review) shall be fitted with an internal manual passenger alarm. Refer to clause 13.10.

1

6.7.1.2 Activation of any push button within a car shall cause a visual indication and an audio alarm on the Operator's Desk. In UTO mode of operation, Visual indication and audio alarms shall be provided at RSC consoles of OCC, BCC & DCCs.

6.7.1.3 An indication shall also be provided on the exterior of each side of each car to indicate that a passenger alarm has been activated in that car.

6.7.1.4 Any event of a passenger alarm activation when the rake is within the station zone or out of the station zone shall not prevent the rake movement.

6.7.1.5 Not used.

1

6.7.1.6 Once the train operator or OCC or DCC has acknowledged the call, he/she shall be capable of initiating a communication link with the activated alarm unit in a full duplex communication.

6.7.1.7 A Hard-Wired passenger alarm loop circuit shall be provided to monitor the status of each passenger alarm unit.

1

6.7.1.8 The circuit shall ensure continuity throughout all non-operated alarms, and the loss of continuity, due to an operated alarm, or failure of the circuit shall provide an audio-visual alarm in TCMS and in RSC consoles of OCC, BCC & DCCs.

6.7.1.9 Further rake movement shall be inhibited until the activated alarm(s) has been reset.

6.7.1.10 In the event of a failure that prevents either the passenger alarm unit from being reset or a fault of the monitoring circuit, then a sealed isolating switch (located in the Operator's Desk) shall be provided to enable the operator to isolate the passenger emergency alarm circuit and move the rake.

6.7.1.11 The isolating switch shall override the passenger alarm monitoring circuit, as far as the controlling Operator's Desk is concerned.

6.7.1.12 Activation of the passenger alarm isolating switch shall enable the service brakes to be released and traction power to be available, although controlled under abnormal operating conditions.

6.7.2 Internal Emergency Egress Device

6.7.2.1 All passenger doorways (locations to be determined during design review) on each interior side of each car, shall be fitted with an internally mounted, manual emergency egress device, which shall have two positions 'normal' and 'emergency release'.

6.7.2.2 Not Used

1

6.7.2.3 The Emergency Egress Devices (EED) shall be concealed inside the door panels and provision shall be made in such a way that the EED shall be accessible only by using a special key, so that access to Passengers shall be avoided.

6.7.2.4 Provision shall be provided for the operations & maintenance staff to activate the emergency egress device by using the door access key.

6.7.2.5 When the device is in the 'normal' position the passenger door shall respond normally to all control commands specified.

6.7.2.6 After moving the internal emergency egress device to the 'emergency release' position, it shall be possible to mechanically un-latch the associated passenger doorway and enable the door leaf's to be manually opened from both inside and outside.

6.7.2.7 In emergency release position, the opening of the passenger doors shall be possible by the effort

1

of one person manually. Opening the passenger doors should only be possible once the rake is proved to be stationary, and the brakes applied.

6.7.2.8 Once the device has been activated to the 'emergency release' position, the device shall be mechanically latched in that position, and shall require the use of the reset key to reset back to the 'normal' position. The reset function shall also be available from TCMS / OCC.

6.7.2.9 Not Used.

6.7.2.10 In the event that the passenger doorway has been opened by activating the emergency egress device, the door leaf shall be capable of being manually set to 'close and latch' condition.

6.7.2.11 The operation of internal emergency egress device shall be possible during train switched off condition also.

6.7.3 External Emergency Passenger Door Release Device

6.7.3.1 Two passenger doorways on each exterior side of the car, total 4 doors in a car, shall be capable of being opened manually, without the assistance of power, using an externally mounted bi-stable manual emergency door release device to release the mechanical door latch.

6.7.3.2 The emergency passenger door release device shall operate in two positions, 'normal' and 'emergency release'.

6.7.3.3 The emergency passenger door release device shall be capable of operation from both the track level and station platform levels.

6.7.3.4 When the emergency passenger door release device is in the normal position the passenger door shall respond normally to all control commands.

6.7.3.5 Moving the external emergency passenger door release device to the emergency release position shall mechanically un-latch the associated passenger doorway and enable the door leaf's to be manually opened from both inside and outside.

6.7.3.6 The opening of the door leaf's shall be possible manually by the effort of one person.

6.7.3.7 Once the emergency passenger door release device has been activated and the door leaf's are open, the emergency passenger door release device must be reset manually to restore its normal position.

6.7.3.8 The location of external emergency passenger door Release Device (2 numbers on each side of each car) shall be decided during interface with PSD Contractor and same shall be submitted for CMRL approval.

6.7.3.9 The operation of external emergency egress device shall be possible during train switched off condition also.

6.7.4 Long Stop Request:

6.7.4.1 Long stop request Push button provision shall be made available near the Wheelchair area inside the coach. This provision shall be available on both sides of the train.

6.7.4.2 Once this button is pressed in any mode of operation, only the corresponding door shall be kept open for longer time increasing dwell time of the train.

6.7.4.3 RS Contractor shall suitably interface with STC Contractor to achieve this function.

6.7.5 Inter-operability of Keys:

6.7.5.1 The Rolling Stock Contractor shall submit the details of the Operator key / keys of the Rolling Stock for door opening, from outside and inside and for manual door isolation. The details shall include the profile of the key, available manufacturers, License / approval for the manufacturing or procurement of the particular keys etc. The details shall be adequate and shall authorize the Platform Screen Door Contractor to manufacture or procure the key in a rightful legal manner for usage in CMRL PSD system. PSD Contractor shall procure / manufacture the key and use in PSD system, so that Operators can use the same set of keys for similar functionalities in RS door and PSD door. Necessary approval shall be taken from CMRL before the procuring/ manufacturing.

6.8 DOOR SYSTEM INTERLOCKS AND BYPASS SWITCHES

- 6.8.1 All passenger doors shall incorporate a mechanical latch, which automatically engages after both the passenger door leaves are fully closed, preventing the passenger doors being opened by the passengers by normal means.
- a) No spurious electrical signals shall cause any door to be un-latched or opened. The Contractor will be required to provide a comprehensive Safety Audit to prove this point to the satisfaction of CMRL.
 - b) There shall be no single point failure of equipment or wiring, or two-point failure with one failure undetected, which would cause a door to open without being commanded.
 - c) The door controls shall be interlocked with the train's zero speed circuitry so that the doors cannot be opened until the train is stopped. However, loss of ATC power at zero speed shall not inhibit door operation. Zero speed signal shall be hard wired.
- 6.8.2 The bypass controls shall be provided to by-pass operation of any defective doors by the train operator through TCMS DDU. Provision shall also be provided in from RSC consoles of OCC, BCC & DCCs for by-passing a faulty door, remotely.
- 6.8.3 The mechanical latch shall be released automatically when the passenger door open controls are legitimately operated or when the local emergency release is operated.
- 6.8.4 Each passenger doorway shall be provided with a manual door lock-out device both inside and outside of each doorway, which mechanically locks-out the specific doorway preventing further operation and isolates the power supply & door monitoring interface to the pair of defective door panels, thus preventing the passenger doors from being opened by normal means. In the event of a failure or during any delayed operation of any specific doorway, then this manual door lock-out device shall be operated by train operator / station controller to enable further rake movement. These internal & external manual doors' lock-out devices per doorway shall be accessible to the operation & maintenance staff through operator key mechanism. It shall be possible to operate these manual doors' lock-out devices without opening any door panels.
- 6.8.5 These manual door lock-out devices shall be inaccessible to passengers and access to be gained only by means of the operator key. The position of exterior manual door lock-out device shall be planned during interface with PSD supplier and same shall be submitted for CMRL approval.
- 6.8.6 In the event of a failure of the door monitoring circuit that causes loss of continuity in the train in ~~non-ATO non-UTO~~ modes of operation, then a sealed isolating switch shall be provided to operate in Operator's Desk to enable further rake movement. The isolating switch when activated shall isolate the door-monitoring circuit interface from the driving controls, enabling the brakes to be released and traction power to be available when operating in a manual-driving mode only. Operation of this isolation switch shall be communicated to RSC consoles of OCC, BCC and DCCs.
- 6.8.7 Activation of the isolation switch shall illuminate the cab indicators to signify that a door is isolated. Indication of the exterior door indicator lamp shall continue to show the correct status of the doors on that car as per clause 8.4.4; consequently, the exterior lamp of the respective offending car where the fault occurs shall remain illuminated as per clause 8.4.3.
- 6.8.8 Operation of a sealed isolating switch shall be reported in the TCMS logs.
- 6.8.9 In the event of a failure of the door monitoring circuit that causes loss of continuity in the train in UTO operation, then it shall be possible to remotely isolate the door monitoring circuit from RSC consoles of OCC, BCC & DCCs to enable further rake movement in UTO operation. Train movement in this condition shall be authorized from OCC/BCC after due verification of CCTV footages that all doorways are closed in the particular train.

In the event of a failure of the door monitoring circuit that causes loss of continuity in the train in ATP / ATO operation, then it shall be possible to isolate the door monitoring circuit from TCMS to enable further rake movement in ATP / ATO operation. Indication of the exterior door indicator lamp shall continue to show the correct status of the doors on that car as per clause 8.4.4; consequently, the exterior lamp of the respective offending car where the fault occurs shall remain

illuminated as per clause 8.4.3.

6.9 EMERGENCY RAMP

- 6.9.1 For side evacuation, suitable arrangement (e.g. bridgeable emergency ramps with box) for filling up the gap between rolling stock doorway to emergency walkway shall have to be provided minimum TWO in each car, detail shall be finalised during PFDR stage.
- 6.9.2 The emergency ramp deployment procedure shall be displayed in Passenger Information Displays.

1

6.10 DETRAINMENT DOOR DELETED

- ~~6.10.1 Detrainment doors shall be provided in the first and last car for emergency egress of passengers. The detrainment door shall be aesthetically designed ensuring clear view of the track from driving car. The door shall aesthetically harmonize with front and side lookout glasses of the emergency operator's desk, shall not block the front view and shall give a look of single glass. The material of front end detrainment Door glass shall meet the specifications in ERTS Section 3.4.9.4 and ERTS Section 5.3. The visibility of the joint between the detrainment door and windshield look out glass shall be bare minimum. The detrainment door system shall be SIL2 compliant and shall be provided with a sealed cover door actuating mechanism. The detrainment door way shall have minimum headroom of 1900mm.~~
- ~~6.10.2 All necessary accessories including folding ramp for ensuring safe detrainment of passengers from saloon to the track plinth on elevated, at grade and underground sections shall be provided in driving car. The folding ramp shall be simple in operation and should be operable by passengers without assistance during emergency. The ramp shall have full length longitudinal handrail and fluorescent material marking on both sides of passenger egress direction. The detrainment door ramp shall be designed for load of 500 kg/m² or more and it shall not sag during evacuation process. The ramp angle shall not be more than 16.5 degrees. The ramp shall also be suitably supported on the track to ensure no tilting of the ramp on straight as well as on curved sections. Retrieval of the ramp shall be easy. Contractor shall demonstrate safe use of the emergency door and ramp in the elevated, at grade and tunnel section on different radius curves specified in the ERTS. The door design shall be consistent with the latest applicable fire safety standards.~~
- ~~6.10.3 The door shall be vibration free and sealed against water ingress and sound transmission. It shall be provided with a safe, simple and secure locking mechanism which shall be unaffected by a single point failure. The walking surface of the deployed detrainment ramp shall be stiff enough and anti-slippery even when wet in rainy conditions. The ramp surface shall also be suitable for operation of wheel chairs over it.~~
- ~~6.10.4 The opening of the detrainment door & ramp shall be possible by any single untrained passenger. The retrieval and stowage of ramp should be easily accomplished by a single trained staff without dismantling any equipment. The stowage shall be possible both electrically and manually. Any tool, if required, for manual closing operation by single person shall be provided in the emergency operator's desk area. In addition to manual arrangement operable by one person, suitable portable power operated devices for stowage of door and ramp shall also be provided near to the detrainment door of each car. If battery of Portable power is weak, stowage of door shall be operated manually. All necessary ancillary equipment to enable the train to be moved after emergency detrainment shall be provided as part of this contract.~~
- ~~6.10.5 Multilingual (English & Tamil) Instructions shall be displayed in all the cars at suitable locations to enable passengers to understand the operation of the emergency door in case of emergency. It shall be able for OCC to communicate with the passengers and provide audible instructions through Passenger Emergency Intercom (PEI) placed adjacent to each detrainment door.~~
- ~~6.10.6 The complete opening of detrainment door and placing of ramp by an untrained passenger shall not take more than 1 minute. The contractor shall demonstrate the complete detrainment door opening and closing operation as part of type test.~~

~~6.10.7 The door status shall be interlocked with the train control circuit so that once the detrainment door is found unlocked the below activities shall occur:~~

- a) ~~Emergency brakes are applied on the train.~~
- b) ~~Request to OCC to permit for door opening. Detrainment door can be opened only after it acknowledged for opening by OCC.~~
- c) ~~Driving console light, Head lights and Flasher lights are automatically lit and CCTV cameras shall automatically focus on this area.~~
- d) ~~Automatic Switching ON onboard CCTV to high speed mode shall occur.~~
- e) ~~Appropriate audio & video messages through PAPIS system shall be broadcasted in the train speakers and displays to guide the passengers.~~
- f) ~~Video messages shall be descriptive enough for a passenger to understand the operation of the detrainment door & ramp. These messages shall show the direction towards the operated detrainment door to the passengers. These video messages shall be submitted to CMRL for approval.~~
- g) ~~Provide the train location in the CMRL section to OCC for further action by them.~~
- h) ~~Such event shall be logged in TCMS and shall be communicated to RSC consoles of OCC as audio visual alarms.~~
- i) ~~The detrainment process shall be monitored with CCTV cameras of train. One CCTV camera dedicated for detrainment process shall be provided. Flasher light shall automatically turn ON when detrainment door is open.~~
- j) ~~Actuation of detrainment door unlocking & opening shall be suitably interlocked and immediately relayed to OCC to take further actions by OCC as mentioned below:~~
 - i. ~~Provide OCC live PA broadcast to guide passengers the de-boarding / detrainment process,~~
 - ii. ~~Provide Communication to nearest station controller about the de-boarding of passengers,~~
 - iii. ~~Communication to switch ON tunnel lights & elevated lights to monitor the passenger detrainment from the train.~~
 - iv. ~~Communication to switch ON suitable tunnel ventilation fans to enable proper ventilation to passengers in tunnel.~~

~~6.10.8 The detrainment door shall be suitable for multiple operations. There shall be no sagging / distortion of the door during entire life time of the car body i.e. 35 years.~~

~~6.10.9 Contractor shall furnish detailed evacuation plan. The Evacuation Scenario will also cover the following conditions:~~

- a) ~~Evacuation in Emergency, e.g. Fire, collision.~~
- b) ~~Controlled evacuation e.g. failed train or failed power supply.~~
- c) ~~The Evacuation plan shall be compliant with the evacuation requirements specified in Railway Group Standard GM/RT2130 'Vehicle Fire, Safety and Evacuation'.~~
- d) ~~The Evacuation plan shall include study of evacuation time, the battery capacity calculation, the infrastructure of the complete CMRL network, time taken for coordination activities with OCC and station controller.~~

~~6.10.10 There shall be no draught, dirt or water entering through the detrainment door and it shall not generate any noise while the Train is in motion. The arrangement shall comply with BS-EN-60529 IP65.~~

~~6.10.11 Detrainment doors shall be provided with means to enable the operator to manually release and open the detrainment door, from inside the operator desk area. This door shall be able to be closed and locked from inside the operator desk area.~~

~~6.10.12 Mechanism of Detrainment door shall have below four functions:~~

- ~~a) Door Un-locking—It shall be possible to Manually unlock the detrainment door either in stationary or dynamic condition of train. The unlocking of detrainment door shall apply irrevocable Emergency brakes in the train. However, the door shall not be able to be opened in this condition.~~
- ~~b) Door Opening—It shall be possible to open the detrainment door only after the acknowledgement of OCC and when the train is in stationary condition and after door is Manually un-locked.~~
- ~~c) Door closing—It shall be possible to Manually close the detrainment door from inside the train.~~
- ~~d) Door Locking—It shall be possible to manually lock the detrainment door from inside the train. Once the door is locked, relevant communication shall be sent to TCMS, RSC consoles of OCC.~~

~~6.10.13 Complete operation of detrainment shall be suited & complied for both Un-attended Train Operation in GoA4 and all non-UTO modes of operation.~~

1

6.11 UTO OPERATION

- 6.11.1 The design of Passenger Doors System and its relevant components in train shall support for the UTO / GoA4 in the CMRL Phase 1 & Phase 1 extension network defined in Chapter 1. Trains shall be operated in GoA2 / ATO mode during the initial stage of commissioning and revenue operations and in GoA4 / UTO subsequently. Hence all the feedbacks, information and train controls which are available on TCMS screen shall also be available in OCC (operational control Centre) and DCC (Depot Control Centre) for smooth operation of passenger service. The Contractor shall submit the details of controls to be provided in OCC & DCC for review and approval of CMRL.

7. VENTILATION AND AIRCONDITIONING

7.1 NOT USED

7.2 GENERAL

- 7.2.1 A Ventilation and Air conditioning (VAC) system shall be installed on each car to automatically control interior temperatures to the complete range of specified set point temperatures; regardless of whether the car is with or without heat loads associated with passengers, heat loads associated with electrical, electronics & mechanical equipment installed in train, lighting, heat transmission and solar gain.
- 7.2.2 The design of the system shall be developed to achieve maximum efficiency and to minimize energy consumption and noise within the saloon. Two identical independent VAC units shall be provided for each car to feed each saloon area, electrical cubicles near gangway, for DMC cars coverage shall also include the Operator's cab area. Air-conditioning in the cars shall conform to EN 14750 or an equivalent internationally accepted standard and/or practices for railway vehicles.
- 7.2.3 The VAC units shall be powered from the auxiliary electrical supplies at the same voltage and frequency as the output of the auxiliary electrical system of train as defined in Chapter 9 for normal operation. Part of the VAC units shall also be powered from train's battery during emergency operation.
- 7.2.4 The cool air shall be ducted to give an even distribution of air-flow and cooling throughout the saloon at all heights from end to end.
- 7.2.5 The VAC system proposed shall have maximum reliability and follow the latest international practice. It shall maximize energy efficiency comparable to the best international practices and similar proven technology.
- 7.2.6 The refrigerant used in the VAC system shall be in accordance with the requirements of the Montreal Protocol or latest better guidelines. Environment-friendly refrigerants, such as R407C or R32 or R410A or better shall be used.
- 7.2.7 All electrical and electronic components shall comply with the EMC and EMI requirements of EN 50121 (all parts), IEEE 16, EN 55011 and IEC 61000-4 standards or other equivalent international standards. The requirements of EMC EMI requirements referred to in clause 10.19 & 2.18 of the Rolling Stock shall be met.
- 7.2.8 Fire properties of the materials used shall comply with EN 45545 part 1 to part 7 latest editions (Category 4-A, Hazard level HL3) as a minimum or better international standard applicable for similar Metro applications. Requirements of clause 2.26 shall be met.
- 7.2.9 Each VAC unit shall have independent over voltage protection and over current protection system which safeguards the individual VAC unit from external electrical disturbances outside the VAC unit.
- 7.2.10 The VAC System functions shall meet all the criteria defined in Chapter 14.
- 7.2.11 Material requirements of all sub systems of train shall be compliant with the requirements of Chapter 19.

7.3 DESIGN REQUIREMENTS

- 7.3.1 VAC units shall be modular units designed and located in such a manner that allows easy access to maintainers for servicing of valves, gauges and test points in-situ and without the necessity to remove the module from the car.
- 2** 7.3.2 The VAC units shall be roof mounted and each VAC unit shall have a minimum cooling capacity of 50 kW.
- 7.3.3 The shape of the VAC unit shall maintain the car roof profile as near as practicable and shall comply with the requirements of the Kinematic Envelope in all locations of CMRL network.

- 7.3.4 VAC units shall be constructed as an integral module to enable removal from the Car as a single complete item without the necessity to break any refrigerant lines or any connections with car body.
- 7.3.5 The VAC units shall be installed on car body using a minimum number of fixings and shall not require the use of sealing compounds between VAC unit and car body roof. Sealants shall not be used for fixing VAC units on the car body roof unless approved by CMRL.
- 7.3.6 Lifting lugs shall be provided at suitable positions on VAC units to ensure that balanced lifting of the VAC unit is achieved.
- 7.3.7 All electrical connections, condensate outlets, rainwater drain outlets from each VAC unit shall be fitted with quick disconnect fittings.
- 7.3.8 The connectors and drainpipes shall be positioned to ensure that they will not get damaged when the VAC unit is removed from the car and placed on a flat surface without the usage of any Jigs.
- 7.3.9 The Contractor shall propose a compressor design which ensures the highest possible energy efficiency is achieved on an annualised basis. If DC motors are proposed for Evaporator fans, they must be of a Brushless type.
- 2 7.3.10 Air filter elements shall be replaceable from ~~roof / outside the car~~ inside the car.
- 7.3.11 Airways handling the intake and airways handling return air shall be separately ducted. Ducts and diffusers handling conditioned air shall have adequate heat insulation layers to avoid accumulation of condensate. Temperature variations inside saloon shall comply EN 14750.
- 7.3.12 The Contractor shall carry out cooling load estimates for all specified design conditions including equipment located inside saloon with the use of internationally recognized reference data. The estimated weight, power requirements and heat load calculations based on the parameters adopted, shall be submitted by the Contractor for approval. Specific measures taken to minimize energy consumption of the VAC unit shall be detailed in the design submittals.
- 7.3.13 The VAC units shall be sized to cater for AW4 load condition with all train sub-system equipment being operated simultaneously. The Contractor shall take the effects of door opening and closing at stations as well as piston and infiltration effects when the rake moves in a tunnel (as specified in relevant standards) into full consideration.
- 7.3.14 The Contractor shall submit the system design, including schematic, equipment sizing and selection, airflow distributions, cooling load estimation and psychrometric charts to meet the environmental requirements in the saloon specified in the Specification.
- 7.3.15 The Contractor shall provide hermetically sealed compressors which have already been service proven in a Metro railway application. Compressors shall be suitable for continuous operation at high ambient exterior temperatures up to 48 °C and in forced ventilation beyond 48°C to 58°C exterior ambient temperatures. Full details of the compressor and its experience in Metro train application, particularly in high temperature, dusty and high humidity environments shall be furnished. Unloading of the compressor shall be linked with the High-Pressure setting.
- 7.3.16 Temperature Distribution: Temperature difference in horizontal and vertical planes spread over full car length shall be minimal. The instantaneous saloon interior temperature at 1.1 m above car floor level shall be 25°C ± 2°C at any given time. The mean saloon interior temperature at 1.1 m (taken over a round-trip period) shall not exceed 25°C. The saloon interior area includes Gangway and Emergency Driver desk areas. The Contractor shall submit details during PFDR.
- 7.3.17 CMRL requires that an energy efficient system comparable with the best available in the industry be provided. Good energy efficiency shall be achieved in cooling and dehumidification operations of the VAC.
- 7.3.18 The Contractor shall furnish expected power consumption of the VACs per car for peak summer, Monsoon and Winter ambient conditions for AW0, AW1, AW2, AW3 and AW4 passenger loads considering the train operated in revenue service conditions.
- 7.3.19 A condensate water and rainwater drain collection system shall be provided without any water spillage and leakage to the saloon area. Adequately sized flexible drainpipes shall be provided for drainage of condensate & rainwater from the VAC units. Suitable means shall be incorporated for cleaning of the water drainage system of VAC unit.

- 7.3.20 Employer expects that an energy efficient system comparable with the best available in the market shall be provided. Good energy efficiency shall be achieved in cooling and de-humidification operations of the HVAC. Contractor shall furnish Energy Efficiency Ratio (EER) for the offered system. In cooling mode, the Coefficient of Performance (COP) of HVAC shall be at least 2.5 in summer ambient conditions under AW4 loading conditions which may be achieved by utilizing variable frequency control (if required) of compressors or any other control mechanism. The COP shall be validated as per IS 8148, ASHRAE 37 or any other relevant standard, as agreed by the Employer. The Contractor shall submit the record of proven system already functional in any metros with the specified COP. The Contractor shall furnish expected COP, cooling capacity and power consumption of the HVACs per car for peak Summer, Monsoon and Winter ambient conditions for AW0, AW1, AW2, AW3 and AW4 passenger loads.

7.4 VENTILATION REQUIREMENTS

- 7.4.1 Ventilation of the car shall be provided by overhead fan-coil units or rotary fans in diffusers or with any better design. Outside air shall normally be supplied into each saloon as per EN 14750 Category B whenever the system is energized at the nominal line voltage. The VAC system shall however reduce the fresh air intake proportionately based on the passenger loading in each car.

In order to minimize energy consumption, fresh air intake volume control shall be based on coach load weight signal and CO2 level inside the car. The fresh air intake shall be rated for at least 2.2 liters / sec / passenger (8m³ / hour / passenger) @ AW4 load condition. The proposal of levels of opening of fresh air dampers shall be finalized during detailed design stage with the approval of CMRL.

- 7.4.2 The ventilation system shall pressurize the saloon to a value higher than outside pressure, and to be determined and approved during design review for conditions with all doors closed, car stationary and the nominal power voltage supply to the fan motors.
- 7.4.3 The air discharge velocities at any outlet grille, shall not create noise disturbing the passengers and shall vary progressively as per EN14750. Minimum air discharge velocities at any outlet grille shall not be less than 0.5 m/s measured at 300 mm below ceiling. The air intake velocity at the re-circulation and exhaust grilles shall not exceed 3 m/s.
- 7.4.4 The minimum volume of fresh air supplied by the artificial ventilation shall be 2.2 liters / sec / passenger (8m³ / hour / passenger) @ AW4 load condition. The air shall be filtered and the CO2 level inside the car shall not exceed 2600 PPM at any passenger location when the outside (ambient) CO2 level is ≤ 450 PPM.

7.4.5 Emergency Ventilation

- 7.4.5.1 The emergency ventilation shall be provided in accordance with the following matrix. Activities during other modes of operation shall also be followed as per below matrix.

Mode	Cooling	Fresh Air	Return Air
Ventilation	Not required	Required	Circulation required
Emergency Ventilation	Not required	Full	Circulation Not required
Smoke/ Fire outside of the train during Cooling mode of VAC	Required	Not required	Circulation required
Smoke during Emergency Ventilation or Smoke during Ventilation	Not required	Not Required	Circulation required

- 7.4.5.2 In the event of an interruption to AC power supply to any individual VAC unit, the evaporator blower fans of all VAC units of the train shall continue to operate from the battery supply at-least for a period of 60 minutes.
- 7.4.5.3 In the event of the system failure or power supply failure of any individual VAC unit, an emergency

ventilation system (one [1] hour operation with battery supply) shall operate automatically to admit fresh air directly into car to maintain the required oxygen level in the fully laden car, in accordance with EN 14750. In this emergency ventilation condition, the outside fresh air shall be admitted into car at a minimum rate of 3.3 litres / sec / passenger (@ AW4 load). The ventilation fan shall be fed from the 110V DC supply with its dedicated inverter per each VAC unit during these conditions.

7.4.5.4 During emergency ventilation, the system shall deliver 100% fresh air, distributed throughout the saloon; including the Operator's cab area. The emergency ventilation shall inhibit cooling and deliver full (100%) fresh air to the saloon without any re-circulation.

7.4.5.5 Not Used.

7.4.5.6 In the event of Smoke or fire being present outside the train, arrangements shall be made to prevent the products of combustion being introduced into the saloon and Operator's cab areas by shutting off the fresh air inlets and operate in a 100% re-circulation mode. In the event that there is a total loss of 110 Vdc power supply to the VAC modules the dampers shall default to the fully closed position.

7.4.5.7 Provision shall be made to power the evaporator blowers from the battery in the event that primary power to the car is lost. This provision shall automatically come into operation in 45 seconds after primary power is lost and this function shall be discontinued upon reinstating of primary power.

7.4.5.8 The VAC system shall automatically restore normal cooling mode operation when power supply returns to normal for the individual VAC unit basis.

1 7.4.5.9 Operation of the emergency mode ventilation shall be recorded by the TCMS and shall be reported to RSC consoles of OCC, BCC & DCCs.

7.4.5.10 As emergency ventilation is a safety requirement, the battery shall be rated to provide power to the blowers for 1 hour in addition to feeding the essential loads apart from VAC as specified in clause 9.4.

7.4.6 Ventilation Mode

1 7.4.6.1 There shall be an option in TCMS and from RSC console from OCC, BCC & DCCs to operate the train's VAC units in Ventilation Mode. This shall be adopted when the train is held idle during inspections / testing in depot or in mainline sections. During the Ventilation mode, there shall be auxiliary supply available to the VAC units. However, upon selection of this mode, the evaporator fans shall be functional and supply fresh air to the saloon. Return air circulation shall also occur in the saloon. This mode shall not have cooling functionality of the saloon air.

7.4.6.2 The outside fresh air intake in this mode shall not be less than 2.2 litres / sec / passenger @ AW4 load.

7.4.6.3 During ventilation, the system shall deliver 100% fresh air, and circulate return air throughout the Operator's cab area and saloon.

7.4.6.4 Not used

7.4.6.5 In the event of fire or Smoke being present outside the train, arrangements shall be made to prevent the products of combustion being introduced into the saloon and Operator's cab areas by shutting off the fresh air inlets and operate in a 100% re-circulation mode.

7.4.6.6 The Contractor shall submit the hazard analysis for fire and/or smoke in the car and lost ventilation.

7.4.7 Not used

7.4.8 Smoke Mode

1 7.4.8.1 In the event of smoke or fire existing outside the train being detected, the system shall shut off the fresh air intake to prevent the product of combustion materials being drawn into the saloon and provide a full (100%) re-circulation of return air within the saloon. Provision shall be made to automatically shut off the fresh air intake and re-circulate the internal air of the saloon, during an emergency condition, such as fire outside the train causing excessive heat and smoke to be drawn into the vehicle. Operation of such provision shall be made automatically in ~~ATO mode & non-ATO~~ UTO mode & non-UTO modes of operation.

1

The closing time of all the fresh air dampers shall be less than 10 seconds from the receipt of smoke signal to avoid ingress of large quantity of smoke coming inside the car. The status of smoke activation, dampers condition shall be displayed on TCMS. These details shall also be displayed in RSC consoles of OCC, BCC & DCCs.

7.4.8.2 During Smoke mode activation in Cooling mode, the system shall maintain the re-circulation of cool air in the saloon.

7.4.8.3 In the event of a loss of power supply after smoke mode is activated, the fresh air dampers shall be kept in "Closed" position and shall not allow any outside air through fresh air dampers.

1

7.4.8.4 The fresh air dampers shall be reset by the rake driver via TCMS and from RSC console of OCC, BCC & DCCs once the system resumes normal. Also, the controls of all dampers of VAC unit shall be available from TCMS, OCC, BCC & DCCs.

7.4.8.5 The dampers shall be capable of being reset locally from the saloon during maintenance.

1

7.4.8.6 Operation of the smoke mode in any VAC unit shall be reported to TCMS, RSC consoles of OCC, BCC & DCCs.

7.4.8.7 In case of false alarm of smoke detection, Provision shall be available to bypass the smoke detectors through TCMS.

7.4.8.8 Location of the smoke detectors and the logic and operation of smoke signal activation shall be designed in such a way that possibility of false alarm is avoided. Full details of the system proposed shall be given by the Contractor during design stage.

7.5 HEATING REQUIREMENTS

7.5.1 Heating is permitted, if required, only to maintain the specified humidity levels.

7.5.2 The heater shall be used for reheating to control humidity.

7.5.3 The control circuitry shall not allow the heaters to be powered unless the evaporator blowers are operating. Heater element over-temperature protection shall be provided for individual heaters. Self-resetting thermostats shall be installed adjacent to the heaters to open the contactors when excessive temperatures are detected. A positive interlock shall be provided to open heater contactors in the event of failure of the Auxiliary Power Supply.

7.6 COOLING REQUIREMENTS

7.6.1 The VAC system shall have adequate capacity to maintain the specified interior temperatures under the conditions listed below. The Contractor shall take into consideration EN 14750 specifications for door opening/closing cycle and the piston and infiltration effects for the rake moving in the tunnel.

7.6.2 The below mentioned Heat gains are to be considered for each car:

- a) Car lighting of the train
- b) Electrical loads, electronic loads and mechanical loads of the train including evaporator fan motors inside the saloon,
- c) car body heat transmission with an assumed 10 kmph relative exterior velocity,
- d) AW4 passenger loading in all cars.
- e) Fresh air heat load
- f) Pre-cooling cycle time shall not exceed 30 minutes under the worst condition.
- g) A solar load representing direct and diffused radiation, convection and radiation from window surfaces, windshield, ~~detrainment door~~, look-out glasses and absorbed heat gain from glazing and car body structure.
- h) Air leakages during door operation at stations with minimum 30 Seconds dwell time.

1

7.6.3 The VAC System shall automatically maintain the internal environmental condition (throughout

the saloon and emergency operator's desk areas) as per the criteria shown below for the corresponding exterior climatic condition at each design point:

Design Point	External Condition	Internal Condition
1	37.3 °C Dry Bulb, 40 % RH	Designed for 24 °C Dry Bulb, ≤ 60 % RH SEC calculation / testing & Operation requirement: 25 °C Dry Bulb, ≤ 60 % RH
2	34 °C Dry Bulb, 65 % RH	
3	31.3 °C Dry Bulb, 80 % RH	

Stated requirements shall be met in AW4 load condition (8 passengers / m²).

7.6.4 Not Used.

7.6.5 When the external ambient temperature exceeds the values specified at paragraph 7.6.3, then the air conditioning shall be designed to maintain the temperature difference between the interior temperature and ambient temperature at not less than 10°C up to the ambient temperature of 42°C. From 42°C to 48°C of ambient temperature, the VAC units shall continue to operate at full load maximum capacity in cooling mode without interruption or degradation and shall maintain constant internal temperature of 33°C. Beyond 48°C ambient temperature, the VAC system shall go into ventilation mode.

7.6.6 Failure of one of the VAC units on a car shall not adversely affect the operation of VAC units on other cars.

7.6.7 The maximum temperature variations permitted with the train stationary after saloon interior have stabilized without passenger loading shall confirm to EN14750 or equivalent international standards.

7.6.8 Saloon Pressure: The VAC supply air blower fan shall pressurize the car passenger area. In car stationary with all doors closed and vestibules blocked condition, the value of interior static pressure shall be minimum 25 Pa.

7.6.9 Uniform Air Distribution: Uniform air distribution must meet the specification of EN 14750 and clause 7.4.3. Computational Fluid Dynamic (CFD) analysis in VAC degraded conditions must also meet the criteria of the air supply requirement of clause 7.4.3.

7.6.10 To minimize energy consumption, ventilation control based on load level measurements using load weigh signal shall be used for controlling the performance of the VAC system. The proposal shall be finalized during detailed design stage with the approval of CMRL.

7.6.11 During the failure of one auxiliary converter inverter, the VAC system attached to the specific auxiliary converter inverter shall enter into degraded mode of operation. In this degraded mode of VAC system, 50% VAC units of each car shall be continuously powered from healthy Auxiliary converter inverter of train and other 50% VAC units of each car shall operate in Emergency ventilation mode on 110V DC supply. This shall be achieved by connecting power supply of alternate VAC unit of each car to alternate auxiliary converter inverter. This requirement shall be properly interfaced with Auxiliary converter inverter design and train wiring of Chapter 9.

7.6.12 Provision of humidity control shall be available in cooling mode in the VAC. Humidity control should be done as per the levels mentioned in clause 7.6.3 and EN14750-1.

7.7 CONTROLS

7.7.1 The saloon interior set point temperature as well as humidity settings shall be controlled automatically by TCMS. It shall be possible to apply an offset to the target set point temperature via the DDU to the range of ±2°C in steps of 0.5°C.

1

It shall also be possible to apply the same offset adjustment remotely via OCC & DCC. The user interface in OCC & DCC shall include an option to apply the offset adjustment to all trains in the fleet simultaneously through a single-step action. Trains shall memorise the offset setting so it will be retained after trains are shutdown.

7.7.2 All the temperature sensors, protection devices and other sensors of each VAC unit shall be easily

accessible to facilitate easy maintenance.

1 7.7.3 Faults shall be reported to the TCMS to enable diagnosis via the TCMS and locally through a portable PC. All the system data, events and faults of complete VAC units of train shall be transmitted to train's DMS and RTR-DMS so that the real time data is available ~~with the Train Operator in the RSC consoles of OCC, BCC and DCCs~~ as mentioned in clause 14.11 & 14.13.

1 7.7.4 Each VAC unit shall be associated with its microprocessor control panel, installed in the electrical control cubicle of car, or suitably provided within the unit, and including all necessary controls. The micro-processor-based system, proven in railway service shall be provided with loading, scheduling, diagnostic and operational data interfaced with TCMS and shall be designed with both ~~ATO-GoA2 UTO GoA4 and non-ATO non-UTO~~ train operations.

7.7.5 The microprocessor shall have memory permitting logging of faults and system events in its memory for sufficiently long durations. The microprocessor shall have suitable interface with TCMS for data communication and display. Suitable communication shall be provided to permit logged events to be downloaded to a laptop/computer. All the variables and parameters of the VAC unit shall be transmitted to TCMS and shall be logged in TCMS. This data shall be able to be transmitted as part of RTR-DMS as mentioned in clause 14.11 & 14.13.

7.7.6 Selected parameters and failures of each VAC unit shall be monitored from TCMS from Operator's Desk. The parameters to be monitored from the Operator's Desk shall be determined during design review.

7.7.7 The VAC control system shall be designed to ensure maximum passenger safety and comfort even in the event of a single failure on any VAC unit of the rake system.

7.7.8 Each VAC unit shall consist of a self-contained individual unit, powered from an independently protected supply with every alternate VAC unit powered from alternate auxiliary converter inverter system to prevent the total loss of a car's VAC in the event of a single point failure of power supply, e.g. auxiliary converter failure, etc.

7.7.9 The principal objective in the design of the VAC control systems shall be to provide a comprehensive form of control, with condition-monitoring/fault diagnosis and fault indication, and maximum reliability. The proposed control system shall be submitted for approval.

7.7.10 The VAC control systems shall not cause electromagnetic interference with any other device on the rake and shall be self-protected from such interference generated by other equipment of train or from surroundings. The overall EMC & EMI requirements of train shall be met as per EMC & EMI requirements in clause 10.19 & 2.18.

7.7.11 The VAC control systems shall be designed to ensure that it is not adversely affected by permitted variations in the electrical power supply. All the components and equipment of VAC units shall be rated to the voltage and frequency requirements of Auxiliary Power system output for 3 ϕ AC, 1 ϕ AC and with 110 V DC battery supply.

7.7.12 An isolation / test switch shall be provided to enable each VAC unit to be individually isolated, i.e. on / off, and to activate a self-test / sequence mode.

7.7.13 Each isolation switch shall be mounted within each saloon adjacent to each VAC control unit. The isolation switch shall be inaccessible to passengers.

7.7.14 Each VAC unit shall employ separate individual temperature sensing, humidity sensing, controls & indications, providing sufficient & reliable fault information to facilitate maintenance.

7.7.15 VAC units throughout the trainset shall be activated automatically when the train auxiliary supplies are operating and shall be load shed following the loss of Traction or Auxiliary power Supply. The starting and stopping sequence of the VAC units and internal components of each VAC unit shall be designed such that the current loading and un-loading on the auxiliary power system is in a staggered manner to reduce current during starting and stopping of VAC system.

1 7.7.16 The units shall be capable of being controlled ~~from the RSC consoles of OCC, BCC & DCCs in UTO mode of operation and from TCMS driving console in all modes of operation in all non-UTO modes and degraded modes of operation~~. Facilities for remotely cutting-out and resetting of a faulty VAC unit shall be provided ~~from RSC consoles of OCC, BCC & DCCs in UTO mode of operation and in the train operator's driving console in all non-UTO modes of operation including~~

all degraded modes of operation.

- 7.7.17 The interface shall include provision of uploading of software of all VAC units of a train from a single point location from TCMS in train. Provision shall also be made for single point download of all VAC logs from a single point access in train. Also, the VAC system shall be compatible with the Real Time Remote DMS system defined in clause 14.11 & 14.13.
- 7.7.18 The physical location of all these cutouts / switches shall be maintenance friendly.
- 7.7.19 Control of passenger area comfort conditions shall be done through Solid State type temperature and humidity sensors having no moving parts. For this, following minimum number of sensors shall be provided:
- a) One fresh air intake temperature sensor in each VAC unit.
 - b) One return air inlet temperature and
 - c) One Temperature sensor in the supply duct of each VAC unit
 - d) One humidity sensor in each VAC unit.
 - e) Temperatures recorded by the VACs return air temperature sensors and the humidity values recorded by the VAC's return air humidity sensors will be the feedback to the VAC control system for taking corrective actions for maintaining the car interior passengers comfort conditions.
 - f) Heat detectors / temperature sensors shall be used and integrated to TCMS / Fire Detection Control Unit for real time monitoring of all connections / terminals of the VAC cables.
- 7.7.20 The Contractor shall propose the overheating and overloading protection arrangement for the compressor motors. The compressor shall not suffer from any damage due to restarting after previously having shut down without carrying out pumping down cycle.
- 1 7.7.21 It shall be possible to remotely isolate and normalize faulty / healthy VAC unit from TCMS in DDU. Also, the same feature shall be able to be controlled from RSC consoles from OCC, BCC & DCCs.

7.8 REFRIGERANT AND PIPING

- 7.8.1 The refrigerant type shall have low / zero Ozone Depletion Potential Index in accordance with the "MONTREAL PROTOCOL" or better environmentally friendly measures. The refrigerant used shall be approved for long-term use. The refrigerant shall be contained totally within a sealed system. No removable components or compression type fittings shall be used.
- 7.8.2 Only permanent / continuous copper pipe with suitable non-ferrous fittings shall be used.
- 7.8.3 Intermediate joints in refrigerant piping (E.g., pipe to pipe) shall not be accepted. The end termination to equipment shall be brazed lap joints.
- 7.8.4 Relative movement between the terminals of the compressor, condenser and evaporator coils resulting from vibration shall taken into consideration in the design of the pipe layout. All tubing joints shall have adequate strength against shocks and vibrations. For maintainability requirements, they shall not be located in inaccessible areas.
- 7.8.5 A sight glass shall be fitted in the refrigerant liquid line to show the refrigerant flow. It shall be easily visible through an inspection hole; from the saloon area.

7.9 CONDENSER AND EVAPORATOR COIL

- 7.9.1 The condenser and evaporator coils shall be made of copper and having copper fins. Cleaning of condenser and evaporator coils should not be required earlier than 6 months.
- 7.9.2 The condenser and evaporator fan motors shall work on 415V, 3 ϕ , 50Hz supply. However, in case of auxiliary supply failure, the evaporator fan motors shall be fed from the inverter. Dual speed motor may be used. The fan motors shall be minimum of IP 56 protection. There shall be separate MCBs for each evaporator fan motor and each condenser fan motor.
- 7.9.3 Adequate measures shall be taken by the Contractor to ensure that under any condition there is no water leak inside the car from the VAC system and from its mounting joints.

- 7.9.4 The refrigerant pipes and condensate tubes which generate condensation over its surface shall be adequately insulated.
- 7.9.5 The Contractor is responsible for assessing the entire network of Phase 1 and its extension for the factors that may contribute to corrosion in the Evaporator & Condenser coil. These factors may include, but are not limited to, substances such as Temperature, Humidity, sulphur dioxide and chlorides. Any necessary additional protective measures shall be implemented.

7.10 AIR DUCTS AND DIFFUSERS

- 7.10.1 Conditioned air from each unit shall be directly introduced into a duct running the full length of the car and be discharged into the car through ceiling outlets. The supply air duct design shall be uniform in all cars. The duct shall be fully lagged with non-combustible insulation material to prevent the formation of condensation.
- The Contractor shall provide a solution to allow the cleaning of ducts to be undertaken during major overhaul without excessive downtime. Access and/or special tooling shall be provided to avoid the necessity for complex removal of ceiling structures and fittings.
- 7.10.2 The supply air duct shall be designed such that even in case of failure of one VAC, the other working VAC will be able to cool the saloon passenger area uniformly. The duct shall be fully lagged with non-combustible insulation material to prevent the formation of condensation. The Duct shall be suitably designed to ensure that there is no leakage of supply air inside the duct. The Contractor shall take into consideration the requirement of maintenance access for duct cleaning as and when required.
- 7.10.3 Computational Fluid Dynamic (CFD) analysis tools should be used to optimize the air distribution within the car. This study should be undertaken to confirm that all the design air velocity and airflow rate values are being achieved and shall be validated during the design stage. The CFD analysis of the duct shall be submitted.
- 7.10.4 Two rows of air diffusers shall be mounted on each side of ceiling panel, blending well with the car interior design. It shall be possible to adjust the air quantity from the diffusers during testing and commissioning, to achieve optimum uniformity in the distribution of air.

7.11 AIR FILTERS

- 7.11.1 Fresh air should be filtered for human comfort and safety, in accordance with internationally accepted norms. The fresh air filter element shall be provided before the fresh air damper and fixed in a metallic frame.
- 7.11.2 The Contractor shall ensure that the overall design of the VAC System; is able to tolerate the extremely dusty and humid environment which prevails in Chennai to the extent that there is no necessity to clean VAC filters before 12,500 kms or within fewer than 30 days train running; whichever is lower. Minimum expected life of filter shall be 100,000 km. The effectiveness of VAC filters shall be adequate enough to ensure that dust deposition in the air ducts is minimal and won't create cause to need to clean the ducts between major overhauls.
- 7.11.3 To ensure the minimum maintenance interval required by Clause 7.11.2 is consistently achieved, the Contractor's proposed design shall specify the minimum expected supply airflow rate for both clean and clogged condition of air filters and evaporator coils. The filter proposed by the Contractor shall be Stainless steel mesh based and the grade of filtration shall be G3 (for Fresh air inlet) and G2 (for Return air outlet) as defined by Table-1 of EN 779.
- 7.11.4 The Contractor shall perform tests in accordance with EN 779 to qualify the design of the overall system by simulating clogged filter conditions and identify the retention capacity, efficiency (arrestance) and Pressure drop verses an incremental increase of dust loading.

7.12 EMERGENCY INVERTER

- 7.12.1 An Inverter of adequate capacity shall be provided in each VAC unit of each car to supply 3 ϕ AC power from 110 VDC battery to power the ventilation fan motors of each VAC unit of the car during

emergency mode, when cooling is off and for supplying emergency fresh air. Inverter shall be IGBT based or better technology and tested in accordance with IEC 61287. The current rating of IGBT shall be such that the junction temperature has a minimum margin of 10°C in the worst loading conditions. The inverter shall be located inside the VAC unit or electrical cabinet.

- 7.12.2 In case of DC motors used for evaporator fans, suitable control mechanism shall be provided to distinguish the Auxiliary converter fed DC supply with battery fed DC supply. It shall be able to remotely isolate the DC evaporator fans from TCMS & RSC console of OCC, DCC, BCC when train is working on Battery supply.

7.13 EARTH FAULT PROTECTION

- 7.13.1 In case of grounding in any VAC unit, it shall be possible to isolate the defective VAC unit without affecting the Auxiliary power supply operation. The Contractor shall submit the proposal for CMRL review during design stage.

7.14 DRIVER'S CAB AIR-CONDITIONING

- 7.14.1 Separate cab AC unit is not envisaged. The cab, driving console and electrical cabinet in the cab shall be conditioned from the saloon VAC and it shall be suitably designed.
- 7.14.2 Facility shall be available for independent air control in the cab. Separate air supply fan motor (AUTO / OFF / LOW / MEDIUM / HIGH speed control) shall be provided for controlling the air supply in the cab. Speed control shall also be possible by TCMS.
- 7.14.3 The temperature inside the driving console and cab shall be same as in the saloon i.e. 25 °C Dry Bulb, ≤ 60 % RH under stipulated conditions.
- 7.14.4 Driver's cab bleeding unit shall be able to operate during emergency mode, when cooling is off.

7.15 UTO OPERATION

- 7.15.1 The design of VAC System and its relevant components in train shall support for the UTO / GoA4 in the CMRL Phase 1 & Phase 1 extension network defined in Chapter 1. Trains shall be operated in GoA2 ATO mode during the initial stage of commissioning and revenue operations and in GoA4 UTO mode subsequently. Hence all feedback, information and train controls which are available on TCMS screen shall also be available in OCC (operational control Centre) and DCC (Depot Control Centre) for smooth operation of passenger service. The Contractor shall submit the details of controls to be provided in OCC, BCC & DCC.

8. LIGHTING SYSTEM

8.1 NOT USED

8.2 GENERAL

- 8.2.1 The lighting system of the train concerns:
- a) Interior lighting for the saloon and the Operator's cab,
 - b) Exterior car lighting.
- 8.2.2 Headlight, taillights / marker lights, door indicator lights, call-on function, all interior lights & exterior lights in train shall conform to latest International Standards related to railway lighting systems.
- 8.2.3 All the 100% of interior and exterior lighting of train shall be powered directly from train's batteries. Train battery shall be of sufficient capacity to maintain the all the train lights for one-hour duration in case of failure of auxiliary supply. This function shall be achievable in parallel working with other essential loads of train as defined in Section VI A ERTS (RS) Clause 9.4.2.
- 8.2.4 The power supply and voltage level requirements of all the internal and exterior lights of train shall match with the voltage supply requirements and voltage ranges mentioned in Section VI A ERTS (RS) Chapter 9.3.
- 8.2.5 Electrical lighting shall be of similar or equivalent performance to EN 13272 as applicable to urban rail transport systems.
- 8.2.6 Relevant type test Certifications such as LM 79, LM 80 for all the types of proposed interior and exterior LED lights shall be submitted to CMRL for review and approval.
- 8.2.7 The Contractor shall submit the details of complete interior and exterior LED lights' energy simulation calculations, details regarding energy efficiency, service life of lights, heat dissipation arrangement to CMRL during the design stage for review and approval.
- 8.2.8 Lighting System functions has to meet the all the criteria defined in Chapter 14 – TCMS.
- 8.2.9 All electrical and electronic components of lighting system shall comply with the EMC and EMI requirements of EN 50121 (all parts), IEEE 16, EN 55011 and IEC 61000-4 standards or other equivalent international standards. The requirements of EMC EMI requirements referred in Section VI A ERTS (RS) Chapter 10.19 & 2.18 of the Rolling Stock shall be met.
- 8.2.10 Fire properties of the materials used shall comply with EN 45545 part 1 to part 7 latest editions (Category 4-A, Hazard level HL3) as a minimum or better international standard applicable for similar Metro applications. Requirements of Section VI A ERTS (RS) Chapter 2.26 shall be met.
- 8.2.11 Material requirements of all sub systems of train shall be compliant with the requirements of Section VI A ERTS (RS) Chapter 19.

8.3 INTERIOR LIGHTING

8.3.1 Saloon lights:

The interior lighting system shall comprise of "Dimmable" type LEDs with six (6) step lighting control (OFF, 25%, 50%, 75%, 100% & Automatic), conforming to EN13272. The following requirements shall also apply:

- 8.3.1.1 The saloon shall be provided with lighting using energy efficient, long service life (burning hours) power LED lights fitted in luminaries which shall achieve the requirements of flame, smoke and toxicity for passenger service metro Rolling Stock applications. All the light fittings shall prevent entry of dirt, moisture and insects.
- 8.3.1.2 All interior LEDs shall be fed by the train battery supply. Each car shall have two separate wiring circuits with individual MCB protection, such that a single point of failure cannot cause a total loss of interior lighting.
- 8.3.1.3 The guaranteed life of the LEDs with their control system and optics / luminary shall not be less

- than 60,000 burning hours. The level of illumination shall not degrade to less than 70% of the originally specified rating in lumens.
- 8.3.1.4 The Contractor shall propose the colour of the LEDs as warm white (corresponding to a colour temperature range of 3000~3300 K) or cool white (corresponding to a colour temperature range of 4000~4300 K) for approval by CMRL. All LEDs are to be procured from the same batch to avoid any risk of differences in colour and/or performance.
- 8.3.1.5 The Colour Rendering Index R_a of all interior LED lights shall not be less than 90.
- 8.3.1.6 The saloon interior lighting intensity shall be uniformly distributed. The level of illumination shall be at least 300 lux at the floor level of the Coach and not less than 500 lux at seating positions. Lighting intensity requirements inside coaches shall also comply with EN13272.
- 8.3.1.7 The system shall be designed to limit glare; especially nighttime reflections on windows.
- 8.3.1.8 Luminaire efficiency inclusive of LEDs/control gears & optics etc. shall not be less than 100 lm/W at the working junction temperature; higher values of lm/W shall be preferred. LED(s) shall have lumen rating as 100 lm/W or above.
- 8.3.1.9 The layout and wiring design for LEDs & their strings / blocks shall ensure that a failure of one LED does not cause the loss of a complete string/block. Similarly, failure of one controller on one string / block should not adversely affect other strings / blocks. Details shall be submitted to CMRL during the design stage for review and approval.
- 8.3.1.10 Cars may remain unpowered in open sunshine causing internal temperature to rise to 70°C. Suitable protection measures shall be taken to ensure that this does not adversely affect the performance, reliability or efficiency of the lighting system and its components. A suitable test plan to verify / validate the above shall be proposed by the Contractor during design stage.
- 8.3.1.11 The junction temperature (T_j) of the LED chips and efficiency of the heatsink, shall be considered in the proposed design to ensure the long term reliability. The design shall ensure that consequential degradation (E.g. lumen depreciation and permanent colour shift) are within the allowable limits specified in this chapter.
- 8.3.1.12 The change of chromaticity over the lifetime of the product shall be within 0.007 on CIE 1976 (u' , v') diagram or equivalent.
- 8.3.1.13 After Two-year, five year and 60,000 operation hours, the colour temperature of the interior lighting shall be within $\pm 5\%$, $\pm 8\%$ and $\pm 10\%$ of the initial value respectively.
- 8.3.1.14 LED luminaires shall be designed to withstand switch cycles of 100,000. A test certificate shall be provided to evidence compliance.
- 8.3.1.15 LED luminaires shall be sealed to IP53 and control gears shall be sealed to IP 54 as per EN 60529 to prevent the ingress of dust, moisture and insects etc.
- 8.3.1.16 The Contractor shall propose LED manufacture(s) during design stage and seek the prior approval of CMRL based on submission of appropriate evidence to demonstrate the reliability and reputation of the proposed supplier / LED design.
- 8.3.1.17 The Contractor shall replace all the LED lighting with a newly improved LED lighting in fleet of trains if either of the following occurs:
- (a) The total cumulative failure rate of the LED luminaires or control gears within Defect Notification Period (DNP) exceeds 5% of the total units, with 20% of LEDs failed in a LED luminaire unit is constituted as a failure of the LED luminaire unit. (or)
 - (b) The illumination level at floor level of any five trains drops below 90% of the initial values at the end of two-year operation of each train, by assuming maximum of 18 hours daily operation and 365 days of operations.
- 8.3.1.18 Since LED technology is fast evolving and the Rolling Stock supply is a long-drawn process, the Contractor shall commit to supply latest generation of LEDs available at the time of design approval.
- 8.3.1.19 In case of LED lights failure, it shall be possible to easily replace new lights from outside portion of the fixture and shall be maintenance friendly.

- 8.3.1.20 The maximum number of LEDs which a driver / power supply can feed shall not exceed 1,000 LEDs.
- 8.3.1.21 Train interior lights shall be compliant to the overall Train Interior Noise requirements in static and dynamic conditions as specified in clause 2.17.
- 1 8.3.1.22 All the controls of the saloon lighting of the train shall be provided from train's TCMS and from RSC consoles of OCC, BCC & DCCs as an override to automatic control of train. In general, automatic working of interior saloon lights shall be as per clause 8.3.1.26.
- 1 8.3.1.23 Activation & Dimming Control of the lights shall be available from the TCMS DDU display of of controlling cab. RSC consoles of OCC, BCC & DCCs shall also have the option to control the lights remotely. TCMS shall automatically control the lighting during transmission from Viaduct section to Underground section vice versa. This shall be possible when the train state is not in the "Off" mode.
- 8.3.1.24 The saloon lighting shall switch off automatically when the train state is in the "Off" condition.
- 8.3.1.25 A provision to select "Maintenance Mode" for saloon lights shall be provided. On activation of one of the switches, all Saloon lights shall be lit even if the Master Controller's Mode Selector is in OFF position. These switches shall be provided at each side of the car's exterior at platform level. A detailed proposal shall be agreed with CMRL during design stage.
- 8.3.1.26 The lighting control logic shall propose real-time automatic selection of the saloon lighting circuits based on individual levels of natural daylight illumination present in each car. This is to minimize power consumption and provide uniformity of lighting levels in all cars.
- 8.3.1.27 The Contractor shall submit the Specifications, Data Sheets and energy efficiency details of all interior lights.

8.3.2 Operator Cab lights

- 1 8.3.2.1 The internal Operator cab lights shall be power LED type, separately switched and electrically independent of the saloon LED lighting. It shall be operated automatically by opening of, Saloon to Cab access door, cab side door, during coupling during operation in any mode, and shall also be controlled manually from TCMS and RSC consoles of OCC, BCC & DCCs.
- 8.3.2.2 The internal operator cab lights shall incorporate passive illumination of at least 200 lux at 1 m above floor level and having sufficient intensity to see and operate all the cabin controls, switches and other cabin equipment comfortably during train operation.
- 8.3.2.3 The illumination of the operator cabin or saloon LED lights shall not create any glare or reflection on the front-end windshield and shall not create any discomfort to the train operator / attender to operate the train in all times of service operation.
- 8.3.2.4 The illumination level in the cab shall provide sufficient illumination throughout the cab in compliance with EN 13272 or equivalent internationally recognized standards.
- 8.3.2.5 All the internal lights and its fixtures shall be proposed such that the aesthetic appearance of the train as specified in Chapter 3 shall suitably match with the interior lighting system of train.

8.4 EXTERIOR LIGHTING

8.4.1 Headlights, Taillights / Marker lights

- 8.4.1.1 All external light units like Headlights, Taillights / Marker Lights, shall be Power LED based and shall be located inside IP 66 rated housings in accordance with EN 60529 to prevent any ingress of water when operating the train at full speed in the worst rainfall conditions. The IP 66 protection shall be achieved without the use of compounds or sealant. The light fittings shall be kept in watertight vermin and insect proof integrated housings. The exterior light lens assemblies shall be sufficiently robust to resist the impacts of flying external objects. The IP protection shall be IP 66 when fitted on the car body.
- 8.4.1.2 Headlights shall be power LED based Cool-white light (colour temperature within 5500 K to 6500 K) with twin power input supply, with provision for low and high beams. Head lights shall be placed beneath the horizontal level of windscreens at approximate spacing of the running rails, at a minimum height of 1.5 m above top of the rail. The headlights shall have a clear glass and shall

be directed to illuminate the running rails approximately 35 m in front of the train.

- 8.4.1.3 Location and orientation of the Head lights shall be designed to provide sufficient and even illumination inside the tunnel bore, track bed, track side signal posts and the station platform edges. The intensity of head light beam shall be such that obstructions on the track shall be visible at the maximum service braking distance from maximum train speed. It shall be possible to read the OHE mast number plates and other information boards like pantograph lower / raised boards which are provided along the route. The illumination level of the head light shall be as per EN15153-1.
- 8.4.1.4 Replacement of individual Head light cluster and taillight / Marker light shall be possible in depot without disturbing the functioning or position adjustment of the light. All exterior Lights of train shall be replaceable and re-fitted without disturbing the weather seal.
- 8.4.1.5 Individual power LED clusters used as exterior lights shall be able to be replaced easily from track level. Access for cleaning, to replace lights and orientation adjustment shall be done from the car exterior. Replacement of individual cluster shall be possible in depot without disturbing the functioning of the light fixture or wiring.
- 8.4.1.6 A means shall be provided to adjust the direction and orientation of the head-light beam during maintenance and commissioning. Each head light beam shall be separately adjustable in both horizontal and vertical orientations.
- 8.4.1.7 Two numbers of bi-colour power LED based marker lights (also operated as taillights) shall be provided in train front-end exterior which shall be lit in both active and non-active cabs based upon functionality of Tail light and Marker light explained in clause 8.4.
- 8.4.1.8 Each LED of Marker Light shall be of dual colour of white and red which shall be operated based upon active / non-active cabin selection & direction based selection from train cabin & from RSC consoles of OCC, BCC & DCCs. White & Red LEDs may be provided within the same block / fitting and shall be used accordingly. This shall also be controlled based upon the running direction as specified in clause 8.4.
- 8.4.1.9 Not used.
- 8.4.1.10 In case of a stationary parked train in any location of CMRL network which is in switched on condition & when any cabin is active, the corresponding active cabin's marker lights shall be lit in white cooler to indicate the front end of the train. The rear in-active cabin taillights shall be lit in red colour to mark the rear end of the train. In case of a stationary train in any location of CMRL network which is in switched on condition & when no cabin is active, then tail / marker lights of both ends of the train shall display in red colour.
- 8.4.1.11 In case of a stationary parked train in switched-off condition in any location of CMRL network, both front and rear trail/marker lights of the train shall be lit in red colour. This power supply shall be fed from permanent supply of Battery even after train shutdown.
- 8.4.1.12 In case of moving train in any location of CMRL network, the control of Headlight, taillight and Marker light shall be based upon the direction of train movement (Considering forward and reverse movements of train) i.e., headlight and marker light (in white colour) should glow in the cab which is ahead in moving direction and taillight (in red colour) should glow in the cab which is trailing cab in the moving direction. This shall happen irrespective of the active/in-active cabin status.
- 8.4.1.13 All the controls of the exterior lighting of the train shall be provided from train's TCMS and from RSC consoles of OCC, BCC & DCCs as an override to automatic control of train. In general, automatic working of all exterior lights shall be proposed as explained clause 8.4.
- 8.4.1.14 The red colour taillights shall be clearly visible from a distance of 300 m in daylight conditions. The minimum viewing angle shall be 45° from the centre line of the beam. The two taillights shall be placed on the same horizontal plane.
- 8.4.1.15 The marker lights and taillights shall be sufficiently large and bright, to enable the lamp to be seen and acted upon by a train operator of opposite train within the service braking stopping distance of the consist travelling at maximum speed.
- 8.4.1.16 The headlights, taillights, marker lights shall not be switched off or be interrupted when the train

is passing through a neutral section.

- 8.4.1.17 The failure of a circuit to an exterior lamp shall not result in the failure of any other exterior lamp. Each head lamp on a cab shall be protected by independent CB's.
- 8.4.1.18 All the exterior lights like headlight, taillight / marker light systems and functions shall be designed as per the latest international practice.
- 8.4.1.19 Complete lighting system(s), their components shall generally conform to relevant ENs/IECs applicable for railway applications and shall be type tested.
- 8.4.1.20 The Contractor shall submit the lighting layout and control circuit information for all exterior lighting.
- 8.4.1.21 The Contractor shall submit the Specifications and Data Sheets on all exterior LED lamps and indicators.
- 8.4.1.22 All the external lights and its fixtures shall be proposed such that the aesthetic appearance of the train shall suitably match with the exterior lighting system of train.
- 8.4.1.23 In case of operation / opening of the Saloon to Cab door of a specific cabin, the corresponding cabin's exterior lights and 100% cabin and saloon interior lights shall be lit irrespective of the active cabin condition. These lights shall be supplied with battery and shall not be switched off until train is shut down or a specific command is provided from train's TCMS / from RSC console of OCC or BCC or DCCs to switch off the lights. During the case of de-boarding of passengers, they shall always be provided with fully illuminated interiors in the train and in the train cabin exterior at the track level.
- 8.4.1.24 Not used.
- 8.4.1.25 All exterior light fixtures shall be compatible with the regular train washing operation in depots.
- 8.4.1.26 The flasher light activation switch shall be located on the driver's side control panel to ensure convenient access and quick operation by the driver.

8.4.2 Call-on Light function

- 8.4.2.1 Control for Call-On function shall be provided in the train's TCMS and in RSC consoles of OCC, BCC & DCCs to cater for Emergency Pull-Push rescue operations. Operation of the Call-On switch on a failed train, with the Mode Selector in any operation mode, shall cause the taillights at the front & rear of the sick train to flash on and off, indicating to the train operator of the rescuing train that he may proceed to effect coupling.

8.4.3 External Car Indicator Light:

- 8.4.3.1 A LED based indication lamp shall be located at an appropriate location at the mid length of exterior side of each car and on both lateral exterior sides.
- 8.4.3.2 This LED lamp on each car side shall be sufficiently large and shall be visible to all the passengers on the entire length of CMRL station platform.
- 8.4.3.3 The functions of this exterior car indicator LED light shall be as per the below requirements:
- The light shall remain in green colour during the below conditions:
 - When no condition of 8.4.3.3 (2) occurs in a specific car, both side car indicator lights shall be glowing in static green colour.
 - The light shall flash in red colour in any of the below conditions:
 - When any passenger emergency communication is done in any car, both side car indicator LED lights shall flash in red for that specific car.
 - when any train door of the particular side of car has locking mechanism failed to register its feedback to TCMS / OCC, preventing traction circuit from picking up.
 - when any train door of the particular side of car is locked out mechanically due to failure
 - when any train door of the particular side of car has communication failure between door and TCMS / OCC.
 - When the corresponding exterior Platform Screen Door (PSD) of the same car side is having communication fault or opening / closing fault.

f. In any other cases where any door of the car is unable to/should not be opened.

8.4.4 External and Internal Door Indicator Light:

8.4.4.1 A LED based indication lamp shall be located at an appropriate location near each door in both interior side and on exterior side. The lamp shall be informative type showing the door signage and other faulty conditions specified below.

8.4.4.2 The functions of both interior and exterior door indicator light shall be same and as per the below requirements:

- a) The lamp shall remain extinguished when respective door is fully closed and locked.
- b) The lamp shall continuously flash in red colour whenever door close command button from the active cab is pressed / ~~ATO~~ UTO door close command is available. It shall continue to flash till such time the door is closed and locked.
- c) The lamp shall continuously flash in green colour whenever door open command from the active cab is pressed / ~~ATO~~ UTO door open command is available. It shall continue to flash till such time the door is completely opened.
- d) The lamp shall be illuminated in static green colour when the door is fully opened.
- e) The lamp shall be illuminated in static red colour when
 - (i) the door locking mechanism has failed to register its feedback to TCMS / OCC, preventing traction circuit from picking up.
 - (ii) the door is locked out mechanically due to failure.
 - (iii) the communication between door and TCMS / OCC fails.
 - (iv) the corresponding exterior Platform Screen Door (PSD) is having communication fault or opening / closing fault.
- (v) In any other cases where the door is unable to/should not be opened.

8.5 UTO / ATO / RM ~~ATO~~ / UTO INDICATING LIGHT

8.5.1 One dedicated indicating ~~Dual~~ LED light visible from lateral sides and front side of the train indicating UTO or ATO or ~~UTO~~ or Restricted Manual mode status, shall be fitted on each external side of the operator's desk. The light shall have the below functions:

- a) Shall indicate in a distinct colour when train is under ATO mode.
- b) Shall indicate in a distinct colour when train is under UTO mode.
- c) Shall indicate in a distinct colour when UTO not being used. It shall be used to understand that it is safe for operation and maintenance personnel to board the train and/or to carry out coupling during rescue operation when this colour is lit.
- d) Shall indicate in a distinct colour when Restricted Mode is activated.

Operating scheme of these light shall be submitted during design stage to CMRL for approval. This light shall be continuously switched on in all modes of operation and even during train switched off condition.

8.6 UTO OPERATION

8.6.1 All the exterior and interior lighting of the trains shall be fully automatic and can be remotely override from RSC consoles of OCC, BCC & DCCs.

8.6.2 The design of train lighting system and its relevant components in train shall support for the UTO / GoA4 in the CMRL Phase 1 & Phase 1 extension network defined in Chapter 1. Trains shall be operated in GoA2 / ATO mode during the initial stage of commissioning and revenue operations and in GoA4 / UTO subsequently. Hence all the feed-backs, information and train controls which are available on TCMS screen shall also be available in OCC (operational control Centre) and DCC (Depot Control Centre) for smooth operation of passenger service. The Contractor shall submit the details of controls to be provided in OCC & DCC for review and approval of CMRL.

9. AUXILIARY ELECTRICAL EQUIPMENT

9.1 NOT USED

9.2 GENERAL

9.2.1 Auxiliary power requirements are described for One Unit of 3 cars (DMC + TC + MC) considering 6 car rake consists of two identical 3 car units for the purpose of auxiliary power supply distribution scheme. The auxiliary power supply shall consist of two static converter & inverters, two back-up batteries & two battery chargers. The Auxiliary Converter shall be suitable for operation at 25 KV AC input supply at pantograph level with the input supply frequency variation from 47~52 Hz and voltage variation from 19~31kV. The failure of auxiliary power supply equipment shall be communicated to TCMS / OCC / BCC. Failure / isolation of main converter shall not cause any reduction in performance of auxiliary converter-inverter. The auxiliary power supply system shall be configured such that it performs reliably for all operating train consists.

9.2.2 The auxiliary power supply distribution scheme shall be so configured that One Unit of 3 cars (DMC + TC + MC) has two sets of auxiliary power supply equipment. When either operator's cab is activated, complete Rake auxiliary converter inverters shall be operated and equally share the entire 100% auxiliary load of a 6 car train. All the auxiliary power supply equipment in the train shall operate parallel with synchronised control. In the event of failure of any One auxiliary power supply equipment in 6 car train, the remaining three Auxiliary power supply system shall share the entire loads of 6 car train. In the event of failure of Two auxiliary power supply equipment in 6 car train, the Two auxiliary power supply equipment must be capable of supplying all auxiliary loads to complete 6-car train except for VAC load which shall work at 50% of the rated capacity.

The auxiliary power supply equipment(s) shall be capable of supplying the specified loads under Normal and Failure mode as explained below:

Failure condition	Load fed by Auxiliary Converter Inverter	No. of healthy Auxiliary Converter Inverter	3-phase bus line isolation contactor status
Normal	Full auxiliary load	4	Close
One Aux. CI (SIV) failure	Full auxiliary load	3	Close
Two Aux. CI (SIV) failure	Full auxiliary load except 50% of HVACs in cooling mode in each car. (50% VAC units shall be operated in cooling mode and other 50% VAC units shall be operated in ventilation mode with fresh air damper closed condition)	2	Close
Three Aux. CI (SIV) failure	Full auxiliary load except all HVACs in ventilation mode	1	Close
Ground fault or short circuit of bus line	Full auxiliary load in healthy 3-car unit	2	Open

9.2.3 Suitable protection and warning systems shall be provided to enable a trainset to complete its journey before withdrawal from service in the event of a battery charger failure and/or battery failure. The failure of an auxiliary power supply shall be communicated to the train operator (if

- 1 onboard) and as well as to TCMS / OCC / BCC / DCC.
- 9.2.4 The Auxiliary converter inverter system and associated equipment shall comply with the power circuit design. The redundancy level within the auxiliary power system shall be proposed by the Contractor as per clause 9.3.14.
- 9.2.5 Regenerated power should support the same train's auxiliary output load first and then feed to the OHE supply system. It shall be possible to record and monitor the breakdown of actual regenerated power supplied back to the OHE system versus the actual regenerated power utilized by train. The train's overall power consumption drawn from the OHE as well as the individual power consumed by each auxiliary converter inverter and Propulsion system shall be accurately measured, recorded and displayed on the TCMS DDU, RSC consoles of OCC, BCC & DCCs.
- 1 The regeneration in the train shall be made available and upto zero kmph speed of the train, so as to achieve smooth and accurate stopping of the train. The design of such electrical braking shall be proposed at the design stage for verification by CMRL.
- 9.2.6 The design life of the auxiliary converters shall be a minimum of 35 years and be capable of operation for a period of 18 years without major maintenance (excluding consumables).
- 9.2.7 Not used.
- 9.2.8 The Auxiliary Converter Inverter system shall meet all the criteria defined in Chapter 14.
- 9.2.9 All electrical and electronic components of Auxiliary Converter & inverter system shall comply with the EMC and EMI requirements of EN 50121 (all parts), IEEE 16, EN 5501, EN 1 and IEC 61000-4 standards or other equivalent international standards. The requirements of EMC EMI referred in clause 2.18 & 10.19 shall be met.
- 9.2.10 Fire properties of the materials used shall comply with EN 45545 part 1 to part 7 latest editions (Category 4-A, Hazard level HL3) as a minimum or better international standard applicable for similar Metro applications. Requirements of clause 2.26 shall be met.
- 9.2.11 A minimum 10% additional spare shall be installed in train for MCBs, cables in looms, internal wiring, terminal block connections, free terminals in the control relays.
- 9.2.12 All electrical cabinets shall have free space of at-least 20% for fitment of any additional equipment anticipated in future.
- 1 9.2.13 All MCBs shall have auxiliary contacts and shall be utilized for communicating the working feedback of the MCBs to TCMS and to RSC consoles of OCC, BCC & DCCs.
- 9.2.14 All the equipment and cables installed inside the electrical cabinets shall be adequately ventilated throughout all the operational conditions of the train.
- 9.2.15 Material requirements shall be compliant with Chapter 19.
- 9.2.16 The connecting hoses, jumper cables and other electrical conduits between cars shall be secured with adequate spacing between the adjacent train components, adjacent cables / conduits / hoses to prevent chafing during train operating and coupling / un-coupling conditions.
- 9.2.17 All the cables which are traversed from underframe to coach, coach to roof & vice-versa shall be adequately provided with cable glands and seals such that it shall prevent the ingress of water, vermin, dust, fire, noise to interior of the saloon from exterior environment.
- 9.2.18 The process of cable laying in various cable ducts inside train, underframe & roof cable ducts shall be proposed to CMRL for approval.
- 9.2.19 All the panels of electrical cabinets of train shall be mounted such that, there shall be easy access to the internal equipment. There shall not be requirement to remove any rigid mountings to access any equipment inside any of the electrical cabinets.
- 1 9.2.20 The output of the auxiliary power supply shall ensure that, after restoration of power following passage through a neutral section, the HVAC system is automatically restarted and is fully functional in the same operating mode and settings as before entering the neutral section, prior to the train doors opening at the next station.

9.3 AUXILIARY CONVERTER INVERTER

- 9.3.1 The auxiliary converter inverter shall utilize metro transit-proven modern solid-state technology (IGBT or Latest better technology) and shall be designed and constructed in accordance with the requirements of IEC 61287-1 and IEC 60146. Power semiconductors shall be mounted on grounded heat sinks. Under all normal and emergency operating conditions, the peak junction temperatures shall not exceed 90% of their declared peak ratings. Natural or forced cooling shall be offered. The Contractor shall ensure interior and exterior Noise requirements for all individual equipment operation and collective equipment operation scenarios as mentioned in the clause 2.17.
- 9.3.2 Electronic equipment used in Auxiliary Power System shall be designed and constructed in accordance with the requirements of IEC 60571 and EN 50155.
- 9.3.3 The auxiliary converter inverter shall be capable of withstanding the full voltage range of the traction voltage supply (Minimum to Maximum voltage range) in the time duration as specified in IEC 60850 for 25 KV 50 Hz system and shall maintain the outputs as specified as per the clause 9.3.10.
- 9.3.4 The auxiliary converter shall be independently supplied from main transformer, with respect to the traction converter supply. The auxiliary converter shall receive its power from a separate winding in the Traction Transformer. The output voltages of Auxiliary converter inverter system shall be as follows:
- | | |
|----------|----------------------|
| Output 1 | 415 V 50 Hz 3 ϕ |
| Output 2 | 230 V 50 Hz 1 ϕ |
| Output 3 | 110 V DC |
- DC voltage supply requirements mentioned in EN 50155 shall be met. The Contractor shall submit the operating characteristics and a load analysis for the Low Voltage Power Supply and for all Output levels proposed in this clause.
- 9.3.5 Each auxiliary converter inverter shall be connected to the main transformer supply by means of an independent main fault isolation device, which automatically isolates the Auxiliary power system in the event of any fault conditions like (but not limited to), Output current overloads, Output over voltage, Input over voltage, Output frequency out of range, Earth fault on loads of auxiliary converter inverter, Short circuit faults on loads of auxiliary converter inverter.
- 9.3.6 The auxiliary converter shall be capable of maintaining full output during the incoming traction supply working range as specified in clause 9.3.3 and for the input frequency varying from 47~52 Hz and shall not suffer any damage in the event of the traction supply voltage exceeding its normal working range and operating in range as specified in clause 9.3.3.
- 9.3.7 The auxiliary converter inverter shall provide both auxiliary DC and AC voltage supplies. The Contractor shall submit for CMRL's review and approval the voltage-drop calculations. The DC supply shall provide control supply power for all control circuits and the auxiliary DC circuits, including battery charging.
- 9.3.8 The design and installation of the auxiliary converter inverter shall ensure continuous operation of the auxiliary supplies, notwithstanding any interruption to the 25 KV main traction supply on any live section. The Contractor shall submit calculations to verify auxiliary electrical system's failed-train rescue capability.
- 9.3.9 While traversing neutral section in the event of momentary non-availability of 25 KV traction supply during service, all the essential loads specified in clause 9.4.2, the emergency lights, cab lights, headlights, control systems, passenger communication systems, supply to Signalling & telecom equipment [OCC / BCC to train interface & DCC to train interface](#) shall work normally. The system shall have the in-built capability to distinguish the difference between normal power outage and when travelling in Neutral section region.
- 9.3.10 The auxiliary converter inverter AC output voltage of 3 ϕ supply shall be regulated within $\pm 5\%$ of the nominal voltage and output frequency within 48~52Hz over the full load range. At individual Auxiliary converter inverter output level, Total Harmonic Distortion (THD-V) in voltage shall be

limited to 3% under all operating conditions for the individual Auxiliary Converter Inverter. Phase to phase imbalance shall not exceed more than 1% between phases. The converter shall be designed and constructed in accordance with the requirements of IEC 61287 and IEC 60146.

- 9.3.11 The auxiliary converter inverters shall be continuously rated to provide full auxiliary load on one unit (DMC + TC + MC) plus other loads specified under paragraph 9.3.4, 9.4.2, 9.4.5, 9.5 and 9.10. Full auxiliary load shall include charging of a discharged battery to 80% of the full charge within 4 hours.

- 9.3.12 The fault isolation device specified in clause 9.3.5 shall be capable of frequently interrupting the maximum operating line current with minimal deterioration. The Contractor shall submit for CMRL's review and approval the description of operating characteristics, load analysis, and voltage interruption analysis for the Auxiliary Converter Inverter. Activation of the isolation device shall only isolate the associated auxiliary converter inverter and not either the traction converter system or second auxiliary converter inverter. Control facilities shall be provided from TCMS, OCC & DCC to reset the fault isolation device. Also, it shall be possible to isolate and reset the Auxiliary Converter Inverter from TCMS, RSC consoles of OCC, BCC & DCCs in case of the occurrence of Major Faults.

- 9.3.13 In the event of an interruption of the 25 KV input traction supply, the auxiliary converter inverter shall automatically re-start safely once the traction supply is re-established, provided that the auxiliary converter inverter has previously been started.

- 9.3.14 ~~Not used:~~ Failure of three auxiliary converter inverter together shall not immobilize the train. The Contractor shall submit data on the redundancy level proposed for the auxiliary converter-inverter and shall explain the degraded modes operation philosophy of auxiliary converter inverter. Individual auxiliary converter inverter system of the 3 car unit (DM+T+M) shall be capable of connecting to 50% of the auxiliary loads in each car of the respective 3 car unit.

In the event of a failure of any one auxiliary converter inverter in the train, 100% auxiliary loads of each car of 6 car train shall continue to operate in normal operation.

In the event of failure of any two auxiliary converter inverter in the train, there shall be no reduction in other 3-phase & 1-phase loads and it shall not cause the loss of any essential load specified in clause 9.4.2, saloon lighting, feed extension for battery charger, main transformer oil flow pump, cab VAC, blower fans (if applicable) and shall not cause loss of 50% of VAC Units in each car. In this condition, each car's, 50% VAC units shall be operated in cooling mode and other 50% VAC units shall be operated in ventilation mode with fresh air damper closed condition.

Also, failure of any one auxiliary converter inverter shall not affect the operation of the other auxiliary converter inverter. This system shall be designed with proper wiring in between all 6-cars and with the help of adequate car to car jumper cables. Degraded modes and philosophy of degraded operations shall be proposed by the Contractor. Entire operation described in this clause shall occur without any power interruption to the train.

- 9.3.15 The auxiliary converter inverter shall be designed and constructed to provide galvanic isolation between the traction supply input and the auxiliary converter inputs. The auxiliary converter inverter shall provide power supply to all auxiliaries including ventilation blower motor, air-conditioned units, air compressor, doors, lighting equipment, communication equipment, signalling and telecom equipment, control units, pantograph control, and low voltage loads. The Contractor shall submit calculations to verify auxiliary power generation and distribution system capability. The entire AC & DC loads of one unit (DMC + TC + MC) shall be evenly distributed among both the Auxiliary converter inverters.

- 9.3.16 Staggered starting and switching off shall be provided between auxiliary power loads on the train to minimize starting and stopping load currents. The Contractor shall submit the calculations for load start and stop sequencing analysis.

- 9.3.17 EMC – EMI requirements:

EMC and EMI of the equipment of Auxiliary power system and related compatibility and immunity interface with the train external and train internal environment shall follow according to EN 50121-2, EN 50121-3-1, EN 50121-3-2 and EN 50121-4.

- 9.3.18 All hinged doors of the Auxiliary converter inverter shall be openable from bottom to top direction

and shall be provided with suitable supports and earthing & grounding cables.

- 9.3.19 The IP protection level of the Auxiliary Converter Inverter shall not be less than IP 65. The connectors shall have IP 67 protection. The cooling arrangement shall ensure no dust deposition on the component and associated electronics.

9.4 CIRCUIT REQUIREMENTS

- 9.4.1 The main auxiliary circuits shall be segregated into essential loads, and non-essential loads. Essential loads are also called as emergency loads or safety loads.

- 9.4.2 Emergency loads or Safety loads or essential loads shall include, but not be limited to:

- a) All Safety Critical circuits (e.g. emergency brake);
 - b) Passenger door controls / operation & Saloon to Cab door control / operation.
 - c) All exterior lighting of train.
 - d) All exterior & interior indicating lights of train.
 - e) Cab interior lights.
 - f) Complete saloon lighting (100% lights)
 - g) Complete communication equipment.
 - h) ATO / ATP / UTO (GoA4) train borne signalling & telecom equipment control.
 - i) ~~Not used-~~ Equipment involved in Train preparation in UTO mode of operation.
 - j) Emergency ventilation, Ventilation blower fans.
 - k) All sensors and controls of train
 - l) Passenger emergency communication equipment,
 - m) Traction and braking system control.
 - n) All train networks.
 - o) ~~Not used-~~ All equipment of Train communication to & from OCC, BCC & DCCs.
 - p) All systems and equipment involved in train rescue operation and in passenger evacuation as per clause 9.10
 - q) Communication systems including public address, passenger emergency alarm, train radio, interior & exterior surveillance system & their recording.
 - r) TCMS.
 - s) Train Horn.
 - t) Driving console indicators, isolation switches and interlocking in master controller.
 - u) Pantograph, VCB, master controller controls
 - v) Windshield Wiper operation
 - w) Functionality of DMS, RTR-DMS & Event Recorder systems as defined in clause 14.11 & 14.13
 - x) Any other train operation which the Contractor feels necessary during emergency conditions.
- 9.4.3 All auxiliary power circuits shall be provided with suitable independently rated MCB circuit protection devices and the coordination of protection devices shall be done. The Contractor shall submit data demonstrating coordination of protection devices.
- 9.4.4 Fuses: Miniature Circuit breakers shall be used for circuit protection wherever possible. Fuses may only be used, with the CMRL's approval, where the use of Miniature circuit breakers is either impractical or inappropriate.
- 9.4.5 Protection and diagnostics
- a) Control circuit logic shall permit testing and monitoring of the auxiliary power system during its operation in static and dynamic conditions of train.
 - b) Protection against single phasing and short-circuiting shall be incorporated into the auxiliary converter feeding 415V, 50 Hz auxiliary drives. The output supply for AC 3 ϕ loads, 1 ϕ loads and

for 110 VDC shall be protected with individual earth fault current leakage detection and protection system which are individual to car and also individual to the voltage level. All the sub-systems of the train shall be considered for designing the detection and protection from the earth fault currents. There shall not be any un-detected earth fault occurrence in train. The proposal for the detection and protection from earth fault currents shall be submitted by the Contractor. This system of earth fault detection and earth fault protection shall not interfere with normal working of train or any other short circuit protection of train.

- c) The auxiliary power control system shall carry out self-tests to ensure the integrity of the equipment. Sufficiently detailed status, fault and diagnostic information shall be transmitted to the Diagnostic and Monitoring System (DMS) to enable protective or corrective action to be taken immediately when necessary. The Contractor shall submit data on the design and functionality of auxiliary electrical system diagnostics.
- d) The auxiliary converter shall use a control scheme that contains extensive self-diagnostics logic, which shall be fully integrated with DMS. At a minimum, the diagnostics system shall identify a range of credible faults, identify whether a Least Responsible Unit (LRU) is responsible for the fault, and whether the LRUs (or non-LRUs) must be replaced, or the system merely reset. The diagnostics system memory shall be retained for at least 1000 events and shall be controlled in FIFO methodology. The Contractor shall submit for CMRL's review a list of faults and functional description of fault logging. The Contractor shall also submit for CMRL's review a list of faults and functional description of trace recording system.
- e) ~~The train operator from the cab shall be able to isolate any defective auxiliary power supply equipment. It shall be possible to isolate and reset the Auxiliary Converter Inverter from TCMS in case of occurrence of Major Faults.~~
 The rake operator from the cab and operators from RSC consoles of OCC, BCC & DCCs shall be able to isolate any defective auxiliary power supply equipment. It shall be possible to isolate and reset the Auxiliary Converter Inverter from TCMS, RSC consoles of OCC, BCC & DCCs in case of occurrence of Major Faults.
- f) All auxiliary power equipment shall be easily accessible for inspection, testing and maintenance.
- g) Contactors of auxiliary converter inverter system shall be rated for maximum current capacity and overload interruption capability.
- h) Condition that the auxiliary converter-inverter has been started previously, in the event of an interruption of the primary power supply including loss of contact of pantograph with catenary, the auxiliary converter-inverter shall automatically re-start once the input power has been re-established.
- i) Contactors shall be rated for maximum current capacity and overload interruption capability.
- j) Electrical protection shall be available for all circuits of each train to prevent any short circuiting or spike in voltage or current while conducting electrical coupling of two trains as specified in clause 9.10.
- k) Protection scheme for auxiliary converter-inverter shall include but not limited to:
 - i. Output Over current detector.
 - ii. Input Over voltage detector.
 - iii. Input low voltage detector.
 - iv. Converter fault output.
 - v. Over temperature of semiconductor.
 - vi. 1 ϕ detector.
 - vii. Inverter fault output.
 - viii. Output AC over voltage detector.
 - ix. Output AC low voltage detector.
 - x. AC output short circuit current detector.
 - xi. Control power supply failure.

- xii. Over voltage of inverter circuit.
- xiii. Over current of inverter circuit.
- xiv. Synchronous fault detector
- xv. Starting failure.
- xvi. Ground fault detector.
- xvii. Output DC over voltage detector.
- xviii. Output DC over current detector.
- xix. Output frequency out of range.
- xx. AC earth fault.
- xxi. DC earth fault.

The settings and calculations of above-mentioned protections shall be discussed and finalized during Pre-Final Design Stage

- 9.4.6 The box for auxiliary converter shall be such that to avoid any corrosion throughout the service life on any account the box shall last for the lifetime of the auxiliary converter unit without needing any attention. The auxiliary converter shall be housed in a container, which is mounted under floor, The material of the container shall be made of stainless steel or aluminium such that the boxes, covers and anti-corrosive coating above them shall last for 35 years. The Contractor shall also provide a declaration for the same during the design stage. The box cover which may have to be removed for maintenance shall be suitable secured against falling. All hinged doors of the box shall be openable from bottom to top direction. The usage of bolts, washers and fittings shall be such that they shall be retained on the panels when the panels are opened.

1

- 9.4.7 An industrial type 415 V, 50 Hz, 3 ϕ socket with spring loaded covers, capable of accepting a shore supply shall be provided on Auxiliary converter inverter at sole bar level, on both sides of the converter. Each socket shall be accompanied by a red lamp, to warn of live sockets, when a shore supply is plugged in. The TCMS control shall ensure that all auxiliary loads are not switched on all at once and the logic shall be proposed by the Contractor for review and approval by CMRL. The Contractor shall also ensure that rake traction is not possible when shore supply is feeding the rake. There shall be an indication in TCMS, [RSC consoles of OCC, BCC and DCCs](#) that the train is in shore-supply powered condition. The design and type of interface connector plug shall match with the train socket design & rating. This detail shall be submitted to CMRL for review and approval. 50 number of depot side shore supply cable of each 25 meter with wall connector sockets, with their mating connector plugs for both ends of the shore supply cable (Train side and depot Shore supply side) shall be supplied by RS Contractor and handed over to the Designated Depot Civil / MEP Contractors' for installation in all depots of the CMRL Phase 1 & [Phase 1 extension](#). The actual number of connectors and length of connecting cables shall be finalized during the design stage for compliance. Rolling stock Contractor shall interface with Depot Civil / MEP Contractor for the proper installation of these mating connectors at the Designated Depot(s). RS Contractor shall submit the voltage and current requirements for these connectors to the corresponding Civil / MEP Depot Contractor.

1

- 9.4.8 The shore supply shall have sufficient capacity, rating and provision to enable CMRL's maintenance personnel to test all auxiliary equipment in one unit (DMC + TC + MC) during shore supply connected condition. Shore power supply connectors of adequate capacity shall be provided at diametrically opposite convenient locations on either side of the car. The Contractor shall submit data on the design and type of interface connector for shore supply and supplier mating contactors.

- 9.4.9 Auxiliary Domestic AC Supply and USB-C Charging Points

- a) Each car shall be provided with two numbers (Preferably at both ends of each car) of 1 ϕ 230 VAC 50 Hz domestic type switched socket outlet fitted with an independent Circuit breaker that is compatible with Indian electrical standards. The electrical supply shall always be available provided the associated auxiliary converter inverter is operating. This socket shall be utilized for the powering of vacuum cleaners and other high powered train cleaning equipment. This specific socket in each car shall be rated with minimum 15 A current rating.

- b) The auxiliary supply socket shall be located within the saloon, positioned to avoid inadvertent contact by heavy objects and shall be physically protected by means of a lockable cover when not in use. Access to the socket shall be achieved by the use of the door access key.
- c) The socket shall be protected by means of single MCB rated at 15A and an associated residual current device.

- d) ~~Sixteen number of High power USB-C PD sockets rated to at least 65W that are capable of charging laptops / mobile shall be provided in each cars. Details on location of USB charging ports shall be submitted by the Contractor during PFDR stage.~~

At least 4 no. of high-power USB-C PD sockets (modular type) rated to at least 65W that are capable of charging laptops shall be provided at both ends of the cars.

- e) Further, at least 16 no. of USB-C PD mobile charging sockets (modular type) shall also be provided for passenger use. These shall be rated for charging of Mobile devices and shall be provided near all saloon seats. Sockets shall be flush mounted with and of the same colour as the surrounding panel to ensure pleasing aesthetics.

- f) Details on quantity and location of USB charging ports shall be submitted by the Contractor during the design review and approval of the Employer / Engineer.

- 9.4.10 For maintenance purposes, there shall be additional by-pass ground switch in auxiliary converter inverter box duly interlocked with safety locks. The Contractor shall submit the detail document for CMRL review during design stage.

Smoke detectors / Heat detectors / LHD / other better heat detection systems shall be provided inside the Auxiliary Converter Inverter boxes, battery charger and in battery control box. The status shall be linked to TCMS and communicated to RSC consoles of OCC, BCC & DCCs as Audio and Visual Alarms. Smoke and Heat detection system referred in clause 2.26 shall be complied.

- 9.4.11 LED based lighting arrangement shall be provided in the auxiliary converter inverter box for maintenance purpose. Its failsafe interlocking with the box cover shall be ensured.

- 9.4.12 All auxiliary converter-inverters shall be identical, interchangeable and under frame mounted. All internal items of the equipment shall be easily accessible and detachable, with the converter inverter “in situ”, to facilitate maintenance.

- 9.4.13 Input power factor of auxiliary converter-inverter shall be near unity under all load conditions. Under no condition the Auxiliary converter inverter shall behave as capacitive load and shall not export reactive KVAR into the system.

- 9.4.14 Provision for single point upload of all software for Auxiliary converter inverter shall be provided from the TCMS of the train. Auxiliary Converter Inverter System shall meet the requirements of Real Time Remote Diagnostic Monitoring System (RTR-DMS) as mentioned in clause 14.11 & 14.13.

- 9.4.15 The DC output provided by the auxiliary converter inverters shall be arranged to ensure that neither the control nor the battery charging supplies are lost in the event of a failure of a single auxiliary converter inverter. This shall occur without any interruption or spike on the existing DC voltage supply.

- 9.4.16 High voltage spikes or transients on the external 25 KV main traction supply shall not be transmitted to the auxiliary converter inverter outputs. The auxiliary inverter shall not suffer any damage or malfunction, when subjected to surges and transients and the worst case surges during train testing or in revenue service operation. All electrical and electronic equipment shall be protected against surge or transient voltages caused by switching (internal or external to the Rolling Stock), lightning discharges and line voltage disturbances by the provision of suitable filters or surge suppressors.

- 9.4.17 Conditions of external transients shall not cause data / memory loss of any electronic equipment inside the train.

- 9.4.18 The opening / closing of the auxiliary converter inverter panel shall be interlocked with Earthing Locking Switch and pantograph isolation of the train through interlocking keys, so that converter panels cannot be opened when HV voltage is available in the train. Refer clause 10.4.2 for

compliance.

- 9.4.19 The procedure for safely accessing the micro-processor cards of the Converter Inverter shall be provided by the Contractor.

9.5 EMERGENCY SUPPLY FEEDING

1 9.5.1 ~~In the event of failure of any auxiliary power supply equipment on one unit (DMC + TC + MC), the remaining auxiliary power supply equipment must be capable of supplying auxiliary power for 50% of all loads per each car in one unit (DMC + TC + MC), which includes categories of 3φ & 1φ supply. However, 100% DC power supply in all cars at 110 VDC loads, all emergency, safety and essential loads on the complete one unit (DMC + TC + MC) shall function in this condition. In this scenario, this healthy Auxiliary converter inverter shall supply a minimum of 50% of all the VAG units of each car of the train and shall maintain proper comfort of passengers in the train as mentioned in clause 9.3.14. Deleted.~~

- 9.5.2 The power supply provided, under this failure condition, shall be sufficient for all of the safety and essential loads, with the exception of battery charging associated with the failed converter inverter.

- 9.5.3 Safeguards shall be provided to prevent any battery from being electrically connected in parallel with any other and from feeding into another battery under emergency supply feeding conditions and during electrical rescue conditions as specified clause 9.10.

1 9.5.4 ~~Not used.~~ The Contractor shall propose the list of loads which shall be permanently connected to battery and which are required for train start up e.g. UTO train preparation loads, Pneumatic Horn, Pantograph air compressor, cabin interior lights, external parking lamps, various contactors, etc. The Contractor shall also submit the complete rating of the permanent loads on the train.

9.6 BATTERIES AND BATTERY CHARGERS

- 9.6.1 The battery shall be charged from the local (Specific to Auxiliary converter inverter) static battery charger. The battery charger with automatic control shall be capable of providing a high rate of booster charge or float charge that is compatible with the characteristic of the proposed battery technology.

- 9.6.2 The battery charger shall be capable of charging a discharged battery to 80% of full charge within 4 hours. Once the battery is fully charged, float charge shall be regulated as per the recommendation by Battery supplier. In case it continues it shall be reported / logged in TCMS. The Contractor shall submit for review and approval the design calculation for battery charger rating.

1 9.6.3 The battery shall be rated and tested as per IEC 60623, IEC 62973 and IEC 60993. The battery shall supply Emergency load (also called as Safety loads or Essential loads) for at least ~~90 minutes~~ 60 minutes (with ALL doors open and close every two minutes) in case of failure of battery charger or its supply with battery charged to a level as expected during service but not better than 80% of its full capacity. Contractor shall also demonstrate that at any time of service, stage of charge shall not be less than 80%, before the voltage level at any device falls below 77 VDC Non-essential load shall be shed after 30 seconds of failure of battery charge supply. ~~The Contractor shall submit for review and approval the load application and shedding analysis.~~ This feature shall be demonstrated during testing.

The battery shall be capable of maintaining full DC loads when the train runs over neutral sections.

Battery supplier shall interface with Auxiliary Power Supply (APS) supplier to ensure that charging of battery charger meet the requirement of battery charging and charges the battery to provide backup of 90 minutes.

Emergency loads shall include, but need not be limited to:

- i) Emergency lighting.
- ii) All Exterior lights.
- iii) Emergency Ventilation but not air conditioning.

- iv) Communication systems including public address, passenger emergency alarm, surveillance system and train radio.
 - v) Propulsion and brake controls.
 - vi) Door controls.
 - vii) TCMS.
 - viii) Electric horn.
 - ix) Driving console indicators, lighting and interlocking.
 - x) ATP train borne equipment.
- 9.6.4 The Contractor shall propose battery of NiCd, Lithium Based, Sib and/or latest better technology for CMRL approval. It shall have a low discharge current and long stand-by time and shall comply with the requirements of IEC 60623 & IEC 62973 or IEC 62928, IEC 62620 & IEC 62619 or equivalent.
- 9.6.5 The battery shall commence supply to the emergency loads automatically upon positive detection of loss of traction power supply.
- 9.6.6 Minimum life expectancy of at least 15 years at local ambient temperature, recharge time, safety margin, etc. shall be considered for the sizing and matching of the battery charger and the batteries.
- 9.6.7 The materials used for construction of battery cells, cables used within battery box and other battery box components shall be flame retardant and halogen free as per requirements of clause 2.26. The design shall be submitted for CMRL approval.
- 9.6.8 It shall be possible to charge the batteries externally or from one train to other with suitable cables and connectors.
- 9.6.9 The proposed design of the battery (including the selected chemistry, capacity and control functions) shall ensure the battery will always have sufficient charge remaining to successfully wake-up the train and raise either of the pantographs immediately after either of the following two (2) scenarios.
- i) The train was put into Sleep-Mode #
 - ii) The train is being restarted from OFF condition after a shutdown was ordered due to low battery voltage detection
- # Note: 24hrs is the minimum duration of Sleep Mode condition which must be achieved (and demonstrated by the Contractor) before the battery charge depletes to the level where the voltage supervision orders a full shutdown of the train. Battery voltage supervision shall always be available when the train is in Sleep Mode.
- Detailed Sleep Mode power requirements will be finalized based on the electrical load interface of the Onboard Signalling Requirement during the Design Stage.
- 9.6.10 Adequate circuit protection shall be provided to ensure the battery load shall be disconnected when the battery voltage has dropped below 75% of the nominal voltage. When the auxiliary load is re-connected, the initial battery load shall not cause the battery output to oscillate.
- 9.6.11 Battery electrolyte capacity shall be such that the batteries will not require topping up more than once in a year. Battery re-conditioning shall not be required before four years. Complete calculation of loss of water and float / boost charging shall be submitted. Batteries shall be designed with integrated topping up provisions. Suitable interconnection shall be provided so that topping up of all the cells can be carried out using from a single point on battery box. The design shall be submitted for review of CMRL.
- 9.6.12 For the calculation of sizing of battery at high and low temperature, ageing de-rating factor and charging de-rating factor shall be considered and calculations shall be submitted to CMRL during detailed design stage.
- 9.6.13 The battery terminal voltage shall float on the 110V DC output of the auxiliary power supply of which the output voltage shall have fine adjustments and good stability to avoid over charging or undercharging of the battery.

- 9.6.14 The control elements taking power from the battery shall be capable of operating between 77~138 VDC. The instantaneous battery voltage shall be monitored and recorded through TCMS.
- 9.6.15 Not used.
- 1 9.6.16 All the trains shall provide real time information of the Battery voltage, battery current, charging indication, discharging current, etc. in TCMS, OCC & DCC. It shall be possible to monitor and download these parameters in graphical manner from the TCMS, DCC & OCC.
- 9.6.17 Battery Protection and Isolation:
- a) Battery fuses of suitable rating shall be fitted in a separate box located adjacent to one of the battery boxes and shall enable easy access from track level.
 - b) Back connected fuse holders shall be provided and the battery fuse enclosure shall be sealed to IP65 in accordance with IEC 60529.
 - c) A battery contactor operable from inside the cab shall be provided to disconnect the battery from the car wiring electrically, when required.
 - d) A low voltage earth bar shall be provided and located close to the negative fuse.
 - e) The status of fuse and circuit breakers shall be monitored by TCMS.
 - f) The circuit breakers shall be controlled by TCMS.
 - g) Battery temperature and the health of battery shall be displayed in TCMS.
- 9.6.18 Battery shall be discharged and recharged for more than 2000 cycles.

9.7 BATTERY BOX

- 1 9.7.1 The battery compartment shall be a separate enclosure suspended from the under-body of the car and mounted in a suitable sliding pullout arrangement to facilitate maintenance. The battery mounting tray when rolled outside the train shall be self-balanced ~~and shall not require any external support or stand beneath to rest when it is removed / slide out~~ for conducting any maintenance or testing work. The battery box shall be made of stainless-steel material. The roll out system shall be corrosion resistant and shall be provided with the necessary stops and locks to limit the travel of the battery box and retain it in both extreme positions. When rolled out, the entire top portion of the battery shall be exposed. All the battery terminals, including battery positive and negative main connections shall be easily accessible for maintenance work. All hinged doors of the box shall be openable from bottom to top direction and shall be provided with suitable supports. All hinged doors of the battery box shall have adequate earthing and grounding system.

1 In case of using an external extraction tool, prior approval of CMRL to be obtained. The complete design for ensuring safe handling, reliability, and easy maintenance without compromising the quality and accessibility to be submitted for CMRL review and approval.

- 9.7.2 The tray shall incorporate a secure quick release latching mechanism to prevent the tray from inadvertently sliding out. The latching mechanism shall be easily identifiable in the release position.
- 9.7.3 A secondary safety latching mechanism shall also be provided to restrain the tray in the event that the primary latching system has not been correctly secured or has failed in service.
- 9.7.4 Activation of the latching mechanism shall not require the use of any tools or keys.
- 9.7.5 The battery compartment shall be naturally ventilated with the provision for dispersing any gas evolving from the battery without affecting the floor or the underframe in any way.
- 9.7.6 The battery cells shall be assembled in fireproof insulated crates and each cell shall be positively located within its crate. The Battery cell casings shall be made of robust flame- retardant material.
- 9.7.7 The battery compartment floor shall be shaped to direct any electrolyte spillage to a liquid drain plug, which shall discharge the spillage outside the train under-frame.
- 9.7.8 The box interior / the roll out trays shall be lined with a non-flammable, electrolyte proof, insulating material of suitable thickness. The box shall be ventilated to preclude the possibility of built-up of

any gas. Vibration proof automatic lock shall be provided to ensure no relative movement of the batteries inside the tray.

- 9.7.9 Battery Box access locks shall be interlocked with the isolation switch of the Battery Box. Battery terminals access shall only be available after the battery is isolated. Similarly, the Battery supply can be made Normalized only after Battery box is completely locked.
- 9.7.10 Battery box shall not de-shape/sag during lifetime of the car. Adequate strength shall be built in the battery box by providing suitable ribs etc. FEM & fatigue report of the battery box shall be submitted to establish the same.

9.8 BATTERY ISOLATION

- 9.8.1 The battery shall be provided with means of electrical protection, by adequately rated fuses placed in both the positive and negative poles. Battery shall also be protected using circuit breaker. These fuses and circuit breaker shall be mounted as close to the battery as possible. The status of fuse and circuit breakers shall be monitored by TCMS.
- 9.8.2 To facilitate maintenance, an isolation switch shall also be provided as a manual means of electrically disconnecting the battery from any Vehicle wiring. This isolation switch shall be accessible from outside the train from Track level.
- 9.8.3 The isolation switch shall be mounted on the under-body, with the battery fuses, in a suitable independent enclosure or an integral part of the battery box and shall be accessible from outside.
- 9.8.4 The enclosure shall be located as close as possible to the battery and shall enable easy access to the isolation switch actuator from the track level.
- 9.8.5 The switch shall have a suitable in-built locking mechanism in Normal and Isolated positions of battery. The maintenance keys shall be utilized for this locking.

9.9 EARTHING

- 9.9.1 Each car shall be provided with separate insulated earthing bars for DC & AC circuits. The Contractor shall submit for CMRL's review the Earthing and grounding Plan.
- 9.9.2 The earthing connection for any one sub-system or component shall not be combined with that of any other sub-system or component.
- 9.9.3 The negative and neutral of each separate AC and DC circuit shall be connected separately to the corresponding earthing bar of the car in which the power originates.
- 9.9.4 All metallic boxes, cases and enclosures containing electrical equipment, including cable ducts, which are not intended to be part of the live circuit shall be properly earthed with an insulated flexible earth bond to the relevant earth bar. The mounting of relays, CB's, connectors, contactors and any electrical equipment shall be properly earthed to the relevant earth bar. All the locations accessed by passengers and maintenance personnel shall be properly earthed.
- 9.9.5 The removal of any earthed equipment or item shall not interrupt the earthing arrangement of any other remaining earthed electrical equipment.
- 9.9.6 Except for the battery, no protective device shall be inserted in any pole connected to earth.
- 9.9.7 All hinged doors of the Auxiliary power system shall have adequate earthing and grounding system to protect the maintenance personnel from any stray electric currents.
- 9.9.8 The system for the detection and protection from earth fault currents at each individual voltage level and for each individual car shall be designed as specified in clause 9.4.5 (b).

9.10 RESCUE OPERATION

- 9.10.1 The Contractor shall propose the details of controls and equipment which shall be functional in both healthy train and sick train during rescue movement. The auxiliary power system shall be designed considering the rescue operation also.
- 1 9.10.2 The requirements of train during rescue operation shall meet the requirements of [front-end](#)

electrical coupling and jumper cables as per clause 4.6 to 4.9.

9.10.3 During rescue operation, the sick train electrical controls and power supply shall be provided by healthy train. The controls shall consist of minimum the below mentioned operations,

- a) Application & release of all kinds of brake functions in sick train
- b) Communication between two trains' (Healthy and Sick) operators

9.10.4 The power supply shall consist of minimum the below mentioned functions,

- a) Equipment required for application & release of all kinds of brake functions in sick train.
- b) Equipment required for Communication between two trains' (Healthy and Sick) operators
- c) External parking lights for the sick train
- d) Cabin lighting of the sick train
- e) External Head lamps of sick train in case of Push operation by Healthy train.
- f) Windshield wiper supply
- g) Pneumatic Horn supply

All networks and TCMS which are required to achieve these above functions shall be available during rescue mode operation between two trains.

9.11 UTO OPERATION

9.11.1 The design of Auxiliary converter & inverter and its relevant components in train shall support for the UTO / GoA4 in CMRL Phase 1 & Phase 1 extension network as defined in Chapter 1. Trains shall be operated in GoA2 / ATO mode during the initial stage of commissioning and revenue operations and in GoA4 /UTO subsequently. Hence all feedback, information and train controls which are available on TCMS screen shall also be available in OCC / BCC / DCC for smooth operation of passenger service. The Contractor shall submit the details of controls to be provided in OCC & DCC for review and approval of CMRL.

1

10. HIGH VOLTAGE & PROPULSION SYSTEM

10.1 NOT USED

10.2 GENERAL

- 10.2.1 All electrical equipment proposed shall comply with the relevant sections of IEC 60077 part 1 to 4, IEC 60349, IEC 61287-1, IEC 60571 and IEC 60850 or as otherwise specified. The Contractor shall comply with the standstill and line test requirements of IEC 61133 for Rolling Stock prior to handing over to CMRL.
- 10.2.2 The Train shall be propelled by a 3 ϕ AC asynchronous motor drive system / permanent magnet motors / any better proven design with variable voltage and variable frequency (VVVF) Control. The VVVF inverter shall be of pulse width modulation (PWM) type using Insulated Gate Bipolar Transistor (IGBT) or Silicon Carbide (SiC) technology or any better latest technology.
- 10.2.3 The Propulsion and Brake control system shall provide regenerative braking blended with pneumatic service braking as required. Regenerative braking shall be fully compatible with the Overhead power supply system under all train loading conditions. The principal highest priority service brake shall be regenerative braking and its capability shall be maximized.
- 10.2.4 All components and equipment of HV and Propulsion system shall operate according to the traction OHE supply input voltage's maximum to minimum range along with their time durations as defined in IEC 60850 for 25 KV system. Also, all the equipment and components of HV and Propulsion system shall operate in the frequency range as defined in IEC 60850 for 25 KV system.
- 10.2.5 The Traction Braking system shall be predominantly controlled by micro-processor based control systems inter-linked via a communication data bus system. Train propulsion, brakes, auxiliary control, onboard equipment status monitoring, fault data logging and first line diagnostics shall be integrated to TCMS.
- 1 10.2.6 It will be necessary to operate trains manually in case of UTO / Automatic Train Control equipment failure. Hardware interlocking control for safety related circuits of HV & Propulsion system shall be provided. This shall include the safety interlock, emergency brake security control loop, saloon doors and Propulsion system interlock controls.
- 10.2.7 All under frame mounted electrical equipment shall be sealed to IP65 at the exception of the ventilated areas unless otherwise agreed. The enclosures shall not be affected by corrosion in the service life in view of Chennai environment.
- 10.2.8 Two type of cut-out mode operation shall be provided, low speed cut-out mode (25 kmph) shall be provided for Depot operations and High speed cut-out mode (40 kmph) shall be provided for mainline operations.
- 10.2.9 Design of all components of HV and Propulsion system shall be suitable for headway operation requirement as specified in ERTS Clause 1.4.4 in CMRL network.
- 10.2.10 The train configuration shall be 6 car with 67% (2/3rd) motoring axles. The HV and traction converter inverter system shall be designed for this configuration.
- 10.2.11 Usage of sealants shall not be permitted for fitting any roof mounted equipment of HV and Propulsion system.
- 1 10.2.12 During traction and braking commands from signalling in ~~ATO~~ UTO and other non-UTO modes, the train's propulsion electronics and Braking electronics shall coordinate with Signalling software to ensure smooth acceleration and deceleration. Jerk in ~~ATO and all Non-ATO~~ UTO and all Non-UTO modes shall be limited to maximum 0.75 m/s³ in all operating conditions including starting and stopping of train. RS Contractor shall conduct necessary interface with Signalling Contractor.
- 10.2.13 Trains will be operated in two Corridors of CMRL Phase 1 & its Extensions as defined Chapter 1.
- 10.2.14 The Specific Energy Consumption (SEC) of complete train shall be as per the requirements of clause 2.25. The HV and Propulsion system shall be designed as per these requirements.
- 10.2.15 Criteria for interior and exterior noise generated by Train shall be according to clause 2.17. HV

and Propulsion system shall design all the equipment to meet these noise criteria.

- 10.2.16 Minimum achievable acceleration and deceleration values in various traction and braking modes shall be as specified in Chapter 2. The Contractor shall interface with Signalling Contractors for achieving this requirement.
- 10.2.17 Not used.
- 10.2.18 HV and Propulsion System functions has to meet the all the criteria defined in Chapter 14.
- 10.2.19 All electrical and electronic components shall comply with the EMC and EMI requirements of EN 50121 (all parts), IEEE 16, EN 55011 and IEC 61000-4 standards or other equivalent international standards. The requirements of EMC EMI requirements referred in Section VI A ERTS (RS) Chapter 10.19 & 2.18 of the Rolling Stock shall be met.
- 10.2.20 Fire properties of the materials used shall comply with EN 45545 part 1 to part 7 latest editions (Category 4-A, Hazard level HL3) as a minimum or better international standard applicable for similar Metro applications. Requirements of clause 2.26 shall be met.
- 10.2.21 Material requirements shall be compliant with the requirements of Chapter 19.
- 10.2.22 High Voltage & Propulsion system requirements are described in this chapter is for One Unit of 3 cars (DMC + TC + MC) considering 6 car rake consists of two identical 3 car units for the purpose of High Voltage & Propulsion system distribution scheme.
- 10.2.23 As the train is designed for operation in all GoA1, GoA2, GoA3, GoA4 and other manual degraded modes of operation, all the controls of HV & propulsion system available in TCMS DDU shall also be provided from RSC console of OCC, BCC & DCCs. However, the train shall be operated in GoA2 / ATO operation during the initial stage of passenger service operations and subsequently in GoA4 / UTO.
- 10.2.24 The Bus bars shall have the insulation to prevent short circuit by the foreign objects.

10.3 HV POWER COLLECTION

- 10.3.1 Power shall be drawn from the overhead line by pantographs. When measured at the train's pantograph level, the Total Demand Distortion for Current (TDD_i) shall be below 5% of the fundamental and Total Harmonic Distortion for Voltage (THD_v) shall be below 2% of the fundamental. The method of calculation of the TDD_i and THD_v shall be according to IEEE 519: 2014 or latest.
- The Rolling Stock Contractor shall submit simulation studies for current and voltage harmonics over the complete operational sections of CMRL Phase 1 as defined in Chapter 1.
- 10.3.2 The pantograph for the 25 KV current collection system shall be suitable for flexible auto-tensioned OHE consisting of catenary and contact wire as well as the low height rigid catenary system provided in tunnelled sections or other locations of the CMRL Phase 1 network.
- Each unit (DMC + TC + MC) shall be equipped with ONE (01) pantograph located on the T-car. The feed from the pantographs shall be connected to the main transformer without duplication of High Voltage equipment.
- Pantograph profile should be similar to Phase-1 existing Rolling Stock in order to avoid change in existing Mainline and Depot OCS and to ensure the compatibility.
- 10.3.3 The pantograph shall be capable of sustained operation and satisfactory current collection from a minimum of 150 mm above the collapsed (lock down) pantograph level and up to the full range of contact wire height. This requirement shall be met throughout the specified range of operating speeds. The locked down height of the pantograph shall be limited to maximum 4048 mm from the top of rail. Pantograph system shall have readily accessible surge tank, clearly labelled with vented cut-out valves.
- 10.3.4 A pantograph auto-drop function shall be provided to drop the pantograph automatically when excessive height is detected. During design stage, the Contractor shall propose a suitable height at which the ADD MED(Maximum Extension Device) shall be activated based on a review of the OHE height at all locations including the mainline, depots and stabling locations. An indication shall be provided to the train operator and TCMS, and RSC consoles of OCC, BCC & DCC when

this function has been triggered.

During pantograph entanglement with OHE catenary, there shall be an indication to the train operator and TCMS, and RSC consoles of OCC, BCC & DCC.

In case of entanglement of any one pantograph of 6 cars train with OHE, other pantograph of the same train shall be protected by Auto Dropping function in the train. The system shall react immediately to lock down position to avoid any physical damage. This safety feature shall be demonstrated for all possible conditions in 6 car train in static and dynamic conditions up to 90 kmph through simulation of activation of ~~ADD~~ valve MED.

1

Similarly, Pantograph Auto drop function shall be provided to drop the pantograph automatically when there is any air leak in the system. So, suitable ADD (Automatic Drop Device) shall be provided.

- 10.3.5 Both hardwired and TCMS control of pantographs shall provide the facility to raise, lower or isolate either or both pantographs via the TCMS screen or pushbuttons onboard the train or via the RSC console at OCC, BCC and DCCs.

1

Simultaneous raising of both pantographs shall only be permitted whilst the train is stationary in order to prevent interruption of power during the changeover sequence. The Contractor shall evaluate the planned operational diagrams and propose suitable software logic to initiate automatic changeover of pantograph in order to balance the rate of contact wear. the logical shall be proposed no later than pre final design stage.

- 10.3.6 An accessible component manifold type control panel shall be provided for local pantograph control and isolation of each pantograph. Contact strips on the pantograph head shall be a metallized carbon design, that is service proven to have a long lifespan whilst causing minimal wear to the contact wire. The Contractor shall specify a predicted wear rate during pre-final design which specifies the expected replacement frequency in distance travelled (Kms).

Provision shall be provided in TCMS to log the running distance of pantograph over a given time period. Insulated pantograph horns as well as pantograph strips shall be secured by a Nord lock or equivalent suitable arrangement. The carbon strip shall be single piece carbon strip tested against EN 50405, glued with Epoxy phenol resin and arrangement for prevention of water ingress in support beam of carbon strip. V-type base support shall be provided as to ensure that strip remains fixed even if gluing ages. There shall be a visible minimum usage level mark embedded on the pantograph carbon strip.

- 10.3.7 The dynamic behaviour of pantographs of the train shall be within the Kinematic Envelope of Rolling Stock in all operating conditions. The width and profile of the pantograph shall be such that the Kinematic Envelope of the car is within the specified limit.

- 10.3.8 The design shall ensure that the OHE contact wire always remains within the carbon strip portion of the pantograph; including during the scenario where the worst conditions of carbody sway occurs whilst OHE stagger is at its outer extremity. The electrical clearance between the live portion of the pantograph and the coach roof shall not be less than 290 mm. The minimum mechanical clearance from fixed structure at any time should not be less than 100 mm.

- 10.3.9 The pantograph shall be of single arm, light weight, direct air operated type and compliant to IEC 60494-2. The pantograph shall be of proven design for both flexible and rigid catenary system. The pantograph shall be complete with air control equipment including air filter, test point, pressure regulator and controlling solenoids. In case air is supplied through air core insulator, the creepage length of the insulators shall not be less than 900 mm and shall be suitable for PD4 category and for unfavourable operating conditions of pollution (Ref EN 50124).

- 10.3.10 Pneumatic pipe, other fittings and equipment provided on the pantograph frame shall be insulated from the frame to avoid damage to pipes due to flow of fault currents on account of Earthing of the frame from any wire accidentally thrown by birds etc. on the roof. The insulation shall be suitable for the 25 KV system and shall operate according to the traction voltage range with durations as defined in IEC 60850 for 25 KV system.

- 10.3.11 Incidences of stray wire being accidentally thrown by birds etc. are quite frequent. With a view to provide definite design solution, the Contractor shall examine various possible solutions and implement the chosen one on the trains, with due consultations with the CMRL. The review shall

also include examination of the possibility of providing insulated roof-top for the pantograph mounting base to eliminate accidental contact of on-board high-tension equipment with earthed car-body. If any insulation is provided on the pantograph roof-top, it shall be placed uniformly without any joints or cuts for the installation. Base frame and roof bus bars / equipment charged at 25 KV and exposed shall be suitably insulated for 25 KV to ensure that direct earth fault does not occur between the base frame and car roof. Arrangement for insulation shall be got approved from CMRL.

10.3.12 The Straight-line distance from platform to any live part on the roof or roof edge shall be more than 3.5 meters and the clearances shall be in accordance with EN 50122-1. **Insulated horns shall be proposed for both the pantographs.**

10.3.13 The Contractor shall submit complete roof layout along with the clearance between roof equipment. This shall also include water drainage arrangement and insulation of exposed charged items. Pantograph and HV system mounting roof area shall be designed such that water shall not be logged or remain during train static condition and during train revenue service or dynamic testing. This shall be designed for water washing and rainfall conditions of Chennai.

10.3.14 As per the interface requirement specified in Clause 2.4.56 of the ERTS Appendix-C the ATS system shall ensure staggered closing of the VCBs of trains located in the same section whenever the power supply is restored so as to avoid tripping of substation VCBs due to high inrush current.. **This system shall be working in all ATO and non-ATO modes of train operation. Design shall be suitable for minimum 180 sec head-way operation of trains in CMRL network.**

Necessary selection of commands from RSC consoles of OCC, BCC & DCCs required for closing of VCB shall be ensured as a part of interface design. This system shall be working in all UTO and non-UTO modes of train operation. Design shall be suitable for minimum 90 sec head-way operation of trains in CMRL network.

10.3.15 Staggered acceleration of the trains within the same power supply feeding zone shall be suitably ensured under **ATO UTO** operation for both normal and extended feeding scenarios arising due to power supply disruption or bunching of trains within the same feeding zone as a part of interface design for avoiding tripping of VCB of substation. Design shall be suitable for **180 sec 90 sec** head-way operation of trains in CMRL network.

10.3.16 Train resistance formulae for elevated, at-grade and under-ground train operation applications refer Part IVA, Section 2 Clause 2.14. Rolling Stock Contractor shall interface with Power supply Contractor for power load requirements specific to corridors of CMRL Phase 1.

10.3.17 Traction power consumption simulations shall be provided for both the elevated and underground tunnel sections of operation.

10.3.18 The HV and medium voltage cables used in this system shall be adequately protected from cable chafing. The cable routing shall follow international practices in features such as cable bending, terminations, routing, fixing in cable trays etc.

10.3.19 Requirements of earthing cables shall comply to Chapter 19.

10.4 HV PROTECTION & DISTRIBUTION

10.4.1 A roof-mounted Vacuum Circuit Breaker (VCB) of proven design shall be provided for the car 25 KV AC system and located close to each pantograph. The VCB shall be of single bottle type having a short circuit rating of 400 MVA and confirming to IEC 60056, in conjunction with C3 category, and additionally type tested with 300,000 operations & with IEC 60077. Protection class for the external portion and internal portion shall be minimum IP 67 and IP 20 respectively. The creepage distance of the insulator shall not be less than 900 mm for the highly polluted environment in accordance with IEC 60815. The auxiliary contacts and control equipment of the VCB shall be located in such a way it is accessible from within the car. The control cables shall be compliant to the requirement of EN 45545 Part 1 to 7 (Category 4-A, Hazard level HL3) latest editions as a minimum or better international standards applicable to similar type of Metro operation in respect of fire, smoke, & toxicity characteristics Requirements of clause 2.26 shall be met. A 110 VDC connector of proven design shall be provided for control of VCB. The VCB base plate along with bottom cover shall be suitably protected to prevent corrosion in adverse

environment of Chennai. The mounting plate of VCB shall be provided with a proper seal to avoid ingress of water from roof. Usage of sealants shall not be permitted in mounting of VCB on car roof. The VCB shall be suitable for repeated switching within short time comparable with the short (6m) neutral sections. Vacuum Circuit breaker operation shall be recorded with time stamp and train location with respect to the open / close command and actual open / close operation. Design life of all the auxiliary switches of VCB shall be minimum 15 years.

- 10.4.2 An Earth Switch shall be provided, with a sturdy key, operable from inside the car, enabling each high voltage (HV) circuit to be earthed during maintenance. The Earthing Switch shall be hand operated from inside the car. The key can only be removed after the Earthing switch is in earth position and both pantographs' air supply is isolated. This key shall be used to release multiple interlocking keys to open / close the covers of boxes of propulsion equipment and Auxiliary converter inverter equipment for maintenance. The Earthing switch shall be interlocked with both the pantographs air inlet supply to prevent the pantographs being raised while the HV circuit is earthed and to prevent the HV circuit from being earthed while the pantograph is raised. It shall be possible to apply padlocks or sufficient locking mechanism in the isolated and earthed position. The Contractor shall submit the details to CMRL for review and approval.
- 10.4.3 A suitably rated high voltage cable shall connect the vacuum circuit breaker to the main transformer. The cable insulation and sheathing materials shall be halogen free, flame retardant, and having low smoke emission meeting requirements of EN 45545 and IEC 60502. The enclosure and termination of the cable shall be properly protected. In the event of the breakdown of the cable insulation or the termination, there shall be no risk of electrocution, or other hazards, to persons inside, persons touching the car exterior and interior components or close outside of the car.
- 10.4.4 A suitable arrangement shall be made to switch off the VCB automatically before train entering the neutral section, resulting in the traction control equipment returning to OFF without Train operator or OCC or DCC intervention while operating in ~~ATO and non-ATO~~ UTO and non-UTO modes. The VCB shall re-close after train crossing the neutral section, causing traction circuit equipment to switch on again in the same operating mode, without Train operator or OCC or DCC intervention while operating in ~~ATO and non-ATO~~ UTO and non-UTO modes.
- 10.4.5 The VCB shall be interlocked with various HV and Propulsion equipment such as main transformer, traction converter-inverter, HV equipment, etc. for opening the VCB in case of emergencies. Rolling Stock Contractor shall propose details of interlocks for opening of VCB.

10.5 LIGHTNING ARRESTOR

- 10.5.1 Gapless type lightning arrestors and surge arrestors of proven design in accordance with specification IEC 60099-4 shall be provided on the roof close to each pantograph for protection against voltage transients caused by lightning or system switching. One Lightning Arrestor each shall be provided on HV incoming side after pantograph and another Lightning Arrestor shall be provided before the HT Transformer Bushing after the VCB, for protection against line voltage transients caused by exterior lightning or train system internal switching transients.
- 10.5.2 The Lightning Arrestor & Surge arrestor shall be rated for not less than 42kV with compatible rupture capacity. The failure of arrestor shall not be explosive in any case. The rated voltage and operating voltage shall exceed the permitted line voltage, in accordance with EN 50163 and IEC 60850, to obviate the passage of current during normal voltage condition. No splintering etc. shall be permissible. This shall be included in the type test plan. The arrestor shall be exposed to line harmonics and line voltage / frequency fluctuations. The Contractor is advised to take actual measurements before design. Frequency fluctuation of the order 47~54Hz may be considered as datum.
- 10.5.3 The lightning arrestor and surge arrestor shall be free from moisture ingress, vandal proof, suitable for installation in polluted environments, non-explosive failure mode, low weight, small size and easy to install.
- 10.5.4 The arrestor shall consist of a non-linear metal oxide varistor fitted in a ~~silicon~~ / porcelain housing, which is sealed off by a flange. This contains a pressure relief device with gas diverter ~~as~~

applicable.

- 10.5.5 The arrestors shall be maintenance-free. Only checking for any damage is supposed to be done. A means of indication shall be provided for easy identification by visual inspection of a failed surge arrestor without dismantling it.
- 10.5.6 Under normal service duty, the minimum service life of the surge arrestor shall be not less than 10 years.

10.6 25 KV POTENTIAL TRANSFORMER

- 10.6.1 A 25 kV Explosion Proof Potential Transformer, duly type tested, to be mounted on the roof, meeting the requirements of IEC 60044-2 and IEC 61869, for protection / measurement shall be supplied. Adequate protection shall be ensured to avoid secondary short circuit at PT output and effect of harmonics on the performance.
- 10.6.2 Accuracy class for measurement as per IEC 60044-2 shall be 0.5 or IEC 60099-A or better.

10.7 AC CURRENT TRANSFORMER

- 10.7.1 Two (2) AC Current Transformers, for protection circuit operation and measurement operations shall be mounted on roof along with 25 KV cable. The design, testing and operational requirements of the AC current transformers shall meet with IEC-60044-1.
- 10.7.2 Accuracy class for measurement Current Transformer shall be 0.5 or better as per IEC 60044-1. The current measurement shall be conducted instantaneously at the 25 KV level itself using this measurement CT.
- 10.7.3 Accuracy class for Protection Current Transformer shall 5P or better as per IEC 60044-1.

10.8 MAIN TRANSFORMER

- 10.8.1 The Contractor shall (no later than Preliminary Design Stage) propose a suitable main transformer with a service life of at least 35 years. The submitted proposal shall be supported by calculations which demonstrate compliance with all applicable ERTS requirements for CMRL's review.
- 10.8.2 The Contractor shall propose a suitable Main Transformer design based on the following requirements:
- a) The KVA rating shall be sufficient to meet the additional load required for emergency operating conditions (including train rescue scenarios) plus an additional margin of 10%, sustained for a 30 min duration. Calculations may be based on run curve data.
 - b) Can satisfy requirement (a) under worst case assumptions for TDD and THD (as defined in clause 10.3.1) at a line voltage of 22.5 KV.
 - c) Is able to meet requirements (a) and (b) as well as the RMS line current profile throughout all ~~three (3)~~ corridors of Phase 1 & Phase 1 Extn. Network; without exceeding any thermal limits.
- 10.8.3 The main transformer shall be designed to conform to IEC 60310 and the temperature rise limits of windings and oil shall correspond to IEC 60310 limits (minus 20° C if forced cooling is adopted). The insulation class of main transformer shall be minimum Class F.
- 10.8.4 The main transformer design shall be forced cooled or naturally cooled design. Components shall be modular in construction, complete with oil pump, oil pump motor, radiator with blower fans (if adopted), conservator (if adopted) and protection equipment (e.g. over pressure, over temperature, Buchholz Relay, etc.) all assembled as a single module.
- 10.8.5 The main transformer oil (if adopted) shall be ester / silicon oil and the requirements shall be as per IEC 61099 and IEC 61203 or IEC 60836. The ester / silicon oil should ensure the minimum acceptable standard for fire load as per EN 45545 Part 1~7 and clause 2.26. The fire load of the transformer shall be furnished and ensure compliance with the specified fire load in clause 2.26.
- 10.8.6 The main transformer shall be under-slung and the resilient mounting arrangement shall be described in detail by the Contractor.
- 10.8.7 Measure shall be included to monitor for, and protect against, traction transformer failure and

1

leakage. The design shall minimize the fire load of the transformer.

10.8.8 Not used.

10.8.9 Following protection devices shall be provided

- a) Thermometer with thermo-sensitive device to activate alarm contact, when oil temperature exceeds a pre-set value and trip command for temperature exceeding the max set value.
- b) Oil flow relay to detect stopping of oil flow due to pump failure to trip the VCB (An over-ride to this function shall also be provided to move train until next station platform)
- c) Pressure relief valve to discharge abnormal pressure generated by gassing of oil, with tripping of VCB and locking of transformer.
- d) Oil gauge level to monitor the oil level. Prismatic glass shall be used for oil level gauge. The gauge shall be mounted such that it can be easily seen from the side of the car. Alarm and trip command based on oil level, detected with Oil Level Detectors (OLD) shall be provided. Redundancy of OLD shall be provided if applicable.
- e) All sensors shall be so located that they are easily accessible for maintenance / replacements.
- f) A Linder Heat Detector (LHD) system shall be provided covering all low and high voltage terminals. The LHD shall be linked to TCMS / fire detection & control unit (refer clause 2.26) so that the status is continuously monitored and logged in TCMS.
- g) Transformer bushings shall be provided with heat-detectors / LHD unit.
- h) All oil level sensors and relays shall be duplicated.

1

The above information shall be logged in TCMS and shall be transmitted to RSC consoles of OCC, BCC & DCC.

- 10.8.10 Protection level for enclosures of the blower motor (if adopted), pump motor & complete transformer, including the terminal box, shall be IP65.
- 10.8.11 Provisions shall be made to switch OFF and ON the radiator blower fan with respect temperature rise of the transformer.
- 10.8.12 Transformer cooling arrangement (if forced cooling adopted) shall be designed to ensure completion of round trip (without loss of time) of already working train with only one radiator fan working in tandem with the oil cooling. In case of already working train, the non-working of radiator fans / oil pump for at least 1 minute shall not affect transformer functionality and train performance in any way.
- 10.8.13 Maximum Transformer efficiency shall be achieved at AW2 load and Normal Mode as per IEC60310 and shall not be less than 97% at 22.5kV. The transformer efficiency shall also be validated in system test bed and line tests.
- 10.8.14 Gaskets and seals used shall be suitable and compatible for use with the transformer oil and high temperature. Test report and design life of gasket and seals to be submitted.
- 10.8.15 All motors shall be dynamically balanced and shall have resilient four-point mounting arrangement. All gauges and sensors shall have easy access for monitoring and replacement.

10.9 25 KV CABLE WITH HV BUSHING AND T-CONNECTOR

- 10.9.1 High voltage Copper cable of adequate voltage rating and diameter shall connect the vacuum circuit breaker to the main transformer. The cable shall be laid in stainless steel pipe from end-to-end terminations from roof to under-frame. The cable insulation and sheathing shall be halogen free, flame retardant and having smoke emission in compliance with IEC 60502, BS 6853 and EN 45545 Part 1 to 7(Category 4-A, Hazard level HL3). The Bushing & Connector shall comply with EN 50180 and EN 50181. The details for roof-end and transformer-end terminations of 25 KV cable shall be provided for the CMRL's review. The cable shall not have any straight through joint / connector between HT bushing on the roof and transformer bushing in the transformer.

10.10 TRACTION EQUIPMENT

- 10.10.1 A traction control system shall be provided which is designed to ensure a high utilization of available adhesion under all wheel / rail conditions and shall not cause any visible or measurable damage to the car equipment, wheels / rail.
- 10.10.2 The traction equipment shall only operate when a train bus signal, consisting of either a forward or reverse command along with a motoring or braking demand signal are received. Secondly, there must be a hard-wired redundancy to enable traction operation. The concept of requiring a hard wired enable signal to be present (in addition to logical signals over the train bus) to initiate motoring or braking is an essential safety requirement.
- 10.10.3 The High Voltage & Propulsion System shall be suitable for operation with 25 KV AC 1 ϕ 50 Hz system.
- 10.10.4 Not used.
- 10.10.5 The traction and braking equipment shall not suffer damage under any conditions that may be encountered including development of maximum traction or braking effort continuously and worst case of slip / slide conditions during rainfall or other external conditions.
- 10.10.6 The traction and braking system and associated equipment shall be fully integrated with control circuits, diagnostic and monitoring facilities, load-weighing and wheel slip / slide systems. The integration shall be designed to minimize the time required to test the equipment and to diagnose faults. The electronics required for the control, diagnostics and monitoring facilities shall be designed and constructed in accordance with the requirements of IEC 60571.
- 10.10.7 The traction equipment shall be designed so that the tractive and braking effort of the metro train is dependent on and appropriate to the passenger load and speed of the train.
- 10.10.8 The manufacturing standards shall have already been proven widely in the railway traction industry.
- 10.10.9 The types of power semi-conductors used shall have had extensive use and experience in traction applications. The circuit breakers, contactors and conventional electromagnetic components used shall comply with the requirements of IEC 60077-1 & -2. The details shall be submitted to CMRL for approval.
- 10.10.10 All the propulsion and HV equipment shall be capable of operation in all GoA1, GoA2, GoA3, GoA4 and other manual degraded modes of operation. ~~However, the train shall be designed to be operated in GoA2 / ATO operation from the initial stage of passenger service operations.~~ However, the train shall be operated in GoA2 / ATO operation during the initial stage of passenger service operations and subsequently in GoA4 / UTO.

10.11 POWER CONVERTER- INVERTER

- 10.11.1 ~~There shall be one Converter-Inverter per bogie in each motor car.~~ There shall be one Converter-Inverter per bogie or per car in each motor car for bogie control propulsion system or car control propulsion system respectively. The Converter-Inverter shall be of proven design, four quadrant IGBT or any other latest metro rail proven technology-based unit, with VVVF control. The equipment shall conform to IEC 61287-1. Natural or forced (air / water) cooling shall be adopted. However, if forced (air / water) cooling is offered, complete details of the arrangement including the method of dust filtration (if applicable) shall be furnished. The Contractor shall provide the details of variation of power factor with power and variation of power with catenary voltage.
- During design of cooling system, it shall be noted that Chennai's ambient conditions are heavily dusty with abrasive dust, high humidity and environment pollutants. The cooling system, natural / forced air shall ensure that the devices / components / electronics are completely sealed against intrusion of dust / water. IP65 level of protection shall be ensured. The design calculation of worst-case temperature rise of equipment shall be made after taking into account of 25% choking of filters and heat sink / radiator fins. The sealing arrangement shall be such that this protection level is ensured after normal maintenance and replacements of components. Gasket shall have minimum life of 12 years.

- 10.11.2 The system shall be designed to minimize switching losses, switching noise and weight and improve heat dissipation. The Contractor shall submit design details to CMRL for approval.
- 10.11.3 The current rating of the semi-conductor shall be such that the junction temperature has the minimum thermal margin of 10°C in the worst loading conditions in Chennai and its surrounding. Contractor shall consider the temperature rise of the air in vicinity of the equipment on account of different factors including proximity impact in the underframe, difference in wheel diameter of the bogie(s) and rescue operation etc.
- The current rating of the semiconductor shall be such that the junction temperature has the minimum thermal margin so as have life of 35 years. The converter-inverter system and transformer shall be capable of withstanding the maximum short circuit under fault conditions. Short circuit protection of IGBTs shall be implemented.
- 10.11.4 The Converter-Inverter system and transformer shall be capable of withstanding the maximum short circuit under fault conditions. Short circuit protection of IGBTs shall be implemented.
- 10.11.5 The continuous rating (not thermal rating) of the converter shall be based on the combined continuous rating of the traction motor and inverter after taking into account the efficiency and power factor of traction motor.
- 10.11.6 The converters in a train shall be controlled such that there shall be no Electro Magnetic Interference and harmonic interference in the signalling equipment and cables used by Signalling Contractor up-to the worst degraded conditions of trains. The Contractor shall interface with signalling and train control Contractors for limiting values of the return current in track ~~ATP~~ in ATP / Signalling frequency range. The frequency details shall be as specified by the Signalling Contractor.
- 10.11.7 The power Converter-Inverter shall be designed to cater to the pantograph bouncing phenomenon. Adequate compensation using suitable rating of DC link capacitor shall be provided for the pantograph bounce time. The Contractor shall submit the design calculations.
- 10.11.8 Traction inverters shall be housed in a container, which is mounted under floor in each of the motorized cars. The material of the container shall be made of Stainless steel or Aluminium such that the boxes, covers and anti-corrosive coating above them shall last for the life of the Car body, i.e. 35 years. The Contractor shall also provide a declaration for the same during the design stage." The container shall house the power electronics, the monitoring devices and the traction control unit. It is connected to the vehicle via high voltage power connections, control connections and 3 ϕ output to the traction motors.
- 10.11.9 Following special modes of operation shall be provided using DDU interface of TCMS.
- a) 3.2 kmph Low speed control to operate the train during train washing on level track or on a ramp.
 - b) High Tractive Effort mode It shall be possible for the Propulsion system to provide 10% extra tractive effort than the maximum specified tractive effort in normal mode for a limited time which may be used during a single Motor Car isolation or rescue operation.
 - c) Low speed cut out mode operation inside Depot for 25 kmph and High-speed cut-out mode operation in Main line for 40 kmph.
- 10.11.10 Wheel Slip / Slide control during powering and electrical regenerative braking shall be provided using speed sensor less vector control subject to its proven design in Metro Transits System. Uncontrolled slip / slide should be clearly recorded in TCMS, OCC, BCC & DCC as critical fault.
- 10.11.11 The Contractor shall submit to CMRL the quality of the regenerated energy including its harmonics analysis according to Clause 10.3.1. The same shall be commensurate with the latest trends in Metro Transit System and shall be in compliance with an accepted international standard. Interlacing of between traction converter inverter units within the train and interlacing between traction converter inverter units between trains within the fleet shall be implemented to minimize the overall effect on the power system. The Contractor shall submit detail document on the interlacing strategy and harmonic reduction measures during design stage.
- 10.11.12 The Contractor shall demonstrate that the limits of electrical and thermal rating for all power components under all conditions of motoring and braking will not be exceeded.
- 10.11.13 Accurate and detailed computer simulations of single power component failures shall be

performed in the design of the equipment.

- 10.11.14 The stipulations of EN 50388 and IEC 62313 shall be complied. Further, the control system shall ensure that the train as an electrical system shall always behave as an inductive load with power factor near to unity (not leading) under all operating conditions of powering mode, regenerative braking mode and coasting mode at all passenger loads and train speeds. The Contractor shall include validation of the same as a part of combined test bed & mainline test.
- 10.11.15 Four (4) trains shall be instrumented (in accordance with EN 50463) with separate Power Quality measuring instruments, data acquisition systems and power analyser (with provision for permanent installation and shall have necessary in-built software / analysis tool) to measure, record and analyse the power quality parameters. This instrument shall also have memory storage for minimum 15 days of testing data. The measurement with these instruments shall include but not limited to Time, kW, kVAR, kVA, THD, TDD, Total pf and Displacement pf. The instruments supplied shall have the adequate capability of measuring and data acquisition to analyse higher order harmonics (up to 50th) and measure power quality parameters mentioned above with minimum accuracy of 0.1% and sampling rate of 100 kHz. Details of instruments shall be finalized during design stage. Other trains shall also have necessary provisions (suitable space, wiring etc.) for installation and recording power quality parameters as per above.
- 10.11.16 If Contractor proposes to measure the power quality parameters as mentioned in above Para, through TCMS (it is preferred). In such case, TCMS shall have the adequate capability of measuring and data acquisition to analyse higher order harmonics (up to 50th) and measure power quality parameters mentioned above with minimum accuracy of 0.1% and sampling rate of 100 kHz. Also, a suitable power analyser, software / analysis tool shall be built in. However, final approval will be provided by CMRL by comparing both proposals.
- 10.11.17 The IP protection level of Converter-Inverter box and auxiliary converter-inverter shall not be less than IP 65. The connectors shall have IP 67 protection. The cooling arrangement shall ensure no dust deposition on the component and associated electronics. The box cover which may have to be removed for maintenance shall be suitable secured against falling. Hinged opening cover arrangement shall be preferred.
- 10.11.18 Separate CTs shall be provided for each converter-inverter for measurement and protection functions.
- 10.11.19 The propulsion equipment shall ensure the guaranteed performance for wheel diameter differences for minimum 4 mm within any bogie without any adverse effect on any equipment. If the wheel diameter tolerances exceed the above limit, there shall be no damage to any equipment.
- 10.11.20 Power system fluctuations within the specified voltage range or feed extensions shall not cause Propulsion system shutdown leading to jerks in the train. Adequate capacity shall be built in the DC link and control parameters shall be selected and fine-tuned suitably so that in no case, system stability is adversely affected. The design shall permit to operate trains at minimum headway (as specified in ERTS Clause 1.4.4) with normal feeding zone of 15 km and extended feeding zone of not less than 30 km without any restriction.
- 10.11.21 At any point during the Project Period; CMRL may at its sole discretion choose to employ an independent Consultant to verify the Contractor's design proposal, power system simulations, power system capacity recommendations, systems integration tests and any other relevant deliverables required of the Contractor in accordance with this ERTS; including the requirements defined in Section-5 of the Interface Appendix-C.
- The Contractor shall fully support the Consultant to undertake his scope of Work, as directed by CMRL. The Contractor shall provide all information requested by the Consultant without hinderance.
- 10.11.22 Based on the operational requirements as above, Contractor shall furnish detail report on the minimum sub-station capacity required for adequate harmony with the all-out mode operation of trains within the feeding zone, low frequency control stability to ensure no operational or reliability issue even if the specified headway and large number of trains in the same feeding zone, number of trains parked on the end depot with extended feed and resonance stability of the complete

system.

- 10.11.23 The component cooling system shall be designed to ensure the control electronics temperature inside converter-inverter / auxiliary converter-inverter never exceeds 70 °C under specified conditions after due consideration of proximity effect. The Contractor shall note that the air intake temperature for cooling can be appreciably higher than outside ambient temperature. The type measurements shall be normalized for maximum specified temperature.
- 10.11.24 For maintenance purpose, there shall be additional by-pass ground switch in Converter-Inverter box duly interlocked with safety locks. The Contractor shall submit the detail document for CMRL's review during design stage.
- 10.11.25 LED based lighting arrangement shall be provided in the Converter-Inverter box for maintenance purpose. Its fail-safe interlocking with the box cover shall be ensured. The Contractor shall submit the detail document for CMRL's review during design stage.
- 10.11.26 Protection shall be provided to ensure that the equipment cannot be damaged in the event of line voltage transients as defined in IEC 60850.
- 10.11.27 A HV and Propulsion system shall be provided for detecting an earth fault in the complete system. The design shall also protect the people and equipment from earth fault. The design shall be of high integrity so as not to affect the availability of the train by nuisance tripping. The Contractor shall propose the earth fault detection and protection system for HV and Propulsion system.
- 10.11.28 The psophometric current of one 6 car train at full rated power shall not exceed 5 amperes. Psophometric current of train shall be measured according to the requirements of EN 50121-3-1 and ITU-T O.41.

10.12 PROTECION AND DIAGNOSTICS

- 10.12.1 Control circuit logic shall permit testing & monitoring, operation and fault simulation of the power converter-inverter. Appropriate test equipment shall be supplied.
- 10.12.2 The power converter-inverter shall carry out self-tests to ensure the integrity of the equipment. Sufficiently detailed status, fault and diagnostic information shall be transmitted to TCMS, to enable protective or corrective action to be taken immediately, when necessary.
- 1 10.12.3 The train operator from the cab and Operator from OCC & DCC shall be able to isolate, reset and lock-out any defective power Converter-Inverter. It shall be possible to view the system details in TCMS, OCC & DCC.
- 1 10.12.4 Wheel slip detection and protection system shall protect the wheels from wheel flat damages. Wheel slip detection and protection system shall be working in tandem with Brake system during traction. There shall be real-time sharing of the traction and brake parameters between Traction Converter-Inverter and Brake electronics for each separate coach individually. There shall be a master-slave concept in prioritising the traction / Brake controls between cars. This Wheel Slip protection system shall be interfaced with Signalling Contractor and shall also function in ~~ATO and non-ATO~~ UTO and non-UTO modes of operation. There shall be instantaneous communication to TCMS, OCC & DCC in case of wheel slip detection in trains. This detection and protection logic shall be automatic and shall not require any intervention from Train operator or OCC or DCC to control it. This function shall be type tested in CMRL premises. The Contractor shall submit the logic of working of Wheel Slip protection for CMRL review and approval.
- 1 10.12.5 Axle based Wheel slide detection and protection system of all cars of rake shall be working in tandem with Brake system and Traction control electronics during service braking (which involves regenerative braking). There shall be real-time sharing of the traction and brake parameters between Traction Converter-Inverter and Brake electronics for each separate coach individually. There shall be a master-slave concept in prioritising the traction / Brake controls between cars. The wheel slide control on trailer car shall match with the control mechanism followed on Motor car. This Wheel Slide protection system shall be interfaced with Signalling Contractor and shall also function in ~~ATO and non-ATO~~ UTO and non-UTO modes of operation. There shall be instantaneous communication to TCMS, OCC, BCC & DCCs in case of wheel slide detection in trains. This detection and protection logic shall be automatic and shall not require any intervention

- from Train operator or OCC operator or DCC operator to control it. This function shall be type tested in CMRL premises. The Contractor shall submit the logic of working of Wheel Slide protection for CMRL review and approval.
- 10.12.6 All propulsion equipment shall be rated to ensure for operation of normally operating train for a further period of 2 hours or a round trip whichever is more with single traction propulsion unit in operation. It shall be possible to operate already working train for 2 hours or round trip, whichever is more, with one unit isolated in high tractive effort mode without exceeding the specified temperature limits.
- 10.12.7 The power converter-inverter shall use a control scheme that contains extensive self-diagnostic logic, which shall be fully integrated with TCMS. At a minimum, the diagnostics system shall identify a range of credible faults, identify whether a Least Replaceable Unit (LRU) is responsible for the fault, and whether the LRUs (or non-LRUs) must be replaced, or the system merely reset. The diagnostics system memory shall be retained when the train is powered down.
- 10.12.8 The train operator from the cab shall be able to isolate any power converter / inverter. Current drawn by each motor shall be measured and recorded.
- 10.12.9 Redundant Temperature / Heat sensor / LHD location shall be in proximity of IGBTs and shall be linked to TCMS / Fire Detection & Control Unit (refer clause 2.26) so that their status is monitored.
- 10.12.10 The equipment of HV and Propulsion system shall comply with the requirements of the Diagnostic Monitoring System and Real Time Remote Diagnostic Monitoring System as defined in Chapter 14.11 & 14.13. Facility shall be available to monitor the events and failures on-line on a maintenance terminal in depot DCC and in OCC. It should be possible to select the events, required to be monitored.
- 10.12.11 Protection scheme for Propulsion system, Traction Converter Inverter, the settings and calculations shall be discussed during PFDR. It shall include the below, but not limited to:
- i. Primary Circuit
 - a. Over Current of Primary Circuit
 - b. Interphase short in secondary circuit
 - c. Interruption of catenary circuit
 - ii. Main Transformer
 - a. Oil Flow Stop
 - b. Over Temperature of Main Transformer
 - c. Pressure Relief Valve
 - iii. Converter / Inverter
 - a. Over Voltage of Primary Circuit
 - b. Low Voltage of Primary Circuit
 - c. Frequency Irregular
 - d. Waveform Irregular
 - e. Over Temperature of Power Unit
 - f. Over current of Secondary Circuit
 - g. Ground Fault
 - h. Low Voltage of DC Circuit
 - i. Over Voltage of DC Circuit
 - j. OVT Failure
 - k. Wheel Slip & slide
 - l. Tractive Effort Failure
 - m. Regenerative Effort Failure
 - n. PWM Failure

- o. Rotation Backward Detection
- p. CPU Fault
- q. Low Voltage of Control Power Source
- r. Low Voltage of Gate Power Source
- s. Low Voltage of DC 110 V Power Source
- t. Calculated Speed Fault
- u. Over current of Main Motor
- v. Phase unbalance of motor current
- w. Over Temperature of Main Motor
- x. Traction Motor Current Unbalance in 4 motors
- y. Fan Fault
- z. Fault of Charging Circuit

10.13 TRACTION MOTORS

- 10.13.1 The Train shall be propelled by 3 ϕ AC asynchronous motor or permanent magnet or latest better motor technology with variable voltage and variable frequency (VVVF) drive Control. The motors shall be designed and manufactured in full accordance with the requirements of IEC 60349-2. Class 200 insulation or better shall be used for stationary and rotating windings.
- 10.13.2 3 ϕ asynchronous traction motors or permanent magnet motors or any better proven design, suitable for the proposed converter/inverter operation shall be offered. The motor shall have adequate built in margin to cater to the environmental conditions given in the specification. The motor shall be designed to suit ripples and harmonics from the inverter and shall have a high degree of reliability in service during motoring as well as regeneration.
- 10.13.3 The traction motor shall be self-ventilated and shall comply with the requirements of IEC 60349-2. An effective and efficient filtration system shall be provided to remove dirt and water from the self-ventilated traction motor cooling air. The air inlet openings shall include a protective screen designed in such a way as to preclude the accumulation of leaves and debris. If installed, filters shall require cleaning in accordance with the manufacturer's recommendations. Any sensor(s) if used shall be easily accessible for replacement and shall not necessitate removal of motor / its dis-assembly. Speed sensors if used shall not generally be placed on the gear case.
- 10.13.4 A specific care shall be taken for the air-cooling quality and sucking points to be particularly adapted for the operation in Chennai. Cooling arrangements shall be defined during detailed design stage.
- 10.13.5 Evaluation of the insulation system for sealing against moisture shall be made in accordance with IEEE 429. The insulation system shall be evaluated for thermal endurance in accordance with the requirements of IEC 60505:2004 (or latest) and its draft supplement.
- 10.13.6 Various ageing parameters viz., thermal and electrical stresses, ambient temperature, humidity, dust and mechanical stresses, vibration etc., should be used in the evaluation and the temperature index of the insulation system corresponding to an extrapolated life of 20,000 hours shall be established. The Contractor shall submit the evaluation of the temperature index of the insulation system for review and approval.
- 10.13.7 The temperature rise limit for the stator winding shall be the maximum temperature index of the insulation minus 70°C when the traction motor undergoes the temperatures rise test, which is specified by IEC 60349-2. The temperature rise shall be verified in system type test bed and the lines (as available) with 25% ventilation blocked. The Contractor shall consider the temperature rise on account of different factors including proximity impact (not less than 10 °C) in the under frame and specified wheel diameter difference in the bogie(s) as indicated in clause 10.11.19 above. The type test procedure and validation of temperature rise is described in Chapter 17.
- 10.13.8 Traction motor rotor shall be Copper or Aluminium material.

- 10.13.9 Simulations on a typical round trip for each corridor and between inter-corridors (as defined in Chapter 1) shall be provided by the Contractor along with calculations showing the temperature curve of the traction motor in normal and downgraded conditions and in all the conditions of passenger loads up-to AW 4
- 10.13.10 The motor bearing maintenance inspection interval (excluding lubrication if required) shall exceed 1.2 million kilometres and the bearing shall have a design life of minimum 2.1 million kilometres. Lubrication of motor and gearbox bearings shall be accessible without the need of any equipment removal. Calculations supporting the choice of bearings shall be submitted to CMRL for review.
- 10.13.11 Insulated bearing shall be used on both drive and non-drive end of traction motors to prevent current through the transmission to the axle.
- 10.13.12 Protection shall be provided to prevent current flow through the bearings in normal and under fault conditions.
- 10.13.13 The grease used for the traction motor bearings shall be selected so as to ensure the expected maintenance interval considering the maximum temperature estimated to be reached in the bearings, under the worst conditions. It should be possible to replenish the grease periodically in situ and overflow arrangement should be provided to avoid the possibility of the over greasing.
- 10.13.14 The motor shall be mounted on the bogie frame via flexible coupling and gear unit, which shall be totally enclosed and free from lubricant leakage. The coupling design and the motor to gear unit mounting arrangement shall minimize coupling dynamic angular displacement. The motor shall be dynamic balanced. The details of the gear drive unit, gear performance, and coupling details shall be submitted to CMRL for approval.
- 10.13.15 The traction motors shall be designed for a life of thirty-five (35) years with no need for major overhaul before 1.2 Million Kms.
- 10.13.16 The mounting arrangement of the traction motor shall be designed to prevent the motor from dropping onto the track should the primary mounting arrangement become disconnected. All components shall have been already proven in previous railway service in similar operating and environmental conditions.
- 10.13.17 AC traction motors used for the traction drive shall comply with the requirements of Relevant standards are IEC 60349-1, 60349-2, IEC 60349-3 and shall, in particular, be fully compliant with the sections on motor characteristics, equipment marking, type and routine tests. Information on all the characteristics of the AC traction motor as stated in IEC 60349-2 shall be provided.
- 10.13.18 Not used.
- 10.13.19 Any inspection covers shall be robust and designed for quick and easy removal/replacement and have secondary retention to prevent loss. Inspection openings shall be as large as possible to facilitate inspection and maintenance.
- 10.13.20 The gearbox case design shall give due consideration to minimizing weight.
- 10.13.21 The coupling of the gearbox shall accommodate all relative movements between the motor and the gearbox, including that caused by a free standing bogie, without damage to coupling.
- 10.13.22 The design of the motor installation shall permit the motor to be removed from, and refitted to, the bogie from above, without any need to disturb the axle and any bogie mounted equipment.
- 10.13.23 Where cables pass through holes in the traction motor frame, oil resistant resilient bushes suitably clamped shall be provided to prevent chafing of cables and to seal against the ingress of oil and water. The cables shall have sufficient freedom of movement to prevent stressing or fouling of other equipment during the full envelope movement of the bogie.
- 10.13.24 There shall not be any permanent flying lead attached to the motor. All connections to the motor shall be bolted, torque tightened and marked.
- 10.13.25 Traction motors shall be fully interchangeable. All components requiring periodic replacement, whether mechanical or electrical, shall be fully interchangeable unless approved by the CMRL.
- 10.13.26 The traction motor shall be connected to a gear unit through a flexible coupling. The coupling design and the motor to gear unit mounting arrangement shall minimize coupling dynamic angular displacement. The motor shall be dynamic balanced. The gaskets shall be of suitable material,

compatible for use with gear case oil and service life shall be more than 1 million km.

- 10.13.27 Each traction motor shall be provided with redundant thermistor for determination of temperature of stator winding. It should be possible to replace the thermistors in the depot without lifting the car. Traction motor terminal boxes shall be provided with heat-detectors / LHD linked to TCMS / fire detection & control unit (refer clause 2.26) so that their status is monitored.
- 10.13.28 Motors shall be provided with noise mufflers or take alternative measures for minimising noise emission from motor.
- 10.13.29 In the event of train getting immobilized in mainline due to mechanical problems like bearing seizure, gearbox or axle defect etc., suitable arrangement shall be provided like wheel skate or similar device to quickly and safely transfer the train to the Designated Depot(s). Suitable jacking points shall be provided beneath the axle boxes for enabling the placement of wheel skate.
- 10.13.30 Not used.
- 10.13.31 Traction motor power cables shall be connected with mistake-proofing terminal connections at motor end and train end. It shall not be possible to improperly connect the phase sequence of the traction motor cables. In all cases of terminal connections, all the motors shall run in the direction of selection of train.

10.14 NEUTRAL SECTION DETECTOR

- 10.14.1 A suitable arrangement shall be made to switch off the VCB automatically before train entering a neutral section, resulting in the traction control equipment switching OFF without train operator's / OCC / BCC operator's intervention in all modes of operation (~~Normal & Degraded~~) up to GoA4. The VCB shall automatically re-close after the train crossed neutral section, causing traction control equipment to switch on again in the same operating mode as before the switching OFF operation, without train operator's / OCC / BCC operator's intervention. The VCB open close operation during neutral section shall not cause any power interruption to the essential loads as defined in clause 9.4.

The detection of Neutral section region in the alignment and activation of this entire function in train shall be conducted independently by the Rolling Stock Contractor either by distance-based logic or any other suitable software logic which are independent to Rolling Stock system. This function shall require minimum interface between Rolling Stock and other system Contractors. Total numbers of Neutral Sections as per Corridor shall be discussed with interfacing OHE Contractor during design stage.

The logic of automatic VCB operation at neutral sections shall be possible in ~~ATO and all non-ATO~~ UTO and all non-UTO modes including those of degraded modes ~~and degraded / including~~ failed TCMS without the supervision of signalling system.

- 10.14.2 The control logic for the neutral section detector shall ensure that the power demand smoothly reduces on approach to overhead line neutral sections and smoothly increases the power demand immediately after the neutral section. Power ramping characteristics shall be submitted for review of CMRL and shall be validated by test.
- 10.14.3 Adequate redundancy shall be built in so that no single point failure of any software / hardware component of the Neutral section detection circuit of train can cause disruption. The status as well as failures of vital components of this circuit shall be logged by TCMS/OCC/BCC displays.
- 10.14.4 Location of neutral section shall be made as an adjustable parameter in the TCMS Neutral section logic which could be edited by CMRL person. The Contractor shall provide training to CMRL personnel in this regard.
- 10.14.5 It shall be possible to operate the train on the track in both the directions i.e. normal direction to traffic and opposite to the normal direction of traffic on same track. The neutral section detection system shall be so designed that the train can run in opposite direction with the same performance as in normal direction.
- 10.14.6 Signalling system shall also provide a signal for operation on neutral section based on location.
- 10.14.7 In case of train operation in ~~non-ATO non-UTO~~ modes without signalling supervision, it shall be

possible to control and operate the train VCBs from train's TCMS using the Train's distance based automatic VCB operation.

- 10.14.8 For the neutral section detection logic, RS Contractor shall interface with OHE / Power supply / Signalling / Telecom Contractors for the details and location of the dead section of neutral sections.

10.15 DYNAMIC REGENERATIVE BRAKING SYSTEM

10.15.1 General

- 10.15.1.1 Dynamic braking shall be automatic at all speeds in response to trainline braking commands in manual modes and to signalling system commands in GoA4 / GoA3 / GoA2 / GoA1 and shall have a smoothness equal to that achieved by the acceleration mode. The dynamic brake shall be regenerative braking in general, with priority being given to regeneration and shall be utilized to the highest possible extent.

- 10.15.1.2 Regeneration shall not occur when there is no wayside supplied voltage present on the OHE. The dynamic braking fade-out point shall be 4 km/hour or as required by the friction material to maintain a satisfactory surface conditioning. The stop will be completed by the friction brakes. The dynamic brake and the friction brake shall be coordinated such that the total braking effort requested will always be produced by a blending of the dynamic and friction braking up to the hardware limit of the friction brake.

10.15.2 Response to Braking Commands

- 10.15.2.1 The dynamic braking control system shall be integral with the propulsion control system and shall receive its commands from the braking control trainlines. The braking functionality shall be automatically responding to the signalling system's traction & braking commands and the train movement shall be controlled. Only in case of manual operation modes, train operator shall control the train movement.

- 10.15.2.2 For both regenerative brake and other friction brakes, loss of load weight signal shall never result in production of braking effort at less than that required for a car weight of AW0 for the brake command in force.

- 10.15.2.3 During braking commands from signalling in ~~ATO and other non-ATO~~ UTO and other non-UTO modes, the train's propulsion electronics and braking electronics shall coordinate with Signalling software to ensure smooth deceleration. Jerk shall be limited to maximum 0.75 m/s^3 in all operating conditions including starting and stopping of train.

1

- 10.15.3 Configuration : Dynamic braking shall be regenerative using the inverters and traction motors in a negative-slip operation. When the pre-set line voltage limit and link voltage are approached, braking energy shall be blended to friction brake. Rapid transitions between regenerative and friction braking due to rapid changes in power system voltage or due to intermittent contact between the Pantograph and the OHE shall be automatic and undetectable by the Operator or the passengers.

- 10.15.4 Friction Brake Interface : Dynamic regenerative braking interface with the friction brake system shall be by means of the brake blending function. Should a propulsion inverter fail to produce the commanded dynamic braking effort, the friction brake shall be applied to a level that will result in no less than the commanded brake. Dynamic regenerative braking interface with the friction brake system shall be by means of the brake blending function. Friction brake load weighing, and jerk limiting shall be accomplished pneumatically completely independent of the electronic logic. Other interface control systems may be proposed to the CMRL for approval.

10.16 PROTECTION

- 10.16.1 Protection shall be included in the power circuit to ensure that circulating currents through motor bearings or pinion cannot occur under any condition, for example, motoring, braking, coasting, wheel slip or slide or towing a defective unit. Additionally, the Contractor shall ensure that circulating currents cannot occur between phases of equipment or between equipment in the HV and Propulsion system.

- 10.16.2 Electronic and mechanical overload protection shall be provided in both motoring and braking. The overload protection shall also be capable of protecting the semiconductor devices against all foreseeable faults.
- 10.16.3 The misfiring of a traction converter-inverter or short-circuit failure of a semiconductor device shall not cause consequential damage to other equipment outside the traction converter inverter container.
- 10.16.4 Over and under voltage protection shall be provided such that the power circuit ceases to operate outside the limits.
- 10.16.5 Protection shall be provided to ensure that the equipment cannot be damaged in the event of line voltage transients. At the design stage the Contractor shall be required to match the protection with the power supply system.
- 10.16.6 High temperature protection shall also be provided for any equipment which is short-time rated if these need additional protection, for example during emergency duties.
- 10.16.7 Intentional / Un-intentional Reverse movement of train in any other mode apart from Reverse Mode shall be limited by 2 meters. This protection shall be applicable in complete CMRL Phase 1 ~~corridors~~ & Phase 1 extension network as defined in Chapter 1. This reverse movement of train shall be displayed in TCMS, OCC & DCC as an alarm.
- 10.16.8 Electrical Grounding
- Flexible safety ground leads shall be provided between the carbody and all parts of the bogies including the traction motor and gearboxes. These ground leads shall ultimately connect to the safety ground brushes to ensure that all bogie parts are at rail potential. Grounding arrangement shall be such as to prevent current flowing through journal, gearbox or motor bearings.
 - The grounding bar required for the Traction Power Supply circuits on each Car shall be electrically connected to at least two wheel sets, on two bogies, by means of separate flexible earth braids.
 - Each car body shall be electrically bonded to at least two wheel sets, on different bogie to that used for the Traction Power Supply return, by a means of separate insulated flexible bonds. The grounding connection for any one system shall not be combined with that of any other system.
 - Each traction motor frame shall be electrically bonded to the adjacent wheel set.
 - The negative or neutral of each car circuit shall be connected separately to the corresponding grounding bar in the same car.
 - All metallic boxes, cases and enclosures containing electrical equipment, including cable ducts, which are not intended to be part of the live circuit, shall be properly grounded with an insulated flexible earth braid to the relevant earth bar.
 - The removal of any grounded equipment or item shall not interrupt the grounding arrangement of any other remaining earthed electrical equipment.
 - No protective device shall be inserted in any pole connected to earth unless it is immediately adjacent to and protecting the battery.

10.17 ENERGY MEASUREMENT

- 10.17.1 The Contractor shall provide means to record usage of actual utilized energy of train with an accuracy of $\pm 5\%$ for motoring and regeneration. The core losses and primary winding losses of main transformer shall also be accounted in the measurement using a measurement CT at 25 KV level. Suitable voltage and current measurement transformers shall be installed at 25 KV level of the train. An Energy measurement type test shall be conducted to verify this 5% accuracy in trains.
- 10.17.2 The record of cumulative energy shall be in units of kilowatt-hours.
- 10.17.3 The energy data shall be non-volatile, easily accessible and monitored by the train management system. The details of energy measurements shall be submitted to CMRL for approval.

10.18 CONTROL LOGIC AND DIAGNOSTICS

10.18.1 Control logic

- 10.18.1.1 Interlocking shall be provided to ensure that a direction change is inhibited while the train is in motion.
- 10.18.1.2 The fundamental requirement of all train-borne systems and sub-systems is that no single event, fault or deterioration of a system, shall cause a service operation delay of more than five (5) minutes.
- 10.18.1.3 In the event of an occurrence of an interlock open circuiting, the effect shall not cause an unsafe condition to arise. Such an occurrence of a single open circuit interlock failure shall not disable both motoring and braking.
- 10.18.1.4 Interlocking between motoring and braking, as well as forward and reverse shall be provided to prevent changes in traction and braking signals arising in an uncontrolled manner.
- 1 10.18.1.5 All the control logics of HV and Propulsion system shall be suitable for ~~ATO~~ UTO operation and also to other ~~Non-ATO~~ Non-UTO modes. The operation interface shall be similar in GoA4, GoA3, GoA2, GoA1 and in other degraded operational modes.
- 10.18.1.6 Rolling Stock Contractor shall propose the various degraded operations (when part of the system fails to operate) of Traction Converter Inverter system and the maximum durations the system could be operated with passengers in these conditions.

10.18.2 Motoring Control Logic

- 10.18.2.1 The traction equipment shall only operate when a train bus signal, consisting of either a forward or reverse command and a motoring demand signal are received, as well as, not receiving a braking demand signal. The concept of requiring two Hard Wired signals to be present to initiate motoring is an essential safety requirement.
- 10.18.2.2 The motoring level of demand signal transmitted via a train Highway shall not be considered as part of this 'two wire start' facility.

10.18.3 Braking Control Logic

- 10.18.3.1 The dynamic regenerative braking equipment shall not operate unless a direction signal and a braking demand signal are received, as well as receiving a signal representing the level of demand.
- 10.18.3.2 In the event of loss of the direction signal, the brake system shall revert to friction braking only.
- 10.18.3.3 Changes in the level of brake demand shall result in an appropriate and corresponding change in brake retardation.
- 1 10.18.3.4 The signal representing the braking demand levels, transmitted by the brake control system, shall be of a resolution fine enough to enable the signalling system (in ~~ATO~~ UTO and other signalling modes) to operate satisfactorily and shall be coordinated with the ~~ATO & Non-ATO~~ UTO & Non-UTO design requirements.
- 10.18.3.5 The brake control system shall be capable of receiving inputs from the combined traction brake controller in the controlling cab and also the signal for the level of brake demand from the signalling system.
- 10.18.3.6 A malfunction of a car's brake equipment shall activate the train's emergency brake and a mechanism shall be provided to remotely isolate, from the driver's cab, only the failed brake equipment on that car and enable release of the train's emergency brake.
- 10.18.4 Diagnostic: The HV and Propulsion system shall incorporate fault data recording feature. This feature shall have sufficient data storage capacity to record all necessary information of faults occurring in the HV and Propulsion system. The fault data shall be easily retrievable with the system remaining in-situ through a portable test unit or notebook computer interface. Both hardware and software required for data retrieval shall be provided. Fault data shall be displayed on the driving console as per the requirements of DMS and RTR-DMS in clause 14.11 & 14.13.

10.19 EMI AND EMC

10.19.1 General

The Contractor shall demonstrate that adequate protective measures have been taken to prevent EMI from all equipment on board the Rolling Stock as defined in this Chapter, clause 2.18 and Chapter 17.

10.19.1.1 All design data, test specifications and test reports shall be delivered and all tests, with the exception of commissioning tests, shall be completed prior to the delivery of the first train.

10.19.1.2 Electro- Magnetic Compatibility and Electro Magnetic Immunity of the equipment of HV and Propulsion system and related compatibility and immunity interface with the train external and train internal environment shall follow according to EN 50121-2, EN 50121-3-1, EN 50121-3-2 and EN 50121-4.

10.19.2 Radiated Emissions

10.19.2.1 The Rolling Stock shall be required to operate in the vicinity of various types of equipment, which are susceptible to the radiated electromagnetic waves of the Rolling Stock.

10.19.2.2 The Rolling Stock radiated emissions shall not affect any equipment operating inside the train or in the vicinity, which may include but not be limited to:

- a) heart pacemakers.
- b) public broadcast services and communication services.
- c) train radio system.
- d) Signalling & telecom equipment used in ~~ATO and Non-ATO~~ UTO and Non-UTO modes of operation.
- e) Signalling equipment used in ~~wayside~~ signalling system.
- f) track based personnel/police and fire department / nearby buildings.
- g) mobile radios and mobile phones used inside and outside the trains.
- h) hospitals.
- i) CMRL SCADA.
- j) visual passenger information system and cab / station platform CCTV.
- k) Station public address system.
- l) Designated Depot(s) working area.

10.19.2.3 Each item of equipment shall be tested in accordance with the requirements of EN 50121 and the results submitted for approval of the CMRL.

10.19.2.4 The maximum levels of radiated EMI of any individual item of equipment shall not exceed the levels specified in EN 50121 and EN 50392.

10.19.2.5 RS Contractor shall submit an EMC EMI control plan for HV and Propulsion system and for Complete Train systems for CMRL review and approval.

10.20 UTO OPERATION

10.20.1 The design of HV & Propulsion system and its relevant components in train shall support for the UTO / GoA4 in the CMRL Phase 1 & Phase 1 extension defined in Chapter 1. Trains shall be operated in GoA2 / ATO mode during the initial stage of commissioning and revenue operations and subsequently in GoA4 / UTO. Hence all the feed-backs, information and train controls which are available on TCMS screen shall also be available in OCC (operational control Centre) and DCC (Depot Control Centre) for smooth operation of passenger service. The Contractor shall submit the details of controls to be provided in OCC & DCC for review and approval of CMRL.

11. BOGIE ASSEMBLY

11.1 NOT USED

11.2 GENERAL

The maximum permissible static load per axle shall be 16T under AW4 load conditions and shall be designed for commercial speed of 80 kmph and designed and tested for a maximum permissible speed of 90 kmph.

The bogie rigid wheelbase shall be between 2200 mm ~ 2600 mm. The Contractor shall propose suitable bogie wheelbase in order to limit the rail wear when moving on small radius curves and achieve stable performance.

- 11.2.1 Each car shall be provided with two bolster-less type bogies. Each bogie shall have two axles and incorporate primary & secondary suspensions. The bogie assembly includes frame, wheel / axle sets and all components related to the suspension system, but excludes traction motors, gear units, friction braking equipment, train control equipment, and their support brackets. Interfaces requiring welding or the removal of metal on structural members, including suspension components mounted to the car body, shall be considered part of the bogie.
- 11.2.2 Bogies shall utilize service-proven designs, components, and configurations designed to operate on CMRL corridors as per this specification. The use of designs that closely replicate existing designs, operating in similar environments with similar track geometry and track quality may permit the relaxation of the proof of design requirements as per clause 11.3, at CMRL's sole discretion. Evidence of design and operating environment similarity will be a pre-requisite to approval of any such concessions.
- 11.2.3 Not used
- 11.2.4 Bogie assemblies shall have a service life of 35 years without structural repairs, rebuilding, strengthening under standard maintenance practices and service.
- 11.2.5 Bogie designs shall comply with the requirements of this Chapter of the Technical Specifications with the lowest possible bogie weight and un-sprung mass to meet the ground-borne vibration criteria specified in Chapter 2.
- 11.2.6 Not used.
- 11.2.7 The bogie systems shall safely function at all speeds up to and including the safe design speed as defined in clause 2.14.1 without any loss of stability, under all conditions of track and Wheel wear on the system as defined in Chapter 2.
- 11.2.8 The bogie design shall minimize flange contact especially on curves on all tracks to minimize wheel and rail wear.
- 11.2.9 All bogies shall have components that are interchangeable to the largest extent possible. Bogie frames shall be identical for **all similar** bogies. All similar bogies must be interchangeable without modification to the bogie assembly.
- 11.2.10 Bogies shall have provision for jacking the assemblies safely and without damage to any of its components. Jacking pads shall be provided beneath all bogie frames for use during maintenance and re-railing. Jacking pads shall have an anti-slip finish. Lifting eyes shall be provided to permit bogie assemblies to be lifted once removed from beneath the car. Appropriate means shall be provided to prevent primary or secondary suspension elements from over-extending during jacking or lifting actions.
- 11.2.11 Bogies shall be configured such that equipment is positioned and oriented in a manner that facilitates access for maintenance.
- 11.2.12 The bogie design shall include the mounting arrangements, but not be limited to:
 - a) the location and mounting for transponders or similar antennas.
 - b) the location and mounting of tacho-generators; and
 - c) the location, mounting arrangements and termination of the associated cabling.

1

- 11.2.13 Under the worst condition the clearance between lowest part of the bogie and top of rail (TOR) level shall be as per the moving gauge. There shall be at least 75 mm clearance between the lowest element on the bogie and the top of the rail under the worst conditions of maximum loading.
- 11.2.14 There shall be sufficient clearance (minimum 25 mm) between the bogie and car body to allow the car to operate with a deflated secondary suspension system such that damage does not occur at maximum operating speeds under conditions of maximum loading and maximum wheel and suspension system component wear, including creeping or settling.
- 11.2.15 Vulnerable equipment, such as conduit, wiring and piping, shall be located as far as is possible above the clearance plane.
- 11.2.16 All bogies shall be designed and manufactured by a builder having a history of producing service-proven bogies.
- 11.2.17 Bogie assemblies shall be easily removable from the car body for maintenance, without the use of any special tools. Car body to bogie connections shall not contain any press fit joints. Any joints on the bogie, which could become frozen or locked over time, shall be sealed from moisture and appropriate materials shall be used to prevent such conditions from occurring.
- 11.2.18 Bogie mounted equipment shall be designed to operate satisfactorily in the environment specified in clause 2.11.1. and shall conform to IEC 61373 in respect of shock and vibration, including the endurance limits for both fatigue and peak vibration levels. These shall be incorporated in the type test of the respective equipment.
- 11.2.19 Not used.
- 11.2.20 All electrical and electronic components shall comply with the EMC and EMI requirements of EN 50121 (all parts), IEEE 16, EN 55011 and IEC 61000-4 standards or other equivalent international standards. The requirements of EMC EMI requirements referred in clause 10.19 & 2.18 shall be met.
- 11.2.21 Fire properties of the materials used shall comply with EN 45545 part 1 to part 7 latest editions (Category 4-A, Hazard level HL3) as a minimum or better international standard applicable for similar Metro applications. Requirements of clause 2.26 shall be met.
- 11.2.22 Material requirements of all sub systems of train shall be complied to Chapter 19.

11.3 DESIGN VALIDATION

- 11.3.1 The Contractor shall submit for approval the design data and calculations for all bogie components including, but not limited to, the bogie frame, wheel & axle sets, bearings, and primary & secondary suspension systems. The data shall include a general description of system operation, drawings or layouts with components clearly identified.
- 11.3.2 **Stress Analysis Requirements**
 - a) A structural finite element analysis of the proposed bogie design, including bogie frame, torsion bars and their attachments, shall be submitted for review. This shall include data on stresses under static and dynamic conditions. Allowable stress values including, endurance limit data for base material and connections shall be clearly identified for the material proposed. The material strength data shall be substantiated by citation of published sources. The stress analysis shall demonstrate that the bogie frame members and structural connections comply with the requirements of clause 11.6.3 and shall be submitted for CMRL approval before bogie production commences.
 - b) Welded and bolted connections shall be analysed in detail to demonstrate compliance with static and fatigue strength requirements of this specification.
- 11.3.3 If existing bogie designs are being used, the Contractor may demonstrate the integrity of the bogie frames and bolsters through previously conducted stress analyses and static and fatigue testing. In such a case:
 - a) The Contractor shall categorically demonstrate that analyses and tests have input load values, load combinations and allowable stress and fatigue life criteria closely comparable to those proposed for CMRL Project.

- b) The Contractor shall demonstrate that the bogie assembly design is compatible with the collision requirements of these Technical Specifications.
 - c) CMRL reserves the right to request a new stress analysis and static and dynamic tests should previous tests be deemed inappropriate.
- 11.3.4 Bogie Frame Stress and Fatigue Testing - Bogie frame static and fatigue load tests shall be performed as specified in clause 17.5.2.10
- 11.3.5 Bogie Strength
- a) The mechanical strength of the bogie frame shall comply with the requirements of UIC 615-4, UIC 515-4, EN 13749 or JIS E 4207 for static test under exceptional loads and fatigue tests. The maximum stress developed under static load shall not exceed 85% of the yield strength of the material. The dynamic effects due to the inertia of the motors and transmission shall also be simulated along with traction and braking forces.
 - b) The number of seated passengers shall be taken as one per seat and standing passengers as 10 person/m² (AW5) for all the above-mentioned strength analyses except for fatigue test. The fatigue load shall be decided based on actual loading which shall correspond to AW3 loading conditions. The loading cycles shall be as specified in respective UIC/JIS. There shall not be any crack at the end of any stage of loading cycles. The passenger weight for this calculation shall be taken as 65 kg/person.
 - c) Loads: In accordance with UIC 615-4 and UIC 515-4, EN 13749 except as noted.
 - d) The Contractor shall ensure that any other loads that may arise on the bogies due to the particular configuration chosen are adequately taken into account. These additional loads shall include, but not be confined to those caused by the effects of motor inertia, equipment inertial loads, damper loads, and the effect of passenger loading and unloading.

11.4 SUSPENSION

- 11.4.1 All bogies shall have primary and secondary suspension systems designed to meet the requirements of this contract. Suspension components shall have characteristics optimized to perform with the track geometry defined in clause 2.9 and shall achieve the ride quality identified in clause 2.13.4 without causing undue rail, wheel or car component wear.
- 11.4.2 The Contractor shall propose a service proven primary suspension system which either comprises of Conical elastomeric springs or Helical coil steel springs. The Elastomeric springs shall be subject to an approved program of preloading or exercising at assembly of the bogie to compensate for the deflection caused by initial "creep" of the elastomer. JIS E 4206 & EN 13913 Standards or any other international standard can be followed by the Contractor. Provision shall be made in the bogie design to compensate for "creep" and keep the bogie properly levelled and trammelled.
- 11.4.3 Different trailer bogie springs and motor bogie springs shall not generally be acceptable unless the Contractor is able to establish its proven use and relative advantages.
- 11.4.4 Suspension characteristics shall be selected so as to avoid resonance between the various elements of the car systems including the car body. Bogie and body frequencies shall be suitable separated.
- 11.4.5 The lowest elements of any body-mounted equipment box shall be limited as specified in SOD above the top of rail under conditions or fully worn wheels, deflated air springs and all operating conditions including steady wind speeds up to as specified in SOD.
- 11.4.6 The lowest elements of any bogie mounted equipment box shall be limited as specified in SOD above the top of rail under conditions of fully worn wheels, deflated air springs and all operating conditions including steady wind up to as specified in SOD.
- 11.4.7 All Rubber / rubber-metal-moulded items used in suspension shall be type tested for specified temperature and humidity conditions.
- 11.4.8 The lateral stop shall be cushioned using a properly designed stiffness value. The lateral stops and all other rubber and metal bonded rubber items shall be sourced from vendors having proven

experience with similar metro applications. Specific approval shall be obtained from the CMRL.

- 11.4.9 The air springs shall have over inflation protection. The maximum permissible increase in height will be decided during detailed design stage.

11.4.10 Primary Suspension

- a) The primary suspension shall consist of Helical springs or Elastomeric springs.
- b) Primary suspension system designs shall include creep adjustment provisions that require minimal bogie disassembly and can be accomplished with standard rail car maintenance equipment.
- c) Spring stiffness in the primary suspension shall be properly sized to allow wheels to align for smooth curve negotiation, without causing undue wheel or rail wear.
- d) The suspension components shall be positively retained when the bogie is lifted in any manner or in the event of a derailment.
- e) The Helical springs shall have a fatigue life of not less than 10,00,000 kms and shall be designed and tested as per EN 10089, EN 13298 and EN 13906. The service life of rubber bonded metal components / rubber of spring type primary suspension shall be OEM rated for not less than 8 years. ~~The Contractor shall ensure that the chosen supplier provides a warranty for the same.~~
- f) A load deflection test and accelerated ageing tests shall be performed to demonstrate that the spring rate of the primary suspension system and the creep rate for the materials used are within the design limits. These tests shall prove that the primary suspension system behaves as predicted and will not result in excessive deflection or a decrease in bogie clearance above top of rail to less than the minimum as specified in SOD.

11.4.11 Secondary Suspension

- a) All bogie assemblies shall have a pneumatic secondary suspension system. ~~The secondary suspension shall confirm to EN 13597, EN 14817.~~ The secondary suspension system shall have supplemental resilient stops capable of supporting the appropriate proportion of an AW4 loaded car in the event of a failure. Resilient stops shall be designed to allow continued operation of the car without wheel climb as noted in clause 11.4.13.
- b) The pneumatic suspension system shall have readily accessible surge tank, clearly labelled with vented cut-out valves.
- c) Alternative secondary suspension systems may be proposed for CMRL consideration and approval.
- d) Hydraulic dampers of suitable capacity shall be provided symmetrically to control and limit the vertical and lateral oscillation of the car body. The damping factors are to satisfy this provision. The damping factor in vertical mode, by wedge test, when tested using a wedge of 18 mm thickness should be between 0.20 and 0.25. Suspension will not be considered acceptable if maximum acceleration and spring displacements do not decay within 2-3 cycles. No leakages of any kind shall be permitted. The design life of the dampers shall be minimum 10 years.
- e) Not Used.
- f) The design life of secondary suspension air bags (all inclusive) shall not be less than 12 years. The air bags and associated components shall not crack, shear, balloon, bulge, burst or deteriorate in performance during the specified design life. In case of failure of meeting the requirement, the Contractor shall propose alternative which meets the criteria and replace in entire fleet.
- g) In the event of Secondary suspension system failure, the design shall ensure safe working speed without any speed restrictions. However, if the Contractor would like to enforce any speed restrictions, it shall be automatically implemented and communicated to TCMS, ~~STC Contractor & RSC consoles in OCC, DCC & BCC.~~

11.4.12 Not used

11.4.13 Natural Frequency

- a) The vertical natural frequency of the primary suspension system shall in accordance with EN

14363 and shall be a “proven design”.

- b) Other suspension frequencies will be considered provided the Contractor can demonstrate that the natural frequencies of the car body and primary and secondary suspension systems are sufficiently different, do not coincide under any operating conditions, and have no adverse effect on ground borne vibration.

11.4.14 Not used

11.4.15 Motion Damping

- a) All dampers (Vertical & Horizontal) including Air spring orifice (non-adjustable damping devices), shall be provided on each bogie.
- b) Dampers shall comply with EN 13802 and it shall be easily accessible for replacement. It shall have a minimum service life of 10 years. It shall be of high quality and guaranteed against oil leakage / oozing.
- c) The characteristics of the dampers shall be optimized to function with the primary and secondary suspension such that the ride quality (in clause 2.13.4) is achieved throughout the life of the damper.

11.4.16 Car body Supports / Centre Bearings

Centre ball or roller bearing rings without side bearings, if provided, shall be designed to allow free rotation of the bogie while providing damping to prevent bogie hunting.

These must be designed for ease of maintenance and shall not require lubrication for the life of the bearing. CMRL reserves the right to review and approve all such designs using alternate types of bearings that may be proposed. The bearing design life shall be at minimum 10 years. The Contractor shall submit design data for the bearings.

11.4.17 Side Bearings

Side bearings, if used, shall be designed to allow free rotation of the bogie the maximum vertical loads. Wearing surfaces shall be self-lubricating and have a minimum life of 5 years. Design data for the side bearing shall be submitted for review and comment. The data shall include the coefficient of friction between bearing pads at all expected loads.

11.4.18 Derailment Safety

The design of the bogie, including the wheel profile, shall prevent the generation of high Lateral to Vertical force (L/V) ratios on any wheel that could result in derailment under all track conditions defined in Chapter 2, and at all permitted car speeds over the CMRL alignment, up to 10% above the maximum speed permitted, the L/V ratio shall not exceed 1.0 under railhead coefficient of friction conditions up to and including 0.5. Yard operation and deflated secondary suspension conditions shall also be considered.

Nadal's limit is the limiting L/V ratio for a single wheel and is defined as:

$$\frac{L}{V} = \frac{\tan(\delta) - \mu}{1 + \mu \tan(\delta)}$$

Where: L is the lateral force component exerted by the single wheel on the rail

V is the vertical force on a single wheel

δ is the flange angle of the wheel relative to the rail

μ is the wheel to rail coefficient of friction.

Dynamic requirements shall be compliant with the specific Indian regulations and legislation. The axles yaw stiffness and the rotational resistance of the complete bogie shall be such that the lateral flange forces generated when negotiating the track alignments for the route specified are not so high as to lead to excessive rail wear and wheel flange wear, but shall be sufficient to obviate bogie or wheel hunting.

- 11.4.18.1 The Contractor shall submit calculations to confirm that the derailment quotient Y/Q shall not exceed 1.0 under the most adverse conditions, where Y & Q are the instantaneous lateral force on the wheel flange and the instantaneous vertical load on that wheel tread respectively under

the most adverse conditions.

The Sperling ride index of the rake at 80 kmph shall not exceed 2.50 in both vertical and horizontal directions in inflated condition of secondary suspension ~~and 3.0 in deflated condition.~~

2

As far as operation with deflated springs are concerned, trials will be conducted up to the speed where the maximum level of parameters as mentioned in 2.13.3 (e) are experienced, and based upon the results, the maximum speed of operation with deflated springs will be decided.

11.4.18.2 The bogies rotational resistance (X factor) test under inflated and deflated air spring conditions would be carried out at the manufacturer's works under tare conditions, the value of which should not exceed 0.08 at rotational speed of 0.8 degrees / second. The rotational resistance shall neither cause excessive flange wear nor cause any possibility of flange climbing but shall be adequate to avoid bogie hunting on straight track. The Contractor shall show by analysis that no flange climbing occurs on any curve and moving at all possible speeds. Test shall be conducted in accordance with clause 17.5.2.10.11

11.4.18.3 The Dynamic Analysis, to evaluate the running behaviour of the cars with the proposed bogie design, shall be carried out by means of theoretical calculations applying multi-body simulation techniques. The following parameters, at a minimum, shall be evaluated / analysed.

- a. Natural frequency of the suspension
- b. Stability of the vehicle and any tendency to hunt.
- c. ~~$\Delta Q / Q$ for track twist (Testing method & test condition with track twist values shall be in accordance with EN14363 Method 3)~~

2

$\Delta Q / Q$ for track twist (Test condition, with track twist values shall be as per maximum specified track twist. The testing method followed shall be in accordance with EN14363 Method 3)

- d. Bogie rotational resistance
- e. Wheel wear index at the tread and flange
- f. Derailment quotient Y/Q
- g. Carbody accelerations
- h. Curving capability and any tendency to hunt.
- i. Ride index lateral and vertical
- j. Coefficient of flexibility.

11.4.18.4 The Contractor shall submit a proposal covering the scope of the analysis and the model for review by CMRL. The maximum values of acceleration measured at central pivot level are:

- a. Vertical acceleration 0.27g
- b. Lateral acceleration 0.27g

The Contractor shall submit calculations to confirm that ride index lateral and vertical shall not exceed 2.5 under all normal operating conditions for new cars and new track, and shall not exceed 3 under all normal operating conditions for worn-out cars operated on rundown track conditions

11.4.18.5 Bogie swing tests shall be conducted in accordance with clause 17.5.2.12, IEC 61133 any other equivalent international standard shall be followed for interface of motor car and trailer car to verify the required degree of rotation (horizontally and vertically) and that cables and hoses are clear from any pinching, chafing and stretching.

11.4.19 Dynamic Modelling

The Contractor shall submit a detailed dynamic model to demonstrate the running behaviour and performance characteristics of the proposed service proven bogie design.

11.4.20 Displacement Criteria – Body Roll

- a) Bogie suspension systems shall be designed to minimize car-body roll within the entire system clearance envelope defined in clause 2.8, including stations. The Contractor shall include an Anti-roll Bar in the design of the bogie if it is required to achieve adequate risk mitigation.
- b) The car shall be capable of negotiating all system horizontal curves without violating the system

clearance envelope defined in clause 2.8. Self-centering systems may be employed. The suspension system design shall take into consideration lateral loading causing car body roll, such as pressure waves from passing cars traveling in opposite directions and the wind loading specified in Chapter 2, Table 2-7.

- c) Flexibility coefficient calculation & test be performed conforming to EN 14363. The Contractor shall measure the following but not limited to flexibility coefficient, roll angle, roll height, lateral movement.

11.4.21 Adjustment Provisions

- a) Provisions shall be made to enable adjustment of the car height to compensate for wear or settlement of any bogie component. The minimum amount of adjustment provided shall equal the amount of wheel wear allowable up to condemning limits.
- b) Adjustment increments shall be sized such that sufficient height can be added to the car to comply with the platform interface requirements of clause 2.2.8.
- c) Adjustments shall be readily accomplished with standard maintenance shop tools. All shims shall be positively retained once applied to the car.
- d) Active height control devices within the suspension system shall not be used to compensate for height loss due to wear.
- e) The Contractor shall submit design and maintenance data describing the method of height adjustment.
- f) For elastomeric suspensions, creep adjustment shall be made, as necessary, throughout the life of the primary suspension components. Shims shall be positively retained.

11.4.22 Suspension Stops

- a) Lateral and vertical stops shall be provided on all bogie assemblies, and must be designed to carry the loads generated during normal service and to produce progressive rates of resistance. Contact shall not be made with stops except under abnormal dynamic conditions.
- b) Metal-to-metal stops shall back up the elastomeric stops to positively maintain the car body within the dynamic clearance envelope under all conditions. No metal-to-metal contact between the bogie and car body shall occur under normal operating conditions.
- c) Contact with suspension stops shall not bypass suspension elements, such that wheel unloading or excessive lateral forces occur.
- d) Wear surfaces and/or resilient elements on all stops shall be readily accessible and shall be replaceable using simple tools and without disassembling bogie.

11.4.23 Equalization

- a) The bogie suspension, in conjunction with the car body, shall be designed to enable cars to operate satisfactorily on track with the maximum specified track twist. The maximum off-loading of wheels 'ΔQ/Q' shall not exceed 50% of nominal wheel load in inflated and in deflated conditions up to maximum permissible speeds ~~and shall not exceed 60% of nominal wheel in deflated conditions up to maximum permissible speeds~~ at AW0 and AW4 loading condition during oscillation trials on actual track conditions. Test shall be conducted in accordance with clause 17.5.2.10.9.
- b) Test method shall be in accordance with EN14363 Method 3 & test condition requirements assessment for Safety against derailment on twisted track, with track twist values of bogie and vehicle body test twist as per maximum specified track twist. The testing method shall be in accordance with EN14363 Method 3 (Railway applications - Testing for the acceptance of running characteristics of railway vehicles) with above acceptance criteria.

11.5 DESIGN AND CONSTRUCTION

11.5.1 Bogie Mechanical Connections

- a) Bogies shall be attached to the carbody with positive mechanical connections so that the bogies remain attached when the car is raised. Connections shall be accessible and detachable with conventional hand tools to disassemble bogie.
- b) The bogie shall be operated freely over all curves and turnouts. Bogie rotational stops shall be provided, if needed.
- c) Threaded fasteners, adjustment points, and structurally critical locations shall be accessible for inspection and work using conventional means.
- d) The car body to bogie connection (Carbody Bolster, centre pivot, bogie frame) shall withstand the following loads without permanent deformation and shall be validated by testing:
 - (i) A vertical load of 0.75 times the fully loaded weight of the carbody (excluding bogies).
 - (ii) A lateral load of half fully loaded body weight subjected to an acceleration of $\pm 1.1g$.
 - (iii) A longitudinal load equivalent to the bogie mass subjected to an acceleration of $\pm 3.0g$.
- e) Bogie & carbody connection shall be designed to avoid transmission of noise and vibration.
- f) Longitudinal forces between car body and bogies shall be considered according to the rules in UIC 615-1, clause 4.2, or JIS E 4207. The bogie frames including vehicle body-bogie connecting gear shall be able to withstand a longitudinal shock load of 3g for Motor Bogie & 5g for the Trailer Bogie as per EN13749 without failure, implies Ultimate Strength as acceptance criteria. This shall be taken as occurring simultaneously with the fully laden vertical load. The Contractor shall validate these requirements by test.

11.5.2 Motor Suspension

- a) The traction motor shall be bogie frame mounted complete with suitable drive and suspension.
- b) Traction motors and drives shall be easily removable in a workshop, after disconnection of cables and fixings without the need to disturb the axle. Individual motors shall be removable by a vertical lift after the bogie has been removed from the car body.
- c) Calculations indicating the natural frequency of the motor suspension system shall be submitted and shall clearly indicate that resonance with the bogie frame is avoided.
- d) A gearbox suspension for frame-mounted motors shall be provided together with safety brackets to provide secondary support where appropriate. Attention is drawn to the need to provide adequate strength to accept forces due to solid track base. The clearance between wheel axle and motor should be enough preventing the wheel axle is scratched by the motor.

11.5.3 Gearbox and Coupling

- a) The Contractor shall provide flexible coupling between traction motor and drive gear.
- b) The gearbox shall be compatible with the flexible coupling. Gear box movements shall be restrained by a torque reaction link between the gearbox and bogie frame. A safety device shall be incorporated to restrain gearbox rotation should the link fail in service. The gears including bearings shall not require overhaul at least earlier than 0.8 million km. The gears shall be designed for a minimum life of 1,600,000 km.
- c) The gears shall be splash oil lubricated and a sight glass shall be provided in the gear case for inspection. It shall not be necessary to change the oil earlier than 200,000 km, except for the first change.
- d) The gearbox shall be subjected to a test based on the actual duty cycle on a specified corridor with the specified torque and speed conditions. Testing shall start with gearbox at temperature of at least 45 °C ambient + 10 °C proximity effect and temperature shall be continuously monitored. The temperature shall not exceed the manufacturer's recommendations consistent with life between oil changes. Test shall be carried out in both the directions. Noise and vibration test shall also be performed along with this test. The Contractor shall submit a Test Procedure based on international practice for approval by the CMRL.

- e) The rpm considered for design and testing shall conform to maximum design speed with fully worn wheels.
- f) Coupling shall not have resonance noise during coasting.
- g) The torque value considered for design of gears and coupling shall correspond to maximum tractive effort requirement for worst duty cycle. The torque value shall be taken with new wheel diameter. The design value of gear box drive and coupling shall correspond to high tractive effort mode of operation and the design shall conform to the requirements of relevant ERTS.

11.5.4 Bogie Electrical Connections

The car shall be equipped with a quick disconnects for all power and control leads from the bogie to the car body. The quick disconnects shall be keyed as to prevent accidental miss wiring.

11.5.5 Safety Hangers

- a) For designs in which failure of a bogie-mounted equipment support may allow the equipment to intrude into the safety clearance, (i.e. outside of the kinematic envelope), safety supports shall be provided. These should be designed to support twice the static load of the equipment to be supported without yielding. Safety hangers shall be provided for emergency support of major components, including traction motors and gear units, so that they shall maintain the safety clearance of the track in the event of primary mount failure. Safety hangers shall be an integral part of the bogie frame and shall not support any weight until a failure has occurred.
- b) Failure of any long bolts or links shall not cause these items to drop and intrude into the safety clearance. Appropriate safety devices shall be provided to prevent this occurring, if the potential for such failures exists.

11.6 BOGIE FRAME

11.6.1 Construction

- a) The bogie frames shall be of service-proven design and shall be fabricated by welding.
- b) Welded structures shall be fabricated to requirements of AWS D1.1, EN15085 or applicable JIS Standards.
- c) Appropriate heat treatment or stress relief shall be done after fabrication to ensure strength requirements are met, unless otherwise approved by CMRL.
- d) All welding on the bogie including application of brackets, pads and other attachments shall be entirely completed prior to stress relieving. Drilling, tapping and machining of finished surfaces shall be accomplished only after stress relief.
- e) Where pockets or partially enclosed spaces exist, adequate drainage must be provided such that no moisture collects.
- f) A critical welds drawing shall be submitted for approval.
- g) If alternative fabrication standards are used, the Contractor shall demonstrate equivalence with the standards referenced in this Specification.

11.6.2 Materials

- a) Fabricated frame material shall be of low alloy high tensile strength (LAHT) structural steel complying with EN 10025-1-5 / JIS G3114 or equivalent. The use of equivalent materials shall require CMRL's approval.
- b) The Contractor shall supply specifications for the steel to be used for the bogie frame.

11.6.3 Strength Requirements

- a) In addition to those loads identified elsewhere in this specification, the bogie frame and all bogie parts, including motor, gear unit and brake equipment supports shall be capable of withstanding the maximum static and dynamic loads imposed by the forces acting on the frame. The basis for determining maximum loads shall include forces resulting from passenger load, track shocks, motor torque, transmission loads, friction brake loads, suspension induced pitching and rolling loads, and any possible combination of these forces when operating under all possible conditions

on track.

- b) Loads will be applied in accordance to UIC 515-4 and 615-4, EN 13749. Design life shall be taken as 10,000,000 cycles, minimum. Alternatively, loads may be applied using the relevant UIC / JIS standards, utilizing various loads and forces such as longitudinal load, traction motor load, gear load, brake load and other accessory loads that shall be considered in addition to the vertical and horizontal loads. In this case, a suitable number of cycles of fatigue load test which ensures a 35 year life as per the UIC/JIS standards, may be used for fatigue load testing. Test shall be conducted in accordance with clause 17.5.2.10.6.
- c) The Contractor shall select the appropriate fatigue allowable stress based on materials, geometry, loading magnitude, and direction, and shall submit these data along with other bogie design data for approval.
- d) The fatigue allowable stresses for welded structures shall not exceed the requirements of UIC 615-4, UIC 515-4, EN 13749.
- e) Alternatively, the Contractor may propose an alternative standard provided that equivalence is demonstrated for each joint class.
- f) The bogie shall be capable of withstanding a lifting load at the appropriate carbody attachments of at least two times its weight without suffering permanent deformation.
- g) All lifting eyes and jacking points and any tie down features shall be designed to carry two times their worst-case design load.
- h) Bogies of powered cars shall be of similar performance as BS EN 13104:2001 / UIC 615-4 and non-powered cars shall be of similar performance as BS EN 13103:2001 / UIC 515-4.

11.6.4 Crashworthiness

- a) In addition to the bogie loading identified in this Chapter, the Contractor shall ensure that the bogies are capable of surviving the collision scenarios specified in clause 3.14.9 without detaching from the car or deforming in a manner that will penetrate the passenger compartment. Equipment supports shall also be designed to prevent equipment from becoming projectiles.
- b) The car body connection to the bogie shall be designed, manufactured and installed in conformance with international standards. The Contractor shall ensure that the bogie assembly does not permanently deform or separate from the car under all worst-case operating conditions and collision scenarios.
- c) Acceleration and braking forces shall be transmitted through the bogie in such a manner that wheel unloading and load fluctuations are minimized. Loading shall be properly distributed to avoid excessive stresses, displacements, and undue wear on components or rail.

11.6.5 Frame Inspection

- a) During initial production, the soundness of bogie frame and major structural welds shall be verified, particularly in areas of potential stress concentration. Groove welds in tension or compression or under fatigue loading shall be inspected per the requirements of EN 15085. Weld inspections shall also be done per EN in support of the joint fatigue classification selected. Critical areas of welds shall be magnetic particle, dye penetrant or ultrasonic inspected per ASTM E142-64 or equivalent.
- b) Radiographic inspection tests shall be done on an agreed upon minimum number of bogie frames and traction bar arrangements as per an approved inspection plan. All inspection results shall be submitted to CMRL.

11.6.6 Trammelling and Axle Parallelism

The bogie frame assembly, when loaded with its proportion of AW4 weight, minus the weight of un-sprung equipment, shall maintain the axles parallel to within ± 1.5 mm at the journal centres and shall limit the difference between diagonally opposed bearing locations to 3 mm, both as measured with the car stationary on level tangent track. Permanent bogie frame tram marks shall be provided and shall be located within 0.12 mm of their true positions. Shims shall not be required to maintain parallelism of the axles when axles are replaced.

11.7 NOT USED

11.8 JOURNAL BEARINGS

- 11.8.1 Journal bearings shall be tapered or spherical roller bearings, grease lubricated, and sealed such that field lubrication is not required. The journal bearings shall be of size and configuration typically available in India, where possible. The Contractor shall carry out bearing life calculations to demonstrate that the selected size of bearing is adequate for L10 bearing life of 3,000,000 km under AW4 car loading (including dynamic force effects) in accordance with the method given in ISO 281/1. The Contractor shall submit all design data, loading assumptions and life calculations for the journal bearings.
- 11.8.2 Journal bearings shall be numbered in accordance with AAR requirements.

11.9 WHEELS, WHEELSETS, AXLES AND AXLE-BOXES

- 2 11.9.1 The wheels shall be mono-block-forged steel, complying with the requirements of EN 13979-1, UIC Code 812-3 / EN 13262 (for 1435 gauge) or AAR M-107 Class B, grade ER8 or equivalent international Standard. However final selection of the grade shall be based on suitability for the type of brake system proposed and the rails used by the CMRL and shall be decided during design review and approved by CMRL.
- 1 11.9.2 The wheel tread shall be of the wear adapted wheel profile S-1002/h28/e32.5/6.7% V135 as defined in EN-13745 NF F03 402. The Contractor shall undertake a wheel-rail interaction / simulation study to optimally derive all other wheel parameters within the range permitted by the SOD. Track parameters are specified in the Interface Requirements (Appendix-C) and the alignment drawings.
- ~~[The Contractor may propose an alternative SOD compliant wheel profile for CMRL's consideration if there are strong justifications to demonstrate improvements over the above-mentioned profile].~~
- 11.9.3 The diameter of the wheels shall be in accordance with Chapter 2, Table 2-1 Rake Dimensions. Optimal diameter in order to get maximum life span shall be proposed by the Contractor.
- 11.9.4 The wheel and suspension shall be optimized to minimize squealing in curves, track curves are 120 m on mainline and 100 m at the Designated Depot(s). This must be confirmed by test.
- 11.9.5 Wheel hubs shall incorporate a bore hole / port for connection of hydraulic special tooling used to aid the removal of wheels during maintenance. Wheels shall also be balanced according to UIC requirements.
- 11.9.6 Wheelsets shall be provided with a Noise Damping System; capable of reducing both "rolling noise" and "curve squeal". The Contractor shall propose a service proven design for CMRL's approval no later than pre-final design stage.
- 11.9.7 Wheelsets shall be protected using a paint system, which will protect the wheel set from damage by corrosion for at least the period between bogie overhauls without maintenance.
- 11.9.8 Easy access shall be provided to both ends of all axles to allow ultrasonic testing of the axles. It shall be possible to carry out ultrasonic testing with the wheel set in site under the cars.
- The Contractor shall submit the detail of ultrasonic testing of powered & non- powered axles. The detail shall include the testing procedure and pattern used as reference for this test, which shall be used by CMRL's maintenance staff/personal.
- 11.9.9 The Contractor shall submit comprehensive details of his wheel set design. The submission shall include, as a minimum, axle detail drawings, axle design calculations, wheel detail drawings, wheel design calculations, details and description of noise damping measures and wheel set assembly drawings and procedures.
- 11.9.10 The Contractor shall propose an appropriate list of tests to be carried out on free-standing (E.g. not installed on a Bogie Frame) wheelsets in accordance with applicable standards for CMRL's review and acceptance. Inclusion of electrical resistance testing between each wheel,

measurement of the wheel profiles and inspection of the axles will be mandatory.

- 11.9.11 Wheel sets comply with requirements as per UIC 813 / EN 13260.
- 11.9.12 The axle shall be designed in accordance with UIC 515-3 / EN 13103 / EN 13104.
- 11.9.13 The powered and non-powered axles shall comply with UIC 811-1 / EN 13261.
- 11.9.14 Wheels, axles, drive gears and axle bearings shall be assembled on axles by interference fit method. Oil injection grooves shall be provided as appropriate.
- 11.9.15 Not Used
- 11.9.16 The Contractor shall furnish the extreme maintenance limits for wheels according to UIC standard. The Contractor shall provide a re-profiling program in order to optimize the life span during the design stage and it shall be verified during the operation.
- 11.9.17 Not used
- 11.9.18 The front and rear seal shall prevent the ingress of water and/or cleaning fluids to the bearing both during normal running and during cleaning.
- 11.9.19 Not used
- 11.9.20 The housings shall incorporate seals to prevent leakage of grease and infiltration of water and dirt and maximize lubricant life. Bearing lubricant shall not, in any circumstances, be allowed to leak or discharge on to the wheel surface.
- 11.9.21 Natural frequencies of the wheels, axles, axle boxes and other un-sprung equipment shall have sufficient separation between natural frequencies with the track structure to avoid resonance.
- 11.9.22 Wide range of lubricants with different characteristics is already available in India. Use of any of these lubricants, especially those which have performed well in similar uses is preferred. In case the Contractor proposes to use other lubricants, he shall simultaneously evaluate the characteristics of lubricants available in India and indicate the equivalent lubricant that can be used for maintenance.
- 11.9.23 Axle Load, Wheel Load and Imbalance
The car axle (including AW0 unbalanced weight) shall not be more than 16T. The measured load per axle shall not exceed the above-mentioned figure by more than 2% according to IEC 61133:1992.
The Contractor shall also comply with the following weight distribution requirements.
 - (i) Measured load on the line of wheels on one side does not differ by more than $\pm 4\%$ from the average of the measured loads on both sides of the wheels.
 - (ii) For a given axle, the measured load per wheel does not differ by more than $\pm 4\%$ from the average load per wheel on this axle.
- 11.9.24 Axle end covers shall consider the required axle end components, such as grounding, speed, sensors, etc.
- 11.9.25 Axle bearing boxes shall be isolated with respect to secure the bearing from electrical shocks.
- 11.9.26 The contractor shall submit the wheel configuration drawings, including details of the wheel profile for CMRL approval.
- 11.9.27 The Contractor shall submit drawings detailing the wheel & axle set dimensions for review and approval. Additionally, drawings detailing wheel set position and contact points at the wheel / rail interface on tangent, curved and special track work shall be submitted for review and approval.
- 11.9.28 Calculations of axle static and fatigue strength shall be submitted to CMRL approval for all axle designs.
- 11.9.29 Wheels, axles, gears, etc., shall be mounted using cold pressure and fits specified in the standard. Axle roller bearing may be mounted in the journal by induction heating. A wheel and axle mounting procedure, complying with standards shall be submitted for CMRL approval.
- 11.9.30 Axles shall be of hot-rolled steel, normalized and tempered after rough machining, shall provide suitable strength, and shall have a design fatigue life of at least 35 years.

- 11.9.31 Finished axles shall, at a minimum, conform to the physical property requirement of Standards and Recommended Practices.
- 11.9.32 Axles shall be appropriately protected against corrosion during shipping and storage.
- 11.9.33 Wheel disc and axle shall be subjected to type tests as per UIC 812 and UIC 811 / EN 13260, EN 13261 & EN 13262. Test procedure for wheel, wheel set and axle along with test results shall be submitted for CMRL.
- 11.9.34 Axle Box Design shall be such that no water ingress is possible inside the axle box housing. Testing shall be done as per UIC 515-5 to the satisfaction of the CMRL for validation of the same.

11.10 WHEEL TRUING PROVISIONS

- 11.10.1 Provisions shall be made to allow for wheel truing without removing the bogies or axles. Access to axle centres shall be available, if necessary, for truing alignment. Details for wheel truing interface requirements shall be submitted for CMRL approval.

11.11 WHEEL FLANGE LUBRICATION (WFL)

- 11.11.1 The Contractor shall provide an oil-type WFL system (also categorised as “Special tools”) conform to EN16028. A suitable design shall be proposed for CMRL’s review and acceptance. The design shall be service proven in a Metro Rail application.
- 11.11.2 The design of WFL system shall ensure precise & cyclic application of lubricant on the flange of the wheel(s) so that the lubrication application is uniformly distributed on the flange surface without any excess deposition on the contact surface. There shall be no flow of lubricant on the tread/braking surface and there shall be no degradation of braking performance under any circumstances.
- 11.11.3 The WFL system shall be designed to minimize oil and air consumption. The nozzles shall be designed to protect against choking / clogging due to the dusty environment. There shall be no movable part in the nozzle. The design shall permit optimized control of oil spray in both straight and curved track by suitably modulating the spraying cycles and quantity of oil in the spray.
- 11.11.4 Control of the WFL System shall be entirely TCMS based. Activation of the oil spray cycle shall be based on the train location. TCMS shall adjust the cycle duration / quantity of oil deployed based on the train approach speed and degree of curve at that location etc.
- 11.11.5 Spray cycles shall be configured to custom profiles for each curve location that is stored on a TCMS database. Each WFL location profile shall be programmable via TCMS to allow for fine adjustment, which the Contractor is required to optimise during service trials.
- 11.11.6 ~~The fine-tuning of WFL custom profiles using TCMS shall be achievable using regular diagnostic laptops that are already provided to CMRL under the scope of this Contract. No additional proprietary software shall be required for this purpose.~~

2

The fine-tuning of WFL custom profiles through TCMS shall be possible by CMRL without the need of changing the software. Necessary training and special tool required shall be provided to CMRL under the scope of this Contract.
- 11.11.7 The only Special tools required to maintain the WFL system shall be solely for the purpose of adjusting the nozzle alignment. Two (2) sets shall be supplied to CMRL and are deemed to be included in quoted price.
- 11.11.8 The health status of the WFL System; including oil-levels in the reservoir tanks shall be available in TCMS. System Isolation shall also be possible through TCMS in case of malfunction.
- 11.11.9 Pneumatic piping shall be stainless steel (grade SUS316LTP) conforming to JIS3459. Oil tanks shall be stainless steel, easily accessible for refilling and include a vertical sight glass with a scale.
- 11.11.10 The Contractor shall additionally provide a mounting provision on the bogies to allow for any future requirement to install of a dry-type flange lubricator on at least 25% of axles on each train.

11.12 OBSTACLE DEFLECTION, DETECTION AND DERAILMENT DETECTION (ODDD) SYSTEM

11.12.1 An Obstacle Deflector Derailment Detection (ODDD) device shall be installed on the lead bogie of each car Driving Motor Car.

In addition to physically deflecting (pushing away) obstacles on the track to avoid risk of derailment, the ODDD device shall also detect either of the following hazardous conditions:

- a) An obstacle strikes the ODDD
- b) Derailment of the bogie

Either condition shall trigger an emergency brake application. TCMS shall differentiate between each condition and trigger an alarm in OCC.

11.12.2 All other intermediate bogies shall be equipped with a Derailment Detection (DD) device; providing the same functionality as Clause 11.12.1 but without deflection / detection of obstacles. The design of Obstruction Deflection Device and its mounting arrangement shall be proven and should be use in similar metro applications.

11.12.3 The design of ODDD and its mounting arrangement shall be proven and should be in use in similar UTO Metro applications and shall comply with international standards: IEC 62267 & IEC (62290-1, 62290-2 62290-3): 2014 or latest. Detailed arrangement shall be discussed during the detailed design and approval of the CMRL shall be obtained. CMRL's decision shall be final and binding. Provisions shall be made to avoid false detection. The actuation of the deflection device due to impact of the objects / obstacles, shall initiate the emergency brake and shall be recorded by the TCMS.

11.12.4 The Contractor shall submit the methodology of detection, detailed calculation of design proof load, installation arrangement, safety against derailment, energy absorbing capabilities etc. conforming to ~~Table-3~~ **Table 6** — Obstacle deflector performance requirements of EN 15227 and EN 13749 during detailed design for CMRL review and approval. Provisions shall be made to avoid false detection. The Contractor shall submit the detailed calculation of design proof load, installation arrangement, safety against derailment, energy absorbing capabilities etc. during PFDR stage

2

11.13 IDENTIFICATION

11.13.1 All bogie assemblies shall have serial number plate permanently installed on the bogie frame in an area that is visible (with skirting removed) from the side of the car but is not detrimental to the integrity of the frame under static or cyclical loading.

12. PNEUMATIC AND BRAKE EQUIPMENT

12.1 NOT USED

12.2 GENERAL

- 12.2.1 The braking system shall comprise of regenerative and pneumatic friction brake. The complete Brakes and Pneumatic air supply system shall be redundant such that no single point failure shall lead to immobilization of train. This latter function is ensured by a complete pneumatic system comprising the following components:
- a) Compressed air system.
 - b) Friction brake control scheme.
- 12.2.2 The Pneumatic and Air Supply System shall consist of, but need not be limited to, the following:
- a) Air compressor (s) unit and 3 ϕ 415V induction motor drive.
 - b) Air dryer and filtration components.
 - c) Auxiliary compressor and 110 VDC motor drive.
 - d) Reservoirs.
 - e) Pressure governors and switches.
 - f) Pipe system.
 - g) Air suspension equipment.
 - h) Automatic coupling actuating equipment.
 - i) Ancillary pneumatically driven devices.
 - j) Pantograph actuating equipment
- 12.2.3 The Brake System shall consist of, but need not be limited to, the following:
- a) Electro-pneumatic friction brake system (EP).
 - b) Electric-regenerative brake system.
 - c) Provision of smooth and continuous blending of EP and regenerative braking.
 - d) Spring applied air-release parking brake system.
 - e) Electro-pneumatic friction emergency brake system.
 - f) Extended EP and Emergency brake during rescue operation.
 - g) Wheel slide protection.
 - h) Automatic coupling actuating equipment.
 - i) Microprocessor based brake control system.
 - j) Emergency brake push buttons.
- 12.2.4 All electrical and electronic components shall comply with the EMC and EMI requirements of EN 50121 (all parts), IEEE 16, EN 55011 and IEC 61000-4 standards or other equivalent international standards. The requirements of EMC EMI requirements referred in Section VI A ERTS (RS) Chapter 10.19 & 2.18 of the Rolling Stock shall be met.
- 12.2.5 Fire properties of the materials used shall comply with EN 45545 part 1 to part 7 latest editions (Category 4-A, Hazard level HL3) as a minimum or better international standard applicable for similar Metro applications. Requirements of Section VI A ERTS (RS) Chapter 2.26 shall be met.
- 12.2.6 Material requirements of all sub systems of train shall be compliant with the requirements of Section VI A ERTS (RS) Chapter 19.
- 12.2.7 The brake system shall comply to UIC 544-1, EN 13452-1 & EN 13452-2.
- 12.2.8 The Rolling stock and all its sub-systems functions shall meet all the criteria defined in ERTS Chapter 14.

12.2.9 Not used.

12.2.10 Bogie Mounted Brake System

- a) Bogies can be fitted with either Tread Brake or Axle mounted disc brake or Wheel mounted disc brake. The intermix of brakes is not acceptable.
- b) The design of the friction brake equipment shall permit the equipment to be removed from and refitted to, the bogie from above or below, without any need to disturb any other bogie mounted equipment.
- c) Brake pads shall be easily replaced by unskilled maintenance personnel, in the minimum time, without the need of special tools. It shall also be possible to easily inspect the pads in situ without the need to remove or dismantle any components.
- d) The life of the brake pad in continuous normal operation shall not be less than 100,000 km. The car builder shall present to CMRL for approval, during design review, the projected life of the brake pad under normal continuous operation.
- e) A common brake pad shall be used for all brake actuators, irrespective of the type of bogie on which they are mounted.
- f) Only asbestos, lead and zinc free brake materials will be accepted. The brake pads shall not create a health hazard or nuisance arising from wear debris, noise or odour during normal operation.
- g) The service brakes and emergency brakes shall operate on the same brake actuators.
- h) Under conditions of a dragging parking brake (occurring on no more than one bogie) for a minimum distance of 3 kilometres at a speed of 10 kmph, no damage shall be caused to the braking system or any bogie component, with the exception of abnormal shoe wear. Detailed figures to be provided during PFDR design stage.
- i) The Spring Applied Parking Brake (SAPB) shall be an integral part of the friction brake actuation system.
- j) The tread brake / brake actuators units shall be installed on the bogie in a manner that allows ready access for inspection, maintenance, brake block replacement and removal and installation of the units without de-trucking. The geometry of the unit and its installation shall prevent any self-energization effect.
- k) Tread Brake Equipment
 - o Each bogie wheel location shall be equipped with a self-contained tread brake unit, subject to CMRL approval. The tread brake units shall be arranged for air supply, spring release operation, and shall incorporate automatic slack adjusters which shall not require additional pneumatic air lines to function. The slack adjusters shall be manually adjustable to facilitate replacing brake blocks.
 - o The design shall provide lateral restraint in order to prevent override and to position the brake head properly for use with an un-flanged brake block. Brake heads shall be made of a material with proven service history and shall be designed to permit brake blocks to be readily removed and replaced. The brake shoes shall be of the flangeless composition type.
- l) Disc Brake Equipment
 - o The Contractor chooses to propose a Disc Based braking system, the discs shall be a wheel mounted type.
 - o Brake disks shall be two (2) half, self-ventilated, with good heat dissipation and the brake assemblies shall adopt a mounting arrangement which facilitates easy access for maintenance.

12.3 COMPRESSED AIR SYSTEM

- 12.3.1 Each rake shall be fitted with a compressed air supply system, which shall comprise of oil free air compressors. One air compressor shall be provided for each Driving motor car. No failure of a single compressor shall immobilize the rake. In the event of a failure of one compressor, the remaining compressor on that rake shall have sufficient capacity to allow the rake to continue to

- operate through the rush hour period and controls until the rake can be taken out of service.
- 12.3.2 All piping shall be of stainless-steel conforming to the requirements of JIS3459, ISO 9329-4 the pipe fittings shall conform to the requirements of DIN 2353.
- 12.3.3 The working pressures of the compressed air system shall be sufficient to meet all the requirements for the associated components that require the supply of compressed air.
- 12.3.4 It is preferable that sizes of pipes are limited to a minimum. Sharp bends shall be avoided, and standard connections shall be used as far as possible.
- 12.3.5 All branches from the main reservoir pipe or control system shall be fed via cocks with or without vent and electrical switches as appropriate. Magnet valves, reducing valves, check valves; silencer and drain plugs etc. shall be incorporated as required.
- 12.3.6 Flexible hoses shall be kept to a minimum and be proven in metro train operation. The Contractor shall submit proposals to increase the integrity of the air supply system against rupturing of inter-car flexible hoses. Burst hose protection shall be provided for hoses. Armoured hoses or a double hose burst protection valve shall be provided in the flexible connections in the parking brake piping along with test reports in compliance with the latest international standard for acceptance by CMRL.
- 12.3.7 Foreign matter shall be removed from all pipes prior to installation.
- 12.3.8 All pipes shall be installed by means of clamps with integral, moulded vibration damping inserts to prevent any rattling in service. Clamps shall not be welded to the pipe. Suitable colour coding shall be applied to all pipe-work for identification. The Contractor shall submit the color-coding scheme for pipe work.
- 12.3.9 Where piping passes through holes in the floor, structure member etc, it shall be rigidly clamped immediately adjacent to the hole to prevent contact to the edge of the hole.
- 12.3.10 All necessary pneumatic sub-systems shall be supplied from the main reservoir pipeline. An isolating valve shall be fitted between the air compressor system and the main reservoir pipeline.
- 12.3.11 The compressor and associated pneumatic equipment shall be positioned to facilitate access for maintenance and ensure freedom from noise, vibration and discomfort to passengers and operator.
- 2 12.3.12 The drive motor shall conform to the requirement of IEC 60349-2 and the temperature rise of the windings of the motor shall be limited to temperature index of the insulation minus 70 °C. The motor shall have at least ~~IP65~~ IP55 protection.
- 12.3.13 The air supply from the compressor(s) shall be controlled under all operating conditions by high and low-pressure governor switches.
- 12.3.14 Equipment using compressed air shall be grouped by function. Each function shall be capable of being isolated from the air supply.
- 12.3.15 The Contractor shall ensure that the pressure leakage from the train under static condition shall not exceed 0.5 bar / 15 minutes from main reservoir setting. This function shall be tested at contractor's manufacturing facility. The contractor shall ensure this requirement is met throughout the entire design life. Any trends of deterioration of pneumatic integrity shall be remedied by the Contractor through an appropriate modification.

12.4 AIR COMPRESSOR

- 12.4.1 The air compressor(s) shall have sufficient capacity to meet all the following requirements.
- a) When TWO (2) compressors are operated, the time required to charge up to full main reservoir line pressure of any rake consist with all reservoirs and equipment at zero pressure, shall be less than ten (10) minutes and full air suspension inflation shall be achieved in a further five (5) minutes. When ONE (1) compressor is operated, the time required to charge up to full main reservoir line pressure of any rake consist with all reservoirs and equipment at zero pressure, shall be less than twenty (20) minutes and full air suspension inflation shall be achieved in a further ten (10) minutes.

- b) The pneumatic system shall be maintained within its service working pressure range when operating in normal operation, with all air operated equipment in use and at the most severe condition of loading and station stoppages
- c) During normal operation the duty cycle shall not be more than 50% of running time at a declared rate of leakage, based upon the brake and auxiliary air requirements of the rake, where duty cycle is determined as:

Duty Cycle = (Total compressor running time on load x 100%) / Total rake service time

The Contractor shall submit the duty cycle calculations for CMRL's review and approval.

- 12.4.2 The compressors on a rake shall be synchronously controlled, ensuring that the duty cycle for each compressor is the same.
- 12.4.3 The compressor and all associated equipment shall be installed as an integrated independent module suspended beneath the under-body on resilient mountings.
- 12.4.4 The compressor shall be directly driven from an associated ac compressor motor.
- 12.4.5 A pressure governor for each compressor shall be provided, which shall be capable of withstanding a pressure not less than the 'open' pressure of the safety valve without damage or deterioration. TCMS shall monitor cut in and cut out of the compressors based on the feedback of a pressure transducer / governor fitted in the MR pipe. Pressure transducers, switches and governors shall be of proven reliability that was demonstrated in previous EMU metro operations. The Contractor shall furnish the reliability figures during the design stage.
- 12.4.6 The air supply and distribution systems shall be designed such that any type of failure can be isolated remotely TCMS & RSC consoles in OCC, DCC & BCC such that the impact on performance capabilities is minimized. In case of any failure, an alarm shall be sent to TCMS and also to OCC.
- 12.4.7 The compressor shall be designed to achieve a minimum of 12,000 running hours between overhauls. Routine maintenance shall not be required at a frequency more than once per year.
- 12.4.8 A pressure switch shall control the cutting in and out of the compressor.
- 12.4.9 Safety valves shall be provided to protect the system from over pressure.
- 12.4.10 Non-return valve shall be provided between the compressor and the main reservoir supply line.
- 12.4.11 The compressor shall not be made to start against back pressure. A soft start feature as a built in part of APS or direct on line shall be provided.
- 12.4.12 Correct functioning and running hours of compressors shall be monitored and recorded by TCMS. A maintenance alarm shall be generated in TCMS if the net air consumption / cumulative operating hours exceeds a given criteria that will be agreed during design stage. The related parameter shall be adjustable.
- 12.4.13 Air dryer and filtration components
 - 12.4.13.1 The air delivered to the pneumatic system shall be clean and dry and shall conform to the air quality specified in ISO 8573. An air dryer and filtration unit proven on Rolling Stock application suitable for extremely hot, humid and dusty conditions prevailing in Chennai shall be provided.
 - 12.4.13.2 The intake air shall be directed through a properly designed filter, suitable for the dusty atmospheric conditions prevailing in Chennai. Filters shall be easy to clean and shall be easily accessible for cleaning and replacement. Since dust & humidity protection of the intake air is very crucial, specific measures shall be taken to ensure under no circumstance the dust / moisture enters into the compressor.
 - 12.4.13.3 The air leaving the dryer shall have a dew point sufficiently low so that there is no risk of condensation forming anywhere in the pneumatic system.
 - 12.4.13.4 The dry air from the compressor shall be stored in main reservoirs and brake reservoirs, which shall be suitably sized to accommodate the air requirements and also to optimize the efficiency of the air production system. Cut-in and cut-out pressures are to be defined according to the reservoir capacity.
 - 12.4.13.5 The grade of filtration at rated pressure shall be minimally as follows:

- a) Particles removal down to : 1 micron
- b) Liquid water removal : > 95%
- c) Dew point depression at 10 kg/cm²: minimum 25 °C.

The Contractor shall advise percentage relative humidity of outlet air. However, the relative humidity at the outlet of the air dryer shall not be more than 35%. Air dryer design shall ensure that no condensation takes place under all ambient conditions prevailing in Chennai.

12.4.13.6 A proven regenerative type of air dryer using desiccant and of a suitable capacity shall be provided between the air compressor and the main reservoir. The air dryer shall be preceded by an automatic drain valve, which collects and discharges the bulk of the moisture in the compressed air, before it enters the air dryer. The air dryer shall have IP65 protection.

12.4.13.7 Suitable means of dust separation, along with automatic drain valve prior to the air dryer shall be provided. An inter-cooler and after-cooler of liberal capacity shall be supplied to ensure efficient operation of the air dryer. Full technical details of the proposed air dryer shall be furnished by the Contractor for review by CMRL. Interval for replacement of desiccant in the dryer unit shall be furnished.

1 12.4.13.8 All failures of the air dryer unit shall be displayed in the TCMS / OCC.

12.4.14 A proven 110V DC operated compressor (oil free) shall be provided for operation of pantograph and VCB during start-up of the train. The compressor shall work satisfactorily within voltage range of 77V to 138V DC. Minimum protection class should be IP 55.

Pantograph actuating equipment shall be fed by air supplied from an auxiliary reservoir, suitably located in each unit with auxiliary compressor, for the purpose of initial raising of pantograph and closing of VCB.

12.5 RESERVOIRS

1 12.5.1 All Reservoirs shall be manufactured using Stainless steel / Aluminium complying with EN 286-3:1994 Category C or any other relevant International standards.

2 12.5.2 Main reservoir with a capacity adequate for the 6 car rake consist shall be provided on each car, which shall be supplied from the main reservoir pipeline. The Quantity and location of Main reservoir(s) shall be proposed during design phase for approval of the Engineer.

12.5.3 Compressed air shall pass in series through the reservoirs if more than one main reservoir is proposed.

12.5.4 The brake service reservoir shall have sufficient capacity to make at least three (3) emergency brake applications and releases with a rake speed of 80 kmph fully loaded (AW4). This shall be achieved without electric brake supplement and without air replenishment from the main reservoir.

12.5.5 The compressor and main reservoir system shall include safety valves to limit the maximum pressure. Safety valves shall conform to EN ISO 4126 (2004).

12.5.6 All reservoirs shall have an associated automatic drain device and, where applicable, an additional manual device for venting / draining the contents of the reservoir.

12.5.7 All drain cocks that are fitted shall be easily accessible and the drain cock handles shall point downwards when in the closed position.

12.5.8 The Contractor shall ensure that no drains are located directly over the running rails but instead, in between the rails.

12.5.9 Reservoirs shall be designed, tested, and stamped in accordance with ASME Section VIII, Division I Boiler and Pressure Vessels Code for unfired pressure vessels or in accordance with the UIC or EN codes.

12.5.10 The inside surfaces of pressurized structures shall be properly cleaned to remove all chips, burrs, mill scale, weld slag, and any other debris which could potentially foul height-control devices. Inside surfaces of pressurized structures shall be coated with a corrosion-inhibiting paint system.

12.6 FRICTION BRAKE

- 12.6.1 The rake braking performances shall be as specified in Table 2-7 and Chapter 2.15.6 of ERTS. The Contractor shall submit a detailed description and calculations of friction brake performance.
- 12.6.2 A friction brake shall be provided which shall function as the ultimate braking system on the rake, acting as a back-up to dynamic braking during normal service braking and as the prime braking system during emergency stops and while the rake is parked.
- 12.6.3 The friction braking shall be achieved by means of a pneumatic brake and shall be fully rated to meet, on its own, the full braking performance and shall be capable of sustaining the continuous full emergency braking requirement.
- 12.6.4 The friction brake system shall be designed to supplement and continuously blend with the dynamic braking. The Contractor shall submit the detailed brake distribution and blending description.
- 12.6.5 In the event of a failure of the dynamic brake, the friction brake shall be capable of carrying out three (3) consecutive emergency brake applications from maximum speed down to standstill of a rake in AW4 Loading condition. The rake shall be deemed to then accelerate at its maximum rate up to maximum speed after each stop.
- 12.6.6 The effect of performing such a braking procedure shall not cause damage to any bogie or brake system.
- 12.6.7 It shall be possible to isolate the friction brake system individually on each bogie (isolation by cock and by TCMS). The isolation device shall be located inside the passenger saloon area (duly protected by a lockable cover) and on the under frame adjacent to the bogie (either side) and be readily accessible. The isolation shall be readily discernible to operation and maintenance staff and shall be displayed on DDU. Isolation of any bogie shall popup an alarm in TCMS **DDU / OCC / BCC** for information and acknowledgement in both operation mode as well as in maintenance mode. Separate magnet valve shall be provided for remote operation to isolate the friction brake system individually on each bogie.
- 12.6.8 Electric Regenerative Braking:
- 12.6.8.1 Priority shall be given to the electric regenerative braking over pneumatic braking whenever a brake command is initiated. The electric regenerative brake shall also be load weighed to ensure consistent performance. The use of electric regenerative brakes shall be maximized in all service braking modes and shall make full use of the adhesive weight on all motor car axles.
- 12.6.8.2 Brake blending logic shall ensure priority of electric regenerative braking over pneumatic braking. If the demanded brake effort is not achievable solely by the electric regenerative brakes, the pneumatic brake system shall provide supplementary brake effort. The Contractor shall submit full proposal for CMRL's review. Electric regenerative brake fade out shall not occur above 5 kmph. For the given brake demand signal, the brake effort achieved shall be same during the transition from ED to EP. After the speed is reduced to a very low speed, holding brakes shall be applied to prevent the train from rolling backwards at station stops and gradient.
- 12.6.8.3 The electric regenerative brake shall be independent for each Motor Car and faults on one car shall not adversely affect the braking performance on the other car. Each Bogie of the rake shall have independent Brake Electronics with independent Electro Pneumatic brake control. Detection of Wheel slide and its protection control shall be per individual axle based.
- 12.6.8.4 In the event of failure of electric regenerative brake or during fading, the friction brake shall be capable of carrying out full braking demand. Smooth and safe changeover from regenerative to Electro Pneumatic brakes in case of failure of regenerative brakes or during fading shall be ensured.
- 12.6.8.5 The Contractor shall submit brake effort vs. speed characteristics showing the contribution of regenerative braking and electro-pneumatic braking separately over the entire speed range and at different loading conditions of the cars.
- 12.6.8.6 Brake system design shall ensure that in the event of isolation of 33% bogie brakes, train can safely work up to maximum speed of 60 kmph. This shall be enforced as automatic speed

1

restriction and shall be communicated to TCMS, **STC Contractor & RSC consoles in OCC, DCC & BCC.**

12.6.8.7 Brake pads shall be of composite material and shall contain no toxic material. Heating by the brake pad shall in no case cause any damage to the wheel tread.

12.6.8.8 The friction characteristics of the brake pad material shall be tested on brake dynamometer, in both dry and wet conditions in the range of 0 to 90 kmph under various designed brake forces. The test scheme and acceptance criterion shall be submitted for CMRLs review. The Contractor shall furnish brief description of the proposed brake system along with the expected life of brake pads.

12.6.8.9 The Brake calculations under all the service operating conditions including wheel-rail interaction study, adhesion calculations and for emergency braking distances under dry and wet conditions shall be submitted. Braking distances for normal service braking with electric brake blending shall also be submitted.

12.6.8.10 All the pneumatic control equipment, safety valves, governors, switches, sensors etc. in the underframe shall be provided in IP53 or higher compliant lockable boxes for dust control. The enclosed lockable boxes shall be made of stainless steel.

1

12.6.8.11 The air supply and distribution systems shall be arranged such that any single type failure can be readily isolated from TCMS / **OCC** such that full performance capabilities are maintained.

12.6.8.12 In case of train immobilization due to application of Parking brakes, it shall be possible to mechanically release the lever from the saloon for release of Parking brakes without the necessity to access train under frame during train operation in mainline / depot.

1

12.6.8.13 The system shall provide adequate protection against brake binding & give indications to TCMS / **OCC.**

12.6.8.14 A proven speed sensor having 2 channel mounted on the cover of each axle box shall be provided for Wheel slide protection, Train speed measurement and for any other function decided by CMRL during the design phase.

12.6.9 Emergency Brake

12.6.9.1 Emergency braking shall be applied by de-energisation of an emergency magnet valve as a consequence of break in emergency brake loop wire. The break can be caused intentionally or by opening of contacts of safety devices in the brake loop, provided in the design, to avoid unsafe conditions.

12.6.9.2 Two Emergency brake loops shall be provided; one normal and the other redundant. Both brake loops shall be controlled by separate feeder MCB.

12.6.9.3 Emergency brake is applied by friction brake system. Electric regenerative brake shall be isolated during emergency braking. The Emergency braking shall be load weighed. Emergency braking rate as specified in ERTS (RS) clause 2.14.3.3 shall be achieved from 80 kmph to 0 kmph up to fully loaded train on level tangent track.

12.6.9.4 Emergency brake push-button shall be installed in each Operator's Desk in the train. Activation of this buttons shall apply emergency brakes under all conditions. Train movement with Emergency push button activated shall be possible only after by passing the Brake loop with a cut out switch provided in the emergency driving desks Activation of the emergency brake push button (EPB) shall not result in opening of VCB and/or lowering of Pantograph.

12.6.9.5 Wheel slide protection shall be available during emergency braking.

12.6.9.6 Activation of the emergency brake by any means shall result in the inhibition of Propulsion system. The Emergency condition shall not get reset till the train has achieved zero speed (i.e. train at stand still). The Propulsion system shall not be re-enabled until the train is at zero speed and the emergency condition has been reset.

12.6.9.7 The Contractor shall furnish emergency braking distances to standstill, for a fully loaded train from speeds, starting from 10 kmph to 90 kmph in increments of 10 kmph.

12.6.9.8 The Contractor shall furnish the maximum braking distance from a speed of 80 kmph to stop, under emergency brake application. The guaranteed maximum braking distance shall satisfy the

requirements specified in ERTS (RS) Clause 2.14.3.2 & 2.14.3.3 for Braking performance.

- 12.6.9.9 The Contractor shall provide the guaranteed emergency brake de-acceleration rate to signalling Contractor during interface. The Guaranteed Emergency Brake rate shall be decided on the basis of minimum initial adhesion of 6% on the Chennai Metro network.
- 12.6.9.10 In case of adhesion being below 6% and actual emergency brake rate is found lower than the guaranteed Emergency Brake Rate, it shall be the Contractor's responsibility to prove to the satisfaction of the CMRL that the initial adhesion is below 6%. For determining the adhesion, UIC 541 shall be followed. The system diagnostic shall record all relevant signals and shall be retrievable for analysis. The necessary software / hardware tools shall be provided by the Contractor.
- 12.6.9.11 Complete friction brake system shall be tested on Brake dynamo-meter and validated during field tests.
- 12.6.9.12 Unintended Parting of the train shall result in an emergency brake application on both halves of the train.
- 12.6.9.13 The speed measurement devices and couplings required for measurement of train speed in a fail-safe manner by the Signalling and Train Control Contractor shall be installed on one / two axle in each single unit (DM + TC + MC). This shall be finalized by the Contractor during finalization of interface with Signalling Contractor.
- 12.6.9.14 The actuation of ODDD (Refer Section VI A ERTS (RS) – Chapter 12 – Pneumatic Brake equipment) mounted on the bogies due to impact of the object (equal or greater than 100 kgf in case of longitudinal impact, 200 kgf in case of vertical impact), shall initiate the emergency brake and same shall be recorded in TCMS / OCC.

12.7 BRAKE CONTROL UNIT

- 12.7.1 Each car shall be fitted with a Fail-Safe brake control unit (BCU) and an associated electro-pneumatic (EP) brake unit. Brake control unit (BCU) shall have independent control over each bogie's brake system available in each car. The BCU shall perform the following functions:
- On receipt of a brake demand, the service brake shall be applied at the correct and corresponding level having regard to the car weight (from information provided by the pneumatic suspension system);
 - When a change in braking effort is demanded, the train and brake control shall control the rate of change to be in accordance with the specified levels of jerk and response times.
 - The BCU shall, through brake blending lead by Train Control, maximize the use of the dynamic brake at all times by interfacing with the traction system. Any shortfall in the effort provided by the dynamic brake shall be achieved using the friction brake;
 - During braking, if the dynamic braking is operating and is providing all the required effort, the BCU shall maintain sufficient EP brake pressure to keep the brake block close to the wheel tread and/or disks but shall not contribute to any braking effort or cause wear to the pads.
- 12.7.2 The associated EP brake unit shall be of the energize-to-release type during Emergency Brake and energize-to-apply for other friction brakes and shall contain all the pneumatic items necessary to control all applications and release of the friction service brakes and emergency brakes on that car.
- 12.7.3 The mechanism of brake force / car weight adjustment employed shall ensure a full proportional adjustment is achieved through the braking range between Tare Loading (AW0) and Crush Loading (AW4) Conditions and for ensuring correct adjustment of the car body by the secondary air springs.
- 12.7.4 A high integrity fast response closed loop digital brake control system shall be provided with the brake regulation rate at $\pm 5\%$ of the deceleration demand. The closed loop is formed by the dynamic brake and the pneumatic brake: use of dynamic brake is maximized, achieved dynamic brake information is provided to pneumatic brake control, and this control applies to the remaining need of brake in order to reach the total demand.

- 12.7.5 The brake system is so designed that failure of any single control component shall not result in loss of braking performance of the train. All circuits and controls essential for braking equipment shall be failsafe, double break circuits, and shall have high integrity 'hard wire' feeds and inputs. These feeds and inputs shall be duplicated. A microprocessor-based brake control system shall be offered.
- 12.7.6 The Brake control unit shall have provision for logging All parameters / signals and faults with related data. Provision shall be available for continuous logging or logging triggered by a particular event of user selectable parameters (up to 20 at a time) for a period of up to 24 hrs. The memory shall be adequate to store the above data including an additional minimum 20,000 incidents. Provision shall be available to download the stored data for analysis and troubleshooting. The diagnostic tools for brake system shall include complete graphical & analytical tools, recording of events, data of the brake system and interface signals etc. It shall also have a provision to add on the necessary signals as required during fault investigations.
- 12.7.7 The Contractor shall submit the details of the brake control system interfaces with the vehicle control circuits, the Propulsion system, the Master Controller, PWM generator / Digital Control and ATP / ATO etc. The brake control system logic shall have adequate redundancy and back-up. PWM data from PWM generator and/or digital data and ATO shall be hard wired but shall also be received through TCMS as back-up. The system design shall also define the fall back mode operation when PWM data / digital data is not available from both the PWM generator / Digital Control and TCMS back-up, because of any reason.
- 1 12.7.8 A Dead man device shall be incorporated into the Master Controller Handle. Activation of the same shall cause emergency brake application in ~~non-ATO~~ non UTO modes. This feature shall be automatically bypassed in UTO / ATO mode. Refer Section VIA ERTS (RS) chapter 5.

12.8 PARKING BRAKE

- 12.8.1 Spring Applied Parking Brakes (SAPB) shall be provided which shall be applied automatically in the event of loss of the main compressed air supply, or whenever the control switch is turned off. The spring-actuated brake shall be designed to prevent the rolling-off of the metro rake in standstill with the maximum passenger load AW4 on the maximum gradient (4%) and under the worst weather conditions and wind.
- 12.8.2 The SAPB supply shall be from the main reservoir pipe via a separate cut-out cock. SAPB's shall be directly actuated by MR pressure.
- 1 12.8.3 The SAPB's shall be capable of being applied or released manually from emergency driving desk and remotely from TCMS / OCC / BCC / DCC.
- 12.8.4 The SAPB shall be an integral part of the friction brake actuation system. Parking brake application indication should be available on the brake actuators and on the driving motor car.
- 12.8.5 Not used.
- 12.8.6 In the case where an SAPB application is demanded; the time taken for parking brakes to apply shall not exceed 15 seconds.
- 12.8.7 Application of SAPB's shall inhibit the traction supply till the parking brakes are released or activation of bypass switch to energize parking brake loop.
- 1 12.8.8 Status of train parking brake shall be displayed in the TCMS and OCC / DCC.
- 12.8.9 It shall be possible to mechanically release individual SAPB's using release levers located inside the saloon of each car. This provision is specified to allow staff attending failed trainsets (E.g. where the MR feed to SPAB(s) has been lost) the possibility to release any SAPB on the train; without limitations caused by insufficient clearance for access to the exterior of the train.

12.9 PRESSURE GAUGES

12.9.1 The below list shall be displayed by analogue pressure gauges in Operator's Desk.

- a) The pressure in the main reservoir.
- b) The pressure in the brake cylinder.
- c) The pressure in the Main pipe.
- d) The pressure in the brake pipe.

1

12.9.2 The below listed pressure information shall be shared to TCMS and the same shall be displayed in RSC consoles of OCC, DCC & BCC.

- a) The pressure in all suspension reservoirs
- b) The pressure in all reservoirs of train
- c) The pressure in all brake cylinders
- d) The pressure in all parking brake units
- e) The pressure in pantograph regulator
- f) The pressure in all Vacuum Circuit breakers
- g) The pressure of Air Generation unit at different stages
- h) The pressure of Auxiliary compressor (used for raising pantograph)

12.10 TEST POINTS

12.10.1 On all cars, test points, onto which test gauges may be connected, shall be provided in the car brake and air supply system. The test points shall be provided, at the minimum, to measure the pressure of the following:

- a) Compressor motor governor.
- b) Brake cylinder pressure
- c) Main reservoir pressure
- d) Parking brake pressure
- e) Brake pressure reservoir
- f) Pressure relief valve
- g) Air spring pressure
- h) Auxiliary compressor reservoir pressure
- i) Any other point, which in the opinion of CMRL is required.

12.10.2 Quick release coupling test points made of stainless steel with blanking plug shall be provided. They shall be located in easily accessible positions.

12.10.3 These shall be located in easily accessible positions. Where quick coupling test points are provided on under frame equipment, they should be accessible from the side of the car without the need for staff to go below the car.

12.11 AIR SUSPENSION EQUIPMENT

12.11.1 A levelling control system shall be provided to ensure longitudinal and transversal control of body height under all conditions of load. In each bogie, two levelling system shall be provided to adjust air pressure in the air springs gradually. In the case of failure of one air spring, the other should quickly bleed out so that the car body is lowered to its stable position. The air supply for the levelling system shall be taken from the main reservoir pipe and a separate reservoir of suitable capacity shall be provided for each air suspension system. A load sensing valve shall be provided.

12.11.2 Levelling valves shall be installed as far as possible outside the wheel in the bogie so that the dynamic load changes are addressed appropriately.

- 12.11.3 The suspension system shall be capable of maintaining a pre-set car floor height within the limits required in ERTS (RS) clause 2.2.8.
- 12.11.4 Loss of pressure due to component failures or leakage on any one side of a bogie shall be rapidly equalized such that the car remains upright and safe operation can be continued.
- 12.11.5 Self-excitation or oscillation of the levelling system shall be avoided through the proper configuration and/or placement of height control devices.
- 12.11.6 All height control devices shall have an appropriate range of mechanical insensitivity so that frequent cycling of the system is avoided. Devices equipped with internal fluid dampening or whose primary failure mode does not result in a loss of pneumatic pressure shall not be utilized.
- 12.11.7 Height control devices shall have indicators that relate the floor height to the state or position of the device, clearly visible to maintainers.
- 12.11.8 A means shall be provided to adjust the height of the car, which shall take into account changes in height of the car, caused by wheel re-profiling, suspension creep and any other relevant factors such that car floor height remains within the range specified on ERTS (RS) clause 2.2.8.

12.12 WHEEL SLIDE PROTECTION

- 12.12.1 Digital wheel slide protection with gradual slide correction shall be provided in all braking modes. Slide detection shall be on per axle basis with correction on per axle basis during all modes of braking. The slide protection scheme provided shall be capable of detecting the severity of the slides and provide appropriate level of slide corrections. Automatic wheel wear compensation shall be incorporated in the wheel slide protection scheme.
- 12.12.2 The system shall be designed to be Fail Safe to ensure that any failure of the system shall not render it ineffective for friction brake control. If a failure of the slide protection system occurs while braking, the system shall not reduce the level of braking below the commanded level for more than three (3) seconds.
- 12.12.3 In the event of wheel slide, the brake electronics shall work in tandem with the traction equipment to manage the strategy to adopt, in implementing electric braking in axles of motor cars and pneumatic braking in axles of trailer cars, without having the blending in opposition.
 - a) The sliding effect shall be maintained during a relevant period of time, in order to increase the available adhesion at the wheel-rail contact with permanent control, in minimizing the air consumption and optimizing stopping distance.
 - b) The Contractor shall demonstrate that the correction process for wheel slip / slide shall not cause infringements of the signalling compatibility requirements.
 - c) The performance of the wheel slide protection equipment shall satisfy the relevant requirements of UIC 541-05. Testing shall be carried out in accordance with Section 2 of the UIC 541- 05.
 - d) The wheel slide system shall detect the onset of slip / slide by either an axle deceleration exceeding a pre-set parameter, or detection of a difference between the relative speeds of the axles of any one axle of any bogie.
 - e) The Contractor shall incorporate the complete compatibility for slip/slide with signalling system and interfaces. The Contractor shall submit full details of wheel slide/slip protection scheme and equipment.
 - 1 f) Wheel slip / slide indication shall be available in the TCMS / OCC / BCC / DCC.
 - g) Wheel slide protection shall be available during emergency braking. Any failure in the wheel slide protection in emergency braking shall result in the application of full emergency brake force (load corrected) and deactivation of the slip / slide system.

12.13 ISOLATION OF DEFECTIVE EQUIPMENT

- 12.13.1 Isolating valves (Main compressor isolation, Brake cylinder isolation, parking brake isolation, Air suspension isolation, etc.) and switches shall be provided to enable parts of the pneumatic system to be isolated.

- 1 12.13.2 Provision shall be available to activate all the above isolating valves and switches to isolate the defective equipment from TCMS and remotely isolate from OCC.
- 12.13.3 Isolating cock handles shall lie parallel to the pipe in which it is installed, in the normal operational (Open) position, and perpendicular to the pipe in the isolated (Closed) position and shall operate in the horizontal plane only.
- 12.13.4 If no. of bogies isolated is more than the minimum bogies required to achieve Guaranteed Emergency Brake Requirement (GEBR), then traction block shall be applied.
- 12.13.5 However, it shall be possible to override the traction block and a speed restriction of 10 kmph (configurable) shall be applied. Speed restrictions shall be finalized during design stage.
- 2 12.13.6 Suitable colour coding shall be applied to all isolation valves and cock for identification. The Contractor shall submit the color-coding scheme during design stage for review and approval by the Engineer.

12.14 ROLLBACK PROTECTION

- 12.14.1 When a train is at standstill there shall be sufficient retention of brakes (holding brake) such that the train does not roll back on a 4% gradient.
- 12.14.2 The brake application shall be retained while traction power is applied and the train takes forward movement.
- 1 12.14.3 Specific provision shall be made in the software and logics to ensure that the train safely starts from an Emergency Brakes applied condition in ~~ATO & non-ATO~~ UTO & non-UTO modes on the 4% gradient.

12.15 BRAKE CONTROL DURING TRAIN RESCUE OPERATION

- 12.15.1 During a rescue operation (E.g. where a healthy train consist is pushing / pulling a defective train consist) the healthy consist shall be able to apply or release the EP brakes of both train consists simultaneously; including when the failed consist is in a “dead” condition.
- 12.15.2 EP brake control of a defective train consist that is in a “dead” condition shall be made possible by dedicated hardwired trainlines. These trainlines will provide both EP brake control as well as an external power feed to energize the BCUs on the dead consist.
- 12.15.3 Trainlines cross-feeding the battery supply from the healthy consist shall be entirely reserved for this specific usage case. The feed shall only energize the BCUs onboard the failed / dead consist and must not energize other train circuits / subsystems that are not vital to the rescue operation. (This is to limit the risk of propagating an electrical defect to a rescuing consist.)
- 12.15.4 The healthy train shall be able to release the SAPBs / holding brakes of the defective train after successful mechanical and pneumatic connection coupling has been achieved.
- 1 12.15.5 The Contractor shall interface with ARE01 Contractor to ensure that full compatibility of train rescue functionality is achieved. The same shall be demonstrated during at type test stage. The existing 4 car trains of CMRL Phase 1 and Phase 1 extension, are equipped with Semi-automatic coupler (Make: Faiveley & Model: Propact SD330) and train to train rescue electrical jumper cable for 110v dc supply

12.16 FAILURE MANAGEMENT

- 1 12.16.1 MR pipe connection (via the semi-automatic coupler) shall (in combination with the brake control requirements described in Clause 12.15) be all that is required to facilitate the rescue of sick trains in all foreseeable modes (E.g. Defective, Immobilized, No battery power or in a shutdown condition). Detailed schematics shall be subject to CMRL review during design finalization.
- 12.16.2 Simultaneous brake application in both the healthy and defective train consists shall always be achieved during train rescue; regardless of whether the sick train is powered on or shutdown.
- 12.16.3 To facilitate the rescue of a defective train which has a burst MR pipe (or total loss of pneumatic integrity); the rescuing train shall be able to push-out a failed train in a condition where the MR

pipe is isolated at the semi-automatic coupler, service brakes are isolated on the defective train (as defined in clause 2.14.2.3).

- 12.16.4 Low speed shunting of a dead train may sometimes be undertaken by isolating the service brakes. In this scenario, the MR pipe of the dead train may intentionally be left in a charged state in order to avoid the application of parking brakes. The risk of this method of shunting shall be mitigated by an Emergency Parking Brake Application Cock (EPBAC).

The Contractor shall provide an EPBAC in the cab area to allow an onboard shunter to rapidly vent the MR pressure to apply the parking brakes on the dead train in case of an emergency. The EPBAC handle shall be located behind a clearly labelled access flap.

- 12.16.5 All details shall be submitted by the Contractor during Pre-Final Design stage for review and acceptance.

12.17 JERK LIMITATION

- 12.17.1 The build-up of pneumatic brake force shall be jerk limited (for changes in brake demand) to increase passenger comfort. The jerk limitation shall not exceed 0.75 m/s^3 . This limit shall also be respected at the time of final stoppage also.
- 12.17.2 The Rolling Stock Contractor as well as Signalling Contractor shall comply EN 13452-1 or equivalent international standards for jerk determination and methodology.
- 12.17.3 Jerk rate control shall be applicable to braking as well as propulsion.
- 12.17.4 Removal of tractive effort and application of brakes under emergency braking conditions shall not be jerk limited.
- 12.17.5 Removal of tractive and brake effort under wheel slip conditions shall not be jerk limited. The reapplication of power and brake effort shall be jerk limited.

12.18 BRAKE OPERATING TIMING

- 12.18.1 The following maximum brake operating timing shall be achieved on all cars of a train. The maximum time for a brake application from initiation of brake application command from Brake control unit to 90% of full Brake Cylinder Pressure (BCP) and for brake release from initiation of brake release command from Brake control unit to 10% of BCP shall not exceed the following:
- Service Brake Application : 2.0 sec
 - Emergency Brake Application : 1.5 sec (max.)
 - Service and Emergency Brake Release : 2.5 sec.
- 12.18.2 The Contractor shall provide timing diagram during design stage for CMRL review and approval.
- 12.18.3 Any malfunction of brake control system, which can cause an unsafe operation, shall result in an emergency brake application. In case of single point failure in brake control system, which can be automatically isolated and fully compensated without affecting the train performance, the application of emergency brake shall be avoided.

12.19 SIL LEVEL REQUIREMENTS:

- 12.19.1 The brakes system shall comply with the following SIL levels:

Emergency Brakes	SIL 4
Service Brake, Train Speed information, Wheel Slide Protection, Holding brake application & Feedback	SIL 2

12.20 BRAKE PIPE (BP) CONTROLLED BACK-UP BRAKE SYSTEM

- 12.20.1 BP controlled back-up system including a separate pneumatic control unit shall be provided in order to take over the control function in case of failure of electronic or electric control elements

in the brake system. In case of such failure, the operator can continue to control braking by using the back-up brake. This system shall also be used to control brake system of dead train during rescue by a healthy train, transit of cars and shunting operation.

OR

Alternatively, contractor may provide extension of EP brake and emergency brake lines from healthy train to defective train through a suitable jumper cable which can be connected manually during such eventualities. The extended EP brake lines shall be in form of coded hardwires brake lines providing service brake in 3/4 steps in both the trains. The jumper connection shall be easily accessible, flexible and self-lockable after connection. The connector housing shall have protection level not less than IP65 and shall be designed to automatically protect the connector against dust and water. The cover shall harmonize with the external finish. One set of jumper cable shall be kept in each cab duly secured. The hardware lines as well as jumpers shall be with 100 % redundancy with one jumper connector on each side of the cab front. The system shall ensure the integrity of these lines by built-in self-test and also their isolation in case of extension of feed to the faulty brake lines of the defective train. Detail shall be submitted during PFDR stage for CMRL approval.

- 12.20.2 For BP backup brake system, brake control unit shall be ergonomically placed on operator's console and shall have three positions for application, charging and lap modes.
- 12.20.3 During the operation of this mode, the dynamic brakes shall be isolated and the pneumatic brake application shall be resorted to.

12.21 UTO OPERATION

- 12.21.1 The design of Pneumatic and Brake equipment and its relevant components in train shall support for the UTO / GoA4 in CMRL Phase 1 & Phase 1 extension network as defined in Chapter 1. Trains shall be operated in GoA2 / ATO mode during the initial stage of commissioning and revenue operations and in GoA4 /UTO subsequently. Hence all the feed-backs, information and train controls which are available on TCMS screen shall also be available in OCC / BCC / DCC for smooth operation of passenger service. The Contractor shall submit the details of controls to be provided in OCC & DCC for review and approval of CMRL.

1

13. COMMUNICATIONS

13.1 NOT USED

13.2 GENERAL

- 13.2.1 The Contractor shall conform to applicable international standards and best practices for communications requirements and shall be responsible for design and interface coordination, installing and testing the entire train communications system.
- 13.2.2 The system components shall be modular and shall be removable for servicing, without affecting other functions or devices.
- 13.2.3 The communications system shall include the following major components:
- Communications Control Heads (CCH) system
 - Public Information System (PIS),
 - Public address system with automatic announcements
 - Exterior and interior message displays
 - Operator's desk-to-desk Intercom (during special situations)
 - Passenger Emergency Intercom from OCC and TCMS
 - Interior and Exterior Video Surveillance and CCTV
- 13.2.4 The Contractor shall verify through testing that all required inter-car communications are totally functional through the car-to-car jumper cables of a 6 car train.
- 13.2.5 All electrical materials, components, and installation methods used in the fabrication of the communication system, including wire, cable, printed circuit boards and circuit protective devices, shall conform to the requirements of Chapter 19.
- 13.2.6 The Contractor shall submit data sheets and/or specification sheets for all communications system components.
- 13.2.7 Structured programming techniques, as specified in Chapter 20 shall be used for all software driven communications subsystems.
- 13.2.8 All communications equipment shall be operable when train auxiliary supply is ON and shall also be functional with battery supply alone.
- 13.2.9 Sufficient extra cable length shall be provided to allow at least three re-terminations at each end of all the cables inside Jumper cable conduits, at terminal block connections, under frame connections, roof connections, saloon interior connections.
- 13.2.10 Each main communication system shall be operated and inhibited independently in case of failure. This inhibition shall be possible from TCMS, OCC, BCC and DCCs.
- 13.2.11 The components of communication system shall be installed such that the mounting hardware is readily accessible for ease of service and maintenance. Exposed hardware is not permitted.
- 13.2.12 Not used.
- 13.2.13 A single point failure in the communication system shall not impact the complete train communication system. Hence sufficient redundancies shall be incorporated.
- 13.2.14 Not used.
- 13.2.15 All memory storage system shall be Solid State Disk (SSD) or Micro SD card or other latest technology available subject to CMRL approval.
- 13.2.16 The Contractor shall provide suitable space, mounting provisions, wiring and separate circuit protection for the communication equipment including power supplies. The power supplies shall be fed from the low voltage power supply and emergency storage battery circuit. The Contractor shall use best practices for equipment wiring and network wiring as per the relevant international standards.
- 13.2.17 The Contractor shall refer to Chapter 3, Chapter 5 and Appendix C for fitment of communication

and interface equipment within operator's desk and in train.

- 13.2.18 The Communications System shall comply with BS EN 60268.
- 13.2.19 The Communications System functions has to meet the all the criteria defined in Chapter 14.
- 13.2.20 All electrical and electronic components shall comply with the EMC and EMI requirements of EN 50121 (all parts), IEEE 16, EN 55011 and IEC 61000-4 standards or other equivalent international standards. The requirements of EMC EMI in Clause 10.19 & 2.18 shall be met.
- 13.2.21 Fire properties of the materials used shall comply with EN 45545 part 1 to part 7 latest editions (Category 4-A, Hazard level HL3) as a minimum or better international standard applicable for similar Metro applications. Requirements of clause 2.26 shall be met.
- 13.2.22 Material requirements of Chapter 19 shall be compliant.

13.3 POWER SUPPLY

- 13.3.1 All communication equipment shall be powered from the low voltage power supply and storage battery with voltage ranges as defined in Chapter 9.
- 13.3.2 The communications system shall be configured with a separate circuit breaker for each major component. Failure of one component shall not affect the functionality of other major components.

13.4 COMMUNICATIONS CONTROL HEAD (CCH)

- 13.4.1 A CCH shall be installed in the Driver Desk at both ends of the train. CCH shall be touch screen display which shall be operable by authorized Operation / Maintenance personnel with a unique login detail. The Contractor may propose any emergency control buttons on operator's desk apart from control from CCH console.
- 13.4.2 The CCH shall provide the Operator with a control interface to the entire communications system, except for the Diagnostic Monitoring System (DMS) and event recorder.
- 13.4.3 The CCH shall interface with all audio and visual communication equipment and shall provide the following functions:
 - a) Control and reset any passenger emergency intercom of the train.
 - b) Select and control operator's desk-to-desk communications.
 - c) Control PIS announcements.
 - d) Play independent and automatic route related audio & visual announcements.
- 13.4.4 The status indications, operation, control and isolation of the features mentioned in clause 13.4.3 shall be provided from CCH console inside the operator desk. The console shall contain all the communication equipment status indications.
- 13.4.5 The communication system shall remain operational even if one of the two CCHs in a train has failed.
- 13.4.6 The Contractor shall submit communication system functional descriptions, display layout of functions in CCH console, control scheme and block diagrams of the CCH and associated communications components.
- 13.4.7 A Train operator microphone, complying with EIA-SE-103, shall be provided on each emergency driver desk. This microphone shall be used for non-automatic PA announcements, and for communication through operator's desk-to-desk and PEI. During UTO / GoA4 operations, this microphone shall be sealed inside the operator's desk panel in a safe manner without damage during operator's desk panels open or closing function. Suitable design of operator's Mic shall be suggested by the Contractor.
- 13.4.8 Automatic Touch screen calibration shall be incorporated within the in CCH display during train restart activity. The touch screen sensitivity shall be suitable for industrial applications and Rolling stock applications. Train operator or maintainers shall not feel discomfort in operating the touch screen.
- 13.4.9 Driver Desk Speakers

- 13.4.9.1 A speaker system shall be installed on each driver desk to ensure train radio and intercom systems communications between the driver and OCC, driver and passengers, and other radio functions required.
- 13.4.9.2 Speaker output shall be adjustable to the minimum required audible output level specified in clause 13.7.2.9.

13.5 TETRA RADIO SYSTEM

The TETRA radio system shall be supplied by the Tele-Communications Contractor shall ensure communications between train operator and control room. The TETRA radio is for operations, maintenance and voice communications and data applications in connection with data of the TCMS systems.

- 13.5.1 The TETRA radio system shall consist of exterior antennae, console-mountable, standard type radios and radio power supply units together with all installation materials and cables required for installation. The RS Contractor shall install and connect these antennae on the train roof, one radio in the console of each cab desk and one radio power supply in each cab desk.
- 13.5.2 Detailed dimensional, weight and power requirement information shall be presented for CMRL approval at the time of Preliminary Design Review.
- 13.5.3 The RS Contractor shall provide suitably space, mounting provisions, wiring and separate circuit protection for the radio power supplies. The radio power supplies shall be fed from the low voltage power supply and emergency storage battery circuit.
- 13.5.4 The RS Contractor shall provide and install cable from the radios to the corresponding antenna, using removable connectors at each end of the cable. The cable impedance shall match the output impedance of the radio.
- 13.5.5 The Contractor shall submit the above said (i.e., 13.5.1 to 13.5.4) for CMRL approval.
- 13.5.6 The antenna-to-radio connection shall be kept as short as possible and shall have no angle connections unless otherwise approved by CMRL.
- 13.5.7 The Contractor shall use gaskets to make the installation of the antennas weatherproof and resistant to damage from the carwash service areas. Sealant shall not be permitted for fixing of roof / exterior mounted equipment.
- 13.5.8 The Contractor shall submit for approval, during design review, detailed information on radio equipment interfaces, mounting, and wiring.

13.6 SILENT ALARM

- 13.6.1 The Contractor shall furnish and install activation switches for the silent alarm in each cab, and wiring between the radio and silent alarm.
- 13.6.2 When activated, the silent alarm shall cause the train radio to send an automatic alarm to the Operations Control Center (OCC), together with the train's identification.
- In addition, it shall be possible for an agreed-upon message to appear on the exterior passenger information displays of the train. This function shall be able to be set to either active or inactive.
- 13.6.3 The switch for the silent alarm shall be mounted in an easily accessible position during normal operation of the vehicle but activation of the alarm should not alert any second party. The details of the switch for the silent alarm shall be presented for the approval at the Final Design Review.

13.7 PUBLIC INFORMATION SYSTEM

The Public Information System (PIS) shall consist of both visual and audible announcements, train information, advertisements that comply with "The Rights of Persons with Disabilities Act, 2016" both inside and exterior of the vehicle. The PIS shall interface with the TETRA radio system and Signalling system to allow ~~broadcast from OCC~~ full-duplex two-way communications between passengers and the OCC, BCC & DCCs and vice versa.

13.7.1 Passenger Information Displays

- 13.7.1.1 The passenger information displays shall consist of exterior information displays and interior information displays. Control of these displays shall be integrated into the overall communications system.
- 13.7.1.2 In general, these displays shall include, but shall not be limited to information on the current running route, route destination station, next station stop, skip station, door opening side, connecting station information as well as further secondary messages to be determined by CMRL during design stage.
- 13.7.1.3 In case of any further extensions / modifications of stations of the corridors and in case of any change in operation strategy of the train, there shall be a requirement of additions / deletions / modifications of these route related messages in future. Also, there shall be a requirement to modify the special / emergency announcements in train. Hence a provision shall be provided to CMRL to increase / decrease / modify / update these messages independently using the Contractor-supplied Software tools. These tools shall be provided during the first train taking over by CMRL.
- 13.7.1.4 The information displays shall allow maximum visibility to all seated and standing passengers.
- 13.7.1.5 Control of all displays in a train shall be possible from the TCMS, OCC, BCC and DCCs.
- 13.7.1.6 The displays shall be all-electric, alphanumeric, and completely self-contained. The display shall be capable of displaying both in Tamil and English languages.
- 13.7.1.7 The character font and size of the messages shall be designed for proper readability for all passengers inside the train.
- 13.7.1.8 All passenger information displays shall comply with “The Rights of Persons with Disabilities Act, 2016”.
- 13.7.1.9 The displays shall be readable in direct sunlight or complete darkness and all degrees of light in-between.
- 13.7.1.10 All the displays shall be LCD displays with LED backlit or any other latest better technology displays. The viewing angle for the displays shall be minimum 178 Deg.
- 13.7.1.11 Not Used.
- 13.7.1.12 The displays shall not require any external mask between pixels and shall not require any framing or support structure between characters that would give a discontinuous appearance.
- 13.7.1.13 The Contractor shall submit for approval information on the design, specifications and location of the interior and exterior displays in design stage.
- 13.7.1.14 Dynamic Route Map Displays (DRMD)**
- 13.7.1.14.1 The saloon of each car shall have a total of eight (8) DRMD screens. The screen locations shall be proposed by the Contractor during PDR stage and is subject to CMRL approval. (Also refer to clause 2.2.15)
- 13.7.1.14.2 Each DRMD unit shall be a single display screen with a stretched aspect ratio. The minimum screen size shall be at least 48”. The use of multiple screens joined together is not acceptable.
- 13.7.1.14.3 Screens shall be LCD (with LED backlight), however, a later / better technology of display may also be proposed for CMRL’s review and acceptance.
- 13.7.1.14.4 There shall be no glare from the mounting frame or from the interior of the vehicle that could impair the display’s readability.
- 13.7.1.14.5 It shall be possible to read route related messages and all details of route map from at least one of the displays from any location within the passenger compartment. The font and size of the details shall be suitably provided.
- 13.7.1.14.6 The Electronic route map shall show at-least the following information:
- a) Destination station.
 - b) Current station.
 - c) Next station.

- d) Distance for reaching the next station.
- e) Expected time of Arrival for Destination station.
- f) Real time clock and date.
- g) Door side opening / closure status.
- h) Door opening information.
- i) Skip station information, etc.
- j) Network map, Route map & Current route.
- k) Any ambient information like speed, temperature, humidity etc.
- l) Interlinking metro stations with places of importance to be highlighted.
- m) Any special announcements from OCC / Train operator.
- n) Scrolling of route related announcements.

1 13.7.1.14.7 ~~Not used.~~ Provision shall be available for OCC, BCC & DCC to broadcast messages on these displays during rescue operation, during UTO operation etc.

13.7.1.14.8 Route maps of Different corridors shall be shown in different colours. Interchanging stations and important places (Malls, hospitals, Bus station, Rail station, Airport, etc.) in the route shall be highlighted while showing the routes. The addition and deletion of important places at any time shall be possible. The Contractor shall provide necessary tools and software to CMRL for updating the information on route maps independently.

13.7.1.14.9 Route information on the display shall align to the train running direction on both left and right sides of the saloon. Station names shall be displayed in English and Tamil languages.

13.7.1.14.10 Not Used

13.7.1.14.11 Internal Electronic Destination Display (IEDD)

There shall be displays on both ends of non-driving cars and at gangway end of driving cars just above the gangway of the Car. The programmable display shall be capable of displaying the next station and destination in Tamil & English language along with other graphic. The minimum size of the display screen shall be 36" corner to corner. The location and specification shall be submitted for CMRL approval.

13.7.1.15 Exterior Displays

13.7.1.15.1 LCD with LED backlit displays or any latest better technology displays shall be provided at both ends of the train above the windshield and side displays shall be provided on each side of the carbody (each covering a full window length) to indicate the destination station and route information. The message shall be displayed in both English and Tamil simultaneously.

13.7.1.15.2 The brightness of the display shall be adjusted automatically according to the brightness of the sunlight so that passengers shall be able to read information on Exterior display at all times.

13.7.1.15.3 In addition to the destination station name, the Train ID details shall be displayed on it. Train ID shall be displayed duly getting location and direction information derived from signalling system and also an independent Rolling stock vehicle locator system.

13.7.1.15.4 The exterior display size shall be approved by the CMRL during design stage.

1 13.7.1.16 ~~Displays for advertisement Purpose~~ Displays for Safety, Operational, Advertisement and Emergency Purpose

13.7.1.16.1 18 no's of LCD with LED backlit displays (or superior technology) shall be provided inside each coach. Screens shall be at least 27" corner to corner and 16:9 aspect ratio. Display locations and specification shall be submitted for CMRL approval.

1 13.7.1.16.2 These displays shall support for broadcasting advertisements Safety, Operational, Advertisement and Emergency in video and picture formats, CMRL promotional videos and route related information.

13.7.1.16.3 By default, these display shall show the route related information similar to Electronic route maps. Provision shall be made available for CMRL to switch over these displays into commercial mode

1 for broadcasting advertisements from single point in the train. In case of any emergency, priority shall be given for broadcasting emergency video.

13.7.1.16.4 The Contractor shall provide necessary storage devices for enabling CMRL to upload the video & Picture files from a single point in train to broadcast on all the train's displays.

13.7.1.16.5 Necessary interfaces shall be provided for broadcasting advertisements in a logical manner such as broadcasting multiple videos one after other or broadcasting a single video for a specified period, broadcasting advertisements at a specific location or station, etc.

1 13.7.1.16.6 During the Emergency / Rescue operation these displays must show the necessary instructions / information for the passenger to operate Emergency Exit door. This control shall be done from TCMS, OCC, BCC & DCC.

13.7.1.16.7 Adequate protection shall be ensured to protect the displays from vandalism.

1 13.7.1.16.8 In the event of fire detection, the necessary interface shall be provided to enable broadcasting of the emergency video. This control shall be available through TCMS and FDS.

13.7.2 Public Address System

13.7.2.1 The PA system shall operate with uniform audio quality throughout a train and shall be designed to inhibit audio feedback or echo.

13.7.2.2 The Contractor shall submit for approval an audibility analysis for the PA system, including the location of each speaker in the car. The minimum acceptable Speech Transmission Index must be better than 0.5

13.7.2.3 The PA system shall be muted when not in use.

1 13.7.2.4 The PA system shall enable the train Operator and OCC/BCC operator, using the CCH microphone, to make announcements from the operating desk to passengers throughout the train and to persons on station platforms (using train's exterior speakers).

13.7.2.5 A switch matrix shall be used to select the PA speakers on the inside of the train, on the outside of the train (independently for left or right side), or both inside and outside the train (with both sides active) during operation and testing purposes.

13.7.2.6 The PA system shall operate without a loss of audio quality on the maximum-length of train.

13.7.2.7 All controls of the PA system shall be located on the CCH.

13.7.2.8 All the announcements being broadcasted using CCH microphone shall be recorded and the recordings shall be available in the train for up-to 7 days.

13.7.2.9 Audio levels of all the announcements in the train shall be automatically adjustable based on both the train speed and dynamic passenger loading in the train. The Contractor shall provide to CMRL, volume control settings at various dB levels which can be selected and followed during train commissioning stage itself suiting to the requirements of passengers.

1 13.7.2.10 All PEI communication with OCC & train operator, DCC & Train operator shall be two way and full duplex type. The sound of communications shall be free from background noise and shall be free from disturbances.

13.7.3 Power Amplifier

13.7.3.1 Power amplifiers shall meet the requirements of EIA-SE-101 or any latest applicable standards.

13.7.3.2 The power amplifiers shall be capable of delivering a minimum of 50 Watts configured as a constant voltage distribution system at not more than 1% total harmonic distortion in the range of 100 Hz to 8 kHz.

13.7.3.3 The frequency response shall be within ± 1 dB from 100 Hz to 8 kHz, with provision for a roll-off of 6 dB per octave below 100 Hz.

13.7.3.4 The signal-to-noise ratio of the amplifier below the compression threshold shall be at least 65 dB

13.7.3.5 Each amplifier shall be stable, with no oscillation present during any normal operation.

13.7.3.6 Amplifier controls shall be equipped with a locking mechanism to prevent inadvertent adjustments and shall be accessible only for maintenance or service.

13.7.3.7 The Contractor shall ensure in the design that in case of failure of Power Amplifier in a car, under

such condition, at least 50% of the speakers shall be fed from the adjoining car. To ensure that in the event of a single failure, at least half of the speakers are still operative in the car.

13.7.4 Speaker General Requirements

- 13.7.4.1 All interior speakers shall be of transportation grade, direct radiating, axial-free, permanent magnet type and shall comply with EIA-SE-103 or any latest applicable standards.
- 13.7.4.2 The interior speakers shall have an axial-free field sound pressure level (SPL) of 95 dB referenced to 2×10^{-11} N/mm² at a distance of 1220 mm from the speaker.
- 13.7.4.3 Off-axis coverage between any two adjacent speakers shall not be greater than 6 dB below the on-axis SPL for uniform sound distribution.
- 13.7.4.4 The enclosure and the speaker shall be removable from the vehicle as a complete unit.

13.7.5 Interior Speakers and Exterior Speakers

- 13.7.5.1 16 number of Interior speakers shall be evenly spaced longitudinally in passenger seating areas.
- 13.7.5.2 Metal covers or plastic enclosures shall protect the interior speakers from dust, moisture, and vandalism.
- 13.7.5.3 The frequency response shall be ± 5 dB from 300 Hz to 8kHz, with a gradual roll-off of response above 7 kHz.
- 13.7.5.4 The exterior speakers shall be similar to the interior speakers except that they shall be suitable for outdoor use and have suitable IP 65 protection.
- 13.7.5.5 Exterior speakers shall be placed such that, they shall not be closed behind the permanent panels of station Platform Screen Doors (PSD).
- 13.7.5.6 The connecting cables of the exterior mounted speakers shall be protected using cable glands.

13.8 AUTOMATIC ANNOUNCEMENTS

- 13.8.1 Automatic announcements shall include, but shall not be limited to, station arrival, Door opening side, current running route, route destination station, next station stop, skip station, door opening side, connecting station information as well as further secondary special and emergency messages to be determined by CMRL during design stage. The announcement control unit shall be an integral part of the CCH or, alternatively, the Passenger Information System (PIS).

- 1 13.8.2 Announcements from the OCC Operator / Train operator / BCC operator / DCC operator shall always override automatic announcement.

- 13.8.3 The announcements shall be broadcasted automatically when the train moves between the stations.

- 13.8.4 The automatic announcement function shall use locally stored predefined digital messages and shall broadcast these messages to passengers automatically at designated track locations by means of location and direction information derived from signalling system and also an independent Rolling stock vehicle locator system. Overriding automatic messages by manual message triggering by the operator shall also be possible.

- 1 13.8.5 Provision shall be available for the operator of train / OCC / BCC / DCC to enter the route related information manually into communication system for the purpose of enabling automatic announcements.

- 13.8.6 The digitally recorded messages shall be broadcast over the PA system. Text messages shall be displayed on the passenger information display units.

- 13.8.7 The audible and text messages shall be synchronized with each other on the displays and speakers to provide audible and visible information compliant with “The Rights of Persons with Disabilities Act, 2016”.

- 13.8.8 A pre-recorded announcement or tone, advising passengers while the doors are opening and when doors are closing shall be broadcasted. These announcements shall be broadcasted by the communications system, triggered by signals from the door control system and signalling door information.

- 13.8.9 It shall be possible for CMRL to record and change the pre-recorded route related messages, special messages and add such recordings to all trains. Necessary tools and software shall be provided by the Contractor to CMRL to perform this function.
- 13.8.10 The preferred method of message storage is by internal storage which can be updated via the network, or by programmable memory cards.
- 13.8.11 Messages shall be recorded by Professionals (both Male & Female for all languages) using a professional recording studio, voice samples shall be approved by CMRL.
- 13.8.12 The Contractor shall provide a detailed description of the message recording and transfer process at the time of PDR. The recording and transfer process and methodology shall be subject to CMRL approval.
- 13.8.13 All the announcements shall be stored in two languages, Tamil and English.
- 13.8.14 During the operation time, CMRL may run the trains in multiple combination of routes within the corridors 1 & 2 which may subject to change during the operation stage. Hence the Contractor shall design the communication system such a way that automatic announcements shall work in trains within any route operated by the CMRL.
- 13.8.15 Implementation of the automatic route related announcement system of trains shall be functioned by using signalling variables as a main function. Rolling Stock Contractor shall interface with Signalling Contractor for this information. The Rolling stock Contractor shall also have an independent automatic route related announcement system in trains for redundancy purpose only. This redundant system shall be functional in all ~~ATO UTO, non-ATO non-UTO~~ and degraded modes of train operation and shall be designed to have all the functions of the Automatic Passenger announcement system. RS Contractor shall provide PAPIS test bench with one display of each type and one audio speaker specific to interior and exterior of train. The purpose of the test bench is to check the audio-visual modifications in the PAPIS software before loading in the train

13.8.16 Manual Pre-Recorded announcements

- 13.8.16.1 There shall be a provision to store pre-recorded voice messages in the communication system by CMRL.
- 13.8.16.2 These pre-recorded messages shall be broadcasted by the train operator from the driver desk Communications Control Head (CCH) in all ~~ATO, non-ATO non-UTO~~ modes and degraded modes of operation.
- 13.8.16.3 ~~Not used. RSC consoles in OCC, BCC & DCC shall have the provision to select pre-recorded messages remotely and to broadcast in any train.~~
- 13.8.16.4 Addition and deletion of pre-recorded messages shall be possible by CMRL. The Contractor shall provide necessary software/ tools to CMRL.

13.9 OPERATOR'S DESK-TO-DESK COMMUNICATIONS

- 13.9.1 Communications equipment shall be provided to permit two-way full-duplex voice communications between the active Driver desk and the non-active driver desk in a train.
- 13.9.2 The Operator shall accomplish desk-to-desk communications by selecting this mode on the CCH and using the microphone.
- 13.9.3 The sound quality of desk-to-desk communications shall be of the same quality as the PA as detailed in clause 13.7.2.
- 13.9.4 The maximum permissible variation in sound levels shall not exceed 5 dB (Standard to check).
- 13.9.5 Desk-to-desk communication shall not be broadcasted in the saloon speakers. A dedicated speaker near to the Driver desk shall be installed for this purpose. This speaker shall have a provision for volume adjustment.
- 13.9.6 The desk-to-desk conversation shall be recorded in the train and the recordings shall be available for up-to 7 days in the train.

13.10 PASSENGER EMERGENCY COMMUNICATIONS

- 1 13.10.1 A two-way full-duplex emergency intercom shall be provided to enable passengers to initiate hands-free communications with the train Operator in non-UTO mode and with RSC console of OCC, BCC & DCCs in UTO mode. All the PASSENGER EMERGENCY INTERCOM (PEI) communication with RSC console of OCC, BCC & DCCs and train operator shall be two way and full duplex type ~~under all~~ in both UTO mode and non-UTO modes of operation. The communications shall be free from background noise and shall be free from disturbances.
- 1 13.10.2 When a pushbutton on the PEI is depressed, an audible and visible annunciation shall be provided on the Train's CCH and in RSC console of OCC, BCC & DCCs based on the mode of operation. The Contractor shall present for CMRL approval during design review the pushbutton type, which should minimize unwarranted activation by passengers. The push-buttons for this purpose shall be flushed mounted with the car interiors.
- 1 13.10.3 A press-to-reset soft button shall be available at the CCH to permit the Operator to reset any activated PEI. Provision in RSC console of OCC, BCC & DCCs shall also be available to reset any activated PEI in UTO mode of operation.
- 13.10.4 The press-to-latch button at the PEI station shall illuminate when activated. The illumination shall turn off when the intercom is reset.
- 1 13.10.5 In each car four (4) numbers of PEI shall be provided to facilitate emergency, full duplex communication with passengers. The PEI locations shall be finalized in consultation with CMRL.
- 13.10.6 The PEI shall be easily accessible to wheelchair patrons and shall be compliant to "The Rights of Persons with Disabilities Act, 2016" and shall have Braille instructions which explain the process of operation of Passenger Emergency communication device.
- 13.10.7 The Contractor shall submit for approval information on the design and location of PEI stations.
- 13.10.8 Not Used
- 1 13.10.9 All the conversation (Audio and Video) between passenger and train Operator / OCC operator / BCC operator shall be recorded in the train and shall be downloadable. These recordings shall be available for at least 30 days.
- 13.10.10 Suitable signage shall be provided in both English and Tamil at the PEI location.
- 1 13.10.11 PEI devices shall include microphones, loud-speakers and an alarm button. A low level / forward facing CCTV camera (tamper proof type) shall be located near ~~inside to~~ each PEI device to deter misuse. The car CCTV System shall automatically select cameras within the specific area of an alarm activated PEI device and display images ~~CCTV screens~~ in OCC, BCC, DCC and on TCMS screens.
- 1 13.10.12 Upon activation of PEI, there shall be an audio & visual alarm in OCC / BCC with the details of train.
- 1 13.10.13 TETRA Contractor shall furnish RS Contractor with the interface required between the TETRA radio system and the on-train public address system/other suitable system of RS to allow onboard PEI call point mic of RS to be used for silent listening of saloon voice through TETRA by OCC. The identifier of the PEI device (which call point in which car of the train) shall be communicated by the on-board TETRA system to the RS system for selecting the mic of that call point to be used for this feature. There shall not be any indication on the PEI call point or any other location on the train, visible for passengers, denoting the silent listening mode activation. RS Contractor shall interface with TETRA Contractor and shall provide necessary hardware and software interface as described above.

13.11 HEARING LOOP SYSTEM

- 13.11.1 The Contractor shall provide and install an induction-based Hearing Loop System or any other latest technology in all designated passenger areas of the train, fully integrated with the Public Address (PA) system to support passengers using hearing aids.
- 13.11.2 The system shall ensure uniform coverage, comply with all applicable standards, and be fully

tested and commissioned. All costs associated with the Hearing Loop System shall be included in the Contract Price.

13.12 NOT USED

13.13 VIDEO SURVEILLANCE SYSTEM (CCTV)

13.13.1 Each car shall be equipped with a video surveillance system to observe passengers and equipment inside and outside the saloons. The CCTV system shall consist of video cameras, operator monitor screens (CCTV DDU), and digital video storage including the control electronics, and associated power supply & network. The video broadcasting in CCH and video recordings shall be available at a frame rate of 30 fps or more. The picture quality shall be minimum level E, at 100% Rotakin measured, according to EN50132-7.

13.13.2 Each car shall be pre-wired to provide power to the video system from a dedicated circuit breaker.

13.13.3 Each car shall be provided with conduit to be able to connect each video camera to the central video recorder (one in each operator's cab of a train). Central Video Recorder shall be redundant to each other. The connection between the cars of a train shall be by jumper conduit with weather-proof quick disconnects at both ends. The memory of each central video recorder shall support to store ~~seven~~ thirty (30) full days of video recordings of all the interior & exterior cameras of the train. After ~~seven~~ thirty (30) days the video recordings shall be overwritten on First in First out (FIFO) basis. Provision shall be available to download video recordings of any camera from a single point in the train. Necessary software for downloading video recordings shall be provided to CMRL.

13.13.4 The Contractor shall propose an interior video surveillance system, including the appropriate number of cameras (minimum six cameras), to provide adequate coverage of the passengers in the coaches, all saloon doors, PEI, Emergency Egress Devices, Wheelchair area and Driver desk. There shall not be any blind spot for video surveillance in the car.

13.13.5 ~~In addition to the cameras provided inside the saloon, the Contractor shall install cameras outside the saloon to monitor the OHE & Pantograph (One Camera) and Platforms (minimum four cameras per car) of each station. External mounted cameras of each coach shall clearly cover platform to coach passenger ingress egress for all the doors of coach. These cameras shall be specific to each coach side. Passenger obstacle detection at any door of train shall be clearly identifiable through these external mounted CCTV camera footages. All external mounted cameras shall have Ingress Protection with IP 65 rating. All interior and exterior cameras of train shall be vandal resistance with IK 10 rating and shall operate in all exterior temperature and humidity conditions mentioned in ERTS 19.54.3 and Table 2-6. They shall operate during all passenger service modes including commissioning. All cameras of train shall be compatible with EN 50155. The recordings from these cameras must be clear in dark, daytime, night time and in all hours of operation even in case of non-availability of any exterior lighting. All the exterior cameras shall be Infra-red type or latest better type. The Contractor shall submit CCTV camera locations for both inside and outside the coach for CMRL approval.~~

~~In addition to the cameras provided inside the saloon, the Contractor shall install cameras outside the saloon~~

~~a) to continuously monitor platforms of each station~~

~~External mounted cameras of each coach shall clearly cover platform to coach passenger ingress-egress for all the doors of coach. These cameras shall be specific to each coach side. Passenger obstacle detection at any door of train shall be clearly identifiable through these external mounted CCTV camera footages.~~

~~b) to continuously monitor track, OHE & Pantograph~~

~~The Train shall be equipped with forward-facing exterior cameras mounted on both driving cabs to continuously monitor track track and forward-facing exterior cameras mounted on the roof to continuously monitor OHE & Pantograph. These cameras shall be integrated with video analytics functionality. The system shall continuously monitor the track, Overhead Equipment (OHE), and the surrounding environment and shall be capable of automatically detecting abnormal or unsafe~~

conditions, including but not limited to track obstructions, infrastructure anomalies, and intrusions. Upon detection of any abnormality, the system shall generate real-time alerts to the Train Control and Monitoring System (TCMS) and transmit the same to OCC and BCC. The number, type, field of view, coverage, and installation locations of the cameras shall be determined during the design stage. The use cases of the system shall include, but shall not be limited to, detection of foreign objects on track, monitoring of OHE condition, identification of track defects, detection of trespassing, and monitoring of environmental conditions such as flooding, smoke, or debris that may impact safe train operation. In addition to video based analytics, the Contractor shall provide LiDAR or equivalent 3D sensing technology in combination with cameras for enhanced monitoring & detection of track obstructions, OHE geometry deviations, and clearance infringements. The system shall be designed using a multi sensor configuration. Further, all alarms shall be integrated with the OCC software for monitoring.

All external mounted cameras shall have Ingress Protection with IP 65 rating. All interior and exterior cameras of train shall be vandal resistance with IK 10 rating and shall operate in all exterior temperature and humidity conditions of Chennai mentioned in Table 2-6. They shall operate during all passenger service modes including commissioning.

All cameras of train shall be compatible with EN 50155. The recordings from these cameras must be clear in dark, daytime, night-time and in all hours of operation even in case of non-availability of any exterior lighting. All the train cameras shall be Infra-red type or latest better type. The Contractor shall submit CCTV camera locations for both inside and outside the coach for CMRL approval.

- 13.13.6 All the interior and exterior cameras shall support for a video resolution of minimum 1920x1080 HD and minimum 30 frames per second, minimum illumination of 0.3 lux (colour), iris control, minimum 90 dB wide dynamic range (WDR) and Power Over Ethernet (POE) compliant. Cameras shall be of proven design in railway applications. The recordings from these cameras must be clear in dark, daytime, night-time and in all hours of operation even in case of non-availability of any exterior lighting. All the Exterior train cameras shall be Infra-red type or latest better type. Camera and Recorder shall comply CCTV Industry standards like onvif. The Visual images from each camera shall be recorded in non-volatile memory without any limitation of repetitive writing of the data. Each camera shall have recorded capacity for at least ~~7~~ **thirty (30)** days. The records shall be easily downloadable.

- 13.13.7 ~~The exterior camera view shall be automatically streamed in CCTV DDU when the Saloon Doors are Opened in the Platform.~~

The exterior camera view shall be continuously streamed in a separate CCTV monitoring screen in OCC, BCC and at the respective DCCs at all Designated Depot(s). However, provision shall be available for the operator to remotely view any train's specific interior / exterior camera's live recording from the corresponding train's CCH, from OCC console, from DCC console and from any Station Control Room (SCR) console (within one station vicinity of the train on either ends). RS Contractor shall interface with Signalling Contractors for this requirement.

- 13.13.8 In case of activation of PEI in any of the car by passenger, the camera recording focusing the PEI shall be displayed on the CCTV ~~DDU monitoring screen~~ available in OCC, BCC & DCC and also in TCMS of the specific train. The cameras shall have inbuilt zoom function. It shall be possible to filter, zoom and select images in offline mode for investigation purpose. The images shall be with time stamping and it shall be possible to link them with respective location of train.

- 13.13.9 Similarly, critical events like opening of Emergency exit door, Fire & smoke inside saloon, ~~opening of Saloon to Cab door~~, opening of driver console desk, obstacle detection by saloon doors, track / catenary / infrastructure events shall also be displayed automatically on the CCTV ~~DDU monitoring screen~~ (TCMS DDU) in train as well as in CCTV screens in OCC, BCC & DCCs. The Contractor shall propose any further list of critical events for this function to occur. Events and logic of automatic popping up of CCTV images of the above events in OCC, BCC DCC and CCH screen in operator's desk shall be submitted for CMRL approval. The Contractor shall submit the above said (i.e., 13.13.1 to 13.13.9) for CMRL approval.

- 13.13.10 Provision shall be available on demand to remotely view live OCC, BCC, DCCs and in SCR live CCTV streaming directly from Cameras / NVR recordings of any train as per clause 13.13.7. Necessary CCTV display devices in OCC, BCC, DCCs and in SCR for this function shall be provided by the STC Contractor. Provision shall be available to live stream, play-back download video recordings of any train from a single point in the OCC, BCC & DCCs. Necessary software for remote downloading of CCTV video recordings shall be provided to CMRL RS division. RS Contractor shall interface with the STC Contractor as per Appendix C requirements.
- 13.13.11 The Rolling Stock Contractor shall provide the suitable means for the transmission of video recordings generated by the On-Board CCTV to OCC, DCC and SCR consoles. Necessary hardware for transmitting videos to STC Network shall be provided and installed by Rolling stock Contractor inside the train.
- 13.13.12 Detailed dimensional, weight and power requirement information for CMRL approval shall be submitted at the time of Preliminary Design Review.
- 13.13.13 The Contractor shall provide suitable space, mounting provisions, wiring and separate circuit protection for the communication equipment including power supplies. The power supplies shall be fed from the low voltage power supply and emergency storage battery circuit. The Contractor shall use best practices for equipment wiring and network wiring as per the relevant international standards.
- 13.13.14 The Contractor shall provide and install cables from the communication equipment to the corresponding antennae, using removable connectors at each end of the cable. The cable impedance shall match the output impedance of the equipment. The Contractor shall submit for CMRL approval.
- 13.13.15 The Contractor shall design the installation of antennae as weatherproof and capable of resisting the carwash. Sealant shall not be permitted.
- 13.13.16 It shall be possible to remotely download the train CCTV footages from OCC, BCC & from DCCs even when the train is in operation.
- 13.13.17 Cameras, NVR, Video management software's etc. shall implement band width optimization techniques like multicast transmission, modern codecs (e.g. H.266 or higher) for the efficient and reliable use of wireless network bandwidth available.

13.14 UTO OPERATION

- 13.14.1 The design of Communications system and its relevant components in train shall support for the UTO / GoA4 in the CMRL Phase 2 corridors defined in Chapter 1. Trains shall be operated in GoA2 / ATO mode during the initial stage of commissioning and revenue operations and in GoA4 /UTO subsequently. Hence all the feed-backs, information and train controls which are available on TCMS screen shall also be available in OCC (operational control Centre) and DCC (Depot Control Centre) for smooth operation of passenger service. The Contractor shall submit the details of controls to be provided in OCC & DCC for review and approval of CMRL.

1

14. TRAIN CONTROL MANAGEMENT SYSTEM (TCMS)

14.0 NOT USED

14.1 GENERAL

14.1.1 Features

- 14.1.1.1 All the trains shall be equipped with microprocessor-based Train Control Management System (TCMS) providing real-time distributed control and modular processing of all sub-systems in fully redundant manner with high reliability and availability required in adverse operating environment experienced in MRTS system.
- 14.1.1.2 All electrical and electronic components shall comply with the EMC and EMI requirements of EN 50121 (all parts), IEEE 16, EN 55011 and IEC 61000-4 standards or other equivalent international standards. The requirements of EMC EMI requirements referred in clause 10.19 & 2.18 shall be met.
- 14.1.1.3 Fire properties of the materials used shall comply with EN 45545 part 1 to part 7 latest editions (Category 4-A, Hazard level HL3) as a minimum or better international standard applicable for similar Metro applications. Requirements of clause 2.26 shall be met.
- 14.1.1.4 Material requirements of all sub systems of train shall be compliant with Chapter 19.
- 14.1.1.5 TCMS shall be a completely integrated system equipped with data acquisition, monitoring, control, record, display, self-diagnostic, fault diagnostic, remote diagnostic, transmission of data to OCC & AMMS server, configuration editing, troubleshooting-guidance, etc., features / functions for the train, its systems and subsystems. The Contractor shall submit a comprehensive list of capabilities for each of the above listed features.

14.1.2 Proven Design

Basic architecture and hardware of TCMS proposed to be implemented / used by the Contractor should already be functioning in Metros since last more than three years in revenue service and shall be compliant with latest version of international norms. The Contractor shall submit basic system architecture for approval at the concept design approval stage and establish 'proven design' as specified.

14.1.3 Maximise Controls & Monitoring via TCMS

It is desirable that the control and monitoring functions are implemented by software, to the extent possible, to reduce hardware and cables. All functionalities that can be implemented by software shall be provided via TCMS unless specifically desired otherwise by CMRL.

14.1.4 Not used

14.1.5 SIL Compliance

TCMS shall be minimum of SIL2 compliant for all vital and safety related control and monitoring functions including but not limited to the following hardware, software and control functions- at all levels etc. Any change in SIL level shall be subject to the hazard analysis and acceptance by CMRL, whose decision shall be final and binding. SIL compliance for the below functions shall be submitted for review and approval of CMRL:

- a) Vehicle Automatic Train Control operation mode (ATP & , ATO, UTO, etc.),
- b) Door Proving loop cut-out,
- c) PWM transmission (communication),
- d) PWM signal (Hardware) failure,
- e) Door Open & Door Close command,
- f) Direction control of train operation,
- g) Holding brake release,

- h) Speed transmission,
- i) Fire alarm transmission
- j) ED (Electro Dynamic) brake cut-out signal transmission,
- k) Actual ED brake effort signal transmission
- l) Wheel Sliding signal transmission to Signalling, Brakes and Traction systems,
- m) ED brake effective signal transmission,
- n) Holding Brake demand signal transmission,
- o) Holding Brake applied status transmission;
- p) Deadman function
- q) Wheel Slip signal transmission to Signalling, Brakes and Traction systems,
- r) Traction / braking command/demand/authorization signal failure,
- s) Traction / braking command / demand / authorization transmission (communication),
- t) Electropneumatic brake isolation in bogie(s),
- u) Brake demand / applied signal transmission,
- v) Request and reset of Passenger Emergency Activation
- w) Real time remote transmission of train data as defined in clause 14.11 & 14.13.

14.1.6 ~~Not Used~~ UTO Compatibility

1

The design of TCMS and its relevant components in train shall support for UTO / GoA4 in the CMRL Phase 1 and Phase 1 extension network defined in Chapter 1. Trains shall be operated in GoA2 / ATO mode during the initial stage of commissioning and revenue operations and in GoA4 /UTO subsequently. Hence all the feed-backs, information and train controls which are available on TCMS screen shall also be available in OCC (operational control Centre), and DCC (Depot Control Centre of all depots in CMRL phase 1) for smooth operation of passenger service. The TCMS architecture, functionality and redundancy level shall be compatible with the UTO mode of operation. The Contractor shall submit the details of controls to be provided in OCC & DCC and details of UTO specific design functionalities for CMRL review and approval.

14.1.7 Signalling Interface

1

TCMS shall have adequate facility and interfaces to communicate ~~(using MVB networking type)~~ with wayside and train-borne signalling for ~~UTO, ATO and non-ATO~~ both UTO and non-UTO modes. It shall be possible to simultaneously operate different trains in a section in ~~GoA4 & GoA2~~ GoA2 / GoA3 / GoA4 without any safety / reliability issue as per IEC 62290-(1, 2 & 3):2014 (or latest version of the standard). Detailed function of ~~ATO~~ UTO operation shall be discussed and agreed mutually. The Contractor shall submit details of all Signalling specific design functionalities which are required for interface with Rolling stock as per Chapter 13, Chapter 14 and Appendix C for CMRL review. ~~Wherever OCC is mentioned in the Chapter 14, it shall mean both Operations Control Centre (OCC) and Backup Control Centre (BCC).~~

14.1.8 TCMS Configuration Details

The Contractor shall submit the complete TCMS configuration details including but not limited to Application Software Logic, Data Acquisition Routines, Control logic, Fault Detection Algorithms, Data Storage Logic etc. Graphical interface for editing and configuring the same shall be provided and submitted for CMRL approval during design stage. The Contractor shall provide necessary training and associated hardware / software tools to make CMRL engineers competent to implement software changes as required within the scope of this contract. The Contractor shall ensure full association and support of the Contractor / Sub-Contractor's design team with CMRL team throughout the project or as the case may be.

14.1.9 Applicable Norms and Standards

All communication protocols, architecture and data acquisition concepts of TCMS shall be of the latest state of the art technology and compliant to international and railway industry standards.

The Contractor shall advise the proposed applicable standards for review and approval from CMRL. The Contractor shall take adequate measures to protect TCMS system from any cyber-attack.

14.1.10 Conceptual Approval Only

Design approval of proposed TCMS shall imply only conceptual approval. Further changes as required by Other Designated Contractors and Rolling Stock Sub-systems during DLP, shall be discussed during the contract execution stage and solution shall be implemented by the Contractor to the satisfaction of CMRL without any additional cost. This will include finalization of event list, fault priorities, diagnostics, RTR-DMS data transfer, details to be transmitted to OCC central server & AMMS central server for operational, fault diagnosis requirements and other requirements defined under the clauses related to TCMS functionalities. If in case the requirements not stipulated in this contract, variation can be raised by the Contractor, subject to approval by CMRL.

14.1.11 The cables which are intended to be used in emergency circuit for alarms and communication shall have intrinsic fire resistant property in compliance with EN 50200-for PH90 and EN 50289.

14.1.12 Voltage requirements:

The equipment and networks of the Train shall be designed for voltage requirements and regulation limits mentioned in Chapter 9.

14.2 TCMS ARCHITECTURE

14.2.1 Data Communication Link & Network Communication technology shall have the below features:

- a) The network communication technology to be adopted for all TCMS data communication links and subsystem communication interfaces shall be based on Ethernet (100 Base TX or better) or latest better service-proven network technology.
- b) Train networks shall be proven train data communication links that are immune to EMI / EMC and harmonics generated by traction equipment or generated from external environment of train. Suitable physical bus interfaces, to ensure error-free and high-speed data transmission shall be provided.
- c) The train network shall be compliant for allowing single point software upload of all sub-systems of the train from TCMS itself.
- d) Network components and transceivers shall be available from multiple sources producers.
- e) When cars of a train are coupled or uncoupled, the network shall automatically reconfigure itself for the new train configuration. The configuration shall identify each car in the new train by its car number.
- f) Defective network equipment or train-lines in a car shall not prevent the proper configuration of the remaining cars in that train.
- g) Network Protocols shall include error detection feature.
- h) The Contractor shall submit for approval the design of the Train-lined Local Area Network.
- i) The Contractor shall explain the protocols of the networks used in the train. It shall be possible for accessing the train networks for any future equipment/components upgrade.
- j) Train networks shall be designed for broadcasting of video advertisements in train displays as per clause 13.7.1.16.
- k) All Train Networks and sub-system networks of train shall be designed for 6 car operation.

14.2.2 Proven train data communication links that are immune to EMI and harmonics generated by traction equipment shall be provided between the cars. Suitable physical bus interfaces, to ensure error-free and high speed data transmission shall be provided.

14.2.3 Ethernet Consist Network (ECN)

Ethernet Consist Network with dual-homing ladder-type topology or Ring Network type or latest

better technology (compliant with IEC 61375-3-4) shall be adopted.

14.2.4 Dual-Homing End Devices (ED)

All the End Devices shall support dual-homing type or any latest technology type of Ethernet connections to ECN via physically independent ports to increase system reliability and availability. All digital and analogue Input / Output interfacing with TCMS (directly or via an interface unit) shall also be fully redundant. In any case, the Contractor shall maintain full system availability, in case of single point failure of any TCMS component or communication link, and the vehicle operation shall not be affected.

14.2.5 Redundant Processors

The processors running the TCMS application software for control, monitoring etc. shall be duplicated with a hot standby redundancy provision within the train. Details for the switchover and recovery times shall be submitted by the Contractor for CMRL review.

14.2.6 Single Point Failure Tolerant

The TCMS shall be of fault tolerant distributed control system architecture. A single point failure of any individual equipment / component / board / communication link etc. shall not affect data acquisition, processing & transmission to OCC & AMMS or cause any adverse performance impact on train performance or loss of data. The Contractor shall submit the failure redundancy matrix for entire TCMS indicating the various failure modes, available redundancies and the effect on train performance.

14.2.7 Spares Provision

The TCMS components shall be modular in design at all levels (i.e. hardware, functional, communication etc.) with minimum 15% spare capacity in each car for expansion at the end of DLP. The spare provision shall exist for all different equipment's pins, terminals, connectors, ports, train lines, communication packets bits, digital I/O's and analogue I/O's etc. and the same shall be available for after DLP. The hardware spares shall be duly wired to the nearest terminal box. Considering that some changes / modifications would be required during DLP, at least 15% spares capacity shall be initially ensured by the Contractor. The Contractor shall submit a detailed proposal for CMRL review and approval during design stage.

14.2.8 Expandability Provision

The Contractor shall also provide 15% expandability provision (i.e., expansion of capacity by adding of additional hardware) for pins, connectors, network ports, PCB cards, train lines etc. The Contractor shall demonstrate to CMRL that adequate space has been reserved inside the cabinets of train to exercise this option.

14.2.9 The hardware system shall conform to IEC 60571.

14.2.10 Minimum IP level of all TCMS cubicles / equipment or the panel in which it is installed shall be IP53 or higher.

14.2.11 Labelling

The type, location and identification of all hardware, software inter-connections, cabling and terminals shall be determined on a coherent hierarchical system basis. Labelling or identification shall use appropriate English language based mnemonics or abbreviations. The labelling shall be easily accessible for immediate verification by working personnel. The Contractor shall submit proposal for review.

14.2.12 Maximum CPU Loading

14.2.12.1 The Contractor shall demonstrate to CMRL's satisfaction that Software expansion requirements, Hardware spare capacity and Mean and Peak loading of the TCMS CPUs / processors are as per the requirements of clause 20.6.5. The Contractor shall keep adequate margins in the design to allow for addition of functionalities to TCMS during DLP period. A verification report for the same shall be submitted. Prior to approval of the network design, the Contractor shall submit detailed calculations of peak and average data traffic levels for approval, including format for transmission.

14.2.12.2 The Contractor shall demonstrate to CMRL satisfaction that none of the TCMS CPUs / processors

are loaded to more than 50% of their processing capacity. During car commissioning, actual peak and average data traffic levels shall be measured to demonstrate compliance with this requirement.

14.3 DATA ACQUISITION

14.3.1 Network Interfaced Systems or Hardwire Interfaced Systems

TCMS shall schedule, initiate and control data acquisition, processing and analysis by interfacing with all microprocessor / microcontroller based on-board systems. These systems shall include, as a minimum with Signalling System, Train Radio System, Platform Screen Door System, VAC System, Auxiliary Power Supply System, Brake System, On-Board Communication System (PAPIS & CCTV), Door System, Propulsion System, High Voltage System, Lighting System, Wayside Wireless Communication, Wheel Flange Lubrication (WFL) System, Fire Detection system, Asset Maintenance Management System (AMMS), etc.,

1

All interface signals with ~~ATP / ATO~~ ATP, ATO & UTO and selected interface signals with other on-board systems shall be monitored and recorded with time stamp.

14.3.2 Hardwire Inputs

1

In addition to above, TCMS will also acquire status data via hardwire from the various identified vehicle control circuit nodes, train lines, ATP, ATO, UTO or any other interface subsystems. This data acquisition shall be fully redundant, bus monitored and duly recorded in TCMS. The interface units provided for this purpose shall be dual homing compliant.

14.3.3 Communication Protocol Details

The software and communication protocols used throughout the TCMS and the interfaces to subsystems shall be compliant to a common standard or standards. The Contractor shall submit details of the communication protocols used in their design clearly indicating how the requirements of monitoring and control are complied with. The Contractor shall also define the dual-homing compliant communication protocols for all end devices. Further details along with any hardware / software tools required shall be submitted during design stage.

14.3.4 Signal List Modification

It shall be possible for authorized maintenance personnel to update and modify the list of data acquisition signals and its associated parameters like periodicity, task cycle, data acquisition routine etc. Suitable graphical configuration editors shall be provided for this purpose.

14.3.5 Clock Synchronisation

1

TCMS shall synchronize its clock with the system master clock through STC Contractor interface. All the microprocessor / microcontroller based on-board systems shall synchronize respective clocks with TCMS clock. The event and fault logging of the respective sub-systems of train shall always be in-line with the TCMS clock in all the ~~ATO, Non-ATO~~ UTO, Non-UTO and other degraded modes of train operation. Detailed clock synchronization proposal shall be submitted for CMRL approval.

14.4 CONTROL FEATURES

14.4.1 Non-Vital Controls

TCMS shall be used to execute all non-vital commands and controls of the train.

14.4.2 Vital Controls

TCMS shall be designed to provide back-up controls of all identified vital commands. Unless otherwise indicated specifically in these specifications, hardwire back up shall be provided for each safety related control functions.

14.4.3 Control Strategy

The Contractor shall submit technical details of the TCMS control system with full explanation of

control methods and strategy adopted in the design. The proposal shall also clearly discriminate between the implementation of vital & non-vital controls as well as manually triggered / operator-based & automatically executed controls.

14.4.4 ~~Not Used~~

OCC Remote Controls

1

TCMS shall have provision for receiving and implementing remote control commands from RSC console in OCC / BCC / DCC via signalling network. console and Depot Control console. Necessary interface with Signalling & Telecom Contractors shall be ensured. All the controls available in TCMS shall also be provided from OCC console and Depot Control console for the train operation in UTO mode. These controls shall also include the over-riding of the UTO commands related to Train sub-system functioning during UTO mode.

14.4.5 ~~Not Used~~

List of Operator Control Functions

Remote Control features of train available from the OCC, BCC and from the DCC's control via remote operation shall include, but not be limited to, the following (These features shall be available in all UTO and Non-UTO modes of operation).

1

- a. Train start up.
- b. Control of various saloon air conditioner parameters such as selective and/or collective starting and switching off, car temperature control, provide override control of operating mode etc.
- c. Isolation of any passenger side door that has been detected as closed and locked.
- d. Override control over automatic selection of the saloon light circuit(s).
- e. Resetting of minor faults in sub-systems.
- f. Provide an automatic VCB control logic during Neutral section traversal as fully functional back up in all driving modes and directions.
- g. Manual Over-riding of any train function remotely from OCC, BCC and DCC.
- h. All the controls available in TCMS DDU of train shall be able to be controlled remotely from OCC, BCC and DCC.
- i. Any other item as desired by CMRL during the design stage reviews.

The Contractor shall submit detailed list of functions / features proposed to be controlled in remote from OCC, BCC and DCC for CMRL's review and approval.

14.4.6 Protective Controls

TCMS shall appropriately shut down or reset equipment in response to self-diagnostic test results or occurrence of specified faults. Detailed scheme for protective controls shall be submitted for CMRL review and approval.

14.4.7 Speed Calibration Control

Automatic speed calibration through doppler radar or better means shall be ensured at each time of train restart. This shall be specifically used whenever wheel is turned and train is moving out of Depot for revenue service.

14.4.8 Speed Sensor Redundancy

1

Adequate redundancy shall be built in for correct train speed measurements in case of failure of any of the speed sensor. System shall also counter check the speed recorded by the ATP / ATO / UTO. For this purpose, the Contractor shall suitably interface with Signalling Contractor.

14.4.9 ~~Not Used~~

ATC Interfaced Controls

1

- a. Remote Initialization: TCMS shall interface with ATC for remote initialization of train at any location of mainline, mainline siding, stabling lines in Depot or from any location controlled by UTO operation. The "wake-up" command from OCC shall be implemented by TCMS

after performing self-tests of different train borne systems. TCMS shall send train 'Train Ready / Train Ready With Fault / Train Not Ready' signal to train ATC else a corresponding fault code shall be sent to OCC. Details of 'Train Ready / Train Ready With Fault / Train Not Ready' shall be submitted to CMRL review during Pre-Final Design stage.

- b. "Train Not Ready" shall be discussed during design stage.
- c. Sleep Control: ATC may initiate automatic train sleep function when trains are not required to be operated in mainline or in depots. Whenever sleep command is initiated by Train Operator / OCC/ DCC, TCMS shall shutdown the relevant equipment except for control supply to necessary equipment. Sleep mode shall contain features to keep the train in sleep mode with minimum operating lights, minimum necessary control systems required to automatically switch on the train remotely from OCC, BCC & DCCs. The Contractor shall propose any additional controls and functions required during the sleep mode. Provisions for remotely selecting/deselecting the sleep mode shall be provided.
- d. Standby Control: Train Standby function may be actuated by ATC system when train is in stabling siding. TCMS on receipt of such command shall switch off auxiliary equipment except compressor, battery charger etc. and shall maintain train in a "Ready" state.
- e. Shunting Control: The shunting operation of train in depot shall be under GoA3/ GoA4 as initiated by ATC. Rolling stock Contractor shall provide the details of ATC controls of train and the details of various equipment & networks which shall be switched on/off in various controls as defined in this clause for CMRL review.

14.4.10 ~~ATO Interface~~ UTO / ATO Interface

- a) TCMS shall be fully compatible and interface with signalling system to ensure safe UTO / ATO operation.
- b) For UTO / ATO operation, the necessary train command digital inputs signals shall be provided by the Signalling Contractor. The ATP / ATO / UTO initiated signal demands shall be redundant. The redundancies shall also be provided on TCMS side by RS Contractor. The form of these inputs shall be coordinated between Rolling Stock and Signalling Contractors.
- c) The Contractor shall also liaise with the Signalling Contractor to harmonize his system with the energy saving modes under ATO / UTO.

14.5 DRIVING CONSOLE INTERFACE

14.5.1 Driver Display Unit (DDU)

Each Driving Console shall be provided with a DDU to display real time information to the train operator. The DDU shall support both text and graphical presentation of information. Commands shall be entered by the train operator via touch screen. Suitable protection features for the safety of the DDU shall be provided.

14.5.2 DDU Display Information

All the details displayed and controlled from train TCMS DDU display shall also be displayed and controlled from RSC consoles of OCC, BCC & DCC with the similar Graphical User Interface.

RSC consoles of OCC, BCC & DCC shall have real time details of all trains. This display shall provide Status (Working Status and Fault status) and Controls (Isolation, System controls, reset controls) as mentioned below:

- a) Train Operator's Display Console with screens as defined in clause 14.5 and clause 5.7.
- b) Status, Isolation, reset controls and system controls of Auxiliary Power Converter Inverter system.
- c) Status, Isolation, reset controls and system controls of HV and Propulsion system.
- d) Status, Isolation, reset controls and system controls of Lighting system.
- e) Status, Isolation, reset controls and system controls of Pneumatic Braking system.
- f) Status, Isolation, reset controls and system controls of Couplers system.
- g) Status, Isolation, reset controls and system controls of Train Networks system.

- h) Status, Isolation, reset controls and system controls of Saloon Doors system.
- i) Status, Isolation, reset controls and system controls of Ventilation and Air Conditioning system.
- j) Status, Isolation, reset controls and system controls of Pantograph.
- k) Status, Isolation, reset controls and system controls of VCB open close.
- l) Status, Isolation, reset controls and system controls of Coupling and Uncoupling between trains.
- m) Status of Mode Selector and Master controller handle.
- n) Train general parameters like vehicle Speed, traction voltage, battery voltage, distance travelled, energy readings, wheel slip, wheel slide, excessive jerk.
- o) Login access with passwords for all Operators and Maintainers of CMRL.
- p) Details of Digital Manometer Pressure Gauge indications of Main Pipe, Brake Pipe, Reservoir, Brake Cylinder, etc.
- 1 q) ~~Status, Isolation, reset controls and system controls of Detrainment doors.~~ Deleted
- r) Status of Platform Screen Doors as part of interface.
- s) Any other indications, status, controls, isolation controls, reset controls, system controls felt necessary by the Contractor for train operation in ATO and non-ATO modes.
- 1 t) ~~Not used.~~ The information available in TCMS shall also be provided in RSC consoles of OCC, BCC & DCC for UTO operation.
- u) Equipment operating status.
- v) Faults and failure of both auxiliary and control functions.
- w) Recommended remedial actions in the event of alarms or faults occurring on the train.
- x) Time: All the screens shall display the time (24-hour format), date (dd/mm/yyyy), the train configuration and approximate number of passengers.
- y) Odometer: A six-digit odometer to display recorded cumulative distance run by the unit, irrespective of direction.
- z) Energy Consumption Data: TCMS shall interface with the relevant sub-systems and shall provide the facility to display energy consumption for one sided / round trip as well as cumulative for each consist and for the train.
- aa) Crew ID and Train ID: Facility shall be available to key in the Train Operator and Train Identification Number (in case same is not available through ATC interface).
- bb) Train Speed: TCMS shall interface with the relevant sub-systems to reliably display and record the train speed.
- cc) Push Button record: All operations of Train operator including pressing of push buttons etc. shall be recorded with time stamp and be made available on DDU.
- dd) Safety Switch Status: Status of safety switches shall be displayed on DDU and shall be acknowledged by the incoming train operator. The status shall be relayed to the Control centre through train radio.
- ee) Slip / Slide Status: Status of slip/slide shall be displayed on DDU
- 1 ff) Any other indications, status, controls, isolation controls, reset controls, system controls felt necessary by the Contractor for train operation in ~~ATO and non-ATO~~ UTO and non-UTO modes.

14.5.3 DDU Screens Design

14.5.3.1 The DDU shall provide minimum four types of primary screen displays (or a number proposed by the Contractor) for interface with the Operator and maintenance technicians:

- a) The Operating Screen,
- b) The Control Screen,
- c) The Faults Screen and

- d) The Maintenance Screens.

The operating screen shall remain as a default screen

14.5.3.2 Operating Screen

- 1
- a) The operating screen shall display the required important operational information of all the systems of the train.
- b) This screen shall be continuously displayed on DDU during train operation in non-UTO modes..
- c) The operating screen shall be pictographically designed to show the train configuration and the important parameters required for train operation.
- d) The login credentials of the train operator shall also be displayed on the screen.

14.5.3.3 Control or Configuration Screen

- a) The configuration screen shall present vehicle set-up data necessary to prepare the train for operation, including prompts for setting time, date, and car identification number.
- b) Car ID, date, and time data from the DMS in the leading car along with driver's identifications code shall be transmitted and used by all fault recording equipment on a train. Date and time data shall be transmitted periodically to all fault-recording equipment to ensure consistency of recorded data.
- c) The screen shall enable car mileage data to be viewed, though this need not be displayed on the Operator's screen when the car is in motion.

14.5.3.4 Fault Screen

- 1
- a) The fault screen shall inform train fault conditions to the Operator of vehicle, OCC and maintenance yard which affect the immediate operation of the train.
- b) The fault screen shall display major failures of the train with respect to the location and system unit details.
- c) The fault data shall include the time, date, unit number, and a system description of the fault, based on the system's software requirements specification. Where more than one of the same type of equipment is installed on the married pair, the fault data will identify the specific equipment exhibiting the fault.
- d) Provisions shall be made to allow the user to scroll fault data for all systems.

14.5.3.5 Maintenance Screen

- a) This screen shall display all the maintenance related information of all the sub-systems of train.
- b) It shall be possible by maintainer to verify the working status of all the sensors, components of all equipment of the train using this screen.
- c) The maintainer screen shall be separately password protected to view the details.

The Contractor shall submit for approval a functional description of all the four screens of the TCMS DDU display and a depiction of its layouts.

- d) The DDU screen displays shall be sufficiently large to present the information to an Operator without undue scrolling.
- e) Each screen may use additional levels of subsidiary screens to present extensive information as well as additional subsidiary screen choices.
- f) If several screens are used to display various levels of primary and subsidiary data, then the screens shall be arranged in a sequential hierarchy that shows the most important and general data first, and allows the user to move to subsidiary data from there.
- g) If subsidiary screens of this sort are used, return to the primary screen shall be possible with one command.
- h) Activation of a touch screen area, if provided, shall be acknowledged by a short audible "beep" and by highlighting the area of the screen by means such as reverse video. The interface for screen selection shall be the same type for all screens.

- i) The position and function of touch screen buttons (if provided) shall preclude accidental or unintentional operation when changing screens.
- j) Display information shall be divided among, and presented on, screens in a logical and orderly manner.
- k) All information shall be displayed graphically, textually, or both. Data shall be displayed in the most efficient manner available. No information shall be displayed in any coded form.
- l) Display screens shall be designed, physically and functionally, to allow for easy addition of display items. Each screen shall be designed with the same layout and format, regardless of its place in the hierarchy of primary and subsidiary data.
- m) Display screens shall be readable in direct sunlight (shading composition is also allowed) or with the operator's desk area lighting at night. The screens shall be glare free.

14.5.4 Editing DDU Screens

The format / no. / contents of DDU screens shall be proposed by the Contractor during design and may have to be changed during the contract execution stage based on Other Designated Contractors and Rolling Stock Sub-systems during DLP, operational / maintenance / functional requirements shall be discussed during the contract execution stage and solution shall be implemented by the Contractor to the satisfaction of CMRL without any additional cost. If in case the requirements not stipulated in Section VI A ERTS (RS), variation can be raised by the Contractor, subject to approval by CMRL. The Contractor shall make such changes as and when required by CMRL during the contract and shall also train CMRL engineers to design, review and execute the changes in DDU screens in post contract period. Necessary software tools & Manuals shall be provided by the Contractor for each Depot.

14.5.5 DDU Access Control Levels

The level of access to distinct screens shall be controlled for the train operator and maintenance personnel. At least three levels shall be defined which shall be username and password protected. The details shall be reviewed by CMRL.

14.5.6 CCTV Screen

The TCMS DDU shall also have the facility to display the CCTV images upon selection by the Operator using a soft key. Provision shall be available in the display for multi-camera view and the Operator shall have the option to select and/or scroll through individual screens.

14.5.7 DDU Hardware

Capacitive-touch screen-based DDU or better shall be provided as approved by CMRL. The display screen shall be of colored Light Emitting Diode (LED) type, suitable for use in rugged railcar environment. DDU shall be equipped with brightness, sharpness, intensity and contrast controls etc.

14.5.8 Not used

14.5.9 DDU Response Time

The response time for most complex DDU screen change from one TCMS screen to other TCMS screen, TCMS to CCTV screens, manoeuvring from one camera image to other under full DDU loading shall be approximately 0.5 seconds. Contractor shall submit compliance details during design stage which shall be got validated during line test.

14.5.10 Touch Screen Calibration & Sensitivity:

Automatic Touch screen calibration shall be incorporated within the in DDU display during train restart activity. The touch screen sensitivity shall be suitable for industrial applications and Rolling stock applications. Train operator or maintainers shall not feel discomfort in operating the touch screen.

14.6 SELF-DIAGNOSTIC FEATURES

14.6.1 TCMS Self- Diagnostic Tests

The TCMS unit shall incorporate built-in self-test diagnostic functions. The results of these self-diagnoses shall be accessible on DDU and any failures shall trigger appropriate faults / alarms / protective action. Details of the same shall be submitted during design stage for CMRL review.

14.6.2 Subsystem Self-Diagnostic Tests

All the on-board microprocessor / microcontroller-based subsystems shall also perform self-diagnostic tests and report the detailed health status to TCMS, both automatically and on specific request (using DDU) by maintenance personnel.

14.6.3 Self-Diagnostic Tests

14.6.3.1 The self-diagnostic tests shall assess and report the health of boards, sensors, memory, watchdog timers, inputs, outputs, bus connectivity, PCB level components status, software, firmware etc. Hardware and software shall be provided for self-diagnostic test of the critical system functions. Detection of a failure shall cause an indication to be displayed on the DDU.

14.6.3.2 The complete scheme of self-diagnostic tests of TCMS and sub systems shall be developed for the purpose of deep dive checking of system's health by maintenance personnel through DDU as well as for UTO when these tests are performed by the TCMS after receiving remote "wake-up" from ATC. Details to be submitted for review of CMRL.

14.6.4 Software / Firmware Versioning

Time stamping of date of software(s) / firmware(s) as well as version of software(s) used in different sub-systems of the train and their compatibility shall be ensured by TCMS. The details of version of software(s) / firmware(s) used in different sub-systems with time of uploading shall be displayed at the TCMS at the time of Power Up (wake-up). The system shall not permit loading of incompatible software(s). Manual override in certain cases can be permitted by CMRL, details to be finalized during design stage.

14.6.5 Feature of self-check and calibration shall be incorporated in the design. Details of the self-diagnostic features shall be submitted during design stage for CMRL review and approval.

14.7 DIAGNOSTIC MONITORING SYSTEM (DMS)

14.7.1 Fault Diagnostic (Diagnostic Monitoring System) Function

14.7.1.1 TCMS shall perform the task of fault diagnostics, in addition to performing the control / monitoring tasks. The design shall consider the train as a complete system and diagnostic capability incorporated in the system shall detect any node or line section failure rapidly to ensure no impairment of normal control and monitoring functions.

14.7.1.2 The Contractor shall provide a fully integrated Diagnostic Monitoring System (DMS).

14.7.1.3 Real-time fault data shall be available from at least, but not limited to the following systems

a) Brake and Pneumatic system.

b) HV and Propulsion.

c) Auxiliary converter inverter / LVPS.

d) Doors system, including Saloon to Cab door & Cab access door status

e) VAC.

f) Lighting system.

g) Interface failures of ATP, ATO, UTO, ATO, ATP, ATC, PSD and Telecommunication systems.

h) Communications system.

i) Speed, time, distance and energy consumption and regeneration.

j) Operational service related failures.

k) Coupling / Uncoupling.

1

l) Communications between ~~OCC to train~~, train to OCC and vice versa.

m) Wheel Flange Lubrication.

n) Any other Rolling stock system required for failure diagnostics by maintainers and operators.

o) Continuously monitor the status and health of all connected equipment and subsystems.

p) Detect and log events and fault occurrences.

q) Perform fault analyses and perform failure management actions by,

r) Wherever necessary shut down affected equipment.

s) Present alarms & conditions / guidance to the train operator.

t) Circuit breaker tripping status.

1

14.7.1.4 The Contractor shall be responsible for integrating the fault data & All stored data of all systems into the DMS of the train which further communicates to OCC, Maintenance yard for further understanding of the failure.

14.7.1.5 The electronics required for the control, diagnostics and monitoring facilities shall be designed and constructed in accordance with the requirements of IEC 60571 / EN 50155 or equivalent.

14.7.1.6 The Contractor shall submit for CMRL approval a list of faults, fault hierarchy, and fault logic which shall be provided in the DMS.

14.7.2 Functional Description

1

14.7.2.1 The DMS shall consist of monitoring and diagnostic logic and shall be accessible from within the vehicle, OCC and maintenance Yard.

14.7.2.2 Each car system shall perform its own diagnostics and shall log fault and status data. This information shall be provided to the DMS in real-time.

1

14.7.2.3 This subset of information shall be reported by way of a car operator display located on the console of each operator's desk, as described in clause 14.5.3 and also the same information shall be available in OCC and maintenance Yard.

1

14.7.2.4 The DMS shall collect, process, store and transmit train data to the specific locations in OCC and in Maintenance Yard. All the information on operator display, configuration screens and fault screen shall be available to OCC and maintenance yard in the real time through RTR-DMS (Real Time Remote Diagnostic Monitoring System) as described in clause 14.11 and 14.13.

14.7.3 Requirements

14.7.3.1 The DMS shall meet all design and documentation requirements of chapter 19 that apply to microprocessor-controlled systems.

14.7.3.2 The DMS shall have sufficient memory capacity to store fault data for the intervals between periodic quarterly maintenance without loss of data or overwrites.

14.7.3.3 The DMS memory data shall not be lost when the train's main power is cut off

14.7.3.4 The Contractor shall submit proposed scheme and fault detection logic for CMRL review and approval.

14.7.4 Fault Detection

14.7.4.1 Degraded performance condition monitoring shall be provided as an integral part of TCMS wherein on-board CPU shall process the inputs from on-board subsystems and be able to determine car level, unit level or train level faults based upon the defined fault parameters / detection logic.

14.7.4.2 The various important parameters / signals of the equipment / subsystems (i.e. associated trace / environment data) shall also be recorded for pre-determined period before and after of occurrence of associated events / faults with a view to enable proper fault analysis.

14.7.4.3 The key indicators of degraded performance, fault parameters / detection logic and trace data signals for all principal car systems shall be proposed by the Contractor and approved by CMRL.

14.7.5 Fault Analysis and Management

1

Appropriate corrective actions shall be taken to reset critical faults and guidance shall also be provided to **OCC operator** / Train Operator in the form of Troubleshooting Directory (as defined in below Chapter). Details of failure management actions shall be submitted during design stage for CMRL review and approval.

14.7.6 Fault Info Display

1

Real-Time Remote Diagnostic Monitoring System (RTR-DMS) shall be made accessible on the ~~operator / controller~~ **OCC console GUI and on the Depot controller console to assist the operator / controller** to operate the train safely, quickly, efficiently, and to rectify resettable faults or failures in mainline and in depot. The detailed requirements of the RTR-DMS system shall be as defined in clause 14.11 and clause 14.13.

14.7.7 Fault Levels

14.7.7.1 The scheme proposed shall differentiate between faults which are not potentially threatening (e.g. air conditioning failure) and other system faults which could be threatening (e.g. failure of the brake system).

14.7.7.2 The faults / events shall be four or more levels with 'Level 1' events displayed on DDU with buzzer, 'Level 2' events displayed on DDU without buzzer, 'Level 3' being events recorded in the memory and operator can view if required in DDU & 'Level 4' being events recorded in the memory and can be viewed from the log files.

14.7.8 ~~ATO Auto~~ -upgradation of Frequent Faults

1

Provision shall exist to temporarily upgrade the level of the fault / event automatically in case of its being experienced for predetermined number of times (settable by the authorized maintenance personnel) in pre-determined time period (settable by the authorized maintenance personnel). Detailed proposal for the same shall be submitted for CMRL review and approval.

14.7.9 Editing Fault Configuration Logic

14.7.9.1 Fault analysis and fault management algorithms, data acquisition routines and data storage logic shall be programmed and presented using Windows or equivalent user interface software and shall be fully editable by CMRL.

14.7.9.2 Authorized maintenance personnel shall have facility to select and edit:

- a) Event details (e.g. displayed fault text, fault level etc.),
- b) List of associated parameters / trace data,
- c) Periodicity of the parameters / trace data,
- d) Time interval for pre and post event capture of parameters / trace data,
- e) Fault detection algorithms and fault management logic.

Complete facilities to implement the same shall be supplied.

14.7.10 Specific Fault Provisions

The following are some faults that shall necessarily be included in fault detection logic:

- a) Popping up and acknowledgement of the status of each safety switches not in normal state at the time of taking traction and cab activation.
- b) Loss of redundancy of equipment and subsystems.

14.8 TROUBLESHOOTING DIRECTORY

14.8.1 General

1

14.8.1.1 For quick guidance of Train operator and Maintenance staff, a summarized menu driven, user friendly Trouble Shooting Directory (TSD) shall be made available in the train DDU, **in OCC console & Depot controller console**. The TSD shall have separate login modes for operators and maintainers. Extensive use of graphics shall be made in TSD for better understanding of the

controllers and operators. Details shall be decided during design & revenue service period.

- 14.8.1.2 In OCC and Depot controller console, there shall be a provision to the controller to select a specific train and view the details of the train. All the details of the TSD displayed in DDU shall be replicated in OCC console and Depot controller consoles.

1

14.8.2 Maintainer Mode

- a) Highlighted Functional Block Diagram (FBD): The maintainer mode of TSD shall display detailed FBD (as per IEC 61131) for the fault detection software logic wherein the relevant pathways of the logic diagram tree that triggered the fault shall be highlighted or any other alternative to be provided for CMRL review and approval.
- b) Input Output Signal State: The TSD shall also display the real-time states of the various input and output signals related to fault detection logic in tabular form.
- c) Action Items: Detailed action item text containing description of fault logic, possible failed device(s) info, troubleshooting instructions and corrective action as collapsible blocks of text shall be included on TSD screen. This text shall be colour coded so as to indicate the most pertinent points for any particular failure.
- d) Mode Switch: It shall be possible to switch from maintainer mode to operator mode of TSD without logging out of TCMS maintainer mode but not vice-versa.

14.8.3 Operator Mode

- a) Graphics and Animations : The operator mode of TSD must include graphics and animations that shall be developed corresponding to all the failed devices, all the failure cause identifications and all the proposed corrective actions for each of the faults. These graphics shall be submitted for review of CMRL and shall be promptly updated as per his decision. The detailed proposal for the same shall be submitted during design phase and shall include a listing of all media files being provided in the TSD library.
- b) Locational mapping: The locational mapping of these graphics files with various train equipment and various fault codes shall also be submitted. The colour highlights and transition effects possible with the graphics shall also be made part of the proposal.

14.8.4 Intelligent Analysis

The TSD shall be smart enough to group together related faults (i.e. faults that have the same root cause) and provide guidance in a combined view for such faults. The various FBD logical pathways as requested above shall be distinguished in this case with different colours.

14.8.5 Editing of TSD

Based on the operational requirements, the directory shall be regularly upgraded during the contract period. The TSD shall be editable by authorized maintenance personnel. Necessary training for the operator and maintenance personnel shall be provided.

14.9 MAINTENANCE TOOLS

14.9.1 Not used

14.9.2 On-board Connectivity

A high-speed suitable communication port shall be provided in each car to interface with diagnostic maintenance laptop computers. All data residing on any node of the TCMS architecture throughout the whole train shall be accessible by a diagnostic laptop connected to a single port. This shall include the capability to download all data-logs, trace data etc. stored on connected train subsystems.

Additionally, it shall also be possible to connect with TCMS remotely and download faults from any train on mainline or at the Designated Depot(s).

14.9.3 Levels of Access

The level of access to distinct functionalities shall be controlled for the maintenance personnel.

At least three levels shall be defined which shall be user name and password protected. The details shall be reviewed by CMRL.

14.9.4 Required Features

The provided diagnostic maintenance laptops shall provide full testing of and interaction with the on-board TCMS at both train and car level. The following minimum capabilities shall be provided:

- a) System monitoring, fault data retrieval and analysis,
- b) Viewing and processing of logged TCMS data,
- c) Uploading new operating software and parameters for all the on-train subsystems,
- d) Uploading new train configuration data (e.g. wheel diameters, etc.),
- e) Downloading of fault and usage information,
- f) Initiating self-test and Downloading self-test reports,
- g) Exercising and checking of digital inputs and outputs,
- h) Checking of train and subsystem serial links,
- i) Checking of train data bus set-up and configuration,
- j) Retrieval of equipment identification numbers,
- k) Initiating function testing of on-board equipment,
- l) Force various inputs / outputs interfacing with Vehicle Control Circuit,
- m) Forcing internal signals of TCMS as a tool for simulation,
- n) Editing of fault logic (clause 14.7.7),
- o) Editing data acquisition signal list (clause 14.3.4),
- p) TCMS configuration editing (clause 14.1.8),
- q) Editing DR data signals list (clause 14.10.3),
- r) Interface with Depot Management Software
- s) Multiuser login shall be possible
- t) Accessing Fracas software shall be available.
- u) Interface with Document management system software of CMRL
- v) Running Energy Saving mode analytical tools (clause 14.12.3).
- w) Viewing of RTR DMS train details as per clause 14.11. Train control is not required.

14.9.5 Single Point Upload of all software of the train

- a) Upload of application software to all TCMS connected train systems (except Onboard Signalling system & Onboard Telecommunication system) shall be possible from a single ethernet port or any latest technology port. At least one suitable port shall be provided in the saloon of each car. It shall be possible to upload to all cars from any of the ports provided.
- b) The overall time required for uploading the software for all subsystems shall not be more than 10 minutes for each complete sub-system of train and the same shall be demonstrated. (Ex. In case of doors sub-system, the time requirement is collectively for all doors of one train)
- c) Download of fault logs and trace data for all connected systems shall also be possible from any of the ethernet ports or any latest technology port (This is in addition to the remote download capability that is defined in clause 14.11.1 (b)).

14.9.6 OS Compatibility and Upgradability

All the software(s) used in train, diagnostics, monitoring or analysis purpose shall be compatible with latest Windows version and upgradable for higher versions of Windows. The Contractor shall either commit to supply upgraded versions to match with higher version of Windows, as and when available or the software(s) shall be so developed to have automatic upgradability with Windows.

14.10 RECORDING FEATURES

14.10.1 Operator Commands Log

1

TCMS shall retain a non-volatile record of all train operators and ATP / ATO / UTO initiated commands and system responses for a minimum of 10 days before overwriting. Overwriting shall be such that the latest information is retained.

14.10.2 Event / Fault Information Log

Adequate redundancy shall be built into TCMS. The size of On-Board Database memory for fault records shall be sufficient to hold all car level and train level events (at least 30,000 events) between normal downloading intervals of 30 days through hardware download. In case of overwriting, 'Level 3' events / faults only may be overwritten.

14.10.3 Data Recorder Log

Separate adequate sized memory shall be available in TCMS for keeping user defined data recording (DR) log files for extensive continuous data logging and fault analysis for more than 200 parameters / signals. The list of parameters / signals and trigger conditions for recording start / stop shall be fully editable.

14.10.4 S&T Interface Signals Logs

1

14.10.4.1 TCMS shall also log information / signals as received / delivered from/to ATP / ATO / UTO and Train Radio equipment supplied by the Signalling Contractor and Telecommunications Contractor respectively. Please refer Appendix C for further details.

14.10.4.2 The Contractor shall also enable Signalling Contractor to record similar data / signal interfaced between Rolling Stock and Signalling. During design and interface, additional signals may have to be interfaced with Signalling Contractor to improve train performance. The same shall be implemented by the Contractor.

14.10.5 Memory Capacity Limit

For the functionalities specified in these specifications, not more than 50% of the provided memory capacity shall be utilized. Further all the memories used in TCMS shall be expandable further as required by CMRL. Requirements of clause 20.6.5 shall be met.

14.10.6 Event Recorder

14.10.6.1 Event Recorder equipment and its installation shall be designed to BS EN 60529 and shall meet the crash protection requirements of RGS GM/RT/2472. The following details should be recorded:

- a) Speed of Train
- b) Distance travelled by train
- c) Acceleration and Deceleration of train
- d) location of Train
- e) direction of travel
- f) Traction power controller position
- g) ATO UTO traction effort signals
- h) brake controller position and brake equipment response
- i) ATO UTO brake effort signals
- j) the driver's safety operator position
- k) status of line power
- l) Status of head lights.
- m) Working of train Horn
- n) Battery voltage in all conditions
- o) Events of any passenger emergency intercom activation

1

p) Any other system information required for CMRL.

14.10.6.2 The Contractor shall supply one event recorder for each train, easily removable, mounted in a car in an approved location.

a) Capacity: The recorder shall have the provision of recording at least 200 signals of the data which should be easily retrievable either by directly connecting the Window based PC or/and the storage media shall be removable type. The event recorder shall maintain a record of monitored signals and parameters in its internal memory. The memory shall be non-volatile such that the contents will not be lost in case of battery failure / low voltage power supply failure and shall be sufficiently large to ensure that signals for at least 3 months of operation will be kept on record for storage before being overwritten in First-In-First-Out (FIFO) method. The use of processed data shall be minimized.

b) Integrity: The Recorder shall be fully protected against illegal tempering, shall maintain its structural integrity and integrity / retrieval of data / device during accident.

14.10.6.3 The event recording equipment shall comply with all applicable international standards.

14.10.6.4 Event recording equipment shall be protected against fire on-board the car, and shall be capable of withstanding impact, shock and crush loads applied to the equipment case, without loss of stored data.

14.10.6.5 The event recorder shall continue recording when the car is stationary but in operational mode.

14.10.6.6 The Contractor shall provide all equipment, computers, storage devices, software, data cables, and any other equipment, necessary to ensure downloading, storage, and analysis of recorded.

14.10.6.7 The method of downloading data from the event recorder shall be Ethernet or HDMI or USB interface or latest compatible interface shall be provided.

14.10.6.8 The Contractor shall submit for CMRL approval data on event recorder design, operation, and functionality, including a list of recorded parameters.

14.10.6.9 All the information in Event recorder shall be available to OCC and maintenance yard in the real time.

14.10.7 Files Format

The file format of all recorded data log files as above shall be submitted along with the tools required for reading and processing the same in batch mode. These files shall also be open and readable via third party tools (windows base). Naming convention for all different data file types shall be submitted for CMRL review. Suitable placeholders for time, car ID, equipment ID, trip ID, train ID etc. shall be incorporated.

14.11 REAL TIME REMOTE-DIAGNOSTIC MANAGEMENT SYSTEM (RTR-DMS)

~~14.11.1 The Contractor shall ensure all the Information, Fault logs, Trace data, etc., of the sub-systems of Rolling Stock including the information mentioned in this Chapter are transferred to Asset Maintenance and Management System (AMMS) for asset management, maintenance planning and alarm / fault recording of the Rolling Stock. This information shall also be displayed in Real time for RSC display in OCC and in Depot (PPIO). The Contractor shall ensure all information to be transferred to AMMS is compatible in terms of format and presentation as well as ensuring full compatibility of protocols and software.~~

1

14.11.1 REAL TIME REMOTE-DIAGNOSTIC MANAGEMENT SYSTEM (RTR-DMS)

The RS Contractor shall design and implement the complete RTR-DMS system to enable the below features in all UTO and Non-UTO modes of operation. The below requirements for this system shall be met:

- a) Remote access of TCMS data and train sub-system data logs of trains shall be available at RSC consoles of OCC, BCC and DCCs of all Designated Depot(s) of CMRL Phase 1 & Phase 1 Extn. Data from trains available in elevated, under-ground, at-grade sections of mainline and depots shall be accessed using RTR-DMS. All the channel data of TCMS and events, faults, variables of each sub-system of train shall be transmitted to OCC, BCC & DCCs for RTR-DMS.
- b) Remote downloading of complete TCMS data & trains' sub-system and On-Board Track Condition Monitoring and Warning system data to the central server located in OCC. The provision of this central server shall be part of Rolling Stock contract scope.
- c) Transmission of data from all trains of CMRL phase 1 & phase 1 extn. to this central server location shall be done by wireless communication network of signalling system. The Contractor shall conduct necessary interface with Signalling Contractors for this purpose and shall be responsible for complete set up, testing, commissioning and satisfactory working of the system until during train defect notification period.
- d) Real time remote data transmission from Trains and On-Board Track Condition Monitoring and Warning system to central server shall occur seamlessly from all locations of elevated, underground & at-grade sections, from all Designated Depot(s) of the CMRL Phase 1 & Phase 1 Extn. network. To achieve this function, RS Contractor shall connect to the Signalling systems of train for so that Signalling system can transmit the data from train. In case of future extensions/modifications in any corridor, the RTR-DMS system shall be functional without any change in Software or Hardware of train.
- e) The purpose of this RTR-DMS is to enable the maintenance personnel in the depot and operation personnel in OCC, BCC& DCC to understand the actual failures of the sub-systems of train even when the train is being operated in mainline. Hence, they could trouble-shoot the faults and provide technical support to OCC operator/Train operator to continue the train to run in the passenger service.
- f) Geographically, OCC and the Designated Depot(s) of CMRL Phase 1 & Phase 1 Extn. network may be placed at different locations. Hence RS Contractor shall interface with Signalling & Telecom Contractors to ensure that the complete data of OCC central server to be made available in all Designated Depot(s) of the CMRL Phase 1 network through secure transmission of signalling system.
- g) Signalling Contractors shall be responsible of RTR-DMS data transmission from central server to various depots of CMRL Phase 1 & Phase 1 Extn. RS Contractor shall interface accordingly.
- h) The facilities of Real Time Remote Downloading shall be in addition to the downloading of logs through hardware in train.
- i) The responsibilities of RS, Signalling & Telecom Contractors for the same shall be specified in Interface specification - Appendix C
- j) RS Contractor shall install the hardware and software for Rolling Stock Controller (RSC)'s console in OCC, BCC and in DCC of each depot in CMRL Phase 1 & Phase 1 Extn. This RSC display shall provide the access for viewing of all train related real time remote fault diagnostic data & events as described in clause 14.11, and 14.13 and 14.15 This RSC display shall also provide the access for controlling of all train related functions in real time during UTO mode as described in clause 14.4. The GUI of this RSC display shall be similar to the Train TCMS – DDU. This RSC console shall be connected to the Central server data placed in OCC. The RS Contractor shall provide all inputs to the Signalling & telecom Contractors to match RSC console with the power & network

1

2

configuration being used on the OCC, BCC and DCC. In addition to the requirements as per clause 14.11, ~~and 14.13 and 14.15~~ this RSC displays in OCC, BCC and DCC shall provide all remote train system controls requested in all Chapters and Appendix C. The size and information GUI of this RSC console shall be designed such that the OCC / BCC / DCC operator is able to access data and control the functions of the complete fleet of trains from this console. RS Contractor shall interface with Signalling & Telecommunication Contractors for the installation and network configuration for this RSC console in OCC, BCC and in DCC.

- k) The transmission of data from trains to central server shall be utilized in two methods.
- l) For display of operational related train information on RSC consoles of OCC, BCC & DCC.
- m) For display of train's fault trouble-shooting related information required to understand and rectify the fault in main-line itself. It shall be possible by CMRL authorized personnel to connect and work on the RS central server in OCC for access of the real time data being transmitted by trains. It shall be possible to replicate the RSC's console in all the diagnostic maintenance laptops provided to CMRL and at a remote location of the depot with minimum interface with Signalling & Telecom Contractors. RS Contractor shall develop a web based secure provision for the access of this information to authorized CMRL representatives in maintenance laptops. These maintenance laptops and in remote web-based locations, only viewing rights shall be provided without any control of train features.
- n) RS Contractor shall interface with signalling & telecom Contractors to list out all the faults and data which need to be displayed on the RSC consoles of OCC, BCC & DCC.
- o) Depot control centre display shall control the train movements within the depot, communicate the train handover / takeover details with OCC. RSC console of DCC shall get the fault information and control of all trains operated in the CMRL phase 1 & phase 1 extn.
- p) The data transmission from trains to central server and from central server to various depot consoles shall be real time and shall have minimum polling cycles.
- q) The RTR-DMS system shall be functional in all UTO and Non-UTO modes of operation including various degraded modes of train.
- r) The RTR-DMS system shall be connected to the battery system and shall be considered as an essential load of train.
- s) Battery power supply interruption shall not cause loss of information of RTR-DMS system.
- t) All data stored by RTR-DMS in train shall last for at-least 3 months without erasing. The central server capacity in OCC shall be designed such that complete RTR-DMS data of all the trains of the CMRL Phase 1 & Phase 1 Extn. network shall last for at-least 3 months without erasing.
- u) RS Contractor shall provide required equipment and components for efficient working of RTRDMS system as per above requirements.

1

~~14.11.2 RS Contractor shall install the complete hardware and software for Rolling Stock Controller (RSC)'s console in the OCC, the PPIO Console in the depot and the Maintainer console in the depot. This console display shall provide the access for viewing of all train related real time remote fault diagnostic data & events as described in clause 14.11 and 14.13. The GUI of this RSC display shall be similar to the Train TCMS DDU. The size and information GUI of this RSC console shall be designed such that the OCC operator is able to access data and view the functions of the complete fleet of trains from this console. RS Contractor shall interface with Signalling & Telecommunication Contractors for the installation and network configuration for this RSC console in OCC. The display options required for PPIO or maintainer console will be finalised during execution stage.~~

14.11.2 Required technical Features of data is as below: (All data available in train shall be available in RSC consoles of OCC, BCC and DCCs).

a) Download Triggers

The triggers for remote downloading to central server shall be time interval actuated, fault actuated, manual triggered from train and also forced downloaded remotely by authorized CMRL personnel.

b) High-Integrity data transfer

Integrity of the data shall not be affected during remote download and in case of any interruption or otherwise the data shall be suitably secured and retrievable.

c) Auto Resume of failed downloads

Connection failure during data download shall not cause restart of download from the beginning. Rather, all downloads shall pickup from the point where connection was broken.

d) Depot management tools, issue of work orders, issue & closure of job cards etc. shall be linked with this system. It shall be possible to issue & closure of job cards for the failures occurred in the train from the RTR-DMS operated in RSC consoles of OCC, BCC & DCCs. It shall be possible to replicate this function in PPIO room in depot maintenance workshop. RS Contractor shall interface with Asset Management Contractor for combined working of RTR-DMS with Depot Management Tools.

e) The Contractor shall supply the multiuser software(s) required for analysis of the faults and predictions / judgments on likely faults / failures. The specification of the software shall be got approved from CMRL

f) A network bus which interconnects all the data logging components shall be integrated with main server for data transfer.

g) Graphical user interface of the faults displays and operational information in RSC consoles of OCC, BCC and DCCs shall be interfaced with signalling & telecom Contractor and shall be designed in such a way that it is adaptable for easy understanding.

h) Provision for editing the variable names and restructuring data projections shall be made via admin login.

i) User specific Customization shall be available to interpret data for convenient access.

j) Provision shall be made to enable / disable specific faults / alarms via admin login.

k) The system shall be capable of self-diagnostic for issues related to performance, memory and network. It shall have the feature of storing the repeated failures and maintain the fault history and related diagnostics required to resolve the issue.

l) The Contractor to ensure that all fault and associated data residing in the subsystem's internal memory shall be retrievable on specific request from the TCMS nodes / wireless terminal.

m) If fault data downloading is interrupted somehow, it shall start from the beginning.

The Contractor shall submit proposal for RTR-DMS as per requirements of clause 14.11 and 14.13 to CMRL for approval.

14.11.3 The Contractor shall provide On board equipment and wayside equipment (if required) by means to enable remote real time wireless transferring of all Rolling Stock data to AMMS. The Contractor shall provide all equipment (hardware including server etc. & software) and install the system to enable remote wireless downloading of all the stored TCMS data, data recordings, environment data and linked files if any.

14.11.4 It shall be possible to receive the data using commercially available GPRS network or the remote downloading shall be possible within the range of all the depots using WLAN or any upgraded latest technology as proposed by the Contractor subject to approval of CMRL. All costs towards network, etc shall be borne by the Contractor.

- 14.11.5 Integrity of the data shall not be affected during remote download and in case of any interruption or otherwise the data shall be suitably secured and retrievable.
- 14.11.6 The facilities of the remote downloading shall be in addition to the hardwire downloading. Apart from normal downloading the system should also have intentional / forced download by authorized CMRL personnel.
- 14.11.7 Updating software, modifying parameters, setting etc through any wireless media shall be restricted. This feature shall be implemented without any interfacing with other contractors.
- 14.11.8 The Contractor shall furnish the details during PFDR stage for review and approval by CMRL.
- 14.11.9 This system shall automatically generate reports from the data. All reports shall be fully customizable and available for download

14.11.10 The contractor shall provide equipment and install the complete system to enable:

- a) Remote access of TCMS data (as defined in clause 14.11) of trains present in mainline or at the Designated Depot(s);
- b) Remote downloading of TCMS data (as defined in clause 14.11 and 14.15) to OCC central server and AMMS server through wireless communication network of signalling Contractor / telecommunication Contractor and their access in OCC, BCC, DCC and various diagnostic maintenance laptops provided to CMRL (in accordance with the requirements specified in ERTS Clause 15.6). The Contractor shall conduct necessary interface and shall be responsible for complete set up, commissioning and satisfactory working of the system before Revenue operation.
- c) The facilities of remote downloading shall be in addition to Hardwire downloading.

14.12 ENERGY CONSUMPTION MEASUREMENTS

14.12.1 General

14.12.1.1 The Vehicle Control Circuit shall be suitably designed to ensure that Energy Consumption values at specified points are measured, recorded and made easily retrievable. The accuracy and integrity of these measurements shall be specifically ensured as the CMRL intends to use the data for getting carbon credits.

14.12.1.2 The measurements shall be:

- a) Made independently at pantograph, converter, auxiliary converter and VAC levels,
- b) Made separately for traction, coasting and regeneration modes for each train,
- c) Linked with Crew IDs (in non-ATO non-UTO mode),
- d) Segregable between mainline and depot consumptions,
- e) Time stamped every 5 seconds,
- f) Stored in TCMS memory for 90-day period,
- g) Retrievable on DDU as cumulative / integrated values with advanced filtering option.

14.12.2 Reporting of Measurements

- a) Display on DDU: The cumulative energy values at pantograph, converter-inverter, auxiliary converter-inverter and VAC levels with both the components viz. motoring (including coasting) & regeneration, shall be displayed on DDU. It shall also be possible to apply time and trip filters to the energy values.

- b) ~~Complete energy data shall be transmitted to AMMS. The data shall be stored for one week and shall be downloadable as and when required. Further details including reporting format shall be discussed and finalized during design.~~

Relaying to Depot Control Console / OCC console: Complete energy data shall be real-time transmitted to Operations control centre OCC, Depot control centre DCC and AMMS. The data shall be stored for one week and shall be downloadable as and when required. Further details including reporting format shall be discussed and finalized during design.

- c) File Format : The Energy Consumption data shall be exportable to Microsoft Excel in the following format,

Parameter	Time ₀	Time ₅	Time ₁₀	Time ₁₅	
Energy Consumed @ Pantograph (Powering)					
Energy Consumed @ Pantograph (Coasting)					
Energy Consumed @ Pantograph (Braking)					
Energy Regenerated @ Pantograph (Braking)					
Energy Consumed @ CI (Powering)					
Energy Regenerated @ CI (Braking)					
Energy Consumed @ APS (Powering)					
Energy Consumed @ APS (Coasting)					
Energy Consumed @ APS (Braking)					
Energy Consumed @ VAC (Powering)					
Energy Consumed @ VAC (Coasting)					
Energy Consumed @ VAC (Braking)					
Odometer Reading					
State (Powering / Braking / Coasting)					
Crew ID					
Train ID and Train Number					
Trip Number					
Last Station ID					
Mainline / Depot					
Train Speed					

In above format, the values in blank cells shall only correspond to the recordings made during the 5 second interval between successive timestamps and shall not be accumulated.

14.12.3 Measurement Accuracy

- Accuracy: All energy measurements shall have accuracy within $\pm 5\%$ of the measurements made with Standard Wattmeter and Standard Instrument Transformers connected at appropriate test point in the Vehicle Control Circuit. This shall be validated during type tests.
- Verification: The Contractor shall be required to submit the detailed arrangement for connecting the standard Instrument Transformers and Standard Wattmeter at the test points for measurement of Energy Consumption for all above defined parameters, during the Type Test.
- Least Count: The least count for recording data shall be 0.01 kWhr at all levels of measurement.

14.12.4 Energy Saving Assist

The Contractor shall also provide suitable analytical tools to screen and analyse the energy data for:

- Optimization of energy regeneration, coasting,
- Right manner / energy saving manner of driving,

- c) Identifying the areas where energy can be saved,
- d) Calculating efficiency values of transformer, converter inverter, auxiliary converter, VAC etc.

1

14.13 NOT USED TCMS – OCC / DCC INTERFACE

14.13.1 Key Alarms

The Contractor shall propose a list of critical / key alarms to be communicated to the OCC in real-time through the signalling network. This list shall include all alarms that are required for maintaining safe train operation. Any repetitive, hierarchical or cascading type faults shall be suitably masked or combined together to ensure brevity of the information being presented to OCC operator.

14.13.2 RSC Display

The Rolling Stock Controller (RSC) in OCC, BCC and in DCCs shall have facility of full TCMS functionality of any train on his workstation on demand through signalling network. Supply of RSC hardware and Development of the DDU application in RSC workstation shall be responsibility of Rolling Stock Contractor. RS Contractor shall interface with the Signalling Contractor for this purpose. The workstation shall be provided by RS Contractor.

14.13.3 OCC GUI

1

Rolling Stock Contractor shall propose a user-friendly graphical user interface in the form of a conceptual schematic / wireframe that shall include page layouts, arrangement of the GUI's content, interface and navigational elements, and a description of how they work together. This proposal shall be submitted to CMRL for his approval well in advance and shall be jointly agreed with Signalling Contractor for implementation. The Rolling Stock Contractor shall provide detailed information of the TCMS-OCC interface as implemented in at least two recently executed UTO Projects for reference during design stage. The name of such projects shall be indicated by the Contractor during Preliminary stage.

14.13.4 UTO OPERATIONS

The design of TCMS and its relevant components in train shall support for UTO / GoA4 in the CMRL Phase 1 & Phase 1 extension network defined in Chapter 1. Trains shall be operated in GoA2 / ATO mode during the initial stage of commissioning and revenue operations and in GoA4 /UTO subsequently. Hence all the feedbacks, information and train controls which are available on TCMS screen shall also be available in OCC and DCC for smooth operation of passenger service.

14.14 TCMS SYSTEM INTEGRATION TEST LAB

- 14.14.1 The Contractor shall establish a TCMS test lab at the site of the Rolling Stock Factory (or elsewhere subject to CMRL approval). The lab shall be fully established at least 3 months' prior to the start of integration type test activities.
- 14.14.2 The intended purpose of the lab is to replicate the actual TCMS architecture of the fleet (including train subsystems and interfaces with other designated Contractors) in order to mature the design development of software and hardware interfaces.
- 14.14.3 The Contractor shall ensure that its supply chain agreements (SLA) with all major train Subsystem supplier's shall contractually oblige on-time delivery of Subsystem hardware to complete the installation of a fully functional test lab. The SLA's shall also include deployment of the supplier's engineering staff / resources to participate in lab based development tests and activities.
- 14.14.4 Notwithstanding the requirements for an "integrated test bed" (called for in the Clause 2.5 of the Appendix-C Interface Chapter) the Contractor shall also include STC and Telecom hardware within the TCMS Test Lab.

14.15 ON-BOARD TRACK CONDITION MONITORING AND WARNING SYSTEM:

- 2**
- 14.15.1 The provision for condition-based track monitoring and warning systems shall be made to monitor the health of rail bed structure. All the parameters/raw data/refined data obtained from these systems shall be sent to RTR-DMS server and same will be communicated to AMMS system. The requirements under different condition-based monitoring system are as below and the details shall be discussed and finalized during design stage.
- 14.15.2 The systems are intended to be provided on Rolling Stock to monitor health of rail bed structure including Track conditions. The Rolling Stock contractor shall provide suitable number of Cameras/sensors/laser devices with automatic real-time detection and warning system including time-stamp, locations/chainage etc., capable of functioning up to 95 kmph of train speed. Additionally, the on-board condition monitoring system shall have the configuring provisions for adding/altering track chainages by the maintenance personnel, from the on board monitoring system controllers or from TCMS, in the event of any future extension/alteration of the section during the DNP period. The on board condition monitoring system shall have the ability to precisely incorporate the track chainages fed by maintenance personnel. The real-time high-priority data with image shall be relayed to the common condition monitoring system server via Signaling network/ public commercial telecom networks as back up. The on-board condition monitoring system shall be capable to monitor self health on start-up and shall report the status to TCMS/OCC.
- 14.15.3 The system shall be capable of monitoring & measuring different parameters & defects of track as detailed below and shall be installed in two (02) different trainsets. The functionalities required by this system shall be as detailed under:
- Detection of Broken rail, Rail Corrugation, Surface Rail Defects, Edge defects, Missing Fasteners, chunking in the rail surface, periodical imprints, wheel slip points, insulated joints, corrugation, Head Checks in the final stage (with the extension module Head-Check, the system is also able to detect Head Check in the early stage), type-independent detection of missing fasteners, rail fractures of at least 1 mm wide i.e. the least count of the rail break detection shall be 1 mm or less, etc.
 - Track geometry, Rail Profile, Rail Wear.
 - False alarms due to oil/water spillage/rain drops, etc must be prevented.
 - In the Sleepers- safety-relevant spallings, safety-relevant crack formations, Crack Check cracks of up to 0.5mm in width can be detected automatically or can be visualized up to 0.3mm in width.
 - In the Ballast – overfilling, underfilling,
 - Turnout detection- automatic detection of the cross frog, storage of the area of the turnout in a separate file
 - The Track monitoring System shall be integrated with TCMS. In the event of track defect(s)/abnormalities, the alarm shall be displayed on TCMS,OCC and recorded at TCMS. The time and location of each event of track defect(s)/ abnormalities encountered shall be recorded. Historic data shall also be available for a period of at least one week on the onboard storage.
 - The system shall be capable to function in both daylight and night at desired accuracy and efficacy/efficiency.
- 14.15.4 Server requirements
- All the data captured/generated shall be relayed and stored in the RTR-DMS server.
 - All the parameters/raw data obtained from these condition monitoring systems shall be stored for 7 days in local server and the refined/processed data shall be stored for 30 days in common condition monitoring system server.
 - The graphical user interface shall be designed to allow users to access processed data, events, historical data, MIS report, etc. from a single common application. The

contractor shall be responsible for providing all necessary hardware and software, including the server, desktop, and application software.

- iv. All the condition monitoring system shall be integrated with Asset maintenance management system (AMMS).

14.15.5 General

- (a) The OEM of On Board & Wayside Condition based Monitoring Systems shall also provide Training to Employer's maintenance personnel and shall provide the training materials, training kits and relevant equipment.
- (b) The integration of the TCMS with the condition monitoring system shall ensure functional independence. It shall be design in such away that it does not compromise the functionality, performance or availability of the TCMS and its interface with other RS systems. Further, the condition monitoring system supplier shall coordinate and interface with the TCMS supplier to ensure that any software updates do not adversely affect the interface between the condition monitoring system and the TCMS.

15. SYSTEM SUPPORT

15.1 NOT USED

15.2 CONTRACTOR'S RESPONSIBILITIES

- 15.2.1 The scope of work for the Contractor with respect to operations, maintenance, training and other prerequisites for operation of the Chennai Metro Rail Project shall include, but not be limited to, the following obligations.
- a) The Contractor shall prepare the overall "System Maintenance Plan" taking into account the specification and configuration of the Works to be provided.
 - b) The Contractor shall prepare the overall "System Training Plan" taking into account the specification and configuration of the Works to be provided.
 - c) The Contractor shall provide technical input associated with the Works for the preparation and subsequent review for technical correctness of rule books, hand books, procedures, regulations and any other documents necessary for CMRL to execute and manage the operation of the Chennai Metro Rail Phase 1 Project.
 - d) The Contractor shall provide equipment operating and maintenance manuals covering all items provided as part of the Works.
 - e) The Contractor shall provide training; training documentation and other training facilities corresponding to the items covered by the equipment operating and maintenance manuals.
 - f) The Contractor shall provide advice to the CMRL with respect to the operational accessories that will be necessary for the safe and efficient operation of the Project.
 - g) The Contractor should provide all drawings such as general arrangements, plans, elevations, principal sections and typical details of critical areas (as hard and soft copies) for all equipment / systems / parts of equipment and part catalogue for easy identification, facilitating training of operation and maintenance personnel.

15.3 SYSTEM MAINTENANCE PHILOSOPHY

- 15.3.1 The Contractor shall provide a "Paperless Maintenance Philosophy" for all its Works for the CMRL Phase 1 Project.
- 15.3.2 This Paperless Maintenance Philosophy shall include all specialized maintenance activities requiring heavy machinery and/or special diagnostic and repair equipment.
- 15.3.3 As a "Paperless" Philosophy, the planning, execution and recording of all types of maintenance shall be undertaken using connected technologies.
- 15.3.4 Tablet Devices shall be issued to Maintenance Staff to ensure the accuracy and efficiency of all Record Keeping undertaken in the field. Features shall include but not be limited to Maintenance Check-Sheets, Maintenance Work Instructions and Trouble-shootings Guides.
- The Tablet Devices shall be interactive to ease navigation. Troubleshooting guides shall be especially intuitive (and shall include a network of Flow-Charts), to optimize the response of staff called to attend service disruption on the Mainline.
- 15.3.5 The Maintenance Philosophy will define the overall requirements for:
- a. Maintenance strategy for Preventive & Corrective maintenance (time based, condition based etc.).
 - b. routine maintenance planning.
 - c. reporting of faults for corrective maintenance.
 - d. location of maintenance facilities.
 - e. Complete list of Maintenance, Repair and Overhaul (MRO) facilities (refer Clause 15.3).
 - f. location of stores.

- g. staffing and outsourcing.
- h. maintenance task documentation.
- i. maintenance training.
- j. procedures for access to the Main Line.
- k. Procedures for safe working.
- 1 l. Procedures for train rescue and coupling in mainline under UTO and Non-UTO modes of operation.
- m. Rectification and analysis Reporting system for failures observed in corrective maintenance.
- n. Procedures detailing activities to be done during the over-hauling maintenance of trains.
- o. Proposed periodicity for each type of examination or inspection or overhaul.
- p. List of tasks to be carried out at each examination or inspection or overhaul.
- q. Man-hours required for each task.
- r. Replacement parts required at each examination or inspection or overhaul; and
- s. Different levels of maintenance activities
- 1 t. Precautions to be taken for UTO train maintenance in various depot lines.
- u. Precautions to be taken for taking earth blocks for OHE switch off for train maintenance with reference to UTO / Non-UTO / Cut-out modes of operation.

15.3.6 The Contractor shall provide input relating to the Works to the “Maintenance Plan”.

15.3.7 This “Maintenance Plan” will include the specification of all Depot plant and workshop and other permanent or portable equipment, which will be required to achieve the maintenance goals and objectives, which will also be specified in this “Maintenance Plan”.

15.3.8 The Contractor’s input to the “Maintenance Plan” shall describe the methodologies to be adopted for the maintenance of the Works provided for the Project and shall address, as a minimum, the following subjects:

- a. Recommended organization and composition of the maintenance team.
- b. Recommended maintenance schedules to be used with the maintenance management system.
- c. Recommended procedures for the identification and rectification of faults.
- d. Recommended preventative maintenance management procedures; and
- e. Recommended procedures for independent checking of correctness of maintenance of Safety Related equipment

15.3.9 The Contractor shall ensure that the specification of maintenance services with all associated maintenance procedures, computer-based control systems and personnel training will enable all maintenance and repair activities to be performed in an efficient and effective manner.

15.4 NOT USED

15.5 SYSTEM TRAINING PHILOSOPHY

15.5.1 The Contractor shall provide input relating to the Works to the “Training Philosophy”.

15.5.2 This Training Philosophy may be based on the creation of a new operating company under the advice and supervision of personnel provided by an established mass transit system operator. However, CMRL may depute its own personnel or its authorized personnel for Operation of the trains and the support systems.

This Training plan shall include Training for Employer’s Management / Supervisory staff in Rolling Stock design, manufacturing, testing in the Contractor’s primary car builder’s facility.

15.5.3 Training will be concentrated at the Training Schools at the Designated Depot(s).

15.5.4 The Training Philosophy will define the overall requirements for OCC operators, Depot Control Centre Operators, Station Controllers, Train Operators, Depot train maintainers and other

- related Operation & Maintenance staff:
- Timing of staff recruitment.
 - Qualifications of trainees.
 - Methods of training.
 - Location of training.
 - Timing of training.
 - Requirements for training aids.
 - Selection of exceptional trainees for more senior positions.
 - Certification of trainees
 - Continuous Improvement of skills of OCC operators, Depot Operators, Station Controllers, Train Operators, Depot train maintainers and other related Operation & Maintenance staff.

15.6 TRAINING PLAN

- 15.6.1 The Contractor shall provide input relating to the Works to the “Training Plan” in accordance with the overall philosophy for training.
- 15.6.2 The “Training Plan” will be prepared based on the System Operations Plan and the System Maintenance Plan.
- 15.6.3 The timing, content, target group, class size, location evaluation method and duration of each operation and maintenance training course shall be defined in the “Training Plan” and shall conform to the CMRL’s service and maintenance requirements for the start of revenue service.
- 15.6.4 The Contractor shall provide training relevant to his Works in accordance with the Training Plan and other requirements as described in the CMRL’s requirements.
- 15.6.5 The “Training Plan” shall identify and give details of the timing, target group, class size and duration of all planned refresher training courses that will be required on a regular basis for existing staff during revenue service.
- 15.6.6 The “Training Plan” shall identify and give details of training courses that will be required for new employees during revenue service adapted to include on the job training elements from existing employees.
- 15.6.7 The “Training Plan” shall include all necessary administrative procedures including the screening of candidates for suitability and competence, assessing progress during training, examination and certification of successful candidates. It shall also consider the training requirements to be provided for re-training or periodical refresher training of the existing staff.
- 15.6.8 The Training plan shall cover the complete technical details of all train systems in an understandable illustrative manner. The purpose of the training plan shall be to completely train the staff in the respective division of operation and maintenance activity. Suitably, the training plan and documents shall be specific to the division of type of work category of the staff.
- 15.6.9 The training plan shall include both theoretical and practical sessions for the staff. Theoretical training shall include complete illustrated descriptive details of the systems covered.
- 15.6.10 The Contractor shall include the cost of the training in cost Centre ‘H’ Schedule of Prices’. The travel, boarding and lodging expenses for CMRL’s trainees will be borne by CMRL. The Contractor shall submit the different training modules, their durations, periodicity and target group of persons at the time of design approval stage. CMRL in consultation with Contractor may at its absolute discretion alter or include new training schedules while finalizing the design.
- 15.6.11 Facilities such as classrooms with projectors will be made available for imparting training at the Designated Depot(s) in India free of cost to the Contractor. However, for training in the Contractor’s Works, such facilities shall be arranged by the Contractor’s at his own cost. The Contractor is however, required to provide at his own cost all other necessary training aids such as written and printed notes, video programs, training documentation, transparencies, slides, films, models and drawings, and other training aids etc.

- 15.6.12 CMRL personnel required to undergo training will be qualified Electrical, Mechanical and Electronics Engineers, Technicians, Supervisors or Instructors, with relevant practical experience. The training syllabus should therefore concentrate on familiarization with particular systems and equipment of the cars and technologies outside of their experience.
- 15.6.13 Training of CMRL personnel shall be conducted as per the requirements of Pricing documents - Chapter 4.4.11 - Price Centre H.

15.7 SUPPLY OF DIAGNOSTIC MAINTENANCE LAPTOPS

- 15.7.1 The Contractor shall supply a quantity of Ten (10) ruggedized laptop computers to CMRL for the purpose of maintenance; including diagnostic troubleshooting of trains.
- 15.7.2 The Contractor shall propose a suitable model for CMRL's review and acceptance. The proposed model shall include a USB-C port data and charging port which shall be compatible with the onboard USB-C-PD charging sockets.
- 15.7.3 All supplied laptops shall include the full range of software required to connect with and use the features of all Rolling Stock subsystems.
- 15.7.4 OS and Application software shall be pre-installed prior to handover and shall have perpetual licences.

15.8 OPERATING RULE BOOK

- 15.8.1 The Contractor shall provide technical input associated with the Works to the CMRL for incorporation into the "Operating Rule Book".
- 15.8.2 The "Operating Rule Book" will contain all rules pertaining to the conduct of personnel, the safety of passengers and personnel, the interpretation of signs and the Operator's obligations to third parties.
- 15.8.3 The "Operating Rule Book" will contain references to the rules to be applied to protect maintenance functions including the planned removal of traction power, etc.
- 15.8.4 The "Operating Rule Book" will cover the actions required to ensure safety for the restoration to normal operation following the completion of any maintenance activities.
- 15.8.5 The "Operational Rule Book" will cover various withdrawal scenarios for train withdrawal from various sections of CMRL Phase 1 Corridors to the Designated Depot(s).
- 1 15.8.6 The "Operational Rule Book" will cover the action plan to be taken by OCC/DCC Operator /Train Operator in case of various train failure scenarios and the action plan by them during train withdrawal to the Designated Depot(s).
- 1 15.8.7 The Operation Rule Book shall consider the requirements of ~~ATO / Non-ATO train operations~~ on the basis of both UTO GoA 4 train operations, non-UTO train operations and Cut-out mode operations.
- 15.8.8 The Operation Rule book shall be updated in case of modifications of any of the above criteria during the project commissioning stage.

15.9 OPERATING PROCEDURES MANUALS

- 15.9.1 The Contractor shall not be responsible for the preparation of the operating procedure manuals and Operating Rule Books but shall be required to review and propose corrections to these documents to ensure technical correctness and to confirm that all input provided by the Contractor as a basis for their preparation has been correctly interpreted and incorporated.
- 15.9.2 The Contractor shall provide technical input associated with the Works to the CMRL for incorporation into the "Operating Procedures Manuals".
- 15.9.3 The operating procedures manuals will contain detailed procedures specific to the various groups of operating staff including train crew, station staff, OCC staff, depot staff and safety & quality management staff.

15.9.4 These operating procedures manuals will cover all aspects of the operation of Train services and the implementation of all procedures for normal, degraded and emergency conditions as identified within the “System Operating Plan”.

1

15.9.5 The Operating Procedures Manuals shall consider the requirements on the basis of ~~ATO train operations, non-ATO train operations~~ both UTO /GoA4 train operations, non-UTO train operations and Cut-out mode operation.

15.10 OPERATING AND MAINTENANCE (O&M) MANUALS

15.10.1 The Contractor shall provide project specific O&M manuals. They shall be written in concise and simple English and shall be sufficient in content to provide the Operator with adequate guidance on all aspects of the operation and maintenance of the Works.

15.10.2 Manuals shall explain the purpose of the O&M scope for the complete system together with its component subsidiary systems and individual items of equipment. The characteristics, ratings and any necessary operating and maintenance limits of the Equipment and Sub-systems shall be provided in O&M manuals. The details of O&M manuals shall show actual component pictures, diagrams of all complete equipment of train in an illustrated manner.

15.10.3 Manufacturer’s standard literature for commercial off the shelf items shall be in English language only provided that it meets all other requirements.

15.10.4 Photographs of actual equipment, explanatory diagrams and display screen shots shall be used to the maximum practicable extent in all operating and maintenance manuals.

15.10.5 A Table of Contents and Sample Formats shall be included in all manual types as well as references to the Illustrated Parts Catalogue.

15.10.6 Illustrated Parts Catalogue shall contain the required individual supplier’s Part numbers, corresponding photographs, supplier’s contact details and other related details for all the complete components of the train.

15.10.7 The Contractor shall provide O&M manuals in sufficient detail to enable the CMRL to operate, test, maintain, overhaul, and repair the Works to meet the specified maintainability, reliability, safety and availability requirements.

15.10.8 Requirements of design of hard copies of O&M manual

- a. The page size shall be A4 international for text and text shall be in Arial size 12.
- b. Foldout diagrams or illustrations may be employed with a maximum size of A3 and the title shall be visible in the lower right corner when the sheet is folded;
- c. Covers shall provide protection appropriate for their use and to a standard to be agreed with CMRL.
- d. The paper and ink shall resist smearing, fading, and deterioration from age and shall be suitable for use in a maintenance shop environment.
- e. All paper shall be bound in loose-leaf type binders and the binding arrangement shall be such as to permit the manual to be laid flat when open at each page.
- f. The document shall be collated and numbered in proper order and correspond to the contents and index tables.
- g. Nomenclature or references to any items of equipment, diagrams, figure numbers or units shall be consistent throughout the text.
- h. Diagrams, drawings, sketches and actual photographs shall be added where this aids comprehension.
- i. Precautions and warnings regarding the safety of personnel and equipment shall be included where applicable and shall be highlighted for clarity; and
- j. Hyperlinks shall be employed within softcopy to facilitate document access from the contents list.

15.10.9 No later than twelve (12) months prior to the commencement of Service Trial, the Contractor

- shall submit for approval two (2) complete colour hard copy sets of the draft operating and maintenance manuals sufficient to indicate the contents and style of presentation. Also one set in an approved electronic format shall be submitted to CMRL.
- 15.10.10 No later than four (4) months prior to the commencement of Service Trial, the Contractor shall submit for approval two (2) complete colour hard copy sets and electronic soft copy of operating and maintenance manuals incorporating feedback from training up to this date and suitable for use during Trial Running.
- 15.10.11 No later than one (1) month prior to the commencement of Service Trial, the Contractor shall submit for approval five (5) complete colour hard copy sets and electronic soft copy of operating and maintenance manuals incorporating feedback from training up to this date and suitable for use during Trial Running.
- 15.10.12 Following any modifications to the Works or other circumstances which warrant a change in maintenance practice, the Contractor shall be responsible for updating all relevant approved manuals and corresponding copies in electronic format up until the Warranty Period expires for all trains. By the end of DNP period, five (5) complete colour hard copy sets of operating and maintenance manuals incorporating updates shall be submitted besides submitting the same in electronic format.
- 15.10.13 Revisions in hard copy and electronic format shall be properly recorded in each revision of document by the Contractor to ensure that they are traceable.
- 15.10.14 The Contractor shall provide clarifications and amendments to the Operation and Maintenance manuals as necessary during the execution of contract. Updates shall be provided for the originals and all copies.

15.11 OPERATING MANUALS & TECHNICAL DESCRIPTION BY OEM

- 15.11.1 The Contractor shall provide Sub-system operating manuals and technical descriptions provided by the Original Equipment Manufacturers for each of the specific equipment. There shall not be any modifications done to these OEM's documents by the Contractor and all the original OEM documents shall be submitted to CMRL.
- 15.11.2 Sub-system operating manuals shall provide detailed instructions for the operation of all equipment provided as part of the Works.
- 15.11.3 These manuals shall be produced specifically for each group of user with due regard to the qualifications of personnel who shall be required to refer to them.
- 15.11.4 The information contained within the various Sub-system operating manuals and technical descriptions by OEM's shall include, but not be limited to the following:
- General functional description of the equipment, other relevant or connected equipment and subsystems.
 - Theory of operation of all elements complete with block diagrams / exploded diagrams.
 - Detailed operating instructions.
 - Illustrations depicting equipment locations and layouts together with appropriate nomenclature to facilitate identification of all controls and indications.
 - Common fault handling procedures including recovery procedures where appropriate.
 - Electrical schematic connections within the equipment and with the other equipment.
 - Input – Output pin diagrams for the electronic equipment.
 - Digital interface of each component with TCMS.
 - Network interface of the equipment.
 - Details of software protocols and firmware protocols utilized for the individual equipment.
- 15.11.5 No later than three (3) months prior to the commencement of Revenue Service, minimum of three (3) hard copies and two (2) electronic copies of all Sub-system operating manuals and minimum of three (3) hard copies and two (2) electronic copies Technical descriptions by OEMs

shall be provided to CMRL. The electronic copies shall be in the original source file format to facilitate future editing.

15.12 MAINTENANCE MANUALS

- 15.12.1 The Contractor shall provide the maintenance manuals for all equipment supplied as part of the Works. The Contractor shall provide maintenance manuals explaining the components description, maintenance requirements, failure rectification and trouble-shooting, software installation, trouble-shooting, over-hauling maintenance details of the complete system together with its component subsidiary systems and individual item of equipment. This shall show details of all the various systems and sub-systems from a maintenance and fault-finding standpoint, with particulars of operating parameters, tools for dismantling and testing, methods of assembly and disassembly, tolerances, repair techniques and all other information necessary to set up a repair and servicing program.

The maintenance manual shall also include Maintenance Work Instructions (MWI) of all major systems and sub-systems of the train in detail. The MWIs shall include details of the required materials and consumables, general tools, special tools and facilities in tabular form.

The Contractor shall provide documentation for all hardware and software for computer systems and other associated electronic equipment. The documentation of software shall be supplied after conditional acceptance (put in-to revenue service) of First train. The maintenance manual shall also include inspection/overhaul procedure and periodicity of various inspection / overhaul schedules in detail including the tools, special tools/plants, and facilities required. The manual shall be subject to review by CMRL.

The characteristics, ratings and any necessary operating and maintenance limits of the Equipment and Sub-systems shall be provided in O&M manuals. Any additional technical information which the Contractor intends to share to CMRL could also be mentioned in these O&M manuals.

A preliminary maintenance schedule specifying the frequency of inspections and the scope of work during such inspections, including facilities, manpower and down-time required shall be included within the O&M manuals.

- 15.12.2 The manuals required for maintenance shall be complete and shall include but not be limited to the following:
- Preventative maintenance manuals including work instruction cards and Job Cards.
 - Corrective maintenance manuals including fault finding instructions & fault rectification instructions up-to the lowest line replaceable unit (first line maintenance).
 - Equipment workshop maintenance manuals including the procedures to remove & refit the equipment from train (second line maintenance).
 - Equipment illustrated parts catalogues down to bottom level components until last components; and
 - Software system manuals including the procedures to install/uninstall software, downloading of fault logs and other train data usage of trace files and any other required software trouble shooting details.
- 15.12.3 Equipment Maintenance Manual:
- General standard practices applicable to maintenance and repair of the equipment.
 - Lubrication list.
 - Schematic diagrams.
 - Cleaning agent list.
 - Wiring and cabling diagrams, including interconnection lists with source and destination descriptions for each wire with its unique label.
 - Torque schedule for various types of fasteners.
 - Paint list.

- h. Material specification list for various structures and parts.
- i. Technical data list for all replaceable items.
- j. Applicable special tools and test equipment list.
- k. Master schedule for the periodical maintenance and cleaning of all modules / assemblies.
- l. Checklist for each level of examinations/overhaul from the lowest level of examination to the mid-life overhaul. The list shall include items of equipment, which determine the maximum interval of a particular examination / overhaul and are Safety Critical.
- m. Bill of materials for each level of examination.
- n. Detailed work instructions for the inspection, reconditioning, testing, adjustment of all assemblies / modules / subsystems for each level of examination / overhaul. The work instructions shall include all precautions to ensure safety to personnel; and
- o. Trouble shooting flowcharts for common failure symptoms.
- p. Preventative maintenance manuals including work instruction cards and Job Cards.
- q. Corrective maintenance manuals including fault finding instructions & fault rectification instructions up-to the lowest line replaceable unit (first line maintenance)

15.12.4 Equipment Workshop Maintenance Manual:

- a. Master schedule for the overhaul and mid-life refurbishment of the equipment, including all modules / assemblies / components.
- b. Bill of materials for workshop overhaul and mid-life refurbishment programs; and
- c. Workshops overhaul procedures for dismantling, lifting, inspection, re-assembly and testing of the equipment including all assemblies / modules. The work instructions shall include precautions to ensure safety to personnel.

15.12.5 Equipment Illustrated Parts Catalogue:

The illustrated parts catalogue of all equipment & components supplied and shall contain sufficient information to identify and requisition the appropriate part by maintenance staff. The catalogue shall comprise 3 sub-sections.

The first sub-section shall be an alphanumeric parts list, which shall include the following information:

- a. Part number
- b. Description
- c. Name of manufacturer
- d. Quantity and Unit
- e. Part number of next higher assembly (usually a line replaceable unit).
- f. Cross-reference to figure number.
- g. Category: e.g. consumable, line replaceable unit, repairable.
- h. Life-expected life, Mean time between failure or mean distance between failure where available.
- i. General or specific purpose
- j. Purchase and technical specification
- k. Equipment hierarchy for the equipment, modules and assemblies, down to component level.
- l. A list of components and related parts, including description, component identification code (similar code as used in the equipment hierarchy), name of the original supplier, supplier contact information, supplier's part number and the Contractor's part number (if different), drawing number; and
- m. Cut away drawings and exploded view drawings for identification of all parts.

The second sub-section is a series of illustrations to indicate the location of each replaceable item, which shall be clear and progressive with exploded views to enable parts to be identified easily by cross-reference with the alpha-numeric list.

- The third sub-section, an indicative price list which shall list in alpha-numeric sequence the part number with the price, lead time and vendor.
- 15.12.6 Software System Manuals:
- Software system manuals shall comply to Section 20 and consist the below details for all the software used in CMRL trains.
- a. Algorithm and flow charts of the software being used in CMRL trains.
 - b. Not Used.
 - c. Revisions of actual software and firmware of all the equipment of train are to be provided.
 - d. For each software package and each piece of equipment that incorporates programmable devices including all software that has been prepared specifically for this application.
 - e. Operational environment requirements.
 - f. Operation procedures.
 - g. Debugging procedures.
 - h. Testing and/or simulation procedures; and
 - i. Verification and/or validation procedures prior to returning to normal operation.
 - j. procedures to install / uninstall software, downloading of fault logs and other train data from DMS & RTR DMS system (as defined in Chapter 14), usage of trace files and any other required software trouble shooting details.
 - k. Usage of Passenger information system with options to modify the audio-visual announcements based on future requirements.
 - l. Introduction and modification of advertisements, CMRL promotional videos etc. on the advertisement displays in trains.
- 15.12.7 All maintenance procedures described in the maintenance manuals shall include or make reference to test procedures to be followed to confirm that the equipment is fit for purpose after maintenance intervention.
- 15.12.8 Equivalent manuals shall also be provided for all training equipment, special tools, software tools and test equipment, supplied under the Contract, to enable maintenance personnel to operate, maintain, calibrate, adjust, repair and overhaul such tools and equipment.
- 15.12.9 The Contractor shall submit detailed instructions for daily maintenance check, periodical scheduled maintenance, periodical overhaul of Rolling Stock and all sub-systems / all equipment of Rolling Stock.
- 15.12.10 Maintenance manual should bring out the list of tools and test equipment to be provided for repair of any equipment of Rolling Stock and also indicate the test equipment / special apparatus as required.
- 15.12.11 Maintenance manuals shall provide a list and quantity of unit exchange spares to be available for day-to-day, periodical schedule maintenance and periodical overhaul of Rolling Stock.
- 15.12.12 The Contractor shall prepare requirements specifications for the workshop layout, depot facilities and maintenance equipment required for the maintenance of the Rolling Stock.

15.13 TRAINING DOCUMENTATION

- 15.13.1 Submission of complete Training Manuals (5 sets of Hard bound colour copy) shall be done after finalization of the training plan and after approval of the training documentation by CMRL. The Contractor shall also submit all the documents in Electronic format.
- 15.13.2 All project specific training documentation shall be written in concise and simple English making maximum practicable use of diagrams, drawings, photographs and screen dumps.
- 15.13.3 Training documentation and other training aids such as presentations, handouts, test sheets and trainer guidance notes shall be prepared on the basis that actual operating and maintenance manuals will be foundation of the training courses.

- 15.13.4 Training documentation shall be prepared separately specific to the type of the staff to be trained and specific to the division of Operation and Maintenance staff.

15.14 TRAINING DOCUMENT SUBMISSION

- 15.14.1 The Contractor shall provide for review and approval the Table of Contents and Sample Formats for each type of manual and the Illustrated Parts catalogue.
- 15.14.2 No later than eight (8) months prior to the commencement of Service Trial, the Contractor shall submit for approval an electronic soft copy of draft training documentation sufficient to indicate the content and style of presentation.
- 15.14.3 No later than seven (7) months prior to the commencement of Service Trial, the Contractor shall submit electronic soft copy of training documentation incorporating the feedback of CMRL.
- 15.14.4 No later than one (1) month prior to the commencement of Service Trial, the Contractor shall submit electronic copy of final training documentation.

15.15 TRAINING FACILITIES

- 15.15.1 The Contractor shall provide trainers, establish facilities for training and submit five (5) colour hard copy sets of training documentation including plans, procedures, training materials no later than six (6) months prior to the Service Trial to enable the CMRL and/or the Operator and Maintainer to conduct examination and certification of staff for the operation.
- 15.15.2 The Contractor shall provide comprehensive training to CMRL and/or Operator's Key Staff in operation and maintenance of all Works as required to enable them to execute and manage the operation and manage the maintenance of Works Equipment.
- 15.15.3 The Contractor shall establish a training capability that shall be fully functional no later than commencement of Service Trial that is provided with plans, procedures, facilities, training materials and trained training staff to enable the CMRL and/or the Operator to provide training, examination and certification of new recruits and refresher training, examination and re-certification of existing staff after commencement of revenue service.
- 15.15.4 The Contractor shall also provide training to the operations, signalling, telecom, PSD systems staff and other related train operation and maintenance staff to understand the interface of train operation.

15.16 REQUIREMENTS OF TRAINING

- 15.16.1 General Scope of supply
- 15.16.2 Training and documentation shall be provided to complete operation, maintenance of Rolling Stock and other systems of CMRL.
- 15.16.3 Training Instructors provided by the Contractor shall be fully qualified and experienced Electrical / Mechanical / Electronics Engineers and experts in the relevant field with experience in training of engineering graduates and Technicians to the level of competency essential for operation and maintenance of Metro trains of similar specifications. The mode of training shall be in English only. If any interpreter is required, it shall be arranged by the Contractor at his own cost. The appointment of Instructors shall be confirmed only after his detailed curriculum vitae have been accepted by CMRL. In the event that an Instructor is subsequently deemed not to be competent by CMRL during training, he shall be replaced forthwith by the Contractor.
- 15.16.4 The Contractor shall submit a detailed Training plan to meet the above requirements duly taking into consideration that it shall be the sole responsibility of the Contractor to adequately train CMRL's personnel so that they can effectively run/operate trains and can provide the desired output in terms of prescribed level of Reliability, Availability, Safety and Maintainability of Rolling Stock supplied by the Contractor. The objective of training of train operating staff is that the batches of OCC Operators, depot controllers, station controllers and instructors who will operate the trains should be able to run the trains safely under all operating conditions.

1

- Training shall be sufficient to enable CMRL the Employer or its delegates to acquire full capability for identification and troubleshooting of the faults in the specified duration. In order to achieve the above objective, the Operating Staff and instructors should be trained in a similar transit railway or in the Contractor's works off-shore and on a test track in ~~ATO and non-ATO~~ UTO and non-UTO modes of operation. It will be preferred that after classroom instructions, the staff are trained in actual operation of cars in a Mass Rapid Transit System or on a test track, having similar cars, to acquire the required confidence. The Contractor's Instructors deployed for training of operating and Maintenance Staff in India shall provide training in classroom, as well as actual driving of trains during and after commissioning of trains in India under ~~ATO~~ UTO mode. The instructors shall also train the operating and Maintenance staff in trouble shooting of the faults and train them emergency operating procedures.
- 15.16.5 The training for Maintenance staff should enable CMRL Inspectors and Staff to achieve the following broad objectives:
- a) Full understanding of all aspects of the system design and functions of all the equipment including proprietary and third party equipment, software etc.
 - b) Full understanding of all aspects of programmed maintenance and overhaul requirements of cars and equipment.
 - c) Full understanding of the electrical and pneumatic schematics of the train for effective trouble-shooting by CMRL
 - d) Procedures to be followed for unscheduled maintenance and repair of cars / equipment.
 - e) Identification of failed components and sub-systems in electronic equipment by use of special test equipment, as necessary.
 - f) Maintenance Management Information System and documentation.
 - g) Monitoring and scheduling trains in the Progress Planning and Investigation Organisation.
 - h) Installation of software in all the components of train
 - i) Downloading of logs and other details from all the components of train.
 - j) Stores inventory planning and control.
- 15.16.6 As a general guide, training shall be based upon a "two-stage" concept. The Contractor shall depute a Training Manager for complete management of the training till the initial training requirements are completed. The Contractor shall propose a comprehensive trains programme comprising of different modules and prospectus for approval. The programme shall be reviewed by the CMRL based on the operational and maintenance needs and feedback of the completed training modules.
- 15.16.7 Stage one shall consist of training in the basic concepts and principles. These shall include system configuration and specification, operation and control of all equipment installed in the cars, preventive maintenance procedures, overhaul & repair concepts, fault diagnostic & trouble shooting, emergency procedures and all other trainings requested in clause 15.12 to 15.15. The training shall consist of classroom (theory) training; computer based inter-active training and mock-up training.
- 15.16.8 Stage two shall consist of "hands-on" site-based practical training on preventive and corrective maintenance and operating procedures explained in stage One.
- 15.16.9 The Contractor shall arrange the experts from the OEMs to impart the "hands on" training at site for the agreed durations during the contract execution. Training evaluation shall be carried out at regular intervals to monitor the progress and suitability of the training programme, and of the Trainees. The performance of the Contractor's Instructors shall also be evaluated by CMRL at regular intervals.
- 15.16.10 Not Used
- 15.16.11 After completion of the training, training aids and materials used shall become the property of the CMRL to enable further training to take place.
- 15.16.12 The training of CMRL personnel off-shore shall include direct exposure to CMRL Technicians, Inspectors and staff in actual repair, maintenance and overhaul of similar cars in the Depots and

Workshops of an operational Mass Rapid Transit System.

- 15.16.13 The Contractor's Instructors deputed to train CMRL personnel in India shall impart theoretical as well as practical training so as to enable them to develop skill and expertise necessary for satisfactory maintenance, repairs and overhaul of cars.

15.17 PARTICULAR SCOPE OF SUPPLY

- 15.17.1 The Contractor shall provide all equipment required to complement the 3D design models and to provide the functionally described in the Employers requirement above. (General Scope and Services requirements)
- 15.17.2 Not used.
- 15.17.3 The Contractor should provide details of training arrangement for operation and maintenance of Rolling Stock they propose to provide to CMRL personnel for efficient operation and appropriate maintenance at depot.
- 15.17.4 Such training should be provided to CMRL personnel both at Rolling Stock manufacturer's premises at the time of manufacture in various stages also at the time of testing and acceptance tests. After supply of Rolling Stock, similar training should be provided in India to CMRL personnel.
- 15.17.5 The contractor should propose the facilities for regular training of CMRL personnel in India in Training institute of CMRL.
- 15.17.6 For this purpose the Contractor should propose the facilities such as models, diagrams, training material, training aids and other infrastructure facilities that is required.
- 15.17.7 The Contractor should provide all drawings such as general arrangements, plans, elevations, principal sections and typical details of critical areas (as hard and soft copies) for all equipment/systems/parts of equipment and illustrated part catalogue for easy identification, facilitating training of operation and maintenance personnel.

15.18 ENDEMIC FAILURES

- 15.18.1 Notwithstanding any other provisions of the Contract, at any time prior to completion of DNP / DLP, if an "Endemic Failure" occurs in any component or sub-assembly, CMRL shall issue notice in writing to the Contractor.
- 15.18.2 "Endemic Failure" means failure occurring in at least (TEN) 10% of the components or sub-assemblies, which is attributable to the same root cause resulting from defects in material, workmanship, manufacturing process and/or design deficiencies, including but not limited to components with inherent or latent defects or consistent maladjustment during manufacture.
- 15.18.3 Upon receipt of the notice, the Contractor shall as soon as reasonably practicable renew / alter / replace (including as necessary redesigning) all such or parts throughout the Works whether or not such part had experienced failure, so as to avoid any subsequent defect therein. The cost of such renewal, repair, alteration or replacement (including any redesign) shall be borne by the Contractor together with the cost of any work ancillary thereto. Before commencing any renewal, alteration or replacement the Contractor shall submit to CMRL for its review, the Contractor's proposals for such renewal/ alteration / replacement.
- 15.18.4 The renewals / repairs / alterations / replacements (including redesign) shall be carried out and completed to the reasonable satisfaction of CMRL and so that the Works will meet the Contractor's obligations under the Contract. The provisions of this Clause 15.18 shall apply to all such renewals, repairs, alterations and replacements as though the part of the Works in question, together with any other part of the Works affected thereby had been the subject of a Taking Over Certificate on the date the renewal, repair, alteration or replacement was completed, provided that shall not exceed sixty (60) months from the Taking Over Certificate for the whole of the Works
- 15.18.5 Any renewals, repairs, alterations or replacements under Clause 15.18 shall be without prejudice to the Contractor's other obligations under the Contract including without limiting the

generality thereof this Clause 15.18. Nothing contained in this Clause 15.18 shall prejudice any other rights or remedies CMRL may have.

- 15.18.6 If the Contractor disagrees with CMRL notification of evidence or failure under Clause 15.18, the Contractor shall nevertheless proceed to effect the renewal, repair, alteration or replacement required and the Contractor's rights in respect thereof shall be determined in accordance with Part 3 – PCC to GCC – Clause 20.

15.19 OPERATION MANUAL

- 1 15.19.1 Requirements of Operation Manual shall be designed as per ~~ATO, Non-ATO~~ UTO, Non-UTO and degraded modes of train operation.
- 1 15.19.2 Complete procedure for normal operation of Rolling Stock online in such a form that the train operator and OCC & DCC operator can clearly understand operational requirements and train functions.
- 15.19.3 Complete procedure for operation of train in the event of any degraded situation related to Rolling Stock. Examples of degraded situation are system fault in train, emergency operation, partial traction failure, uncoupling of Rolling Stock, brake failure, etc. The list is indicative and not exhaustive.
- 15.19.4 Complete procedure for testing of the Rolling Stock individually and in rake form before taking it out of depot for commercial operation.
- 1 15.19.5 Trouble shooting by Train operator on board the rake in case of malfunction of any system of the Rolling Stock working in ~~ATO or non-ATO~~ UTO or non-UTO modes and degraded modes of operation.

16. MANAGEMENT PROGRAM

16.1 NOT USED

16.2 GENERAL

- 16.2.1 This chapter defines the minimum management program that the Contractor shall maintain to provide an effective process for planning, scheduling, controlling and reporting on the progress of the Work.
- 16.2.2 The Contractor shall cooperate with the Employer and its representatives and consultants in their review of the design, inspection of manufacturing, witnessing of testing and supervision of any other portion of the Work; including asset management activities that will take place during the Project Period.

16.3 PROJECT MANAGEMENT PLAN

- 16.3.1 The Contractor shall designate a full-time Project Director; herein referred to as the Contractor's Representative. The Contractor shall delegate responsibility and authority to the Contractor's Representative to the full extent required to ensure prompt decision making and effective management of the Works. The Contractor's Representative shall be made available at the Designated Depot(s) premises until completion and discharge of Contract. The Contractor shall ensure that organizational structures, lines of authority, and resource levels promote effective contract management.
- 16.3.2 The Contractor shall submit for CMRL approval - The Project Management Plan that explicitly defines the Contractor's project organization, project Controls, planning and scheduling methodologies. The plan shall include:
- An organization chart which clearly identifies all staff expected to be allocated to the Works; indicating reporting lines to the Key Staff or any additional departmental managers proposed.
 - Resumes for each Key Staff member listed in Clause 16.4.
 - A job scope clarifying of the duties and responsibilities of each departmental manager / Key Staff member over and above that which is reflected in Clause 16.4.8
 - A description of the methodology to be used to track and control program progress against the program schedule.
 - Master Program Schedule as described in ERTS Section VI A (RS) 16.6.
 - A resource plan for the project from NTP through the end of the Project Period, showing the levels of staffing to be provided at each phase for each discipline and functional area.

16.4 RESOURCING

- 16.4.1 The Contractor shall submit their Complete Staffing proposal for all the following Key Staffs duly in compliance with the conditions / criteria specified below, within 7 days from the Date of Commencement, for Notice of No Objection (NONO) from CMRL.
- 16.4.2 At any time during the course of the Works, if the Contractor wants to replace any of the Key staffs, the Contractor shall propose replacement candidate with equal or better qualification / experience criteria and shall obtain NONO from CMRL at least 30 days before such replacement.
- 16.4.3 CMRL's consideration to grant a Notice of No Objection for substitution of Key Staff shall be on the condition that any proposed replacement(s) is no less qualified or experienced than their predecessor and the same criteria continues to be met:

No.	Position	Total Work Experience (years)	Experience in Similar Works* (years)
1	Contractor's Representative (as defined in GC 4.3)	20	10
2	Project Manager	15	7
3	Dy. Project Manager	12	7
4	Engineering Manager /System Integration Manager	18	10
5	Interface Manager	15	7
6	Project Quality Manager	15	7
7	Project OSHE Manager	15	7
8	Procurement Manager	10	5
9	Testing and Commissioning Manager	10	5

* Only time served in a role / designation which has direct involvement in similar responsibilities, duties and industrial sector will be counted as experience in similar Works.

- 16.4.4 All Key Staff shall be allocated to this Contract on a full-time basis. Their deployment shall continue until the end of the period defined in Clause 16.4.8; AND the full scope of activities which they are responsible for has been completed.
- 16.4.5 Throughout the full duration of the Contract, prior approval by CMRL shall be sought for any absence or leave of Key Staff from their usual work location. A suitable replacement shall be provided by the Contractor on a full time basis throughout the period of absence.
- 16.4.6 If, at any time during the Contract, CMRL considers that insufficient, or inappropriate, resources are being committed, progress payments shall be delayed until such time as the situation has been rectified to CMRL's full satisfaction.
- 16.4.7 All Key personnel shall be able to speak, read & write in English language.
- 16.4.8 This Sub-Clause broadly defines the scope of the Key Staff positions, their level of responsibility and their minimum period(s) of deployment:-
- Contractor's Representative** - as defined in GC 4.3 shall have complete responsibility for delivering all aspects of the Work. This person will represent the Contractor and be able to make binding decisions on all aspects of the Work. The Contractor's Representative shall deploy to the Designated Depot(s) premises within 28 days of commencement of the Works and remain until completion of the defect notification period for the final train.
 - Project Manager** – shall be the owner of the Works Programme, shall be competent to deputize for the Contractor's Representative and suitably empowered to make decisions. The Project Manager shall deploy to the Designated Depot(s) premises within 28 days of commencement of the Works and remain until completion of the defect notification period for the final train.
 - Dy. Project Manager** - shall be the Deputy Owner of the Works Programme, shall be competent to deputize for the Contractor's Representative and suitably empowered to make decisions. The Dy. Project Manager shall deploy to the Designated Depot(s) premises within 28 days of commencement of the Works and remain until completion of the defect notification period for the final train.
 - Engineering Manager / System Integration Manager** – responsible for coordination between design, manufacturing, project implementation and for Systems Integration. This shall include train borne and other systems wide Contractors as defined in clause 16.9. This person shall

- deploy to the Designated Depot(s) premises within 28 days of commencement of the Works and remain until completion of the defect notification period for the final train.
- e. **Interface Manager** – with responsibility as defined in clause 16.16. The Interface manager shall deploy to the Designated Depot(s) premises within 28 days of commencement of the Works and remain until completion of the defect notification period for the final train.
 - f. **Project Quality Manager** –responsible to ensure all aspects of the Project Quality Plan are upheld at all manufacturing sites (including sub-supplier premises). Also responsible for quality validation of all modifications during testing, commissioning and warranty phases. Shall deploy to all respective sites (as required) within 28 days of commencement of the Works and remain deployed where required until completion of the defect notification period for the final train.
 - g. **Project OSHE Manager** – responsible to ensure all aspects of the Project Safety Plan are upheld at all sites at all times. Accountable for all Safety Health and Environment matters and shall prepare an OSHE audit score report, inspection reports, procedures, plan etc. The Project OSHE Manager shall deploy to the Designated Depot(s) premises at least 6 months' prior to delivery of the Prototype train and remain until completion of the defect notification period for the final train.
 - h. **Procurement Manager** - shall be the Owner of the Procurement Programme, suitably empowered to make decisions. The Procurement Manager shall deploy to the Designated Depot(s) premises within 28 days of commencement of the Works and remain until completion of final train handover.
 - i. **Testing and Commissioning Manager** –responsible for testing and commissioning of all trains at both the depot and the manufacturing plant and shall deploy to the Designated Depot(s) premises at least 6 months' prior to delivery of the Prototype train and remain until completion of the defect notification period for the final train.
- 16.4.9 The Contractor shall commit to the program the types and levels of resources which they have been identified in their submitted Program Management Plan.
- 16.4.10 In case the Contractor is a Consortium, all Key Personnel shall be empowered to act on behalf of the entire Consortium Organisation. All Key Personnel shall be wholly and substantially accountable for their respective scope of the entire Works.

16.5 COMMUNICATIONS

- 16.5.1 Formal communications shall be between the Contractor's Representative and CMRL (or its nominated representative such as the Engineer).
- 16.5.2 CMRL reserves the right to initiate meetings or discussions directly with subcontractors and vendors with the mandatory attendance of the Contractor.
- 16.5.3 The Contractor shall use PMIS (described in clause 16.7) to obtain a document number for all formal communication and submittals. This will adopt a unique numbering system which has been assigned for this project.
- 16.5.4 The Contractor shall at all times ensure that communications are in full compliance of the requirements for Submittals (defined in Clause 16.12) as well as PMIS (defined in Clause 16.7).

16.6 MASTER SCHEDULE

- 16.6.1 The Contractor shall submit for approval a Master Schedule.
- 16.6.2 It shall be prepared using the latest version of Primavera for Windows, MS Project or a superior equivalent and shall be submitted to the CMRL in both the original file format as well as in PDF format.
- 16.6.3 The approved master schedule shall serve as the baseline schedule for the project and shall be updated monthly until acceptance of last train.
- 16.6.4 The period covered shall commence from NTP through to completion of the DLP Period defined in Part-3, Section VIII Particular Conditions Part B, Clause 25.
- 16.6.5 The initial submission of the Master Schedule shall only be submitted for review by CMRL after it

- has been reviewed and endorsed by both the Project Manager and the Contractor's Representative who have overall responsibility for the Work.
- 16.6.6 The Contractor shall provide supplementary written information, sufficient to describe the methods to be used and the resource constraints applied.
- 16.6.7 Work shall be scheduled such that any specified intermediate milestone dates and completion dates are met, as specified in these Contract documents.
- 16.6.8 The Contractor shall revise and resubmit the precedence network diagram and master schedule when any of the following conditions occur:
- A change or delay significantly affects any specified intermediate milestone date, completion date, or the sequence of activities.
 - The Contractor elects to change any sequence of activities affecting the critical path, or to change the previously approved work plan significantly.
 - It is CMRL's opinion that the status of the Work is such that the detailed network diagram and supporting analysis are no longer representative for planning and evaluation of the Work.
- 16.6.9 Requirements: Time-Scaled Network / Bar Chart
- All programs shall be developed by computerized Critical Path Method (CPM) using the Precedence Diagramming Method (PDM) and shall be presented in either bar chart or time scaled network diagram format, suitably coloured to enable easy reading. All duration for the purpose of programming shall be in calendar days. All reference to network shall mean time scaled network unless otherwise specified.
 - The coding structure shall be such that the activities can be summarized to various levels. Each level shall be summarized and collapsed to the next level using the programming software.
 - The Contractor shall propose essential codes and activity codes to be used for CMRL's review. CMRL may require additional activity codes subject only to restrictions imposed by the programming software. Additional codes where necessary may be created by the Contractor with the approval of CMRL. Each activity in the network shall be coded, as a minimum, with the following:
 - Contract number, activity type, and unique identification numbers.
 - Activity codes to indicate Unit, Segment, Stage or Phase, for e.g. design, manufacturing, delivery, installation, etc.
 - The Contractor shall note that the breakdown of the system into sub-systems is essential and shall be carried out not through further coding but through activity descriptions in a consistent manner such as to allow storing. However, CMRL shall have the right to require the Contractor to code sub-systems, using codes approved by them, if necessary.
 - Area and location details under Activity Code – Unit.
 - Cost and resources.
 - Cost and resources codes shall be submitted for the approval of CMRL. For tender purposes, the Contractor shall use his own codes.
 - All logical and necessary relationships between activities shall be shown.
 - All key dates indicated in the Contract shall be shown. In addition to the key dates, the Contractor may require certain events that are critical to his work to be reflected in his programs. These shall be reflected as "milestones". Appropriate activity codes shall be used to distinguish "milestones" from the key dates.
 - The level of program development, information and detail shall be sufficient to permit CMRL to have a good appreciation of the Contractor's project management plan especially with regard to the co-ordination and timing of his work in relation to the Work of the other Designated Contractors and the obtaining of necessary approvals from the relevant local authorities. It shall demonstrate ability to meet specified key dates through a logical work sequence that has taken account of the Project constraints.
 - Activities pertaining to review / acceptance by CMRL and local authorities shall be identified.

Where duration for review of the Contractor's submissions are specified elsewhere in the Contract, they shall be used. Where they are not specified, a duration of 30 days for review of each submission shall be used.

- h) Activities outside the scope of the Contract that may affect the Contractor's progress shall be shown.
- i) The activity network shall be organized so that major work sections are carefully coordinated with the Civil Contractor and the System-wide Contractors to allow opportunity for all to work with as minimal disruption as possible.
- j) Critical paths shall be identified.
- k) Activity descriptions shall be brief (<48 characters) and shall convey the nature and scope of the Work. Uncommon abbreviations shall be explained in the legend. Float time shall be distinguished from schedule performance.
- l) The CPM Network Diagram shall be developed to permit modification to the schedule and allow for impacts on the schedule to be analysed by introduction of "what if" statements into the input data.

16.6.10 Time Scaled Network / Bar Chart Details

- a) **Design:** The Design network/bar chart shall detail the various design, submission and acceptance stages including approval by local authorities and CMRL, preparation, submission and approval of drawings, manuals and all other activities related to the design.
- b) **Manufacturing:** The manufacturing network chart shall indicate the relationship and duration of the activities necessary to procure, fabricate manufacture, assemble equipment / complete car tests, ship and deliver Rolling Stock in time to support the activities at site. It shall establish milestones for monitoring the progress of the manufacturing process. Major areas of work shall be shown as separate and distinct activities. The network shall also cover the activities of Sub-Contractor as appropriate, including testing.
- c) **Testing and Commissioning:** The Factory and On-Site Testing and Commissioning network/bar chart shall present the relationship and duration of those items relating to Commissioning tests including those related to other Designated Contractors. The network / bar chart shall present the testing approach to be used, the deployment of resources in accordance with train delivery dates.
- d) **Instrumentation Tests for Pilot Rake:** Instrumentation Tests network/bar chart shall indicate that activities related to Instrumentation Tests, including Oscillation Trials, followed by Statutory approval, on the Prototype Rake including those related to Designated Contractors.
- e) **Integrated Testing:** The Integrated Testing network/bar chart shall indicate the activities required to verify the functioning of the Rolling Stock in conjunction with activities of the System-wide and Civil Contractors.
- f) **Service Trials:** After completion of Commissioning, the Contractor shall be required to carry out service trials.

The network / chart shall indicate tests, measurements and interface tests required to be carried out to verify system performance and readiness for revenue service.

16.7 POST-AWARD CONFERENCE

16.7.1 A post-award conference shall take place no later than 20 days after NTP, at CMRL's or the Contractor's facilities, as directed by CMRL, to accomplish the following:

- a) Introduce CMRL's key personnel to the Contractor.
- b) Confirm the Contractor's management team and key staff and the scope of supply of subcontractors.
- c) Establish formal channels of, and procedures for, communication (e.g., letter and meeting numbering)
- d) Establish an understanding of the Contractor's project control methodology and plans for initial activities before the start of formal progress reporting.

- e) Confirm that the Contractor is familiar with CMRL's intended operations and maintenance environment.
- f) Identify the early information needs and decisions required by the Contractor from CMRL.

16.8 PROGRESS REVIEWS AND REPORTS

- 16.8.1 Progress review meetings shall be held monthly at CMRL headquarters. Additional meetings shall be held at CMRL's or the Contractor's or its subcontractors' facilities as deemed necessary by CMRL.
- 16.8.2 The first monthly progress review meeting will be held not more than 30 days after the post award conference (ref. TS16.7)
- 16.8.3 Within 5 working days after the conclusion of each meeting, the Contractor shall prepare the minutes of each progress review meeting and distribute them to each participant and the CMRL for approval. The format of the minutes of meeting shall clearly indicate the participant details, agenda discussed, action to be taken, responsible entity, target dates, next meeting schedule, etc. in a matrix format. All such Minutes of Meeting shall have a unique numbering system and shall be followed throughout the project execution.
- 16.8.4 The Contractor shall submit Monthly Progress Reports that assess actual progress against planned progress. The report shall include the following information:
 - a) An updated master schedule showing progress as of the reporting date, together with an updated precedence network diagram, if required (ref. TS16.6.4).
 - b) A schedule report listing all activities, elapsed and remaining durations of activities, early start and early finish dates, late start and late finish dates, predecessor and successor activities, and float.
 - c) A narrative report that, as a minimum, describes:
 - (i) Work accomplished during the reporting period with the details of activities planned for the next one-month period. It shall describe the status of work performed, significant accomplishments, including critical items and problem areas, corrective actions taken or planned and other pertinent activities, and shall, in particular, address interface issues, problems and resolutions. It shall include a simplified representation of progress measured in percentage terms compared with percentage planned as derived from the Works Program.
 - (ii) Percent of design, manufacturing, delivery, testing, and system support elements completed during the reporting period, and percent of overall work completed.
 - (iii) Delays incurred during the reporting period, their causes and effects, and the corrective actions proposed or taken to mitigate those delays.
 - (iv) Changes in activity duration, and reasons for those changes.
 - (v) Changes in activity logic, and reasons for those changes.
 - (vi) Letter Correspondences sent to CMRL.
 - (vii) Letter Correspondences received from CMRL.
 - (viii) Financial Status: A narrative review of all significant financial matters, and actions proposed or taken in respect to any outstanding matters. A spreadsheet summarizing each Cost Centre, the budget, costs incurred during the period, costs to date, costs to go, cost forecast (total of costs to date and costs to go) and cost variance (difference between cost forecast and budget). A spreadsheet indicating the status of all payments due and made. A report on of the status of any outstanding claims. The report shall in particular provide interim updated accounts of continuing claims.
 - (ix) Milestones Status: A report on the status of all Milestones due to have been achieved during the month and forecasts of achievement of any missed Milestones, and those due in the next month.
 - (x) The monthly issue of the Three-Month Rolling Program.

- (xi) Planning and Co-Ordination: A summary of all planning & co-ordination activities during the month and details of outstanding actions. A schedule of all submissions and consents/approvals obtained / outstanding.
 - (xii) Procurement Report: A summary of all significant procurement activities along with the purchase technical specifications during the month, including action taken to overcome problems. A report listing major items of plant and materials, which will be incorporated into the Works. The items shall be segregated by type as listed in the Specifications and the report should show as a minimum the following activities:
 - I. Purchase Order Date – Scheduled / Actual,
 - II. Manufacturer / Supplier and Origin,
 - III. Letter of Credit Issued date,
 - IV. Manufacturer / Supplier Ship Date – Scheduled / Actual,
 - V. Method of shipment,
 - VI. Arrival date in India- Scheduled / Actual.
 - (xiii) Production and Testing: A review of all production and manufacturing activities during the month. Summaries of all production and manufacturing outputs during the month together with forecasts for the next month. Review of all testing activities (both at site or at the manufacture's premises) during the month.
 - (xiv) Safety: A review of all safety aspects during the month including reports on all accidents and actions proposed to prevent further occurrence.
 - (xv) Environment: A review of all the environmental issues during the past month to include all monitoring reports, mitigation measures undertaken, and activities to control environmental impacts.
- d) Updated drawing list (ref. clause 16.11.2.1).
 - e) Updated car weight estimate (ref. clause 16.14.3).
 - f) Updated Hazard Mitigation Traceability Matrix (ref. clause 18.5.4.8).
- 16.8.5 The Contractor shall submit progress reports at least 5 working days prior to each scheduled monthly progress review meeting.
- 16.8.6 The Contractor shall submit special reports and/or shall hold special topical reviews, as requested by CMRL, to address special concerns or problem areas.

16.9 SYSTEM INTEGRATION

- 16.9.1 The Contractor shall actively employ system integration principles throughout the design, production, testing & Commissioning and during Statutory testing phases of the Contract, to control and coordinate integration among the rake's systems and between the rake and other CMRL Contractors to incorporate the operational and maintenance requirements.
- 16.9.2 The Engineering Manager / System Integration Manager shall be a knowledgeable engineer with an understanding of the interaction of car systems & parameters, and with experience in coordinating interface requirements.
- 16.9.3 The System Integration Manager shall participate in all scheduled design reviews.
- 16.9.4 The System Integration Manager shall coordinate and control system parameters and requirements including, but not limited to, the following areas:
- a. Car Level:
 - i. Car weight
 - ii. Ride quality
 - iii. Exterior and interior noise levels
 - iv. Vibration levels
 - v. Warning device parameters, horn sound level, headlight intensity level

- vi. Car stability parameters
- b. Car Exterior:
 - i. Equipment boxes and enclosures (physical envelopes and equipment weight orientation and access)
 - ii. Static and dynamic clearances (including truck clearance provisions, for normal and worst-case scenarios)
 - iii. Jacking and hoisting provisions
- c. Car Interior:
 - i. Equipment boxes / enclosures (physical envelopes and equipment orientation and access)
 - ii. Lighting intensity levels and light distribution
 - iii. PA system sound levels, distribution, and quality
- d. Car interface circuits and controls:
 - i. Circuit voltage, current, and other electrical parameters
 - ii. Surge protection and suppression
 - iii. Failure modes and effects Criticality analysis for fail-safe and safety-critical circuits
 - iv. Interfaces for exchange of data over all architecture (E.g. MVB, IP, CAN and RS485)
 - v. Cable routing
 - vi. Connector termination and cable compatibility
 - vii. Communication port standardization
 - viii. Compressed air system
- e. Auxiliary Power Supply, AC and DC load management:
 - i. AC generation, load and capacity
 - ii. LVDC load and capacity analysis
 - iii. Battery capacity
 - iv. Harmonic and ripple limits
 - v. Voltage and frequency range
 - vi. Voltage drop analysis
 - vii. Protection coordination
 - viii. Load shedding and load sequencing
- f. VAC:
 - i. Internal component sequencing under start-up, normal operating and worst-case conditions
 - ii. Special modes of operation (including protection from simultaneous starting when two or more VAC systems are operating)
 - iii. Air balancing
- g. Propulsion and Brakes:
 - i. Performance parameters, acceleration and deceleration
 - ii. On-board power generation
 - iii. Special modes of operation
 - iv. Brake blending
 - v. Wheel spin/slide control
 - vi. Car signalling compatibility.
 - vii. Zero-speed function
- h. Communications, including interior and exterior displays:
 - i. Communication links with exterior information displays.

- ii. Communication links with interior information displays.
- iii. Prerecorded message triggering and operation
- i. Functioning of Diagnostic Monitoring System and Real Time Remote Diagnostic Monitoring System, Real time data transmission from trains to OCC server, display of the train data at OCC display and at Depot DCC displays, Communication links (digital, analogue, and serial)
- j. Train control: All interfaces between car and train control
- k. EMC AND EMI:
 - i. Susceptibility limits
 - ii. Emission limits
 - iii. Car wiring requirements
 - iv. Transient suppression and protection
 - v. General EMI mitigation techniques
 - vi. Complete train system EMI EMC control plan and interface with other Contractors for mitigation of the EMI.
- l. Maintenance:
 - i. LRU approach
 - ii. DTE philosophy, equipment, and software standardization
 - iii. Maintenance shop interface requirements.
 - iv. Interface with the various machines of depot used for train maintenance, testing, cleaning, train movement, etc.

16.10 INDUSTRIAL DESIGN

- 16.10.1 Industrial design principles shall be employed throughout the design and manufacturing processes. These principles shall include, as a minimum, aesthetics, human factor interfaces, passenger comfort, material choices, colour schemes, and graphics.
- 16.10.2 Industrial design principles shall be applied to all interior and exterior equipment, panelling, covers, and attachments.
- 16.10.3 Industrial design activities shall be fully integrated with the car design and shall commence immediately following NTP.
- 16.10.4 Industrial design aspects of the car shall be reviewed during all scheduled design review meetings. Topical reviews to address key issues shall be held as needed.
- 16.10.5 The Contractor shall submit to CMRL design calculations, layouts, and other documentation summarizing the human factors considered in the car design. This documentation shall be submitted during design reviews and shall include the following:
 - a. A description of the major assumptions made concerning human capabilities and limitations, including data ensuring that operator performance and passenger considerations have been addressed.
 - b. The results of 3D design models or layout reviews and of simulation programs made to determine design requirements.

16.11 CONFIGURATION CONTROL

- 16.11.1 The Contractor shall submit for approval a Configuration Management Plan which clearly defines all methods and processes deployed to control the following:-
 - a) Integration of Configuration Management with the Asset Maintenance Management System (AMMS)
 - b) Engineering Change / Change Control Process

- c) Baseline Design Configuration
 - d) Modifications Implementation (tracking of installed hardware and software)
 - e) Document Revision Control (including, but not limited to; schematics, drawings, method statements, process documents, interface documents)
- 16.11.2 The Contractor shall submit a proposed Product Breakdown Structure, Drawing Tree and List of Drawings in accordance with the guidelines outlined in this section.
- The Product Breakdown Structure (PBS) shall be a multiple-level logical hierarchy covering all Rolling Stock assets, which drills down Line Replaceable Unit level.
- The proposed drawings list shall indicate those items which require submittal and review by CMRL and include space for tracking the submittal status.
- Updates of the drawing list shall be provided with each monthly progress report.
- As part of the drawing tree submittal the Contractor shall include a description of the primary drawing numbering system, including the significance of the characters.
- 16.11.3 The Change Control System shall clearly demarcate level of design approval awarded for each subsystem at each design stage. Final Design Review (FDR) shall be reflected a baseline.
- Changes proposed after FDR which may affect previously agreed design characteristics shall always be submitted for approval to CMRL for prior approval.
- 16.11.4 The production baseline shall be established at First Article Inspection (FAI). Changes after FAI shall be documented in the form of Engineering Change Proposals (ECP) for both Hardware / Software, shall be submitted to CMRL for approval.
- 16.11.5 The Contractor shall maintain accurate and current configuration records in AMMS, which has the capability of identifying the following:
- a. The composition of any part, component, subassembly, or assembly, at any level, in terms of subordinate and next-part numbers
 - b. Software and hardware revision / version status
 - c. Engineering changes and records of superseded configuration requirements
 - d. Configuration of spare parts, and any retrofit or replacement requirements.
 - e. Engineering Incident Reports submitted by CMRL in case of any design/safety issues observed in the trains during the defect notification period of last train.
- 16.11.6 Component Serialization
- 16.11.6.1 The Contractor shall assign discrete serial numbers in sequence for the model series of the following:
- a. Air compressors
 - b. Air conditioning apparatus
 - c. Axles
 - d. Batteries and battery chargers
 - e. Converters
 - f. Couplers
 - g. Door operators and controls
 - h. Journal bearings
 - i. Auxiliary power units
 - j. Principal units of communications system equipment
 - k. Principal units of traction and braking apparatus
 - l. Temperature control apparatus
 - m. Traction motors
 - n. Truck castings and/or weldments

- o. Wheels
 - p. Brake control units
 - q. Any other item of equipment customarily numbered in sequence.
- 16.11.6.2 The Contractor shall submit for approval a list of items to be serialized and a description of the serialization method to be used. The Contractor shall provide a complete list of serialized items for each car within the Car History Book.
- 16.11.7 Component Identification
- 16.11.7.1 All assemblies, subassemblies, and components shall have an identification label placed in a location that is easily viewable by maintenance personnel. These labels shall be of metallic type and shall not be deteriorated during the usage. The label shall contain:
- a. Equipment/component ID or Name
 - b. Part number (OEM and the Contractor, where applicable)
 - c. Serial number (where applicable)
- 16.11.7.2 All assemblies, subassemblies, components and individual equipment shall also be identified by a QR code label which shall be accessible for maintainer. The information contained in the QR code and the QR code format shall be mutually agreed upon by the Contractor and CMRL. This QR code shall be unique to the component to each specific train so that the codes shall be used for maintenance information. These QR codes shall be pasted adjacent to the components and shall not be in passengers' sight. These QR codes shall not be damaged during normal operating conditions and with regular train washing.
- 16.11.7.3 The life expectancy of the label shall be the same as that of the part to which it is attached. The label shall be easily cleanable by spraying a mild cleaner and wiping it with a clean cloth.
- 16.11.8 Contractor As-Built Drawings
- 16.11.8.1 The Contractor shall provide CMRL 5 hard copies with complete set of as-built drawings on Mylar sheets or approved equal, and shall provide an electronic copy of the drawings on DVD. The DVD files shall not be write-protected.
- 16.11.8.2 As-built drawings are intended to show the Works exactly as constructed. These are prepared by amending the manufacturing drawings to take into account changes necessitated by manufacturing methodology. These drawings shall be completed on a regular basis as the Works progress, and not left until the completion of the Warranty (Defect Notification Period).
- 16.11.8.3 The Contractor shall submit these as-built drawings in 3D / AATOCAD format.
- 16.11.8.4 At least 1 months but not more than 3 months prior to the anticipated date of delivery of the Pilot rake, the Contractor shall compile and submit to CMRL for recording purposes all those documents and drawings, constitute the complete record of the design and manufacture of the Works.
- 16.11.8.5 The updated compilation of the complete record of the design and manufacture of the Works shall be submitted at the end of the Defect Liability Period
- 16.11.9 Manufacturing Drawings
- Detailed manufacturing drawings will not normally be required for acceptance but shall be submitted for comment if CMRL so requires.
- 16.11.10 Post Acceptance Changes
- Changes to accepted drawings, whether they are initiated by the Contractor or CMRL, shall be submitted for review and approval of CMRL. The same process of submission, review and approval as defined in clause 16.12 shall be adopted.
- For requesting any change to the accepted design, the Contractor shall submit the relevant design details for review of CMRL. The Contractor shall not implement any change without receiving 'No objection' from CMRL.

16.12 SUBMITTAL REQUIREMENTS AND APPROVAL PROCESS

16.12.1 Contractor Requirements

- 16.12.1.1 The Contractor shall establish a CMRL-approved electronic data transfer system to enable the Contractor to submit all deliverables (e.g. documents, letters, and drawings) to CMRL electronically.
- The objective of the design submission process is to ensure that the proposed resulting works comply with the specifications, are capable of being produced consistently to exacting quality standards, achieve low life cycle costs and can be operated safely to the satisfaction of CMRL.
 - The design submissions include Design Calculations, Design Reports and Design Drawings. All design submissions shall include a 'clause by clause' compliance status to all this Contract.
 - In the event that a statutory body (e.g. Government of India Ministry of Railways, RDSO, Commissioner of Metro Railway Safety, etc.) requires design information in a particular format, it shall be incumbent upon the Contractor to provide the same, as directed by CMRL.
 - As soon as practicable after Contract Award, the Contractor shall review all applicable data, criteria, standards, directives and information provided to him as the basis for design. Any apparent inconsistencies or erroneous information shall be brought to the attention of CMRL. Such information shall not alleviate the Contractor from his responsibilities under the Contract.
 - Drawings and CAD data shall comply with the requirements of Appendix G. Reports, calculations, specifications, technical data and similar documents shall be provided in A4 format, and Five Hard copies shall be ring bound to facilitate photocopying. A3 size drawings included in documents shall be folded to A4 size.
- 16.12.1.2 All Design Submission Program documents and its annexures / attachments shall be submitted in English and shall comply to the requirements in Annexure G. Unless otherwise approved by CMRL, submittals shall be submitted electronically in searchable PDF format.
- 16.12.1.3 Drawings shall be submitted in individual packages that pertain to a single subject. Each package shall have a separate transmittal letter. The drawing package shall be complete and shall include all interface and complementary drawings, including those for lower-order assemblies, unless such drawings have been submitted previously and their revision level remains current.
- 16.12.1.4 Individual manufacturing drawings shall be prepared for each part designed and/or manufactured by or for the Contractor.
- 16.12.1.5 The Contractor shall submit all documentation as required elsewhere in this Contract. Without limitation, the Contractor shall also provide additional information or documentation related to the design and production of the cars if requested to do so by CMRL. In the event that the Contractor deems specific documents to be proprietary, the Contractor must demonstrate to CMRL's satisfaction that the documents are proprietary and shall enter into a suitable confidentiality agreement that is acceptable to CMRL. For the purpose of this paragraph, confidentiality agreements related to proprietary documentation shall provide CMRL with sufficient access to readily verify compliance with Contract requirements and shall provide the Contractor with appropriate commercial protection for sensitive information.
- 16.12.1.6 Electrical schematic drawings shall be drawn in accordance with IEEE standards or IEC 60617 / DIN unless approved otherwise by CMRL.
- 16.12.1.7 The Contractor shall thoroughly review and approve all submittals from subcontractors before transmitting the documentation to CMRL.
- 16.12.1.8 CMRL will consider any draft submittals to be for information only, unless the Contractor specifically requests a review by CMRL.
- 16.12.1.9 Approval Process
- 16.12.1.9.1 Submittals requiring approval prior to implementation will be reviewed and classified by CMRL as follows:
- Notice of No Objection (NONO):** CMRL concurs with the information in its submitted form. The material may be incorporated into the program. NONO shall not be construed as:

- a) Permitting any departure from the Contract
 - b) Relieving the Contractor of the responsibility for any error, including details, dimensions, materials, and calculations.
 - ii. **No Objection With Comments (NOWC):** CMRL conditionally agrees with the submitted information in principle, but some details must be revised to make the information fully approved. The material must be resubmitted in revised form for further review by CMRL to issue NONO.
 - iii. **Rejected:** CMRL does not concur with the submitted details. The Contractor shall not incorporate the material into the program. CMRL's objections must be reconciled and the material must be resubmitted in revised form for further review by CMRL.
- 16.12.1.9.2 Submittals classified by CMRL as "Rejected" shall be considered, for the purposes of schedule progress reporting, to have not been submitted.
- 16.12.1.9.3 All technical data, test schedules, test procedures, test results, progress schedules and reports, drawing lists, drawings, samples, and other data requiring review and approval will be handled in accordance with the above provisions.
- 16.12.1.9.4 CMRL will respond within 30 working days to any review submittal, calculated from the date of receipt of documents by CMRL to the date a response is sent to the Contractor, provided the Contractor submits such review material in a reasonable time sequence and manageable volume, unless specified otherwise in the contract. CMRL and the Contractor shall establish the general parameters of "reasonable time sequence" and "manageable volume during the project kick-off meetings.

16.13 DESIGN REVIEWS

- 16.13.1 Design reviews will be conducted to evaluate the progress and technical adequacy of the design and compatibility with the performance requirements of these Technical Provisions.
- 16.13.2 The design reviews shall take place in three (3) phases as detailed below:-
- i. The Preliminary Design Review (PDR);
 - ii. The Pre-Final Design Review (Pre-FDR);
 - iii. The Final Design Review (FDR);
- In the Contract document, wherever the various details / documents are being asked to submit at Design stage, it shall mean the Pre-Final Design Stage unless otherwise specified.
- 16.13.3 Each design review phase must be completed to the satisfaction of CMRL before the next phase may begin. Completion of a design review is defined as approval by CMRL of the meeting minutes. The FDR for each subsystem must be completed before production of that subsystem may begin.
- 16.13.4 An agenda of the topics to be covered during each design review shall be forwarded to the CMRL no later than 30 working days before the design review.
- 16.13.5 Design review material shall be submitted no later than 15 working days prior to each review meeting, and shall include the drawings, technical data, analyses, calculations and other items required for the review. Note that the requirement of TS16.12.2 takes precedence over this requirement.
- 16.13.6 The Contractor is encouraged to submit design review information incrementally, as part of periodic in-progress reviews, in order to reduce the duration and impact of the formal design review meetings. Ideally, the formal meetings should be limited to confirmation of previously reviewed and approved-in-principle submittals, and to resolution of open items.
- 16.13.7 Subcontractors shall attend design review meetings as directed by the prime Contractor and by CMRL.
- 16.13.8 The schedule for periodic design reviews shall be included in the master schedule (as specified in TS16.6). The location of meetings for PDR, PFDR and FDR shall be distributed between CMRL offices, the Contractor facilities and, as required, subcontractor facilities, with at least 50% of the meetings held at CMRL offices.

- 16.13.9 The Contractor shall prepare the minutes of each design review and distribute them to each participant and the CMRL.
- 16.13.9.1 Meeting minutes shall be recorded by a person whose sole job is to accurately capture the discussion.
- 16.13.9.2 During the meeting, draft meeting minutes shall be projected simultaneously onto a wall that is easily viewable by all participants.
- 16.13.9.3 Draft meeting minutes will be distributed at the end of each business day to all participants for comment.
- 16.13.9.4 Final meeting minutes shall be transmitted to the CMRL for approval within 5 working days of the last day of the meeting.
- 16.13.10 Preliminary Design Review
- 16.13.10.1 The Preliminary Design Review (PDR) shall be conducted to summarize the progress and adequacy of the selected design approach and to evaluate compliance with these Technical Provisions. The purposes of the Preliminary Design Review submission are as follows:
- State the design criteria.
 - Design the overall system, and propose the system configuration.
 - Identify the functions of each system, sub-system, equipment or other element within the overall design, and specify the relationships and interfaces between elements of the system.
 - Identify the functions of each system, sub-system, equipment or other element within the overall design, and identify the relationships and interfaces between elements of the Contractor's system and those of other Designated Contractors; and
 - Verify the tender designs and calculations. In case of simulations, the inputs, relevant formulae, principles, assumptions, algorithm and logic followed shall be submitted with a sample calculation for each case. It shall be obligatory on the Contractor to submit any further details as required by CMRL to approve the results. Any spreadsheet if submitted shall be supported with the linked formulae and calculations.
 - Incorporate CMRL's suggestions and changes based on the Technical Specification and/or operational requirements.
- The PDR shall represent a minimum of 40% completion of the total engineering effort.
- 16.13.10.2 The PDR shall address the following topics as a minimum:
- Interior and exterior styling details
 - Industrial design documentation (ref. TS16.10.5)
 - Equipment layout, showing maintenance access
 - Interior layout
 - List of all interior components and materials for approval by CMRL
 - functional descriptions of the car systems and major components
 - Outline drawings of major equipment components showing:
 - Overall dimension, orientation, centre of gravity, points of normal support, and method of support during mounting and removal.
 - Location of access doors and covers.
 - Required draw-out space and area required to open access doors.
 - Location and space requirements for ventilation intake and for cable and pipe entrances.
 - Mounting, electrical, and piping interfaces.
 - Top-level drawings, assembly, and major subassembly drawings, structural drawings, installation and arrangement drawings for each system.
 - Single-line power diagrams, control schematics, and functional block diagrams for each system.
 - Single-line piping and flow diagram drawings for each fluid circuit showing valves, operators, and

control components.

- xi. Software design descriptions (first level of software documentation) for microprocessor-based or other programmable equipment.
 - xii. List of trainlines and proposed coupler pin arrangement.
 - xiii. Load calculations for VAC system, including psychrometric charts for each control condition.
 - xiv. Engineering calculations, computer printouts, and other relevant data that verify that the carbody, bogies, VAC, auxiliary inverter, doors, Propulsion system and friction brake equipment meet the specified performance requirements and thermal duty cycles.
 - xv. Propulsion generator and alternator characteristics (if used).
 - xvi. Propulsion motor characteristics showing speed, voltage, and tractive effort versus motor current.
 - xvii. List of special tools and DTE for each system.
 - xviii. List of all person-machine interfaces in the Operator cab area.
 - xix. Roll-centre location and list of carbody motion limits in relation to truck as follows: vertical, lateral, longitudinal, roll (degrees).
 - xx. Suspension characteristics including:
 - a) Damping constant of each shock absorber.
 - b) natural frequency and spring rate of primary and secondary suspension.
 - xxi. Final version of the Contractor guidelines and standards for safety analyses and certifications.
 - xxii. Operating and Support Hazard Analysis (ref. TS18.5.4.6).
 - xxiii. Design of electrical truck disconnect and truck removal approach.
 - xxiv. Electrical load management concepts.
 - xxv. Preliminary brake failure mode analysis.
 - xxvi. Finalized list of the subsystem and major component suppliers.
 - xxvii. Other items identified in these Technical Provisions for PDR, and for all design reviews.
 - xxviii. Complete list and copy of International standards proposed.
- 16.13.10.3 Throughout the PDR the Contractor shall address safety analysis, as per clause 18.5.4.
- 16.13.11 Pre-Final Design Review (Pre-FDR):
- i. In the Pre-Final Design review stage the conceptual designs (including interfaces with those of Designated Contractors of CMRL, and of the Contractor's vendors) are required to be fully developed. In this stage, each element of the system will be considered and preliminary specifications with supporting calculations developed. Preliminary electrical and control schematics shall be developed to illustrate how various operational and functional requirements are achieved. Software design and development shall also be carried out at this stage.
 - ii. Manufacturing units will be allowed to commence production only after receiving 'no objection' (NONO) advice from CMRL for this stage of review. This submission shall include sufficient detail from prospective suppliers to demonstrate that they have adequate understanding of the requirements. It will include either evidence of or proposals for design verification. Interfaces with other Designated Contractors shall be finalized by this stage.
 - iii. Development of maintenance manuals & methodology of other derived maintenance activities (as defined in Chapter 15).
 - iv. Pre- Final Design Review shall address the following topics as a minimum:
 - a) Complete details regarding Design Criteria.
 - b) Detailed Technical Descriptions and Drawings of all the subsystems and major items of train.
 - c) RAMS data of all items.
 - d) Failures and Protection schemes of the major components.
 - e) Detailed Engineering calculations used for the design requirements.

- f) Detailed description regarding design simulation.
- g) Detailed description regarding the software and firmware.
- h) detailed description and details regarding power diagrams, control schematics, and functional block diagrams for each system.

The Contractor shall submit Pre-Final Design Review (Pre-FDR) documentation to CMRL for approval.

16.13.12 Final Design Review

- 16.13.12.1 A formal Final Design Review (FDR) shall be conducted incrementally when the detailed design of a system or subsystem is complete and prior to the production drawings being released to manufacturing.

The purpose of the Final Design submission is to agree with CMRL that the equipment is satisfactory, compliant with the specification, fit for purpose and safe. The Final Design shall be the level of design developed to the stage where all manufacturing drawings (including those received from Designated Contractors of CMRL, and Vendors of the Contractor) are fully defined and specified and in particular:

- i. calculations and analyses are complete.
- ii. all main and other significant elements are delineated.
- iii. all other work, including studies, investigations and reports are complete.

The level of detail presented at the FDR shall be sufficient to determine that the system under review will satisfy the design requirements established in these Technical Provisions and shall confirm the exact interface relationships between that system and other equipment or facilities.

- 16.13.12.2 The FDR shall address, as a minimum, the following topics for each system or item of equipment on the car:

- i. Latest revisions of the drawings and documentation submitted for the PDR.
- ii. Assembly drawings down to the LRU level.
- iii. Final design calculations showing compliance with the Technical Provisions for every subsystem.
- iv. Software documentation at the second level, consisting of structured data flow diagrams to the lowest level of decomposition with software module descriptions (or elemental process descriptions) in structured narrative format.
- v. Load-flow analyses, shut-down and start-up sequences and details of any required load shedding for all electrical systems.
- vi. Electric wiring and schematic drawings, down to the individual signal or wire level, for each electrical circuit.
- vii. Flow schematics for each fluid or pneumatic circuit if applicable, showing control and check valves, test points, orifices, and other circuit details.
- viii. Final brake failure mode analysis.
- ix. Functional descriptions, drawings, and diagrams of DTE, and a list of special tools.
- x. Final configuration of the mock-up for CMRL approval.
- xi. Detailed Test procedures and test specifications.
- xii. Other items identified in these Technical Provisions for FDR, and for all design reviews.

- 16.13.12.3 Throughout the FDR the Contractor shall address safety analysis, as required in TS18.5.4.

16.13.13 Final Design Document Delivery:

All the final design drawings shall be submitted in 3D format and shall be openable and editable in solid works latest version; wherever applicable. The Contractor shall also provide a licensed copy of latest solid works software along with its 3-D visualization CAD tools.

Based on CMRL's review of the Final Design Document Submission, the Contractor shall then re-submit the entire Final Design Document Submission together with the following documents:

- i. joint statements of completed design interface with the Designated Contractors of CMRL.

- ii. a signed statement confirming that he has incorporated all comments of CMRL.
 - iii. a Design Certificate duly endorsed.
- This above jointly will be known as "Final Design Document Delivery".

16.14 WEIGHT CONTROL PROGRAM

- 16.14.1 The Contractor shall establish and maintain a car Weight Control Program. The program shall provide for the review and control of design efforts in order to ensure that the car complies with the weight requirements specified in clause 2.12.
- 16.14.2 As a minimum, the Weight Control Program shall:
- a. Set design weight goals for major systems and components.
 - b. Communicate the requirements of the program to all subcontractors.
 - c. Provide for periodic review of estimated and actual weights throughout the design and production phases.
- 16.14.3 The Contractor shall calculate the AW0 weight for each car of the married pair, truck weights, axle loads, and weight imbalance, and shall indicate the relative proportions of the totals that are calculated, estimated, or actual weights. The Contractor shall submit the weight and weight distributions for approval. Weight calculations shall be updated monthly until delivery of the first married pair and shall be included in each monthly progress report.
- 16.14.4 The empty (AW0) weight for each car of each married pair shall be confirmed by actual measurement at the point of shipment. A certified weight ticket shall be provided for each car and shall be included in the married pair's Car History Book (ref. TS16.15).

16.15 CAR HISTORY BOOKS

- 16.15.1 The Contractor shall provide a Car History Book for each 6 car trainset and it shall be submitted in three categories.
- 16.15.2 First category shall be submitted before the Train dispatch from the manufacturing facility. This Car History Book shall contain the following information:
- a) Certified weight (ref. TS16.14.4)
 - b) List of serially numbered apparatus, components and equipment (ref. TS16.11.6)
 - c) List of adjustment points and initial settings.
 - d) Description of modifications and completion dates of incorporation.
 - e) List of defects noted and the disposition of each.
 - f) List of non-conformances reports of the components (NCR)
 - g) Provision for recording malfunctions, inspection, servicing, and major overhaul.
 - h) Summary of each car-levelling test.
 - i) Axle, wheel, journal-bearing, and gear-mounting certification records.
 - j) Record of certifications for other certifiable items.
 - k) List of repairs.
 - l) List of all gaps and clearances of bogies and car body systems.
 - m) Configuration list of all components and equipment of each car. This list shall include the part number, name and quantity of each component for each car.
 - n) Copies of all acceptance test reports from Manufacturing Stage until dispatch of the train to the Designated Depot(s).
- 16.15.3 Second category shall be submitted before the Train Conditional Acceptance (Train induction into Revenue Service). This Car History Book shall contain the following information:
- a) Copies of all acceptance test reports from train arrival at the Designated Depot(s) until the train's

- Conditional Acceptance (Train induction into revenue service).
- b) List of open issues identified during the above period and their rectification reports.
 - c) Details of Engineering/Design modifications conducted in the specific train.
- 16.15.4 Third category shall be submitted before the Train Acceptance (Completion of Train Warranty period). This Car History Book shall contain the following information:
- a) List of Job Cards, other Operational & Maintenance issues identified during the above period and their rectification reports.
- 16.15.5 The Contractor shall maintain Car History Books until the trainset is accepted and all discrepancies are resolved. The Car History Book shall be turned over. Car History Books shall be provided in standard D-ring binders.
- 16.15.6 Documentation recording changes made during the warranty period shall be submitted for inclusion in the Car History Book.

16.16 INTERFACE WITH DESIGNATED CONTRACTORS AND OTHERS

- 16.16.1 The Contractor is responsible for detailed co-ordination of his design and manufacturing activities with those of the System-wide Contractors, Civil Contractors, Consultants and other Contractors whether or not specifically mentioned in the Contract, who may be working on or adjacent to the site for the purpose of the CMRL Phase-II Project.
- 16.16.2 All of the above parties are referred to as Designated Contractors. A list of some of the main Designated Contractors and some of the identified major interfaces are provided in Appendix C. The Contractor shall note that there are other Contractors, Consultants, Agencies etc., which CMRL may engage from time to time, and with whom the Contractor shall have to similarly co-ordinate. Such co-ordination responsibilities of the Contractor shall include the following, but need not be limited to:
- a) To provide all information reasonably required by the Designated Contractors in a timely and professional manner to allow them to proceed with their Design, Manufacturing, Construction activities, and to meet their milestones and key dates.
 - b) To ensure that the Contractor's requirements are provided to all other Designated Contractors, in a timely and reasonable manner.
 - c) To obtain from the Designated Contractors information that is reasonably required, to enable the Contractor to meet his own design submission dates.
 - d) To closely coordinate with the Signalling and Communication Contractors on matters of interface provisions required for all train borne Signalling and Communication equipment; such that all the interface requirements are identified and incorporated in to the design.
 - e) Where execution of the Work by Designated Contractors depends upon the site management or information to be given by the Contractor, the Contractor shall provide to such Designated Contractors the services, or the correct and accurate information required to enable them to meet their own program or construct their own Works.
 - f) To ensure that there is no interference with the Works of Designated Contractors.
 - g) To attend regular interface co-ordination meetings convened by the Designated Contractors and CMRL. The Contractor shall conduct separate meetings with the Designated Contractors as necessary to clarify any queries raised. A record of the decisions taken in each such meetings shall be furnished to CMRL. The party who convenes the meeting shall prepare minutes recording all matters discussed and agreed at the meeting.
 - h) To ensure that all correspondence, drawings, meeting minutes, programmes, etc. relating to the Contractor's interface co-ordination with the Designated Contractors are issued to all concerned parties. Soft copies shall be issued to CMRL no later than seven calendar days from the date of such correspondence and meetings.
- 16.16.3 The Contractor shall in carrying out his co-ordination responsibilities raise in good time and provide sufficient information for CMRL to decide on any disagreement between the Contractor

and the Designated Contractors as to the extent of services or information required to pass between them.

- 16.16.4 If such disagreement cannot be resolved by the Contractor despite having made all reasonable efforts, then the decision of CMRL shall be final and binding on the Contractor.
- 16.16.5 Where a Designated Contract is yet to be awarded, the Contractor shall proceed with the co-ordination activities with CMRL until such time as the Designated Contractor is available. The Contractor shall provide the Designated Contractor with all information necessary to enable the Designated Contractor to follow-on and proceed with their coordination.
- 16.16.6 Any claim of additional costs by the Designated Contractors as a result of the Contractor's failure to keep to specified target dates or to meet specific requirements shall be borne by the Contractor. The Contractor shall note that exchange of information is an iterative process that shall always be done at the earliest opportunity and shall continue on a regular and progressive basis in order to complete the process to the extent that is required for each design stage; in accordance with the specified dates.
- 16.16.7 CMRL maintains the right to impose Delay Damages on the Contractor for non fulfilment of Key Dates (in accordance with Part 3: Section VIII Particular Conditions Clause 35) where such delays are as a result of lapses in interface coordination. The decision of CMRL shall be final and binding on the Contractor.
- 16.16.8 The Contractor shall submit Interface Management Plan in accordance with Appendix C.

1 16.17 PROJECT MANAGEMENT INFORMATION SYSTEM (PMIS)

- 16.17.1 CMRL has implemented the PMIS for this Project, which is a web-based platform on cloud to monitor and track the progress of the whole project, tailored to match the specific needs of the project.
- 16.17.2 The aim is to provide CMRL & GC with insights critical for the smooth and timely execution of the project. The Contractor will be required to submit the data and information for the PMIS as described by CMRL.
- 16.17.3 The contractor once awarded the contract shall develop a Method Statement for the control of document and management information as per the requirements of chosen system in co-ordination with CMRL which shall also detail various processes of the PMIS. The information shall include but shall not be limited to Schedule related information, Progress related information, Issues related to the project, Safety related information, Quality related information.
- 16.17.4 The integrated system will also take inputs from Primavera and project the possible delays and achievements of the various Contractors and also the overall project. The management team can review the overall health and synopsis of the entire project on the master dashboard.
- 16.17.5 The contractor will be managing the PMIS for entire contract duration including the defects liability period for their contract package including sharing the proportionate cost of
- a. Cloud based server (CMRL will be acquiring the common cloud based server for all contract packages of phase 1 and back charge the proportionate cost of the Server, Cloud services and the manage services of the cloud server to each contractor
 - b. 3 no's user licenses cost for Primavera P6 Enterprise Project Portfolio Management Cloud Service (1 No. each to be used by the Contractor, GC and CMRL). Please note that the Contractor can ask for more licenses if he wish to but strictly on his cost
 - c. 3 no's user licenses cost for Project Management Software to be procured for 1 No. each to be used by the Contractor, GC and CMRL. Please note that the Contractor can ask for more licenses if he wish to but strictly on his cost.
 - d. CMRL will be hiring a professional agency to implement P6 EPPM for whole project and integrate it with PMIS. The contractor for each package will have to share proportionate cost for their package. Any other software required to interact with PMIS for their contract package needed to update the information as explained above.
- 16.17.6 The cost to deploy and maintain PMIS shall be recovered from the Contract Amount at a

- predetermined rate. A deduction rate of 0.05% of the Accepted Contract Amount shall be applied over the Contractors' running bills for all Price Centres that are applicable to the project delivery period. (E.g. there shall be no deductions applied to Price Centre RS-CMC as it is not part of the project delivery period). The scope of services procured by the recovered costs shall include software, implementation, service, training and maintenance, etc.
- 16.17.7 PMIS, which will be containing, amongst many other modules, a module on document management system (DMS), such that all documents generated by the Project and Interface Contractors can be transmitted to GC & CMRL, by electronic means, and vice versa, and that all documents generated by all parties are electronically captured at the point of origin and can be reproduced later, electronically and in hard copy. The Contractor shall note that a limited number of his staff will receive specific training in the use of the PMIS system, which shall be organized by CMRL at a time and location yet to be determined.
- 16.17.8 The Method Statement for the control of document and management information to be submitted by the Contractor shall also detail the uploading, maintaining, and archiving the following submittals, included but not limited to:
- Contractual Works Programmes, Work Segment Programmes, and supporting reports (including plans) as per the format and using the software as defined in the Contract,
 - Drawings (including As build drawings) and designs created by the Contractor as per the construction asset (classification) and on the software platform defined in the Contract,
 - Records of measurement or Contractor's Statements or both, in a format defined in the Contract,
 - Construction asset details needing to be updated in the Contractor's Monthly Progress Reports,
 - Geo-referencing of the alignment,
 - Geo-referencing co-ordinates of assets into a geographic information system (GIS) which the Contractor's Monthly Progress Report has utilized,
 - The Contractor's Monthly Progress Reports, and
 - Source files for submittal as required by GC / CMRL.
- 16.17.9 The Contractor is required to assess the entire cost associated with all above requirements and include the same in his quoted price. The PMIS will contain a module on document management system, such that all documents generated by the Project and Interface Contractors can be transmitted to GC & CMRL, by electronic means, and vice versa, and that all documents generated by all parties are electronically captured at the point of origin and can be reproduced later, electronically and in hard copy.
- 16.17.10 The Contractor shall keep updated configuration of the System. The Contractor shall implement a Configuration Control System, which scope shall cover documentation, materials and software pertaining to CMRL Project. The Configuration of the System shall record the authorized version of any part, piece of software and document related to the System. It shall also record the technical breakdown of the System, including specific configuration of similar items installed at different locations, or performing different functions in the System. This Configuration Control System shall feature all relevant procedures and tools to control and manage all evolutions and anomalies. Such procedures and tools shall be detailed within a Configuration Control Plan, due to be submitted no later than one (1) month after the Commencement Date. The Configuration Control Plan should include software configuration and the following:
- Configurations item definition
 - Configurations item breakdown
 - Reference configuration, associated schedule and documentation.
- 16.17.11 A list of configuration items shall be produced as part of the Configuration Control plan, which shall detail, inter alia:
- List of last valid specifications
 - List of valid drawings
 - List of control and testing procedures

d. List of valid software

16.17.12 All documents shall be recorded featuring, Title, ID number, Revision number, Validity date, etc.,

17. TEST PROGRAM

17.0 NOT USED

17.1 GENERAL

- 17.1.1 The complete car and its apparatus shall be subjected to a test program in accordance with IEC 61133 & EN 50215, as defined herein, to substantiate the design and performance requirements, and to determine compliance with reliability, availability, maintainability & safety requirements specified under this Contract.
- 17.1.2 If any of the required tests have been previously performed by the Contractor, under conditions similar to those defined in this Contract, a copy of the test procedure and report may be submitted for CMRL's evaluation. Upon review of such submittals, CMRL may waive the actual performance of the test and accept the test results as being adequate to demonstrate compliance with the requirements of this Contract. CMRL will make every reasonable effort to accommodate and accept previously performed tests similar to these Contract requirements. If Submitted data is not be acceptable to CMRL, the Contractor shall complete the tests as specified, with no increase in contract cost or extension to the delivery schedule.
- 17.1.3 Approval may be given to waive tests required by the Technical Provisions if compliance with the requirements can be demonstrated adequately by analysis. A formal waiver request shall be made for each instance of such, and approval will be at CMRL's discretion.
- 17.1.4 All test plans, procedures, and reports shall meet the requirements of clause 17.2 and 17.3 and are subject to review and approval by CMRL.
- 17.1.5 CMRL will, at its option, witness all tests. At least 30 days' notice, if the test is held outside India, and 15 days if held in India, prior to commencing of each test, the Contractor shall notify CMRL in writing of the date, time, and location the test will be performed.
- 17.1.6 Unless indicated otherwise, all costs associated with conduction of testing shall be borne by the Contractor. In the event of failure to meet the requirements of these Technical Provisions in any test, the Contractor shall make necessary corrections to the equipment and re-test at his own expense.
- 17.1.7 CMRL shall bear the expenses for the travel and lodging for the CMRL representatives participating for the testing.
- 17.1.8 In general, the Contractor shall try to conduct the routine testing (which shall be repeated in all trains) in an automated manner which can save testing time.
- 17.1.9 All trainsets shall be adequately protected against accidental damage to its aesthetics prior to commencement of testing. Flooring shall be protected by 3mm Plywood or a suitable alternative. Grab poles / finished metal surfaces shall by a plastic protective layer.
- 17.1.10 In case of any change in the place of manufacture (either trainsets or major subsystems) then related type tests shall be repeated.

17.2 TEST PROGRAM

- 17.2.1 The Test Program shall include all tests required to verify compliance with these Technical Provisions. In general, all specified requirements shall be subject to verification by test. Tests, by definition, include, but are not limited to: visual observation, non-destructive examination, equipment operation under extreme environmental conditions, accelerated life operation, normal and abnormal performance, and observation of normal operation and maintenance.
- 17.2.2 The Contractor shall submit to CMRL, for approval, a Master Test Plan covering all tests and adjustments listed in these Technical Provisions.
- 17.2.3 All changes to the plan shall be submitted for CMRL approval.
- 17.2.4 The Master Test Plan shall incorporate System Assurance requirements (clause 18.3). The plan shall include as a minimum the requirements described below:

- a) All tests, adjustments and inspections shall be identified by reference to the appropriate Chapter numbers of these Technical Provisions.
 - b) A detailed schedule, in the form of a bar chart, shall be submitted showing the anticipated date and location of each test. The schedule shall be updated as part of the monthly progress report.
 - c) All Test Procedures and their identification method should be listed.
 - d) All tests shall be identified as to which tests are to be actually performed and which tests are planned to be covered by submittal for acceptance of previously obtained test results and reports.
 - e) Details of availability of testing procedures which are pre-requisites for conducting any testing.
 - f) Separate list of interface testing planned and the requirements from other interface Contractors.
- 17.2.5 The Contractor shall provide its own test facilities, equipment, and personnel.
- 17.2.6 The Contractor shall establish a test activities update and test schedule coordination system to ensure that all affected parties are informed of any pending or actual changes continually and are given the opportunity to reschedule their resources efficiently.

17.3 TEST PROCEDURES AND REPORTS

- 17.3.1 Test and inspection procedures shall be carried out in accordance with IEC 61133 or unless otherwise specified within the requirements of this Performance Specification. For each test, the Contractor shall submit a detailed test procedure for each of equipment / sub-system for CMRL approval. Any such test procedures shall be prepared by the manufacturer of the system or component to be tested. The Contractor shall thoroughly review any test procedure before submittal to CMRL to ensure that testing also verifies system integration parameters.
- 17.3.2 Test procedures must be approved before the associated tests are conducted. Tests performed without CMRL approved Test Procedures might not be recognized by CMRL and might have to be repeated at the sole discretion of CMRL.
- 17.3.3 The test procedures shall include, as a minimum:
- a) Test objectives, which, as a minimum, will reference the Technical Provisions and the design parameters.
 - b) Scope
 - c) Prerequisite tests and follow-up activities, indicating testing that should be completed successfully before, and testing that should be completed after, the tests described in the test procedures
 - d) Equipment, instrumentation and measurement tools required.
 - e) Test setup, including sketches and drawings indicating the proper equipment setup.
 - f) Instructions to ensure that the equipment is calibrated and in good working order
 - g) Test methodology
 - h) Operational monitoring requirements
 - i) Pass-fail criteria for each item in the methodology
 - j) Provisions for re-testing
 - k) Means for updating test procedures with proper revision details
 - l) Means for collecting test data and for formatting and representing results.
 - m) Proper approvals by the test procedure author, validation and test experts.
 - n) Provision for signature of Cognizant engineer, QA engineer, test engineer, and safety officer (if safety-related).
 - o) References to ERTS clauses.
- 17.3.4 Where microprocessors are used, microprocessor software test procedures and test cases designed to uncover software errors shall be performed as part of the validation and verification process.
- 17.3.5 The Contractor shall submit a test report of each test in CMRL approved format.

17.3.6 Test reports shall include, as a minimum:

- a) Test procedure with cross-reference to the specification requirements satisfied.
- b) Summary of results indicating, as a minimum, that the test was successful.
- c) Statement of whether criteria were met.
- d) Description of failures and corrective action.
- e) Analysis.
- f) Listing of all serialized components.
- g) Raw test data sheets.
- h) Copies of inspection records.
- i) Identification of personnel conducting and witnessing the testing.
- j) Proper approvals by the author, cognizant engineer, test engineer, and safety officer (if safety-related).
- k) Observations of the CMRL.
- l) Action taken report for the CMRL's observations.
- m) Pictures conducted during testing.
- n) Details of previous test references and proper version numbers.

17.4 TEST CLASSIFICATION

The tests to be performed on equipment's, Sub-system, cars and trainset are categorized as follows:

17.4.1 Design Conformance Tests

Design conformance tests are to be conducted to demonstrate compliance with design requirements at operating and environmental design conditions and extremes. These tests shall be performed on production components, assemblies, subsystems, and cars, and shall be performed on the first level of assembly that will allow demonstration of design compliance. Design conformance tests are limited to the number of units needed to demonstrate design compliance, typically one or two for the type of equipment proposed. These test requirements are described in clause 17.5 and include performance and operational tests. The units to be subjected to the design conformance tests shall previously receive the related production conformance test.

17.4.2 Production Conformance Tests

Production conformance tests shall include all efforts necessary to demonstrate that each unit delivered operates within specified limits and is in compliance with design requirements. Production conformance test requirements may vary from an inspection and functional demonstration for a simple component to a full system demonstration of a car. These tests are routinely performed at ambient conditions unless a specific environmental or operating limit is necessary to demonstrate acceptable operation. These tests are described in clause 17.6.

17.4.3 Train Acceptance Tests

Acceptance tests shall be performed at CMRL's property by the Contractor prior to handover of each train to CMRL. The Contractor's tests shall be completed prior to the start of Service Trial testing period, described in clause 17.10. The purpose of these train acceptance tests is to verify that no damage has occurred during shipment and to ensure that the trains are properly tested in static and dynamic conditions and are in suitable condition for operating in passenger operation in integration with other Designated Contractors having interfaces with the train. The acceptance tests are described in clause 17.7, 17.8 & 17.9.

17.5 DESIGN CONFORMANCE TESTING

17.5.1 General

The Contractor shall demonstrate that all components, subsystems, systems of trains supplied

meet the requirements of these Technical Provisions. At a minimum, the design conformance tests specified in this Chapter shall be performed to demonstrate compliance of all components, systems and the complete car with this Technical Specification. All combustible materials supplied for this car shall be tested to the flammability and smoke emission requirements of clause 2.26.

17.5.2 Component Design Conformance Tests

17.5.2.1 Component qualification tests shall be conducted on production components and shall stress the components under extreme operating conditions. While stressed in this way, components shall demonstrate that they perform their intended functions without failure.

17.5.2.2 Any equipment attributes that can be tested during subsystem testing need not be tested at the component level.

17.5.2.3 Car Shell Structural Qualification Testing

17.5.2.3.1 General

- a) The Contractor shall test the first production car shell to show that the car structure complies with these Technical Provisions. The structural tests shall be conducted at an appropriately equipped facility with personnel having prior experience in such tests. The proposed facility will be subject to CMRL approval.
- b) The specimen shall be prepared such that all critical structural members can be viewed. Any "plug-in" cabs or similar car end structures, even if they are not part of the structural shell, shall be installed. The weight of underfloor and roof equipment shall be simulated by introducing equivalent loads at the corresponding locations. The test car shell shall be supported on bogies during the tests. Prior to installing the test equipment, the test specimen shall be weighed. All structural testing shall be conducted on this specimen.
- c) All test equipment shall be calibrated, with calibration validity extending beyond the test completion date.
- d) A data acquisition system shall be used to permanently record the test data and printouts shall be provided that allow ready and convenient review and analysis of the test results.
- e) The car shell (prior to equipment setup) shall be available to CMRL for a period of one day for inspection.
- f) If testing of the first production shell uncovers noncompliance in any structural area, then a second car shell shall be tested. In such case, the Contractor shall be responsible for the cost of the test and for all modifications required to make this car shell and all other cars specification compliant. The Contractor shall also reimburse CMRL for all of its cost associated with the second and any subsequent test.

17.5.2.3.2 Test Procedure

The test procedure shall include graphical representations showing the location of the measuring devices on the car shell. CMRL approval of the car shell stress analysis shall be obtained before testing is allowed to begin.

17.5.2.3.3 Vertical Load Testing

The tests shall be performed in accordance with EN 12663. Further, the Contractor shall also perform the following tests:-

1

- a) All doors of the car ~~including detainment door~~ shall be installed. The doors shall be fully operational and all thresholds, seals, and weather stripping shall be in place.
- b) The test car shell shall be supported on test fixtures / supports and shall be loaded to have the equivalent total weight of the complete ready-to-run car (AW0) minus the weight of the bogies.
- c) One seat frame of each type shall be mounted in the car shell at the time the vertical load test is conducted on the car shell. To these seat frames loads mentioned in Clause 3.6.5.8 shall be applied at the midpoint of each occupant position in a vertical downward direction and it shall be shown that there is no excessive sidewall deformation.
- d) Subsequently, loads equivalent to passenger loads AW2 and AW4 shall be added. The loads shall be distributed in proportion to the weight distribution of the finished car.

- e) The vertical deflection of the car shell shall be measured at each of the three load cases. The doors shall be operated electrically through their full open and close cycles at each of the load cases. The door leaf opening and closing times shall be measured and recorded. If the vertical deflection of the car shell prevents any door from operating at the specified speeds, or show any signs of binding, then the Contractor shall perform corrective action on the car structure or door elements, as required, to ensure that the doors can operate as specified. If corrective action is necessary, then the vertical load test shall be repeated in its entirety.
- f) In addition to the strength requirements stated in Chapter 3, the maximum vertical deflection at maximum loading shall be in accordance with clause 3.13.11 at any point along the side sills. The maximum difference between the camber on each side sill, measured at the location of maximum deflection, shall not exceed 3.2 mm. The maximum residual vertical deflection after test load removal shall be less than 0.8 mm. There shall be no permanent deformation, fractures, cracks, or separations in the car structure.

17.5.2.3.4 Compression Load Test

Car shell structure shall be tested to demonstrate compliance with the structural requirements specified in Chapter 3.

17.5.2.3.5 End Sill Load Test

Car shell structure shall be tested to demonstrate compliance with the structural requirements specified in Chapter 3.

17.5.2.3.6 Coupler Anchorage Test

Car shell structure shall be tested to demonstrate compliance with the structural requirements specified in Chapter 3 and Chapter 4.

17.5.2.3.7 Roof Load Test

Car shell structure shall be tested to demonstrate compliance with the structural requirements specified in Chapter 3.

17.5.2.4 Crash Energy Absorption Element Test

The main crash energy absorption elements of the cars structure shall be tested by the Contractor in accordance with the requirements of clause 3.14.10.3

17.5.2.5 Diagonal Jacking Testing

- a) The test car shell, loaded to its AW0 weight and with all its bogies, or an equivalent weight, hanging from their mounting devices on the car structure, shall be supported symmetrically at all side sill jacking pads. Body side windows and windshields shall be in place for this test.
- 2

b) One of the jacks supporting the car section being tested shall be lowered ~~until the load on that jack is 10% of its original load~~ by 10 mm.
- c) The maximum material stress levels as defined in TS3 of these Technical Provisions shall not be exceeded. There shall be no permanent deformation, fractures, cracks, or separations in the car structure. Windows and windshields shall not be damaged.

17.5.2.6 Floor and Roof Structure Conformance Fire Testing

17.5.2.6.1 The Contractor shall test a representative floor structure sample, including penetrations and floor-to-wall junctions, to show compliance with the applicable requirements of EN 45545 (Part 1 to 7), NFPA 130 & BS 6853 and Chapter 19.

17.5.2.6.2 The Contractor shall test the floor assembly in accordance with Clause 7 of BS 476: Part 21: 1987 to demonstrate a 30-minute endurance rating, and to meet the following criteria:

- a) The test specimen shall be a full-width car section including side sills or that portion of the wall that extends below the floor, and shall completely represent the actual car configuration. The specimen shall have a minimum exposed area of 9.29 m². If approved by CMRL, the exposed area may be reduced to meet a length limitation imposed by the size of the test furnace, but the length shall not be less than 3,353 mm.
- b) No fewer than two typical penetrations, spaced at a distance from each other no greater than that that will exist in actual construction, shall be included in the test specimen. The specimen shall

include typical floor splice configurations.

- c) The test specimen shall be loaded to simulate AW4 passenger loading conditions. Concentration loads shall be applied to simulate underfloor equipment. The test specimen shall include at least three typical transverse supports.
- d) The test specimen shall represent the actual construction utilized in production. This includes the floor covering, floorboards, floor structure, thermal and acoustical insulation, and floor pans.

17.5.2.6.3 The Contractor shall not procure any flooring material necessary for car production prior to receipt of CMRL approval of the test procedure and test facility.

17.5.2.7 Structural or Weight Changes

- a) Any structural changes or modifications made during construction, assembly, or testing shall be subjected to the entire test series.
- b) If the production car's actual ready-to-run (AW0) weight exceeds the weight assumed for AW0 during structural testing by more than 2.5% then the complete test series shall be repeated on one car shell using the actual AW0 weight where referenced. The re-testing shall be at the Contractor's expense.
- c) Any structural modifications resulting from testing or re-testing shall be incorporated into all cars manufactured before or after these tests.

17.5.2.8 Windows Qualification Testing

1

Windshield ~~and detrainment door~~ glazing shall be impact tested according to EN 15152. Body side windows, cab windows and passenger door windows shall be impact tested according to DIN 52306 and fulfil bending according to EN 1288. One sample of each type of window, selected at random by CMRL, shall be tested. Structural requirements for rail vehicle structures shall be tested and conform with GM/RT2100, UIC 566, EN 12663-1, UIC 651, EN 15152.

17.5.2.9 Coupler System Components Qualification Testing

The coupler and draft gear system shall be tested to document compliance in performance and/or capacity. The following specific tests shall be performed:

- a) Buff and Draft Loading Test
- b) Draft Gear Deflection Test
- c) Draft Gear Emergency Release Test
- d) Gathering Range Test
- e) Mechanical Coupling and Uncoupling Test
- f) Pneumatic coupling and uncoupling test
- g) Electrical Coupling and Uncoupling Test
- h) Centring Test
- i) Vertical Strength Test
- j) ~~AATO~~ Auto coupling test with mechanical, pneumatic and electrical coupling

1

17.5.2.10 Bogie Qualification Testing

17.5.2.10.1 One complete bogie frame, including the journal bearing housing, bearing/sliding pads and connecting elements such as traction rods shall be subjected to static and fatigue testing to demonstrate compliance with the loads in clause 11.6.

17.5.2.10.2 The Contractor shall submit a detailed bogie frame static and fatigue bogie test procedure to CMRL. The test procedure shall clearly describe the following:

- a) The bogie configuration to be tested.
- b) The test equipment and the data acquisition system.
- c) The location and orientation of all strain gages.
- d) The arrangement of the actuators, support framing and load reaction points relative to the bogie.
- e) The input load values, load combinations, load phasing and number of cycles for each test

sequence.

- f) A description of the calibration steps.
- g) A description of any periodic adjustment required during the test.
- h) Pass/ Fail criteria.

- 17.5.2.10.3 Areas of stress concentration shall be located using theoretical analysis, and an adequate number of strain gauges applied at these areas. Strain gauges shall also be positioned at known strain points and at other points at the discretion of the Contractor and CMRL. Readings shall be taken to determine that the stresses are within the design requirements. The test results shall be submitted to CMRL.
- 17.5.2.10.4 Not used
- 17.5.2.10.5 All bogie frames, and other primary structural members, shall be qualified by radiographic inspection of all critical welds.
- 17.5.2.10.6 A fatigue test shall be performed to verify the design will meet the requirements defined in clause 11.6.3. The proposed test arrangement and table of loads and cycle frequency shall be submitted to CMRL for review and approval. The test shall be run for a suitable number of cycles of fatigue load test which ensures a 35 year service life as per the JIS standards and the results shall be submitted to CMRL. Damage equivalence of 10,000,000 cycles must be demonstrated by the results of this test.
- 17.5.2.10.7 At regular intervals during the fatigue test, the bogie shall be visually inspected for developing cracks. The test shall be halted if evidence of crack initiation or progression is found and the Contractor shall determine the cause of such failures and propose corrective action to CMRL. Any modifications shall be subject to CMRL approval. Test continuation or restart shall require CMRL consent.
- 17.5.2.10.8 A magnetic particle or dye-penetration inspection shall be performed on the bogie test specimen before the test commences and immediately after the conclusion of the test. Identical inspection procedures shall be used for both inspections.
- 17.5.2.10.9 A load equalization test shall be performed on one motor bogie and one trailer bogie installed on the first completed married pair at AW0 and AW4 load conditions. For this test, one wheel of the bogie shall be raised and then lowered 63.5 mm with respect to the plane formed by the other three wheels of the same bogie as they rest on level track, and additionally wheel unloading ~~testing method 8~~ test condition with track twist values of bogie and vehicle body test twist ~~shall conform to method 3 of EN 14363 as per maximum specified track twist. The testing method shall be in accordance with EN14363 Method 3.~~ An alternative design and service proven load equalization test may be presented to CMRL for approval during design review. During the test, the other three-wheel treads shall maintain contact with the rails. Additionally, with one wheel raised and lowered 51mm with respect to the plane formed by the other three wheels, the neutral wheel load of the other three wheels ~~shall not change by more than 50% shall be in accordance with and comply APTA PR-M-S-014-06 standard.~~
- 17.5.2.10.10 During the static load test, a Primary Suspension Test shall be performed to show that the primary suspension deflection and the material creep rate are within the design parameters.
- 17.5.2.10.11 The bogies rotational resistance (X factor) test under inflated and deflated air spring conditions would be carried out at the manufacturer's works under tare conditions, the value of which should not exceed 0.08 at rotational speed of 0.8 degrees/second. The rotational resistance shall neither cause excessive flange wear nor cause any possibility of flange climbing but shall be adequate to avoid bogie hunting on straight track. The Contractor shall show by analysis that no flange climbing occurs on any curve and moving at all possible speeds. Bogie rotational resistance test procedure along with test results in report format shall be submitted to CMRL
- 17.5.2.11 Bogie swing tests shall be conducted between interface of motor car and trailer car to verify the required degree of rotation (horizontally and vertically) and that cables and hoses are clear from any pinching, chafing and stretching.
- 17.5.2.12 Wheel disc and axle shall be subjected to type tests as per UIC standards 812 and 811 or EN 13260, EN 13261 & 13262. Test procedure for wheel, wheel set and axle along with test results

shall be submitted for CMRL.

17.5.2.13 Traction Motor Qualification Testing:

The first motor and two others selected at random by CMRL shall be given an IEEE Standard 11 and Standard 112 or IEC 349 "type" test by the manufacturer, including a heat run, to demonstrate the motor capability and power rating. One motor shall be tested for acoustic noise, under load and at various speeds as well as sweep through speeds. Overall noise level and pure tone noise shall be measured.

17.5.2.14 Qualification Testing of Other Motors of train: The first motor of each type and an additional one of each type selected at random by CMRL shall be given an IEEE Standard 112 or IEC 349 "type" test by the manufacturer, including a heat run, to demonstrate the motors' capability and power rating.

17.5.2.15 Not Used.

17.5.2.16 Traction Gear Unit Qualification Testing:

- a) The traction gear unit qualification test shall be a 100-hour test on two gear units, selected at random by CMRL, and shall be mounted with torque load simulation. The test shall subject the unit to conditions that are RMS torque load +20% of the RMS speed of the standard load cycle with sinusoidal supply.
- b) The test shall be started with the unit at room temperature 55°C. A fan or other device may be provided so that in-service airflow conditions are simulated. The temperature rise measured in the oil sump shall not exceed the gear oil supplier's recommendations for maximum temperature consistent with the life between oil changes, as called out in the Contractor's maintenance manuals. The direction of rotation shall be reversed every 8 hours, until the 100-hour test is completed.
- c) During the test, the gear units shall display no signs of exceeding the manufacturer's established limits for the oil temperature and shall remain within the noise and vibration limits established by the manufacturer. After completion of the test, the gear units shall be disassembled, and all parts examined.
- d) Gear tooth mesh shall be checked and recorded before and after the creep speed test (20 kmph). Any sign of deterioration of any part shall be investigated jointly with CMRL.
- e) The test report shall include test records of running time, oil temperatures, and vibration and sound-level readings taken at such intervals as required to verify compliance with these Technical Provisions.
- f) One gear unit shall be tested for acoustic noise, under load and at various speeds as well as sweep-through speeds. Overall noise level and pure tone noise shall be measured.

17.5.2.17 Equipment Noise Tests

Noise tests conducted on equipment prior to its installation shall be performed early in the production phase. The test data shall be used by the Contractor to predict and mitigate, as necessary, the assembled car noise emissions during static and dynamic conditions, in order to comply with the requirements of clause 2.17.

17.5.2.18 Battery Qualification Testing

Train battery bank supplied shall be tested to establish that the batteries will meet the requirements specified in Chapter 9.

17.5.3 System Design Conformance Testing

- a) Major subsystems shall be assembled separate from the car and shall be tested to verify compliance with these Technical Provisions. Related subsystems shall be tested together to verify compliance of the individual subsystems and to verify the design of the interface between them.
- b) The interfaces between equipment and between subsystems are viewed as crucial aspects of the system design. To verify these interfaces, subsystem tests shall be designed to include as many system interfaces as possible.
- c) The subsystems to be tested shall include, but are not limited to, the systems discussed under

this Chapter. The Contractor shall identify the subsystems to be tested in the Master Test Plan (as defined in clause 17.2), subject to CMRL approval.

- 17.5.3.1 Ventilation and Air Conditioning (VAC) Subsystem Qualification Testing - One complete Car shall be climate room tested by the Contractor. The climate room facility will be subject to CMRL approval. A test laboratory independent from the VAC unit manufacturer is preferred.

The VAC unit shall be tested according to EN14750-2 Standard and to meet the requirements specified in Chapter 7. Noise and vibration levels shall be measured for all operating modes of VAC unit. The following tests shall be included as a minimum:

- a) Dimensional and visual inspection
- b) Control stability
- c) Cooling capacity
- d) Performance at extreme operating conditions
- e) Modulation pressure switch operation verification
- f) High-pressure cut-off switch function verification
- g) Low-temperature operation, with and without passenger and solar loading
- h) Condensate carry-over
- i) Refrigerant sample
- j) Test of protection devices operation under restricted or no-airflow conditions and over-temperature conditions
- k) Water-tightness
- l) VAC system startup in-rush current
- m) Compressor start-up in-rush current.
- n) Air velocity measurements
- o) Fresh Air Quantity Measurements: This shall be done with Air capturing hood with pressure balance air flow measurement. The airflow shall be automatic measurement suitable for air flow measurements in turbulent air flow streams and providing airflow volume directly.

One car (if Air duct design is same for all type of cars, else different cars to be tested as below) equipped with all interior finish and all underframe mounted equipment, shall be tested to demonstrate the effectiveness of the equipment in meeting the specified temperature and humidity conditions inside the car as per Chapter 7. Heating and humidifying equipment shall be provided in the car for test purposes. The objective of the planned tests is to ensure the complete train is compliant with the requirements of Chapter 7. Minimally, the following criteria of tests shall be included. The following VAC subsystem tests shall also be conducted to confirm satisfactory subsystem performance:

- i. Induced shock and vibration.
- ii. EMC / EMI compatibility
- iii. Car monitoring system interface.
- iv. Air Flow Tests: Air velocities and air flow rates will be measured at the fresh air inlets to the VAC unit, exhaust air openings, inlets to cubicles and return air inlets for different fresh air damper openings for clean and clogged filters and evaporator coils. Emergency ventilation and any other special air flow requirement shall also be measured for verification. Interior static pressure shall be recorded for all conditions. Measured values should satisfy the requirements of Chapter 7, relevant standards and design values. Condenser fan inlet and outlet airflows shall also be measured.
- v. Air Distribution Tests: Air velocities and air flow rates shall be measured at all saloon supply air diffusers to ensure even distribution of air along the length of the car for each duct partition. Air velocities should not exceed the limits defined by the ERTS or applicable engineering standards. Air velocities inside supply air ducts, at different saloon passenger areas, at return air and exhaust air grilles / openings shall be measured to check that they do not exceed the

requirements of Chapter 7 and standards limits.

- vi. Cooling capacity tests (with doors opening every 2 minutes for 30 sec) including pre-cooling from steady state environmental condition.

These tests shall be conducted inside a Climate Chamber for judging the cooling and dehumidification performances of the VAC system for Summer, Monsoon, high ambient, low ambient, high humidity and any other ambient conditions as per EN 14750 or any other equivalent standard. Heating and humidifying equipment shall be provided in the car for test purposes. Testing shall be done for different passenger loads for:

- Pre-cooling (without passenger heat load) – Set temperature should be achieved in 30 minutes.
- Regulation (doors closed) - Cooling capacity of VACs shall be sufficiently high to demonstrate 3 complete regulation cycles during the regulation test.
- Doors open-close - It should be done for door open-close cycles for complete to-and-fro route run.
- Any other tests deemed by CMRL as required by the Contractor shall also be carried out at no additional cost.
- Measurements of thermal conductivity (K factor) and cooling capacities shall also be done as per EN 14750-2.
- Fresh air flow rate shall also be verified by using dummy passengers as per full passenger load and measuring interior CO2 levels with doors closed and doors open-close situation in all different types of cars.
- Parameters to be Measured: Temperature, humidity, pressure, current, voltage, power etc. at various locations of the VACs, test car, climate chamber and equipment used for creating the ambient and interior heat load conditions. Each parameter shall be recorded on a digital data logger.

- vii. Acceptance Criteria: the requirements of the ERTS, any relevant standards and specified design values should be achieved. In regulation tests, there should not be any large variations in the interior climatic condition. Pre-cooling timings should be less than 30 minutes. It must be demonstrated that the VAC system is consistently able to quickly recover to the average interior temperature and humidity over long durations with average doors opened / closed intervals without any degradation of performance. Ambient temperature test.

17.5.3.2 Auxiliary Power Supply System Qualification Testing

The first production set of auxiliary power generator, inverter, low-voltage power supply and battery charger shall be qualification tested to show proper operation as a total power-supply system, to meet the requirements specified in Chapter 9. The following tests shall be performed as a minimum:

- a) System output range and stability over the full range of input voltage
- b) System capacity verification
- c) System ability to provide start-up and in-rush power for simultaneous motor start loads (e.g. VAC compressor motors)
- d) Fault detection and annunciation
- e) Heat run for worst-case loading (lowest input voltage with highest output load and highest input voltage with smallest output load)
- f) Battery charging capacity and charging regulator
- g) System noise measurements over a range from no load to full load.
- h) System harmonics verification as required in Chapter 9.

17.5.3.3 Propulsion System Qualification Testing

- a) A comprehensive laboratory test shall be conducted on one set of propulsion equipment, using a dynamometer that simulates car inertia and rake resistance.

- b) The propulsion equipment shall be tested for acoustic noise under load and at various speeds as well as sweep-through speeds. Overall noise level and pure tone noise shall be measured for the propulsion components. The propulsion equipment shall meet the requirements as specified in Chapter 10.
- c) The test system shall be fully functional and shall include the complete signal interface to the friction brake system, including the electronic controller for the friction brake system. Combined Propulsion system testing shall be in accordance with IEC 61287-1 and IEC 61377.
- d) Testing shall include simulated service operation, fault handling, including wheel slip/wheel slide control with traction converter inverter, braking and load weigh interfaces and abnormal operation and failure condition operation.

17.5.3.4 Friction Brake System Qualification Test

- a) The friction brake system verification and tread brake temperature test (and disc brake, if used) shall use a dynamometer or other approved test equipment to verify compliance with all of the Friction Brake System Qualification Test requirements of Chapter 12.
- b) The friction brake system shall be tested to verify the braking force, clamping force, time, power dissipated, and magnitude of response to all control inputs.
- c) Dynamometer test runs shall be made for simulated car weight AW0, AW2, and AW3 & AW4 from each of the entry speeds of 16, 24, 48, 80, 90 kmph). For each entry speed, input signals calling for 25%, 50%, 75% & 100% of full service braking effort and for emergency braking effort shall be used.
- d) Each test shall be run starting with both cold and hot initial tread and (disc, if used) conditions.
- e) Results shall be plotted to show both the instantaneous and average relationship between input signals and output braking effort over the speed and weight ranges for both motor and trailer bogies.
- f) Measure SPM count before and after test to various level of pollution.
- g) Dynamometer test procedure along with test results shall be submitted in report format for the conducted test,
- h) Brake calliper test procedure shall also be submitted for CMRL.

17.5.3.4.1 Brake System Capacity Qualification Test

A braking tread brake block and/or disc pad, if used, and calliper assembly shall be tested on a dynamometer to verify the brake-system capacity with both cold and hot tread brake block and/or disc initial conditions. The block and/or disc and shoe surface temperature shall be measured and recorded throughout the test. At the completion of this test, the tread brake unit and/or brake disc and calliper assembly shall remain in an undamaged, fully operable condition. If brake components other than the tread brake block and/or disk brake components are used, such components shall be subject to equivalent thermal capacity testing.

17.5.3.4.2 Brake System Endurance Qualification Test

A complete friction brake system including the electronic control unit shall be subjected to and shall successfully complete an endurance test of one and half (1.5) million cycles of normal apply and release applications. Brake reaction forces shall be simulated on the actuators.

17.5.3.4.3 Brake System Environmental Qualification Test

A test setup in an approved environmental laboratory shall be made to simulate the worst-case climatic conditions to be encountered during revenue service and shall include conditions of rapid temperature and humidity fluctuations. Each cycle shall be completed within 30 seconds. During environmental testing, system function, ambient temperature, and humidity shall be recorded.

17.5.3.5 Communication System Design Conformance Test

One complete set of car communication equipment, including public information system, radio interface, cab-to-cab communication and passenger emergency communication system shall be tested in a laboratory set up simulating the equipment distribution and wiring of the actual car to show compliance with Chapter 13.

17.5.3.6 Door System Design Conformance Test

The body side doors shall be tested for strength and shall meet the requirements as specified in Chapter 6. The following test shall be carried out on a complete double leaf door and operating assembly equipment with its control gear.

17.5.3.6.1 Endurance test:

Two million operations shall be performed. A record of the velocity profile shall be taken at the beginning and the end of the test. It should also be demonstrated that no undue wear or compression of seals has occurred. This test shall be performed under representative dry and wet conditions. Endurance test shall be done on actual replica of the door portion of the car and door shall be as assembled in the car. Approval of CMRL shall be sought on the complete arrangement.

1

~~Detrainment door: The detrainment ramp shall be tested with an uniformly distributed load of 750kg. The loading and unloading shall be repeated for 500 cycles. The detrainment ramp shall not deform after the test. Deleted.~~

17.5.3.6.2 Vibration Tests:

Vibration test shall be carried out as defined in IEC 61373. These tests shall be completed before the first car is ready for final assembly. Failures recorded during testing must correlate within specified reliability values. Door speed and noise tests shall be performed at the beginning, mid-point, and end of the life test for comparative evaluation. Door testing shall include the effects of wind.

17.5.4 Rake Qualification Testing

Tests shall be conducted on the first completed train (all 6 cars) to verify the performance of all car subsystems and all interfaces between them. The Contractor shall conduct tests at the Contractor's facility to the maximum extent possible. The car performance requirements to be tested shall include, but are not limited to, the requirements discussed in this Chapter. The Contractor shall identify the performance requirements to be tested in the Test Program Plan, which shall be subject to CMRL approval.

17.5.4.1 Ventilation Watertight Test

All ventilation intake devices on the car shall be tested for their water exclusion properties. For this test, the associated fans shall operate at maximum speed, and water shall be sprayed for at least 5 minutes. Exterior enclosures shall be tested for water tightness at the point of manufacture.

17.5.4.2 Air Leakage Test

All cars of the first rake shall be tested for the ability to maintain positive internal pressurization. For this test, the car shall be pressurized to at least 0.001 bar. Ventilation openings shall be sealed during this test. Air leaks detected with the help of escaping smoke from a smoke bomb shall be closed by the car builder on this and all other cars.

17.5.4.3 Car Weight and Weight Distribution Test

All cars of the first rake shall be weighed and the weight distribution shall be determined to verify conformance with the requirements of Chapter 2.

17.5.4.4 Car Dimension and Clearance Check

- a) The outside dimensions of all cars of the rake shall be measured on the first completed rake and the static envelope shall be verified.
- b) Clearances shall be verified between the carbody and bogie components and between the bogie and carbody components and the top of rail. These clearances shall be checked with the cars loaded to AW4 condition
- c) All ~~three~~ six cars of the rake shall be coupled and checked for proper inter-car and coupler clearance under the worst-case geometric conditions.
- d) Gangway shall be checked for proper function at entry to and exit from curves and in reverse curves.

17.5.4.5 Trainline Test

1 The first ~~three~~ six car rake shall be tested to demonstrate that all trainline functions perform satisfactorily between cars when cars are coupled together. These tests shall include dynamic and static tests. Cars shall be coupled in all possible combinations with trainlines verified from both ends of the rake.

17.5.4.6 Door Operation Test

1 Before delivery, the first ~~three~~ six car rake shall have all doors operated in similar operating simulation for 1,000 continuous trouble-free cycles while loaded to AW4 conditions. Any door or door control failure occurring prior to completion of the test will nullify the test, and the test shall be re-run completely after the fault has been corrected.

17.5.4.7 Light Intensity Test

1 Light intensity readings shall be taken (without light from other sources) on one ~~three~~ six car rake to verify conformance with the requirements clause 8.3.

17.5.4.8 Rake Performance Test

17.5.4.8.1 General

1 ~~Three Six~~ car rake running tests shall be performed on systems related to traction and braking on the first rake in CMRL section. The tests shall verify the requirements of Chapter 2 and all individual Chapters related to the test. This series of tests shall also be used to determine the equipment settings and calibrations to be used for the rake acceptance program. All ~~three~~ six car rake performance tests shall be performed on CMRL's designated test site. A clearance test will be conducted on CMRL's system. If any ~~three~~ six car rake under any load condition or rake configuration, or any apparatus fails to satisfy the specified performance and design criteria, the cars, with the necessary adjustments, shall be re-tested at the Contractor's expense. If modifications are necessary, they shall be verified by appropriate retest, as determined by CMRL, and implemented on a fleet-wide basis at the Contractor's expense as retrofits or modifications.

17.5.4.8.2 Instrumentation

Test instrumentation shall be selected by the Contractor as necessary for the verification of all required parameters and submitted to CMRL for approval.

17.5.4.8.3 Traction Performance Tests

This series of tests shall be run at loads of AW0 and AW4. Compliance with all the performance requirements including train Harmonic content verification as specified Chapter 2 and Chapter 10 shall be demonstrated. (Braking shall be monitored during the traction tests.)

17.5.4.8.4 Braking Performance Tests

This series of tests shall be run at AW0 and AW4. For the all-friction brake stop tests, brake discs shall be cooled to a maximum of 120° C before initiation of any test. Compliance with the performance requirements in Chapter 2, Chapter 10, and Chapter 12 shall be demonstrated.

17.5.4.8.5 Thermal Capacity Tests

1 One ~~three~~ six car rake shall be instrumented and tested to verify compliance with the duty cycle requirements specified in Chapter 2 and Chapter 10.

17.5.4.8.6 Wheel Slip and Wheel Slide Test

1 All power and braking modes (Service braking including regenerative braking, friction braking) shall be tested to verify compliance with Chapter 2 and Chapter 10. Required data for the slip and slide test shall be monitored and recorded for all axles of all cars of the test trains. This test shall be conducted in ATP, ATO and ~~ATO~~ UTO modes of operation. Wheel Slide Protection (WSP) test Complete train (AW0 & AW4) shall be subjected to Wheel slip-slide type test as per UIC 541-05. The detailed type test specification shall be submitted for CMRL review and approval. Followings shall be included in the type test

- a) Braking Modes as EB (Emergency Brake), FSB (Full-Service Brake with ED Dynamic Brake), FSB (Full-Service Brake without ED Dynamic Brake) and EB (Emergency Brake) with 1 M & 2 M car ED brake isolated for Evaluation with at least 4 valid runs each.
- b) Braking Modes as FSB (Full-Service Brake with ED Dynamic Brake) followed by Failure of ED

Dynamic Brake, FSB (Full-Service Brake with ED Dynamic Brake) followed by EB (Emergency Brake) for reference with at least 3 valid runs each. (iii) Low Speed and Low Adhesion WSP Tests will be done for reference at speeds of 25kmph and initial adhesion < 5%

- c) WSP Tests will be done on Randomly selected 3 trains in Tare Load in speed range 60- 30kmph for Braking Modes as EB (Emergency Brake), FSB (Full-Service Brake with ED Dynamic Brake), FSB (Full-Service Brake without ED Dynamic Brake) for evaluation by CMRL.
- d) Initial Adhesion will be evaluated as per UIC 541-05 i.e., when the First axle starts sliding irrespective of location on train. In the case of Full-Service Brake with Dynamic Brake First axle to slide is expected from Motor car due to Dynamic Brake applied on Motor Car.
- e) An Axle will be considered Sliding if its speed is at least 10% lesser than Reference Speed.
- f) Minimum Slide Criteria will be fulfilled based on Braked Axles of complete Train Set i.e. At least 50% of braked axles, of train. Axle will be considered Sliding if it is sliding for more than 35% of the time (Actual time taken from 85-45 kmph or 60-30 kmph).
- g) Extension of Stopping Distance in Wet Condition over Dry Condition, for Adhesion Braking Distance under Dry and wet condition shall be within the distances specified Chapter 2.
- h) WSP software shall be fine-tuned to ensure minimum reduction of brake distance due to low adhesion and shall be state of art being used in metros worldwide by the Contractor.

17.5.4.8.7 Auxiliary AC Power Supply Test

The Contractor shall operate the auxiliary AC power supply test instrumentation throughout all car performance testing to verify that the requirements of Chapter 2 and Chapter 9 are met. The chart recordings so taken shall be available for inspection by CMRL and shall be furnished to CMRL by the Contractor upon delivery of cars for acceptance.

17.5.4.8.8 Operational Performance Test

The Prototype Train shall be given an operational performance test for a minimum of 10,000 km through the CMRL alignment before handover to CMRL. This testing shall be conducted in **ATO** mode only. The train instrumentation during these tests shall be sufficient to determine that all systems are functioning properly.

The test shall be conducted in simulated revenue service, with an AW4 passenger load, stopping at every station and cycling the doors. The raw data recordings shall become part of the permanent record for the cars and shall be handed over to CMRL with the test report, along with any paper chart recordings which were made.

Any failure found shall be diagnosed and repaired expeditiously by the Contractor at the Contractor's expense. The train shall continue in the next trial only after rectification of the failures by the Contractor. During the last 400 Km of the test, there shall be no failures of any equipment of train in **ATO** mode. If a failure occurs in the last 400 Km, the test shall be repeated until achievement of 400 Km without any failure.

17.5.4.8.9 TCMS functionality test

All the requirements of RTR-DMS, single point upload of software, single point download of all fault logs and other requirements mentioned in Chapter 14 shall be tested for conformity.

17.5.4.8.10 Parking Brake Test

A parking brake system test shall be performed on one **three six** car rake. Design compliance with Chapter 2 shall be demonstrated by measuring the force required to move the train with the parking brake applied (occurring on no more than one (1) bogie).

17.5.4.8.11 Ride Quality Test

- a) Ride quality tests shall be performed on one **three six** car rake. The tests shall prove compliance with the ride quality requirements of clause 2.13.4.
- b) At a minimum, ride quality tests shall consist of operating the **three six** car rake at speeds up to 90 kmph over track segments selected by CMRL, under two load conditions: AW0 and AW4.
- c) Instrumentation capable of measuring the magnitude of the vertical, longitudinal, and lateral shocks and vibrations, shall be provided and monitored by the Contractor.

- d) Sensing units shall be located on the car floor above the intersection of the car longitudinal centreline and a bogie transverse centreline, at the center of the car between bogies, and at three seat locations to be determined by CMRL. Provision shall be made for recording vertical, lateral, and longitudinal shocks and vibrations concurrently.
- e) In the event that the dynamic behaviour of the car does not meet the Specification requirements, the Contractor, within 60 calendar days, shall submit an analysis of the problem and a plan of action for its correction for CMRL review. If authorized by CMRL, the corrective measures shall be implemented on the test car within 90 days at the expense of the Contractor, the car shall be re-tested, and, if the measures are successful, they shall be applied to all cars. If not successful, the analysis and corrective action steps shall be repeated, and the car retested until Specification compliance is attained.

17.5.4.8.12 Noise and Vibration Test

1

- a) After equipment installation, noise and vibration tests shall be performed on one of the ~~three~~ six car rake to confirm compliance with the requirements of clause 2.13 and 2.17.
- b) Compliance with the Specification is to be based on measurements taken in a free-field environment such as outdoors, away from any reflecting surfaces other than the ground, ties, and ballast, on track with newly welded and ground rail. Compliance with the specifications is to be based on measurements according to ISO 3381 and ISO 3095.

All measurements shall be made with an ambient sound level in the vicinity of the test measurement locations of not less than 10 dB below the noise produced by the equipment being measured, when evaluated using the same scale or octave band.
- c) The results shall be evaluated, and any corrective action required shall be approved by CMRL. After corrective actions are implemented, the applicable tests shall be repeated. If the corrective action is successful, they shall be implemented on all cars. If not successful, these steps shall be repeated until Specification compliance is attained.

17.5.4.8.13 Warning Device Test

Warning devices, as mounted on a 6 car rake, shall be tested for compliance to requirements clause 5.8.

17.5.4.8.14 Car Stability Qualification Test

The bogie stability tests shall be carried out in accordance with the requirements of UIC 518. All equipment and instrumentation necessary to accurately measure tilt angle and wheel unloading shall be provided, set up and monitored by the Contractor.

17.5.4.8.15 VAC Qualification testing

1

- One ~~three~~ six car rake equipped with all interior finish and all underframe mounted equipment, shall be tested to demonstrate the effectiveness of the equipment in meeting the specified temperature and humidity conditions inside the car as per Section VI A ERTS (RS) Chapter 7. Heating and humidifying equipment shall be provided in the car for test purposes. Complete train shall be tested for below points as minimum with the requirements of Section VI A ERTS (RS) Chapter 07:
- a) Air Flow Test: Air flow will be checked at the fresh air inlet to the unit, and at the return air inlet.
 - b) Air Distribution Tests: Saloon air ducts shall be checked to ensure even distribution of air along each duct.
 - c) Cooling capacity test (with doors opening every 2 minutes for 30 sec) including pre-cooling from steady state environmental condition.
 - d) Ambient temperature test.

17.5.4.8.16 Fire, Smoke & Heat detection verification testing

All the requirements of clause 2.26 regarding fire, smoke and heat detection systems installed in all sub-systems of train shall be verified for conformance.

17.5.4.8.17 Obstacle deflection system:

Obstacle deflection system defined clause 11.12 shall be tested for conformance.

17.5.4.8.18 Roll back testing of train

Prevention of roll back of train while started and operated on a gradient as mentioned in clause 12.14 shall be tested for confirmation with Rolling stock system.

17.5.4.8.19 Train Coupling test

All the functionality of train couplers shall be tested at rake level with other trains as per the requirements of Chapter 4.

17.5.4.8.20 ~~Detrainment door functional operational testing: Deleted~~

1

~~Detrainment door functionality during the passenger detrainment shall be tested for conformance according to Chapter 5, Chapter 6, Chapter 13 & Chapter 14. Deleted~~

17.5.4.8.21 Validation of SEC:

Validation of SEC shall be tested for conformance according to Clause 2.25.10 & 2.25.11

17.5.4.8.22 ~~Validation of Multi-consist Train Operation: Deleted~~

1

~~Validation of Multi-consist Train Operation shall be tested for conformance according to clause 2.2.31. Deleted~~

17.5.4.9 Electromagnetic Compatibility and EMI

1

An electromagnetic compatibility and EMI test shall be performed on one ~~three~~ six car rake by methods referenced in clause 2.18 and 10.19 for compliance with those requirements and for the compatibility with CMRL's signal and communications systems. Demonstration of EMC / EMI compliance shall be considered a type test requirement. During these tests, confirmation of appropriate emissions limits as previously developed shall be conducted by monitoring the signal and communication systems functions.

17.6 PRODUCTION CONFORMANCE TESTING

17.6.1 General

17.6.1.1 These Functional and acceptance tests shall be performed on all assemblies and on all the completed rakes. Tests shall be conducted at the point of each train manufacture. Acceptance tests shall ensure that all aspects of the train performance and manufacture are at least at the same quality level as the unit presented for first article inspection, which includes conformance to specification and cited reference requirements. Factory acceptance tests shall comprise component, system, and car tests to be performed at a subcontractor's or the Contractor's facility.

17.6.1.2 The specific tests to be conducted shall be proposed in the Test Program Plan and submitted for CMRL approval. Copies of all factory acceptance tests shall be incorporated into the Car History Books, and preliminary copies of the test reports shall be provided to CMRL upon request.

17.6.1.3 All qualification tests shall be completed before the first train (Pilot train) is shipped from the Contractor's facility. Tests shall be conducted in accordance with approved test procedures. Acceptance testing procedures shall be updated based on experience gained from testing.

17.6.1.4 Testing procedures shall be expanded to focus on areas that prove to be troublesome. Tests may also be simplified in areas where a high degree of confidence is developed. The tests to be performed shall include, but not be limited to, those tests discussed in this Chapter.

17.6.2 Electrical Apparatus Testing

Each component that is separately assembled, housed, and wired into a packaged unit prior to installation in the car shall be tested at its point of manufacture and a certified test report, signed by the responsible Quality Assurance representative of the manufacturer, shall be furnished to CMRL.

17.6.3 VAC System Testing

All VAC system components shall be functionally tested by the component manufacturer before shipment and shall meet the requirements specified in Chapter 7.

17.6.4 Motors Testing

Each motor shall be given a "routine" test by the manufacturer in accordance with IEC 60349.

17.6.5 Not Used.

17.6.6 Not Used.

17.6.7 Not used.

17.6.8 Not Used.

17.6.9 Low voltage power supply production conformance tests shall include the following:

- a) High potential test in accordance with clause 17.7.4 or IEC Publication 77.
- b) Output voltage shall be adjusted to be within +1, -0 percent of the specified nominal output voltage.
- c) Output current limit shall be adjusted to be within +10, -0 percent of the Contractor's stated nominal rated output current. In the event the power supply design for current limit function incorporates two or more break points, the current or voltage setting at the additional points shall be adjusted to be within +10, -0 percent of the Contractor's stated nominal value.
- d) Over voltage and under voltage shut off points shall be adjusted to be within +1, -0 percent of the specified values.
- e) A one-half hour run at nominal output voltage as adjusted above, rated output current, and nominal input voltage.
- f) Proper functioning of safety interlocks shall be demonstrated.
- g) All other features such as time delay relays, and layover shutdown, shall be exercised and adjusted, as required, to be within +10, -0 percent of the Contractor's stated values where appropriate.

17.6.10 Battery Test

Two number of batteries supplied shall be selected at random and shall be given a capacity test at the point of manufacture in accordance with IEC Publication 623, Chapter 4.2.1 and also shall meet the requirements specified Chapter 9.

17.6.11 Brake Equipment Test

All valves shall be tested and certified for performance in accordance with manufacturer's specifications and test codes, as approved by CMRL. All electrical and electronic assemblies shall be functionally tested and certified for performance in accordance with the manufacturer's specifications and test codes, as approved by CMRL. All reservoirs and accumulators shall be tested and certified in accordance with ASME, UIC or EN Codes.

17.6.12 Communications System Test

All electrical and electronic assemblies shall be functionally tested and certified for performance in accordance with the manufacturer's specifications and test codes, as approved by CMRL.

17.6.13 Car body Water-tightness Acceptance Testing

The Contractor shall subject each car to a complete test for water tightness. Water tightness shall be conducted on Car Body including all exterior appointments or car body seams that may affect water tightness of the car body—such as destination signs, indication lights, crew switches, Doors, VAC, windows, front & rear end cabins and all equipment —shall be installed at the time of this test. Water droplets shall not enter into the coach during conduction of test as per the following specifications:

- a. Prior to the car body water test, the door shall be adjusted and tested to verify that they meet the requirements of Chapter 6.
- b. All spray applications shall run for ten minutes before the inspection for leaks begins and shall run continuously during the inspection.
- c. The test shall be performed in accordance with IEC 61133 & IEC 60529 (at least IP x5)
- d. Underfloor boxes, which are required to be watertight, shall receive a pressure water test similar to the watertightness test for the carbody.

17.6.14 Subsystem Functional Acceptance Testing

The Contractor shall demonstrate that all subsystems meet or exceed the functional requirements described in these Technical Provisions.

17.6.15 Coupler Electric Pin Signal Verification Functional Acceptance Testing

The Contractor shall demonstrate that the car meets the functional coupler electric pin signal requirements of Chapter 2.

17.6.16 Bogie Quality Testing

- 17.6.16.1 All production bogie welds including the frame and any other primary structural members shall be subjected to magnetic particle or dye penetrant inspection, except critical welds, which shall be inspected by radiography. Magnetic particle inspection shall be in accordance with ASTM E 709. Dye penetrant inspection shall be in accordance with ASTM E165. Cast bogie frames shall be 100% magnetic particle inspected. Radiographic inspection shall be continued at a rate of one bogie frame for each ten bogies produced. If defects are found during sampling inspection, the Contractor shall positively locate the beginning of such defects in previous bogie frames and apply appropriate corrective action.

17.6.16.2 Bearing Lateral Clearance

All mounted journal bearings shall be measured to verify conformance to installed lateral clearance requirements.

17.6.16.3 Wheel Back-to-Back Distance

All wheel-axle assemblies shall be measured to verify conformance with back-to-back distance requirements in clause 11.9.

17.6.16.4 Shunt Resistance

All wheels-axle-wheel assemblies shall be measured to determine the shunt resistance from wheel to wheel. The results shall be submitted to CMRL and a copy shall be inserted into the corresponding Car History Book.

17.6.16.5 Axle Runout

All wheel-axle assemblies shall be measured to verify conformance to axle runout (concentricity) requirements in clause 11.10.

17.6.16.6 Wheel Runout

All wheel disc on wheel-axle assemblies shall be measured to verify conformance to lateral and radial runout requirements in clause 11.9.

17.6.16.7 Tram and Axle Parallelism

All bogie assemblies shall be measured to verify conformance to tram and axle parallelism requirements in clause 11.6.6 and reports to be submitted in Car History Book.

17.7 CAR STATIC TESTS

- 17.7.1 The tests listed in this Chapter shall be performed on each car prior to delivery to the Designated Depot(s). The Contractor's static tests shall include all tests and adjustments which can be made prior to delivery in order to keep the post-shipment acceptance testing as specified in clause 17.8, and any subsequent adjustments, to a minimum.

17.7.2 Weighing

The Contractor shall weigh each car at the time of shipment. The weight at each bogie of the car shall be provided separately. A permanent record of the weight which shall be submitted to CMRL. Copies shall be included in the Car History Book. The weighing device shall be maintained within an accuracy of $\pm 0.2\%$. The Contractor shall submit written verification that the weighing device was calibrated within two weeks prior to the first weighing and has been calibrated at least once each year over the life of this Contract.

17.7.3 Grounding Acceptance Testing

- a. A direct current ground insulation test shall be made on each car by disconnecting all ground

wires, disconnecting the storage battery at its terminals, and performing leakage testing of each nominal voltage circuit separately.

- b. During this test, all other circuits shall be grounded. If this test shows freedom from ground connection, the high-potential test specified below shall be applied.
- c. Battery circuit resistance to ground shall be measured with a 1,000-Volt Megger or a resistance bridge instrument, or by the Volt-ammeter method.
- d. All the metal boxes, metal cabinets, cable trays, passenger access metal components & metal enclosures of each car shall be tested for earthing and grounding with the car body and with the track.

17.7.4 Hi-Potential Acceptance Testing

- a. A high-potential ground insulation test shall be performed on all circuits above battery voltage and on associated apparatus in each car. Auxiliary circuits and apparatus shall be tested at two (2) times the highest-rated voltage plus 1,000 volts AC (50 Hz) for one minute.
- b. All wires, cables and/or equipment not meeting the requirements of the tests shall be removed and replaced by the Contractor. After replacement of any such defective parts, materials, or equipment, the car shall be subjected to re-testing.

17.7.5 Wiring Continuity (Ring-Out) Acceptance Testing

All wiring circuits shall be rung out to verify continuity and proper polarity after assembly and installation of all equipment. All frame grounds and terminal connections shall be checked for tightness.

17.7.6 Leakage Acceptance Testing

- a. The Contractor shall perform a leak test on the assembled air piping system on each car in accordance with IEC 61133. A copy of the test report for each car, including retest reports if appropriate, shall be included with each Car History Book.
- b. Loss of main reservoir air pressure due to cumulative leakage in the entire pneumatic system—not including that required for system functioning, per car—shall not exceed 0.5 bar in 15 minutes, following a 5-minute settlement period from the time at which the system was fully charged, and the air compressor was shut off.

17.7.7 Doors, Operators and Controls Testing

- a. The doors and their operating equipment shall be tested and adjusted on all cars to assure smooth functioning, attainment of the required speed of operation, and proper functioning of controls, signals and interlocks, as specified in Chapter 6.
- b. All doors shall be operated a minimum of 100 consecutive, successful cycles. Initiation of the cycling shall be through the train lines. Proper forces for opening and closing shall be verified on every door before and after the above cycling.
- c. The obstacle detection feature as per the criteria mentioned in Chapter 6 shall be checked for proper operation and adjusted, if necessary, prior to the start of the cycling test. This feature shall operate properly, without the need for readjustment at the end of the cycling test.

17.7.8 VAC System Acceptance Test

The thermostatic operation of the air conditioning equipment in all cars shall be demonstrated by test. A procedure for this test, including instrumentation, devices and facility used, shall be submitted for approval. Equipment and instrumentation necessary to perform the test and to record the data indicated below shall be provided by the Contractor. All functions, including sequence of all operating modes and capacity modes, all pressure control switches, expansion and solenoid valve operation, system modulation shall be verified.

17.7.9 Headlights, Marker Lights and Tail Lights Testing

The headlights, marker lights, and tail lights on each car shall be functionally checked, aimed and adjusted to comply with clause 8.4

17.7.10 Traction Control Testing

With the traction power shut down, all electronic and electro-mechanical components of each

traction control and reverser system shall be tested for correct sequence of operation in both powering and braking modes by operating the master controller, observing the functioning of the various apparatus involved. Any component that fails to function in the proper sequence shall be repaired and the test repeated until successful before proceeding to the next sequence of the traction test series.

17.7.11 Friction Brake Testing

The Contractor shall perform a complete functional test of the friction brake system prior to shipment of each car from its facility. Tests shall include verification of the feedback command and load-weigh signals and the appropriate response; brake cylinder pressure settings, brake cylinder pressure retention time, control and indicator checks; WSP control tests, brake system leakage test; and a functional test of the brake fault detection system.

17.7.12 Communication System Testing

The PA system, cab intercom, the passenger information system and PEI (passenger emergency intercom) shall be tested for proper function, volume level and clarity of voice transmission and reception, both during standstill as well as during traction and braking. Test shall comply with requirement of Chapter 13.

17.7.13 Trainlines Testing

The Contractor shall verify the accuracy of each car's trainline connections by the use of a test panel which shall be connected to the coupler's electric head and indicate, by the illumination of lights, or other appropriate means, that the proper trainline wires are energized when all car controls, and train-lined systems are operated.

17.7.14 System Functional Verification

After completion of each car and prior to shipment, the Contractor shall demonstrate that each car subsystem is operational. The tests shall be conducted by activating main power of the car and functionally test all car systems. The test procedure for this test shall include and use a check list that shall become a record that all systems have been actuated and have functioned as required.

17.7.15 Di-Electric testing:

Di-electric testing shall be conducted on all the AC and DC cables of train in a separate chamber in a safe manner. Reports shall be part of the Car History Book Volume 1.

17.8 POST-SHIPMENT ACCEPTANCE TESTING

On-site acceptance tests shall be conducted on all train of CMRL. Tests shall be properly conducted by the Contractor on each trainset to demonstrate conformance of the cars and train consist with these Technical Provisions. The sequence of verifications and testing at CMRL site shall be as specified below:

a) Arrival Inspection

A joint inspection shall be performed by the Contractor along with CMRL to demonstrate that no transit related and loading / unloading damages have occurred to the cars or its components. Any damages/issues found during this inspection shall be corrected by the Contractor at his own cost to the satisfaction of CMRL. For joint arrival inspection, the Contractor shall make the train formation by connecting all the mechanical, pneumatic and electrical connections between cars.

b) Miscellaneous Body Tests and Adjustments (MBT)

Shall comply as per requirements of clause 17.8.5

c) Non-Regression Static test (NRT)

All the equipment of train and its sub-systems shall be tested for functionality after completion of Miscellaneous Body tests & adjustments. This test shall be conducted at the Designated Depot(s) in train static condition as per requirements of clause 17.8.2.

d) Routine Dynamic test (RDT)

After the approval of NRT test report by CMRL, further the Contractor shall demonstrate the

fitness of all components of train in dynamic condition in mainline of the CMRL corridors. Shall comply as per requirements of clause 17.8.1.

17.8.1 Routine Dynamic Tests

- a. After receipt of the rake at the designated delivery point and before passing into regular operation, each rake shall be inspected and tested with CMRL. Any part, device, or apparatus requiring adjustment, repair, or replacement will be called to the attention of the Contractor, who shall make adjustment, repair, or replacement at the Contractor's own expense.
- b. All aspects of car construction and manufacture that cannot be tested at the Contractor's facility shall be tested at this time. Testing shall include verification of trainline operation for ~~three-unit~~ ~~six-unit~~ train consists. Test procedures for rake acceptance tests on CMRL property shall be submitted at least three months in advance.
- c. CMRL reserves the right to make, operating tests of each rake separately. The Contractor shall assign a competent representative to witness such operating tests. Any defects disclosed by such tests in apparatus, materials, or workmanship shall be corrected at the Contractor's expense.
- d. The Contractor shall bear all expenses and costs incurred in the removal of cars from the designated delivery point for correction of defects. If any rake is delivered to CMRL that has previously been rejected, the Contractor shall bear all expenses for acceptance testing that must be repeated.
- e. During acceptance testing, each rake shall be operated in dynamic condition by the Contractor to demonstrate proper performance of all equipment at all speeds necessary to cycle the control equipment. The following characteristics shall be monitored and recorded on a chart recorder and the results shall become the property of CMRL:
 - Time and distance
 - Acceleration and deceleration rate
 - Jerk rate
 - All auxiliary voltage levels
 - Traction motor current and voltage for each motor group (if used)
 - Brake rate
 - Analog rate control signal
 - Speed
 - All trainline signals.
 - Fault information
 - Any further information required for train operation in dynamic condition.

17.8.2 Non-Regression Static test (NRT)

All the individual equipment functions of train and its sub-systems shall be tested for compliance. This test shall be conducted at the Designated Depot(s) in train static condition. This test shall be conducted after completion of Miscellaneous Body tests & adjustments in train.

17.8.3 Communication System Acceptance Tests

The Contractor shall perform the necessary tests to demonstrate compliance with the requirements for all carborne communication equipment as defined in Chapter 13. The PA system and Passenger Emergency Intercom shall be tested for clarity of voice transmission and reception as part of non-Regression test and Routine Dynamic Tests in static and dynamic conditions respectively.

17.8.4 VAC System Acceptance Test

All functions of VAC system as per Chapter 7 shall be tested and recorded as part of non-Regression test and Routine Dynamic Tests in static and dynamic conditions respectively.

17.8.5 Miscellaneous Body Tests and Adjustments

The following tests and adjustments shall be performed at the acceptance site on each ~~three-car~~

six-car rake prior to Non-Regression Static testing at CMRL.

- a. Bogie clearances, car dimensions, and car height shall be verified.
- b. Couplers shall be verified for proper alignment and level.
- c. Air springs, if used, shall be adjusted to within the specified air pressure design tolerance.
- d. All mechanical clearances related to moving components of train shall be proposed by the Contractor in this verification

17.9 INTEGRATED TESTING AND COMMISSIONING:

17.9.1 The Integrated test procedures for all trains shall include, but not limited to, the necessary tests related to each train to verify the functioning with the Designated Contractors responsible for the following systems as per the Interface requirements of Appendix C:

- a) Signalling and Train Control Contractor (STC)
- b) Telecommunication TETRA Contractor
- c) Platform Screen Door Contractor
- d) Railway Electrification, Power Supply Contractor
- e) Track works Contractor
- f) Civil Constructions for elevated, at grade and underground sections
- g) Depot Machinery and Plant Supply
- h) Tunnel Ventilation system
- i) Other Rolling Stock Contractor
- j) Any other CMRL system which require interface with Rolling stock or train's operation.

17.9.2 Integrated testing of each train shall comply with the accepted international standards agreed between the Contractors and agreed with the CMRL.

17.9.3 Integrated testing specific to each train shall be done at the Rolling Stock factory, depot and main line of CMRL to ensure satisfactory performance of all train control, STC, telecommunications and PSD interfaces.

17.9.4 Integrated tests subsequently shall be signed-off jointly by the Rolling Stock, Signalling & Train Control, Telecommunications and PSD Contractors.

17.9.5 For ~~ATO and other non-ATO~~ UTO and other non-UTO modes of operation, the Integrated test between the Rolling Stock, Signalling & Train Control, Telecommunications and PSD Contractors shall include tests on mainline to confirm below minimum features:

- a) realization of demanded acceleration rate, deceleration rate, Jerk in all ~~ATO and non-ATO modes~~ UTO and non-UTO modes of operation as per the requirements of Chapter 2 & Appendix C
- b) train stopping accuracy in stations,
- c) synchronization with PSDs,
- d) automatic train operation with all the train controls from OCC/BCC/DCCs of all depots,
- e) Train RTR-DMS data transmission to OCC server and display of fault information at OCC and Depot controller console as per the requirements of clause 14.11 & 14.13.
- f) Verification of alarms and other vital information transmission from train to OCC and vice versa.
- g) Passenger to OCC communication and vice versa
- h) Train radio verification Automatic passenger announcements in train and manual announcement from OCC
- i) Live streaming of external CCTV images of train in CCTV monitor screens OCC, BCC & DCC. All internal and external camera's live footages shall be accessible from OCC, DCC and from the nearest two station SCRs (either side of the train in mainline).
- j) Automatic route related passenger announcements in train

k) Any other requirements in Chapter 13, Chapter 14 and Appendix C.

1

l) Any other requirements that need to be tested for ATO & UTO operation of trains from initial passenger service.

17.9.6 RS Contractor shall highlight any other required interface testing in the test plan.

17.9.7 All the above requirements shall be tested in all the sections of Corridor 3, corridor 4 and corridor 5 and their extensions if any.

1

17.9.8 ~~ATO~~ UTO shall be the predominant mode of operations. The Contractor shall develop and submit the detailed scheme for tests (in addition to the tests mentioned in clause 17.9) required to be done for the safe and reliable operation in ATO mode. Contractor shall successfully conduct these tests. CMRL shall witness these tests.

17.9.9 Testing of Chapter 17.9 shall be conducted only after successful completion of testing & verifications of clause 17.8.

17.9.10 These tests mentioned in clause 17.9 shall be completed before the start of the Service trials for each train individually.

17.9.11 All the details of clause 17.9 shall be proposed by Contractor after interfacing with other interface Contractors shall be submitted to CMRL for approval.

17.9.12 The Rolling Stock Contractor shall demonstrate GoA4 compliance with Signalling and/or Other Designated Contractors and/or by demonstrating the requirements using Simulated Test Conditions.

17.9.13 **UTO Test:** The Contractor shall carry out comprehensive testing of trains in UTO mode, including automatic train control, station stopping, door operations, emergency handling, and fail-safe functions. All testing shall be coordinated with CMRL to ensure uninterrupted passenger operations and all results shall be submitted for review.

1

~~17.10 BURN-IN TRIALS / SERVICE TRIALS IN ATO GoA2~~ BURN-IN TRIALS / SERVICE TRIALS IN ATO (GoA2) & UTO (GoA4):

1

17.10.1 All trains shall be subjected to pre-revenue BURN-IN / service Trials in network of CMRL Phase 1 & Phase 1 extension in ATO mode during initial phase of commissioning and subsequently in UTO mode. Service trials are simulated passenger trials and are intended to prove not only the satisfactory running performance of the trains, but also to enable practical evaluation of their reliability in service, in parallel with the work of other Designated Contractors, and adequacy of the trains and equipment for all performance requirements envisaged in the specification.

1

17.10.2 ~~Service Trials for all three-car rake other than the Prototype Train shall be carried out for 2000Kms for each train. Service trials/Burn In trials for Prototype Train shall be conducted for a minimum of 10,000 Kms. All Service trials/Burn In trials shall be conducted in GoA2 ATO mode only.~~

Service Trials for all six-car rake other than the Prototype Train shall be carried out for 2000Kms for each train in ATO mode initially and additional 1000Kms for each train in UTO mode subsequently. Service trials/Burn In trials for Prototype Train shall be conducted for a minimum of 10,000 Kms in ATO mode initially and additional 2000Kms in UTO mode subsequently.

17.10.3 The Contractor shall submit the Service Trial Procedure for review and approval of CMRL, enlisting the various operability and maintainability aspects to be performed during the service trials.

1

17.10.4 Before starting the Service Trials, the Contractor shall ensure to obtain the ATO / UTO train fitness from concerned Signalling and Telecom Contractor, as applicable.

1

17.10.5 RS Contractor shall make all necessary arrangements including temporary provisions in his system to ensure safety during service trial period under ATO / UTO mode. CMRL shall arrange competent train operator for trials. The Contractor shall depute staff to monitor the performance of the trains during these trials. Any failure found during the trial shall be diagnosed and repaired expeditiously by the Contractor at the Contractor's expense. Any failure observed in Service trials shall be attended by Contractor immediately. The train shall continue in the next trial only after

rectification of all the failures by Contractor.

17.10.6 Successful completion of service Trials with the rectification of all failures/issues observed during the trials shall be one of the pre-requisite for providing the conditional acceptance for each train.

1 17.10.7 Contractor shall submit a report confirming that the Rolling Stock is safe and ready for commencement of revenue service in ATO / UTO mode after closure of all the below mentioned points:

- a) Upon successful completion of Service trials in ATO / UTO mode & rectification of faults observed.
- b) upon rectification of faults observed during all the testing prior to service trials,
- c) upon closing of all the pending snag/open/quality issues related to inspections conducted in manufacturing plant
- d) Upon conducting a quality inspection of train in de
- e) pot and closing of all points observed.
- f) Upon intensive cleaning of train interior, exterior, roof & underframe.

2 17.10.8 Burn-in trials / Service trials in ATO (GoA2) will be considered for Revenue Operation / Employer's Taking Over. Burn-in trials / Service trials in UTO (GoA4) is for the purpose of demonstration and payment for Price Centre RS-F2.

17.11 SUBMISSIONS FOR STATATORY APPROVALS:

17.11.1 The Contractor shall be responsible for all necessary submissions required to obtain all statutory approval(s) necessary to permit the fleet to enter revenue operation. Entities involved shall include but not be limited to: Research Designs and Standards Organisation (RDSO), Ministry of Railways (MoR) and Commissioner of Metro Railway Safety (CMRS).

The Contractor shall identify the requirements based on the latest prevailing legislation and ensure that the Master Schedule Program identifies appropriate document submission deadlines which reasonably allow for the lead-times required to obtain statutory approvals in order that the planned revenue operation start dates of the wider Chennai Phase-II programme are not compromised.

1 The following are the list of Documents to be referred for the Documents related to Statutory certification.

- a. Procedure for Safety Certification and Technical Clearance of Metro Systems by RDSO – Latest revision along with all amendments issued by RDSO/Gol.
- b. Technical Circular No. 48 – Guidelines for Inspection of Rolling Stock, Opening of Metro Railways and Periodical Inspection of Operational Metro Railways – Latest revision along with all amendments issued by CRS/Gol.
- c. The Indian Electricity Rules for EIG inspection and certification.

For guidance, the following submissions of documents (Mechanical & Electrical) required for statutory approvals,

17.11.2 Brake System

- a) System description of air supply and brake system, Standards followed.
- b) Train brake calculation including Emergency braking distance and details.
- c) Technical details of Air Compressor as supplied by OEM (CFM, Max. Pressure, Operating pressure, Cut-in and Cut-out pressure etc.).
- d) Air consumption calculation.
- e) Brake and piping diagram.
- f) Wheel slip and slide protection document

17.11.3 Bogie System

- a) System description of bogie.

- b) Drawings and Design Data for Bogie.
- c) Finite Element Analysis Report of Bogie Frame duly accepted and signed by Rolling Stock Head.
- d) Fatigue test data of bogie frame and endurance parameters calculations.
- e) Thermal calculation of wheel.
- f) Axle strength Calculation Powered axles.
- g) Axle strength calculation Non – Powered axles.
- h) Life rating calculation of axle box bearing.
- i) Suspension drawing and design parameters.
- j) Driving Motor Bogie assembly drawing
- k) Trailer Bogie assembly drawing
- l) Driving Motor (DMC) wheel set assembly drawing
- m) Wheel drawing for all type of Coaches
- n) Trailer Coach (TC) wheelset assembly drawing
- 17.11.4 Vehicle Dynamic Analysis on Track Data as Specified by Metro Administrations – Vehicle Model
 - a) Natural frequencies of the suspension system (consisting of all the springs and dampers).
 - b) Stability / Safety of bogie (Conforming to the Limiting value $\Delta Q/Q < 0.5$ and $Y_{rms}/Q < 1$) (Results of simulation software) up to design speed with AW0 and AW4 load at critical
 - c) curves in Inflated and Deflated Secondary spring condition)
 - d) Wheel / track off-loading.
 - e) Bogie rotational resistance calculation results.
 - f) Wheel wear index at the tread and flange.
 - g) Lateral force and derailment quotient.
 - h) Ride index.
 - i) Acceleration values of car body and bogie frame.
 - j) Criteria for assessment of riding behaviour of vehicle.
 - k) Kinematic Envelope (KE) Calculation
- 17.11.5 Finite element Analysis of car body structure as per manufacturer
- 17.11.6 Relative movement between coaches / coach and bogie
 - a) Coupler movement calculation
 - b) Gangway movement calculation for specified radius.
 - c) Calculation of relative movements between coach and bogie on different degrees of curvature.
- 17.11.7 Passenger Saloon Door description & drawing.
- 17.11.8 Coupler – Technical description
 - a) Front Automatic Coupler drawing
 - b) Semi-Permanent Coupler half (with GH) drawing
 - c) Semi-Permanent Coupler half (with Rigid Bar) drawing
 - d) Semi-Permanent Coupler drawing
- 17.11.9 Fire Safety System
 - a) Fire load calculation : Design calculation of Fire load above & below body frame.
 - b) Fire Protection System and compliance to relevant International Standards (duly accepted and signed by Rolling Stock Head).
 - c) Measures for emergency evacuation of passengers.
- 17.11.10 Crashworthy Simulation as per EN 15227 and GMRT 2100 (duly accepted and signed by Rolling Stock Head).

- 17.11.11 Description of Metro Coaches and Pay load calculation.
 - a) Layout of train formation
 - b) Layout of Driving Motor / Driving Trailer Coach
 - c) Layout of Trailer Coach
- 17.11.12 Weight particulars of stock
- 17.11.13 Test Procedure of various systems to be given for information
 - a) Test Procedure of Dynamometer test.
 - b) Test Procedure of Brake calliper unit.
 - c) Test Procedure of Static and Fatigue tests of bogie frame.
 - d) Test Procedure of Bogie Rotational Resistance test.
 - e) Procedure of Oscillation trials.
 - f) Test Procedure of Wheel offloading test.
 - g) Test Specification of Coupler.
 - h) Test Procedure of Wheel.
 - i) Test Procedure of Wheel set.
 - j) Test Procedure of Solid Axle.
- 17.11.14 Following Design Calculations to be furnished for records sake
 - (i) Adhesion calculation.
 - (ii) Gear pinions, analysis of stresses, selection of bearing, gear case and transmission assembly.
 - (iii) Tractive and braking effort vs speed curves showing balancing speed.
 - (iv) Curves of efficiency, power factor, frequency, slip as a function of speed.
 - (v) Traction Motor performance curves.
 - (vi) Harmonic calculations.
- 17.11.15 Following drawings to be furnished for information.
 - (i) Schematic diagram of power, dynamic braking, control, and auxiliary circuits including multiple operations.
 - (ii) Tractive effort transmission diagram.
 - (iii) Brake system schematic diagram.
 - (iv) Drawing showing mounting arrangement of traction motor.
 - (v) Motor suspension arrangement.
 - (vi) Power converter cooling arrangement
 - (vii) General arrangement for wheel slip detection and correction system.
 - (viii) Drawings for Pantograph / third rail current collector.
 - (ix) Air Conditioning arrangement
- 17.11.16 EMI / EMC compatibility, test plan & results
- 17.11.17 Simulation results for TE, BE, Performance curves for Rolling Stock for identified section of Metro.
- 17.11.18 Details of electrical protection system of metro unit, various equipment and their subassemblies.
- 17.11.19 Safety plan and standards followed and references for proof of major assemblies and sub-assemblies.
- 17.11.20 Design details of cables, relays, switchboards, earthing, lighting arrestors, TCMS with interfacing documents, Convertor and Auxiliary Convertor, Battery including load calculations
- 17.11.21 [Technical Specification on Rolling Stock covering pantograph/current collector, main transformer/High Speed Circuit Breaker\(HSCB\), VCB, traction motor, traction converter/Inverter.](#)
- 17.11.22 [Technical Specification on Rolling Stock covering Auxiliary Supply System and Battery Charger,](#)

Battery, HVAC, TCMS, Cables.

- 17.11.23 Technical Specification on Rolling Stock covering Relay, Earthing Concept, Surge Arrester, PT, CT.
- 17.11.24 Electrical control drawings of all systems.
- 17.11.25 Dynamometer car test report.
- 17.11.26 Cable type test report
- 17.11.27 Climatic chamber test report
- 17.11.28 Safety Integrity Level (SIL) certificates for TCMS, Service Brake, Holding Brake, Wheel Slide Protection (WSP), Emergency Brake, Passenger Door, Fire and Smoke Detector, Obstacle Deflection, Detection and Derailment Detector (ODDD) fire suppression system and applicable subsystems in the Train to be made available. The contractor shall submit the certificates at least 4 months prior to the commencement of service trials of the Prototype train. The certificates shall be issued by the employer approved independent third-party certification body.
- 17.11.29 The Contractor shall submit the Train Level Safety Case demonstrating compliance with applicable safety international standards and system safety requirements at least four (4) months prior to the commencement of service trials of the Prototype train.

18. SYSTEMS ASSURANCE

18.1 NOT USED

18.2 SYSTEM ASSURANCE STANDARDS

- 18.2.1 The Contractor is required to provide a car that is safe, reliable, and readily maintainable. The detailed requirements as identified within this Chapter provide processes and metrics designed to provide evaluation of the car.

18.3 SYSTEM ASSURANCE PROGRAM PLAN

- 18.3.1 The Contractor shall develop and implement a Systems Assurance Program Plan that describes the organization and process by which the Contractor will integrate systems assurance activities. The system assurance program shall be maintained through the duration of the Contract until completion of defect notification period of last train.
- 18.3.2 The elements of the Contractor's systems assurance program shall be imposed on all entities within the Contractor's organization and on all subcontractors. The Contractor shall assure conformance with the system assurance program requirements of all such entities. The Contractor shall make available for CMRL review and inspection, all procedures, plans, manuals, and any other documentation to be used to ensure conformance.
- 18.3.3 The Systems Assurance Program Plan shall include plans for system safety, reliability, maintainability, availability and quality assurance. These may be submitted by the Contractor as individual documents or compiled into a comprehensive plan. In any case, the elements of the Systems Assurance Program Plan shall be fully integrated and consistent with one another. If separate plans are submitted for safety, reliability, availability, maintainability and quality, they shall all be considered to be a document submission, with delivery dates as per the System Assurance Program Plan.

18.4 SAFETY AND REGULATORY REQUIREMENTS

The safety goals shall be in accordance with the NFPA or EN safety guidelines, local rules and regulations and stipulations of local fire authorities.

- 18.4.1 CMRL cars shall be designed and constructed to be safe for passengers, persons near the car, and employees, both under normal operating conditions and in the event of equipment failure or malfunction. The Contractor shall ensure that all systems' safety aspects are considered for each individual system and for systems as integrated to complete the car design.
- 18.4.2 Conflicts between performance and safety requirements will be addressed on a case-by-case basis. The guidelines for resolution of conflicts will be as follows:
- a) Applications which, in accordance with the requirements of this section, are determined to have a significant impact on passenger safety will conform to applicable safety requirements. Requirements for other material characteristics or properties will conform to that of materials typically used for the application that are available at the time of award of contract. Typical examples of this application are materials used in the interior of the car body.
 - b) Applications which do not meet the criteria described in the previous paragraph will require conformance to all operational, performance, service, and maintenance requirements.
- 18.4.3 All equipment shall comply with applicable codes, standards, and regulations cited in clause 18.4.4 and elsewhere in this Specification. Where conflicts exist between standards, the more restrictive, as determined by CMRL, shall apply.
- 18.4.4 All equipment of Rolling stock shall comply with applicable:
- a) Local building bye-laws;
 - b) relevant published standards of UIC;

- c) all Statutory requirements, guidelines and directives; and
- d) Stipulations of fire service department.

18.5 SYSTEM SAFETY

The quality measures of hazard severity and risk acceptance shall conform to EN 50126 / IEC 62278 / higher standard. Rolling Stock safety systems shall conform to EN 50126 / IEC 62278, EN 50129 / IEC 62425 / as approved by CMRL.

18.5.1 System Safety Program Plan

- 18.5.1.1 The Contractor shall develop and implement a System Safety Program Plan (SSPP) that defines the activities, management controls, and monitoring processes by which the Contractor shall ensure that safety considerations, compatible with other system requirements, are incorporated into the design of the car to minimize the potential for accidents.

Components critical for safety shall be 'fail safe' or 'checked redundant'. The system safety plan shall identify and list safety critical components, which list shall be updated periodically during the Concession Period.

- 18.5.1.2 The SSPP shall contain the following information as a minimum:

- a) Specific information showing how the Contractor shall verify attainment of system safety requirements during design and test phases.
- b) Description of organizational relationships and personnel responsible for system safety. The contractor shall set up an organization that satisfies the requirements defined in the EN50129 standards. The Contractor's System Safety Engineer shall report to the Contractor's Project Manager through the Safety Director. If a different organizational approach is used, the Contractor shall demonstrate that independence of safety analysis is assured.
- c) Procedures to ensure that the Contractor's system safety personnel participate in all design reviews and approve all safety-related elements of this Contract.
- d) Detailed listing, description, and schedule of specific tasks
- e) Procedures for reporting, recording, and resolving hazards identified during design, installation, and testing.
- f) Schedule indicating key milestones to ensure that system safety activities are performed in a timely manner.
- g) Description of hazard categorizations and safety design standards as required by this Chapter.
- h) Description of the process by which the Contractor will certify the safety of the car and major systems.
- i) Verification and traceability matrix to the design specifications and SSPP.

18.5.2 Hazard Categories

This Chapter describes the hazard categories that must be considered by the Contractor for the design of the car and its systems to be judged safe.

18.5.2.1 Category I – Catastrophic

The category includes equipment failures, human errors, and/or external circumstances that result in multiple fatalities, destruction of cars, or damage to stations or track segments such that affected segments of the transit system cannot operate for an extended period. Category I hazards result in a major accident or catastrophe, such as destruction of a rake with fatalities. Effective or timely corrective action by the train Operator / ATO / UTO is not realistically possible.

18.5.2.2 Category II – Critical

The category includes equipment failures, human errors, and/or external circumstances that result in extensive damage to equipment, physical distress such that train Operators cannot be relied upon to perform their tasks accurately or completely, or adverse effects on the traveling public, including up to a few severe injuries or, exceptionally, a fatality. The rake or affected fixed facility is in jeopardy unless proper corrective action occurs quickly enough and is effective

enough to prevent the condition from progressing to Category I.

18.5.2.3 Category III – Marginal

The category includes equipment failures, human errors, and/or external circumstances that reduce the capability of the transit system or the ability of Operators to cope with adverse operating conditions to the extent that, for example, safety margins or functional capabilities are degraded; equipment sustains non-disabling damage; conditions occur that impair Operator efficiency; or the traveling public experiences some minor injury, discomfort, or danger. Although safety margins may be significantly reduced—for example because of loss of redundancy or forced operation on backup systems—rakes, fixed facilities, or personnel are not in *immediate* danger. A subsequent increase in the severity of the hazard requires an additional failure or gross error by Operators.

18.5.2.4 Category IV – Negligible

The category includes equipment failures, human errors, and/or external circumstances that do not significantly reduce safety and that require a response well within the capability of the Operator. Negligible hazards may include, for example, a slight reduction in safety margins or functional capabilities; a temporary and slight increase in Operator workload, such as manual rake operation; or some inconvenience to the traveling public. Category IV hazards are considered nuisance events or at worst, hazards only when coupled with incompetent operation or action.

18.5.3 System Safety Criteria and Acceptability

18.5.3.1 System Safety Criteria

- a. The Contractor shall define design criteria to ensure that system safety objectives are implemented throughout all phases of design development, manufacturing, testing, delivery, operations, and maintenance. The Contractor shall submit for approval a System Safety Program Plan (SSPP) that defines the activities, management controls, and monitoring processes by which the Contractor shall ensure that safety considerations, compatible with other system requirements, are incorporated into the design of the car to minimize the potential for accidents.

The SSPP shall demonstrate that the Contractor has a clear understanding of system safety requirements and has an organization in place that can identify safety hazards and performing analyses to verify that they have been eliminated or adequately mitigated.

- b. The following criteria, as a minimum, shall be adopted by the Contractor:

- (i) Potential / actual hazards identified through analyses shall be mitigated in accordance with the following order of precedence:
 - I. Use of design techniques
 - II. Use of safety devices
 - III. Use of warning devices
 - IV. Use of special procedures.
- (ii) No single-point failure shall result in or produce the potential for Category I / Category II hazard. Multiple, latent, undetected failure modes shall be considered as a single-point failure.
- (iii) The car design shall incorporate component interlocks wherever an out of sequence operation could cause a Category I / Category II hazard.
- (iv) Emergency equipment shall be provided for public use and shall be clearly identified and readily accessible.
- (v) The following redundancy requirements shall be met:
 - I. Where redundancy is used in safety-critical areas, there shall be no single-point failure that could result in loss of safety
 - II. Redundant paths shall not contain a common mode failure
 - III. Failures in a redundant element or circuit shall annunciate to the OCC / BCC operator, DCC operator and rake Operator,

IV. Inspection intervals and procedures shall be specified to ensure that both paths are operational.

18.5.3.2 Acceptable Hazard Probability

- a) The Contractor shall implement a process for determining acceptable hazards, based on hazard severity and probability of occurrence. In general, the more severe the hazard, the more unlikely it should be.
- b) For the determination of Hazard Probability, the Contractor shall use the following Hazard Probability Classifications:
 - A – Frequent – Likely to be experienced continuously
 - B – Probable – Likely to be experienced recurrently
 - C – Occasionally – Likely to be experienced occasionally
 - D – Remote – Likely to be experienced on only rare occasions
 - E – Improbable – So unlikely that it can be assumed it will never occur
- c) The Contractor's analysis shall demonstrate that the design meets the following requirements:
 - (i) Category I hazards shall not be expected to occur during the entire operational life of the car. Based on the operating hours and life of the base-order fleet (refer clause 1.4 and 2.3), the probability of Category I hazards shall be shown through analysis to be less than 1.0×10^{-9} per Train-hour of operation for each hazard [Probability E].
 - (ii) Based on the operating hours and life of the base-order fleet (refer clause 1.4 and 2.3), the probability of Category II hazards shall be shown through analysis to be less than 5.0×10^{-7} per train-hour of operation for each hazard [Probability D].
 - (iii) Category III hazards shall be resolved using standard fail-safe engineering practices.
 - (iv) No special safety measures are required for Category IV hazards.
 - (v) Probabilities shall be based on all sources of the category hazard, not only individual sources.

18.5.4 Safety Analysis

18.5.4.1 The Contractor shall assess the effect upon safety of malfunction or failure of the car and of car systems, subsystems, and line replaceable units, including their interfaces. The Contractor shall examine the effects of car interfaces with other transit elements such as signalling, facilities, support equipment, operational procedures and environments, and maintenance programs. Interface management requirements have been developed and are included in Volume 2 – General Provisions of the contract documents. During the design phase, the Contractor shall perform safety analyses that accomplish the following:

- a) Identify potential hazards and establish appropriate safety criteria.
- b) Assess the design, based on safety criteria.
- c) Modify the proposed designs as necessary to satisfy the safety criteria.
- d) Demonstrate compliance with the criteria.

18.5.4.2 The Contractor shall coordinate the format for all safety analyses with CMRL to enable a seamless integration of the passenger car safety analyses into CMRL's system-wide safety effort.

18.5.4.3 Preliminary Hazard Analyses

- a) The Contractor shall develop and implement a Preliminary Hazard Analysis (PHA). The PHA shall provide a systematic, high-level examination of all proposed system elements in order to identify and classify potential hazards to the overall transit system.
- b) The PHA shall be created following a CMRL approve format.
- c) The PHA shall address the vulnerability of system functions, rather than assess any particular hardware or software design. The PHA shall be qualitative and shall be conducted using experienced engineering judgment.
- d) The PHA shall develop safety design requirements for the system and establish the framework for subsequent safety analyses. It shall provide information about potential hazards and assign a

hazard severity and hazard probability categories to each as detailed in clause 18.5.3.2 b and c above.

- e) Each identified hazard shall be assigned a Risk Index derived from the following table:

Risk Index Severity Table 18-1

Probability	Catastrophic (1)	Critical (2)	Marginal (3)	Negligible (4)
Frequent (A)	1A	2A	3A	4A
Probable (B)	1B	2B	3B	4B
Occasional (C)	1C	2C	3C	4C
Remote (D)	1D	2D	3D	4D
Improbable (E)	1E	2E	3E	4E

- f) In addition to those hazards identified by the Contractor, the following hazards shall be considered Category I or II and shall be included in their respective PHA:
- (i) Doors un-lock on wrong side of car.
 - (ii) Door un-lock at a car speed greater than zero speed and brakes are not commanded.
 - (iii) Door closes on person or object and indicates that the door is closed and locked.
 - (iv) Door proving loop erroneously indicate that the door is closed and locked.
 - (v) Train rolls back or moves in an un-commanded direction.
 - (vi) Friction brakes are completely non-functional.
 - (vii) Dynamic regenerative brakes are completely non-functional.
 - (viii) Friction and dynamic regenerative or other brakes are non-functional on a train.
 - (ix) Propulsion is not removed when requested.
 - (x) Safety grounds are lost / another failure occurs that exposes persons to injurious voltages.
 - (xi) Failure to apply full service or emergency braking when requested.
 - (xii) Failure of parking brake to hold the rake under AW4 condition on critical gradients.

18.5.4.4 Failure Modes and Effects Criticality Analyses

- a) The Contractor shall develop a Failure Modes and Effects Criticality Analysis (FMECA). The FMECA shall provide a systematic, comprehensive, bottom-up evaluation that uses design data to analyse the effects their Criticality of potential component failures in a system, as installed.
- b) The FMECA shall assess the impact of failures on subsystem and system operation, and consequently on the operational safety of the transit system. The FMECA shall assess all failures that could cause or contribute to Category I / II hazards.
- c) FMECA analysis shall be submitted for both component level FMECA and Functional level FMECA for all Sub-systems and functions of Rolling Stock.

18.5.4.5 Sneak Circuit Analysis

The Contractor shall perform a Sneak Circuit Analysis (SCA) to detect functional and/or Category I / Category II safety problems that could arise from wiring faults or errors and shall submit the analysis for approval. The SCA shall ensure that there are no unintended circuit paths that will result in functions other than those intended. The SCA shall be performed for the overall car and shall consider interfaces with subcontractor-supplied equipment and coupler-pin assignments.

18.5.4.6 Operating and Support Hazard Analysis

The Contractor shall develop an Operating and Support Hazard Analysis (O&SHA). The analysis shall evaluate the operating and maintenance procedures of critical systems to ensure that neither Operator error nor incorrect maintenance gives rise to unwanted system effects. Critical systems are defined as those in which a failure could cause or contribute to a Category I or II hazard.

18.5.4.7 Fault-Tree Analyses

The Contractor shall perform a Fault-Tree Analysis (FTAs) that quantify the probability of each Category I and Category II hazard identified in the PHAs. The FTAs shall consider all interfacing items that, in conjunction with the analysed system, could lead to the occurrence of the identified hazard. FTA shall comply with IEC 61025.

18.5.4.8 Hazard Mitigation Traceability Matrix

The Contractor shall develop and maintain a matrix of all Category I, II and III hazards. The matrix shall describe each hazard and its ultimate resolution and identify its current status. The resolution of each hazard must be verified by identifying a specific drawing, procedure, analysis, or report. The Contractor shall submit updates of the list each month as part of the monthly progress report (ref. clause 16.8.4).

18.5.4.9 Operating and Maintenance requirements

The Contractor shall define, draft and submit to CMRL for approval all the operating and maintenance requirements that the Contractor considers necessary to reach the safety objective.

18.5.5 Fail-Safe Design Requirements

18.5.5.1 All safety-critical applications shall be designed to be fail-safe. Equivalent methods of design will be considered, based on the Contractor's substantiation, and will be subject to approval by CMRL.

18.5.5.2 Fail-safe circuits shall be based on closed-loop principles; that is, the occurrence of such conditions as broken wires, damaged or dirty contacts, failure of relays to respond when energized, or a loss of power supply energy shall not result in unsafe conditions.

18.5.5.3 Self-detecting component or system failures shall cause the rake to stop or run at a safer, more restricted speed than the speed permitted with no failure.

18.5.5.4 Component or system failures that are not self-detecting shall not cause unsafe conditions, even if added to other failures.

18.5.5.5 Any number of simultaneous component or system failures attributable to the same cause or related causes, shall not cause unsafe conditions.

18.5.5.6 Any component / wire becoming grounded / any combination of such grounds, shall not cause unsafe conditions.

18.5.5.7 CMRL shall have the right to audit the design of any software used in a fail-safe application.

18.5.5.8 Electronic fail-safe circuit design shall provide protection against the following types of component failures:

- a. Two-terminal devices: Open, short, partial open, or partial short
- b. Multi-terminal devices: Any combination of opens, shorts, partial opens, or partial shorts.

18.5.5.9 Any amplifier breaking into spurious oscillations shall not result in an unsafe condition.

18.5.5.10 Filters used in fail-safe circuits shall be passive and shall be designed to prevent undesired signals from passing through the filter at a level which could cause unsafe conditions, even in the event of component failures within the filter. Exceptions to this requirement shall be justified and subject to approval.

18.5.5.11 Fail-safe equipment shall undergo type acceptance testing, as specified in Chapter 17. Type acceptance testing of components shall consist of bench tests on breadboard or prototype units as directed by CMRL. Type acceptance testing of systems or subsystems shall consist of bench testing and/or field testing of the unit, as directed by CMRL. All expenses incurred by the Contractor during type acceptance testing shall be borne by the Contractor.

18.5.6 Fire and Life Safety

18.5.6.1 The entire car and its components, subsystems, and systems shall comply with the requirements of EN 45545 Part 1 to 7 (Category 4-A, Hazard level HL3) as defined in Chapter 2. Measures shall be adopted to minimize injury due to fire, smoke, explosion, or panic due to fire. Measures shall be adopted to protect equipment from damage by fire or explosion. The Contractor shall develop a Fire and Life Safety Report and submit to CMRL for approval. Documenting all design and test efforts taken to comply with the requirements of this Chapter, NFPA 13, BS 6853, EN

- 45545 or the Japanese Standards. Fire barriers shall comply with the requirements of EN 45545-3.
- 18.5.6.2 The car shall be designed to prevent penetration of an under floor or roof fire to the car interior, as specified in clause 19.61 and 17.3. Fire stops shall be provided at floor and roof penetrations. Equipment shall, whenever practicable, be located outside of the passenger compartment. Enclosures for control and other critical equipment shall provide protection against environmental contamination and mechanical damage.
- 18.5.7 Safety Tests
- Specific tests shall be performed to demonstrate that mitigation measures provided for any Category I / Category II hazard are fully effective. The Contractor shall submit to CMRL a list of such tests.
- 18.5.8 Safety Assessment
- The Contractor shall support CMRL and actively participate in the safety assessment of the metro project by the Commissioner of Metro Railway Safety (CMRS). Therefore, the Contractor shall:
- (a) provide to CMRL all the documentation that the CMRS could require for his assessment,
 - (b) assist CMRL during the CMRS statutory inspection.
 - (c) prepare and submit to CMRL a Specification Conformance Checklist. This checklist shall make it possible to ensure that Rolling Stock is compliant to all the applicable regulations, rules and standards, and provide the references of the related test reports and certificates.

18.6 RELIABILITY PROGRAM

- Reliability, Availability, Maintainability and Safety (RAMS) requirements and goals shall be developed in terms of Mean Distance Between Failures (MDBF), percentage Availability and Mean Time to Repair (MTTR).
- The Contractor shall comply with the guidelines of EN 50126 (all parts), IEC 60300-1, IEC 60300-2 and IEC 60571 / IEC 61709 for electronic equipment, and IEC 60300-3-5 / similar international standards in meeting the reliability, availability, maintainability and safety requirements of equipment. The RAMS plan shall be submitted by the Contractor.
- 18.6.1 The Contractor shall develop and implement a program to ensure that each train and its major systems meet or exceed the reliability requirements specified in this Chapter. The Contractor shall be responsible for providing all measures required to meet the specified reliability requirements, including design, manufacture, installation, retrofit of the entire fleet, and all changes.
- 18.6.2 The Contractor shall develop a Reliability Plan that identifies the approach to be taken in meeting the requirements specified herein. At a minimum, the plan shall contain the following information:
- a) The methodology that the Contractor intends to use to comply with the reliability requirements.
 - b) Means and techniques for ensuring that subcontractors and vendors support the reliability requirements.
 - c) A reliability program schedule.
 - d) Reliability design and analysis techniques.
 - e) Reliability program status reporting.
 - f) Definition of interfaces between the reliability program and other closely related programs such as system safety, maintainability, availability and human factors.
- 18.6.3 Reliability Estimate
- The Contractor shall submit reliability estimate demonstrating how the train will achieve compliance with the reliability requirements.
- 18.6.3.1 The reliability estimate shall be for the entire train level and for each major system (excluding CMRL furnished equipment) down to at least the LLRU. Estimates shall be given by failure type and shall be expressed in terms of mean distance between failures (MDBF).
- 18.6.3.2 Estimates shall be based on actual revenue service results for identical equipment operating

- under service conditions and duty cycles equivalent to, or more severe than, those specified in Chapter 2. Reasonable extrapolations may be made for non-identical but similar equipment.
- 18.6.3.3 For equipment that is a new design or a significant evolution or upgrade of existing equipment, the prediction shall be developed based upon the methodology of MILHDBK-217 or historically reliable data, including RAC NPRD.
- 18.6.3.4 Where appropriate, the Contractor shall include additional reliability analysis to shown how compliance with the reliability requirements is to be achieved. Such analysis may include reliability block diagrams, reliability FMECA, etc.
- 18.6.4 Failure Classification
- 18.6.4.1 Failures that require subsequent verification / maintenance / corrective action shall be as below:
- a) Type 1 / Service Failure:
- Failures that result in service operational delay in the specific train for more than 2 minutes at any location of the mainline or during induction from depot/mainline in the CMRL Phase 1 Network. These failures also include the list of scenarios for which the train shall be withdrawn from revenue service (refer Appendix I). Unscheduled removal of train from revenue service, prevention of scheduled entry of a train into service due to a failure at starting from depot / mainline shall also be included in this category.
- The train withdrawal scenarios are described in Appendix I. It includes possible anticipated failure scenarios which can affect safety, punctuality and passenger comfort. This list shall be further developed during DNP/ DLP. It is clarified that when such failures occur, the incident will not be categorised as a Type-1 / Service Failure if the train had continued running until the end of service without affecting punctuality.
- b) Type 2 / Relevant Failure:
- A relevant failure of an item is an independent failure which results in a loss of function of that item caused by a fault in an equipment / sub-system of the train while operating within its design and environmental specification limits or a maintenance error made by the Contractor in undertaking its obligations during DLP / DNP period. Improper operation, maintenance, or testing of the item as a result of the Contractor supplied documentation or Failures of transient nature including those with post investigation status as 'No fault found', shall be considered as relevant failure if in the opinion of CMRL these are attributable to Rolling Stock. The decision of CMRL shall be final. The reliability data for extension of sub-system level DLP / DNP extension will be based on the targets set by the Contractor as in Clause 18.6.
- 18.6.4.2 Any above Type 1 / Service Failure of failure occurring in any part of the train shall be considered as train failure.
- 18.6.5 Reliability Demonstration
- 18.6.5.1 The Contractor shall conduct a reliability demonstration test to prove achievement of the fleet reliability figures defined in Clause 18.6.6. The formal test shall commence at the start of initial revenue service and shall continue for a period of two years, or until the final approved fleet reliability figures are achieved to the satisfaction of CMRL.
- 18.6.5.2 Each 6 car rake shall be included in the reliability test once it has been conditionally accepted for induction into the revenue service.
- 18.6.5.3 The reliability figure reported for failure type 1 as defined in clause 18.6.4 shall be the total sum distance travelled by all revenue operational trains in Km (Considering the sum of each operational train mileage) during a given time period, divided by the total number of type 1 failures that occurred during the same time period for the same set of revenue operational trains. The Reliability demonstration shall be conducted in the operational fleet with revenue operational Train's mileage and revenue operational train's failures for the specified periods of clause 18.6.6 until the reliability targets are achieved for the fleet of trains as per clause 18.6.6. Train mileage is the actual Kilo-Meters (KM) distance travelled by the train in passenger service operation on the mainline of CMRL Phase 1 network.
- 18.6.5.4 The Contractor shall record the MDBF for all major systems while the train is operated in revenue service ~~on all the three corridors of CMRL Phase 1 project~~ Phase 1 & Phase 1 Extn. Network.

The Contractor shall document the achieved reliability in a Reliability Report and shall submit the report every month to demonstrate compliance with the requirements of clause 18.6.6. Analyses shall be provided demonstrating resolution of Type 1 failures.

18.6.5.5 The Reliability Report shall be updated monthly and resubmitted throughout the general & extended warranty periods and until fleet defects are corrected to the satisfaction of CMRL. This monthly reliability report shall be submitted to CMRL until the achievement of reliability targets for fleet of trains as per clause 18.6.6.

18.6.5.6 ~~It is clarified that even if trainsets are not deployed to the network to the extent that is required to earn the design mileage (defined in Clause 1.4.5) the same MDBF targets and respective calculations taken for Reliability demonstration shall prevail.~~

2

The Targets mentioned below are based on the assumed average train travel per year as specified in 1.4.5 of Chapter 1, as 1,50,000 km per year.

For every 10% reduction in Actual Average Train Travel of fleet with respect to specified values as referred in 1.4.5, i.e. 1,50,000 km, the Reliability Targets as mentioned in Table 18-2, shall be reduced by 5%. As an illustration, in case actual train travel per year is 1,35,000 KM then Level 1 MDBF Target shall be 76,000 KM instead of 80,000 KM.

18.6.6 Reliability Requirements

18.6.6.1 The following table sets out the requirements for fleet Reliability Demonstration (RD). It defines the calculation methodology, reporting requirements and Target Thresholds. Stated periods are derived from the Revenue Introduction Date (RID) of the 1st Trainset:

Table 18-2: Requirements for Reliability Demonstration (RD):

RD Period	Criteria for Evaluation of Fleet Reliability Demonstration			MDBF Target (For Type-1 Failures)	Duration of Rolling Evaluation Period
	RD Evaluation Period Starts	Reporting Submission Start Date	Criteria to Complete RD Period		
Stabilisation	1 st Train RID	1 st Train RID +1 Month (Informal Reporting Only)	1 st Train RID + 6 Months	No Target / Reporting Only	1 Month
Level 1	1 st Train RID + 6 Months	1 st Train RID + ~~13~~ Months-7 Months	MDBF Target met for ~~48~~ 6 Reporting Months (accumulated)	80,000 Km	6 Months
Level 2	1 st Train RID + ~~6 Months~~ 12 Months	1 st Train RID + ~~19~~ Months 13 Months	MDBF Target met for 12 Reporting Months (accumulated)	1,25,000 Km	12 Months

1

- Upon reaching the "reporting submission start date" for each respective RD Period the Contractor shall start to include that MDBF calculation in their Reliability Demonstration Report submitted each month.
- The reported MDBF for each RD Period shall be individually calculated according to the corresponding "Rolling Evaluation Period" and reporting shall continue until the acceptance criteria shown in Table 18.2 has been met to conclude the Reliability Demonstration.
- Wherever 'MDBF' is referred to in this specification, it shall be taken to mean the average MDBF achieved over the entire train fleet which has entered revenue operation during applicable rolling evaluation period. Whereas 'MDBF target' (defined in Table 18.2) shall be taken to mean the minimum average MDBF threshold which must be achieved for the respective reporting month to qualify and count towards the accumulated number of qualifying reports needed to complete Reliability Demonstration (RD).
- For the fleet Reliability Demonstration to be satisfactorily completed overall, both criteria (E.g. Level 1 and Level 2) must be independently met as specified in Table 18-2..

- e) Until such time that the Contractor completes Reliability Demonstration (E.g. accumulates the number of qualifying reports mentioned in Table 18-2) the DLP / DNP Period shall be extended by one (1) month for each month where the submitted monthly Reliability Report did not meet applicable criteria (either Level-1 or Level-2).
- 18.6.6.2 For the purposes of the above calculation, a chargeable failure is defined as any failure that requires repair or replacement or correction or action on any of the train's subsystem (hardware or software or firmware) or component which is not an approved consumable item, or which is an approved consumable but has not achieved its design service life. Exclusions to this definition are failures caused by:
- a) Occurrence of a failure in another system or subsystem other than train.
 - b) A failure by CMRL to perform recommended preventive or service maintenance actions.
 - c) Collisions, vandalism, incorrect operation or abuse of equipment.
 - d) Operating or weather conditions of unusual aspect or severity beyond those specified in clause 2.11. The term "unusual aspect or severity" shall be understood to mean a condition that does not on average occur on CMRL right of way more often than once in 10 years. The time, place, or type of service operated by the car at the time of failure shall not be of any consequence.
- 18.6.7 Reliability Design Criteria
- The Contractor shall include the following in the Train's design criteria to ensure maximum reliability:
- a) The specific design criteria for reliability of each critical component, equipment or subsystem specified are consistent with the system element requirements.
 - b) Standardization and high-reliability parts are being used in critical design areas.
 - c) Standard and proven circuits are utilized where possible and required adjustments have been minimized.
 - d) Solid-state devices are used wherever possible and heat-transfer devices or designs are efficient.
 - e) Mechanical support structures are adequate.
 - f) Where possible, equipment has been designed to eliminate the need for shock mounts and the installation of vibration isolators.
 - g) Reliability trade-offs have been considered and employed to improve the design.
 - h) Redundancy has been provided where needed to meet reliability goals.
- 18.6.8 Reliability for Retrofits / Modifications
- 18.6.8.1 In case of any retrofits or modifications done by RS contractor or their sub-supplier in any specific system / sub- system / function / component / software of any train or on spares, these retrofit / modifications shall be applicable to specific system / sub-system / function / component / software for all other trains and spares supplied under the contract.
- 18.6.8.2 In case of any retrofits or modifications done by RS contractor or their sub-supplier in any specific system / sub- system / function / component / software of any train or spares, this specific system / sub-system / function / component / software shall be subjected to 24 months warranty from the date of completion of retrofit / modification in that train or the specific spares. This is in order to mitigate any issues that would arise due to the retrofit / modification. This specific 24-month warranty is irrespective of the train DNP / DLP / warranty.

18.7 MAINTAINABILITY AND AVAILABILITY

The plan for maintainability shall conform to EN 50126. Reliability of electronic components shall conform to IEC 61709 or equivalent international standards.

18.7.1 General

- 18.7.1.1 The Contractor shall ensure that the design of the car and its systems gives maximum consideration to maintenance, troubleshooting, component removal, repair, and inspection requirements. The objective shall be to minimize maintenance labour and materials costs,

passenger car downtime, and the need for especially skilled or highly skilled service personnel.

18.7.1.2 The Contractor shall develop and submit a Maintainability Plan that identifies the approach to be taken in meeting the requirements specified herein. At a minimum, the plan shall contain the following information:

- a) The methodology that the Contractor intends to use to comply with the maintainability requirements.
- b) Means and techniques for ensuring that subcontractors and vendors support the requirements.
- c) A maintainability program schedule
- d) Maintainability design and analysis techniques
- e) Maintainability program status reporting
- f) A definition of interfaces between the maintainability program and other closely related programs such as reliability, availability, system safety, and human factors.

18.7.2 CMRL's Maintenance Approach

CMRL's approach to car maintenance will be to minimize train downtime. Thus, failed equipment will normally be removed from the train for repair in the workshop, and the failed equipment will be replaced by equipment known to be operational. CMRL will maintain failed equipment down to the level of printed circuit boards (PCBs). CMRL does not anticipate undertaking repairs of PCBs.

18.7.3 Maintainability Requirements

18.7.3.1 Modular Design

- a) The Contractor shall employ modular design principles to the greatest extent practicable. Components shall be packaged together, in replaceable subassemblies, according to their logical function. Dimensions and components shall be standardized to achieve flexibility in use.
- b) Components or subassemblies requiring occasional removal shall preferably be plug-in units. Plug-in units shall be adequately identified, secured, and keyed to prevent misapplication.
- c) Modular equipment shall include, as a minimum:
 - (i) VAC unit
 - (ii) Traction Motors
 - (iii) LVPS and Battery tray
 - (iv) Propulsion and Auxiliary Converter Inverter
 - (v) Propulsion control logic unit
 - (vi) Brake control unit
 - (vii) Bogie (complete)
 - (viii) Door actuating system
 - (ix) Communication and passenger information system units.

18.7.3.2 Line Replaceable Units (LRUs) and Lowest-Level Replaceable Units (LLRUs) - The Contractor shall submit a list of LRUs and LLRUs that identifies those units that can be replaced on the car (LRU) and those that must be replaced in the workshop (LLRUs).

18.7.3.3 Adjustments

The need for adjustments shall be avoided. If any adjustment points are approved by CMRL, they shall be readily accessible, adequately identified, and self-locking to prevent inadvertent adjustment or drift. The Contractor shall provide a list of adjustment points and initial settings in the Car History Book (ref. clause 16.15).

18.7.3.4 Accessibility

Ready access shall be provided to all systems and components to be serviced as part of periodic preventive maintenance. Such access shall not require the removal or physical movement of components unrelated to the specific maintenance and/or repair tasks involved. The relative accessibility of components, measured in time needed to gain access, shall be inversely

proportional to the frequency of maintenance and repair.

18.7.3.5 Interchangeability

Assemblies or components that are functionally interchangeable shall be physically interchangeable. Assemblies or components that are not functionally interchangeable shall not be physically interchangeable.

18.7.4 Maintainability Design Criteria

The Contractor shall include the following in the car's design criteria to ensure maximum maintainability:

- a) Systematic fault isolation procedures shall be developed for inclusion in maintenance manuals.
- b) Built-in test points shall be provided and marked.
- c) Failure indicators should be provided and identified. Colour-keyed indicators shall be used wherever possible.
- d) All test points, fault indicators, modules, wire junctions, pipes, tubes, and wires shall be identified by name plates, colour coding, number coding, or other means.
- e) Components shall be placed in equipment cabinets, enclosures, or confined places so that the most accessible positions are given to those items requiring the most frequent maintenance or adjustment.
- f) Door panels and openings shall be of sufficient quantity and size, and placed in such a way as to provide ready access from normal work areas.
- g) Standard, commercially available industrial components and hardware shall be used wherever possible.
- h) Captive fasteners shall be used on covers and access panels.
- i) Access to structural components shall be provided to the greatest extent practicable to enable inspection for cracks and corrosion.
- j) Major components shall be designed for ease of removal.
- k) Means shall be provided to verify the operability of redundant or parallel hardware components and associated switching devices during maintenance, troubleshooting, and testing.

18.7.5 Time Required for Maintenance

18.7.5.1 Preventive Maintenance

Elapsed time to perform preventive maintenance (exclusive of servicing) on each Car shall not exceed 4 hours. Preventive maintenance shall not be required more frequently than every 12,000 km or 45 days, whichever occurs first.

18.7.5.2 Servicing

Servicing shall be restricted to the replenishment of consumables (such as oil, grease and other fluids); cleaning or replacement of filters; and inspection of brake pads.

Servicing shall not be required more often than every 5,600 km or 30 days, whichever comes first, and shall not require more than one hour in elapsed time nor more than two person-hours per car. A 30 day interval will be acceptable for the VAC filter cleaning under dusty conditions.

Interior and exterior cleaning and refilling of windshield washing fluid containers are excluded from this requirement.

18.7.5.3 Component Change-Out Requirements

In addition to the above, the Contractor shall design the car such that the component change-out requirements listed in Table 18-3 can be met. The person-hours are based on fully trained maintenance personnel using standard tools and test equipment.

Table 18-3: Component Change-Out

Item	Maximum Person-Hours
Motor Bogie (complete)	6.00

Item	Maximum Person-Hours
Gear Transmission (each)	6.00
Windshield (excluding sealant curing time)	6.00
VAC unit	2.00
Propulsion Converter inverter (complete)	4.50
Brake disc (each)	1.00
Side window (excluding sealant curing time)	4.00
Auxiliary Converter Inverter	4.00
Coupler (complete)	3.00
All air filters	3.00
Brake pad (pair)	0.25
Battery filling	0.25
Saloon Light (each)	0.25
Headlight (each)	0.25
Saloon Door (each)	0.75
Each Car body lifting from Bogies	2.00
Replacement of Battery box	1.00
Car separation from train (Including mechanical and electrical connections)	1.00
Pantograph removal and refitment	2.00
VCB	2.00
Traction motor	1.00

18.7.6 Maintainability Verification and Testing

- 18.7.6.1 The Contractor Maintainability Plan shall include criteria for verifying and testing maintainability requirements. The Contractor shall demonstrate that train can meet maintainability requirements for which CMRL requires verification.
- 18.7.6.2 In addition, the Contractor shall demonstrate that a car mean time to restore that does not exceed 1.5 hours, with a maximum maintenance repair time of 3 hours, is achievable for at least 95% of all failures using the diagnostic tools and procedures provided by the Contractor. The restoration shall not require more than two service personnel.

18.7.7 Availability

- 18.7.7.1 Availability Requirements shall be assessed by the following measure

$$\% \text{ Availability} = 1 - \{ [\text{DT(SC)} + \text{DT(OPM)} + \text{DT(CM)}] / \text{Total Time} \} * 100$$

Total Time Where:

- Total Time is the time in hours in the assessment period multiplied by the number of trains commissioned under this Contract.
- DT(SC) Down Time due to Service Checks, is the total down time in hours due to service checks summed over all the trains during the assessment period.
- DT(OPM) Down Time due to Other Preventive Maintenance, is the total down time in hours due to Preventive Maintenance other than service checks, summed over all sessions carried out on all trains during the assessment period.
- DT(CM) Down Time due to Corrective Maintenance, is the total down time in hours due to corrective maintenance, summed over all sessions carried out on the trains in revenue operation during the assessment period. Any unreasonable delay in handing-over the train

for repairs for reasons not attributable to the Contractor shall be excluded. Time spent on train integrity inspections after train reformations arising from corrective maintenance work shall be included.

- (v) Not used.
- (vi) DT(CM) shall be counted starting from the moment when the defective train is handed over to the Contractor, and shall end when the train is restored to service condition.
- (vii) The down times DT(SC), DT(OPM) & DT(CM) shall also cover the full content of the maintenance work concerned, including safety precautions, inspections, servicing, replacement of equipment, defect detection and rectification, testing and restoration to service condition.

18.7.7.2 Availability Target:

The trains supplied shall achieve minimum average availability of 95.0% for fleet of trains for the assessment durations mentioned below.

18.7.7.3 Availability Demonstration

- i. The availability of trains shall generally be more than 90% during the period prior to 18 months from the start of revenue operation of the first train.
- ii. The average availability of the trains shall be assessed after 18 months from the start of initial revenue operation under the contract. The total down times for all trains shall be collected by the CMRL on monthly basis, and the average availability during the preceding six months, shall be worked out from the above-mentioned formula in clause 18.7.7.1.
- iii. Minimum 6 reports (with each report of 6 months' average duration) shall be achieved with this formula. The assessment period for the availability calculation shall be scheduled from the actual date of initial revenue operation.
- iv. In the event that the availability target mentioned in clause 18.7.7.2 is not achieved for any six-month duration, the determination of availability achievement in the six - month period shall be continued at monthly incremental intervals until the target is achieved.
- v. In the event that average availability target is not achieved in any month after 18 months from start of revenue operation for the trains under reliability verification, the Contractor shall, at his own expense, take whatever action is deemed necessary to meet the availability requirement.
- vi. The Contractor shall submit the plan for achieving the Availability requirements (as per clause 18.7.7).

18.8 QUALITY ASSURANCE PLAN

18.8.1 Quality Assurance Program Plan

18.8.1.1 The Contractor shall develop and submit Quality Assurance (QA) Program Plan. The QA plans shall include a company policy statement, which defines the authority and role of QA within the Contractor or subcontractor's organization, particularly with regard to schedules and cost. The plan shall be formatted in accordance with ISO 9001, which shall be used as the guiding document for all QA activities. Subcontractor QA plans shall be approved by the Contractor and submitted to CMRL during Pre Final Design stage.

18.8.1.2 The Contractor and subcontractors shall maintain a Quality Assurance Program with established quality control functions in accordance with the approved Quality Assurance Program Plan. The Contractor shall audit subcontractors and suppliers to ensure that they adhere to all elements of the Contractor's Quality Assurance Program Plan and Contract requirements. The QA programs will be subject to regular audits by CMRL to ensure implementation throughout all phases of the Contract.

18.8.1.3 The Quality Assurance Program shall include an Inspection and Test Plan that provides a narrative description of the manufacturing, inspection, and testing processes and a schedule showing major manufacturing and inspection milestones.

The Inspection and Test Plan shall also include a rectifying feedback system that provides

- information to the Contractor's or subcontractor's engineering, industrial and production groups. The plan shall be updated as milestone dates or other significant items change. CMRL's quality representative will use the Inspection and Test Plan to identify the Contractor's inspection, witness, test, and hold points.
- 18.8.1.4 The Quality Assurance Program shall include a system of Configuration Control and Software Management and Verification. The Contractor shall establish and implement measures to ensure that engineering procedures are well defined and designs are controlled, prepared, verified, issued, and revised in accordance with the requirements of the Quality Assurance Program. The Contractor's QA staff shall verify that each component, assembly and car is manufactured and tested in accordance with the approved drawings, procedures, software, and documentation.
- 18.8.1.5 The Quality Assurance Program shall include a system and procedure to ensure that all measuring and test equipment is calibrated, adjusted, and maintained at prescribed intervals against certified equipment, to adhere to national or international standards.
- 18.8.1.6 Written procedures shall be implemented to:
- Ensure that purchased material conforms to the requirements of purchase specifications.
 - Ensure that items are handled, stored, and shipped to prevent damage and loss.
 - Prevent the use of items that do not conform to specifications.
 - Control those manufacturing and production processes shown on the approved manufacturing and inspection plans.
- 18.8.2 Quality Assurance (QA) Program Criteria
- 18.8.2.1 The QA function shall be placed within the Contractor's organization in such a way that schedule and cost considerations shall have no effect on the quality of products delivered under the terms of this Contract. Any conflicts that may arise as a result of this provision shall be brought to CMRL's attention by the Contractor's Quality Assurance designee and shall be resolved to CMRL's satisfaction before affected items are shipped.
- 18.8.2.2 Management responsibility for the QA function shall be set forth in the Contractor's policy statement and organization chart and shall be independent of the production function.
- 18.8.3 Management Review Board and Control of Non-Conforming Material
- 18.8.3.1 The Contractor shall establish and implement measures to ensure that items that do not conform to specified requirements are controlled to prevent inadvertent installation or use. The control measures shall contain procedures for identification, documentation, segregation, and disposition of non-conforming materials, and for notifying the affected organizations, e.g. subcontractors or engineering. Nonconforming material shall be tagged or otherwise marked and segregated in a designated holding area, pending disposition.
- 18.8.3.2 The Contractor shall establish a written Material Review Board procedure. The procedure shall define, but not limited to, departmental responsibility, authority to determine disposition, definitions of dispositions (e.g. rework, repair, use-as-is), root-cause analysis, corrective action, preventative action, and forms. The Contractor shall submit a Material Review Board procedure for CMRL approval as part of the Quality Assurance Program Plan.
- 18.8.3.3 All non-conformances to the Quality Assurance Program Plan, drawings, specifications, procedures, or Contract requirements, as applicable, shall be documented and concerned entities shall be notified. Non-conformances shall be submitted to a Management Review Board (MRB), as described below, and their disposition shall be to the satisfaction of CMRL.
- 18.8.3.4 The Contractor shall establish an MRB to determine the disposition of non-conformances and to investigate and recommend corrective and preventative action.
- The MRB shall consist, as a minimum, of representatives of the Contractor's Procurement, Manufacturing, Quality Control and Engineering groups, and shall be convened as the need to dispose of non-conformances arises. All Repair and Use-As-Is disposition must be approved by the Contractor's Engineering group and submitted to CMRL for prior approval. "Rework", "Return to Supplier", and "Scrap" dispositions do not require CMRL approval. CMRL shall have the right to attend all MRB meetings.

- 18.8.3.5 All reworked material shall be inspected by the Contractor QA staff and shall either be rejected or certified as conforming. At no time shall nonconforming material be installed for rework or replacement at a later time. Approval shall be required before nonconforming material is redirected into the production flow.
- 18.8.3.6 As a minimum, the MRB shall issue a monthly report that summarizes activities since its last meeting. For nonconforming materials, these reports shall contain a complete listing of parts received and shipped from an area set aside for rejected parts and shall provide a description of part problems and dispositions.
- 18.8.4 Quality Assurance Audits
- The Contractor and subcontractors shall provide access for CMRL to audit QA and quality control activities and determine compliance with the approved Quality Assurance Program Plan. During the initial audit of the Contractor's QA functions, CMRL will audit the QA programs of subcontractors.

18.9 INSPECTIONS

- 18.9.1 General
- 18.9.1.1 The Contractor shall assure inspection and verification of compliance at all the Contractor and subcontractor facilities. Further inspections shall take place at the Contractor's and CMRL's facilities to identify any components, systems, or cars damaged during shipment or during any stage of the project.
- 18.9.1.2 CMRL may make inspections of items, completed or in-progress, in conjunction with or in addition to the Contractor's inspection. This provision shall in no way eliminate or lessen the Contractor's obligation to conduct thorough inspections. The Contractor shall be completely responsible to prepare train/inspection equipment for the CMRL inspection with minimum quality open issues.
- 18.9.1.3 Exceptions taken to the quality of car workmanship, by either the Contractor's or CMRL's inspection representatives, shall be posted in a manner convenient to review on the affected component or car. The rejection or approval status of each exception shall be readily identifiable throughout the car's manufacturing cycle and shall be kept current by the Contractor's inspection force on a routine, daily basis.
- All rejected work shall be corrected, re-inspected, and approved by the Contractor's and CMRL's quality control representatives before the next phase of production begins.
- 18.9.2 Scheduling Inspections
- 18.9.2.1 The Contractor shall give 10 calendar days' notice prior to any shipment of major items from subcontractors to enable CMRL to conduct source inspections of the items.
- The Contractor shall not schedule more than two vendor inspections on the same date without prior approval by CMRL.
- 18.9.2.2 Within five days after receipt of such notice, CMRL will advise the Contractor as to whether a CMRL representative will inspect the shipment.
- 18.9.3 The Contractor Provisions for CMRL during Inspections at the Contractor's facilities:
- 18.9.3.1 The Contractor shall provide adequate office facilities and equipment for use by CMRL inspectors, comparable to the Contractor's employees. The office space shall be equipped with desks, outside and interplant telephones, an additional telephone line for a PC modem, file cabinets, and chairs. Security measures and area protection equivalent to that used by the Contractor for the Contractor facilities shall be provided for CMRL facilities and equipment.
- 18.9.3.2 Copies of all drawings, diagrams, schedules, changes, deviations, and data shall be furnished for use by CMRL inspectors. Data shall be adequate to enable CMRL to verify design, construction, assembly, installation, workmanship, clearance, tolerance, and functioning of the cars.
- 18.9.4 CMRL Inspections
- 18.9.4.1 CMRL reserves the right, to perform inspections and tests at the place of the manufacture, the shipping point, or the destination, to verify conformance to the applicable requirements.

- 18.9.4.2 CMRL reserves the right to inspect and test all materials and each part or detail of the components, assemblies, or car. Upon request from CMRL, the Contractor shall provide information and permit access to all parts of the work. The Contractor acknowledges and agrees that any additional inspection or testing of the materials, part or detail of the components, assemblies, or car as deemed necessary or advisable by CMRL may be done by CMRL.
- 18.9.4.3 CMRL may, at any time, reject any material, component, assembly or car for failure to comply with the applicable requirements, whether or not previous reviews, inspections, tests or approvals were conducted by CMRL.
- 18.9.4.4 In the event that the Inspection and Test Plan shows a specific inspection or approval to be conducted by CMRL representative, or if CMRL requests the right to conduct a specific inspection or approval, the Contractor shall not proceed with any work that would preclude CMRL from making such inspection or approval until CMRL has made the inspection or approval or has provided a written waiver of its right to inspect or approve.
- 18.9.4.5 CMRL shall at all times have access to the work whether it is in preparation or in progress. The Contractor shall provide proper technical support, drawings, specifications, tools, and proper facilities for such access for inspection and testing.
- 18.9.5 Contractor Inspections
- 18.9.5.1 In order to effect the control of the quality of the work by means of inspection, the Contractor shall establish procedures for source inspection, receiving inspection, in-process inspection, and final inspection.
- 18.9.5.2 The Contractor shall maintain a system to track inspections of all components, materials, assemblies, and cars. The system shall identify the status of any such item to indicate acceptance, rejection, disposition, or pending inspection. The system shall be capable of identifying the present inspection status of any car.
- 18.9.5.3 Inspection stations or hold points shall be at the best locations to inspect or test components, assemblies, or cars before they are concealed by subsequent fabrication or assembly operations. These shall, as a minimum, include, major car body sub-assemblies, structural car body assembly, pre-paint inspection, paint inspection, water test, under frame equipment installation, roof equipment installation, interior equipment installation, cable and wiring installation, interior panel installation, pre-test inspection, test, after-test inspection and final inspection.
- 18.9.5.4 Sampling procedures to determine acceptable quality levels (AQL) and average outgoing quality levels (AOQL) shall be performed under MIL-STD-105, ANSI/ASQC Z1.9, or other approved standards.
- 18.9.5.5 The Contractor shall specify 100% inspection, or sampling inspection, for discrete items of work. If sampling plans are proposed, the Contractor shall submit complete details of the plans to CMRL as part of the Quality Assurance Program Plan.
- 18.9.6 Statistical Quality Control
- 18.9.6.1 Statistical quality control (SQC) methods may be used on a case-by-case basis to accept parts and materials and to evaluate processes. Such methods shall be performed under MIL-STD-105 guidelines, and results shall be documented.
- 18.9.6.2 The Contractor shall submit a list of parts and material to be inspected by SQC.
- 18.9.7 First Article Inspections
- 18.9.7.1 The Contractor shall develop a First Article Inspection (FAI) Procedure to ensure compliance and control of FAIs with respect to the Quality Assurance Program Plan. The plan should include a system to monitor the status of each FAI and a feedback system to address noted exceptions or issues. The procedure is to be submitted to CMRL for review and approval.
- 18.9.7.2 An FAI shall be performed jointly by CMRL and the Contractor on all major components and equipment, including the first complete car. The Contractor shall develop a FAI list that identifies the major components, assemblies and sub systems and their respective manufacturer or supplier. The FAI list shall be submitted to CMRL for approval.
- 18.9.7.3 The FAI shall establish the baseline configuration of the as-built configuration and the as-designed

configuration. Any changes after FAI approval that affect form, fit, function, interchangeability, maintainability, reliability, or safety must be submitted to and approved by CMRL before the change can take effect.

- 18.9.7.4 Equipment or assemblies shall be shipped from the point of manufacture or proceed in the Contractor's production line only after an FAI has been offered and has either been passed or waived by CMRL. The Contractor shall provide in writing a minimum of 15 working days' notice to CMRL before performing any FAI, whether it is internal or external.
- 18.9.7.5 At least 10 working days prior to each FAI, the Contractor shall submit a data package that includes the latest drawings, test procedures, specifications, and quality documentation required for adequate checkout of the equipment under inspection; and a controlled list of drawings. The list of drawings shall be identified by revision and shall be complete to the LLRU.
- 18.9.7.6 The Contractor shall perform pre-FAIs as needed to ensure that a subcontractor is fully prepared for a formal FAI. The Contractor shall not schedule more than two FAIs on the same day without prior approval from CMRL.
- 18.9.7.7 The FAI will evaluate component and system maintainability where possible. The FAI shall establish the quality of workmanship for the balance of like components. The quality of workmanship shall be established jointly by CMRL and the Contractor.
- 18.9.7.8 The FAI shall not be conducted until the design drawings of the article have been approved by CMRL. If conditionally approved drawings are used, CMRL's conditions for approval shall be satisfied at the FAI and represented by the inspection article.
- 18.9.8 The following requirements shall also apply to each FAI:
- a) A complete set of approved (or conditionally approved) drawings with CMRL's comments shall be available for the item to be inspected.
 - b) A copy of the vendor's purchase order, with commercial items excluded, shall be available.
 - c) Completed inspection forms for in-process and final work shall be available.
 - d) A complete list of any deviations to the approved configuration shall be available.
 - e) Completed test documents shall be available.
 - f) The inspection article shall be displayed on a stand or table.
 - g) Tools and labour to take mechanical or electrical measurements shall be provided.
 - h) Tools and labour for disassembly and removal of covers shall be provided.
 - i) Testing in accordance with approved test procedures testing shall be performed.
- 18.9.9 Hold Point Inspection
- 18.9.9.1 As part of its inspection and test procedures, the Contractor shall establish hold points, as for approval in the manufacturing and testing process, to provide the most critical form of inspection and test for completed operations or installations, or for items that will be covered during succeeding assembly operations.
- 18.9.9.2 Nonconforming products shall not be released from a hold point area until all discrepancies have been corrected. The Contractor shall use inspection forms to record the list of discrepancies noted. The inspection forms shall be posted at or near the point of inspection for each car and included with the Car History Book when all discrepancies have been eliminated (ref. clause 16.15). CMRL shall have the option to witness inspections and tests.
- 18.9.9.3 In the event that the Quality Plan shows that a specific inspection or approval is to be conducted by the CMRL, or if the CMRL requests the right to conduct a specific inspection or approval, the Contractor shall not proceed with any work that would preclude the CMRL from making such inspection or approval until the CMRL has made the inspection or approval or has provided a written waiver of its right to inspect or approve.
- 18.9.10 Source Inspection
- 18.9.10.1 The Contractor shall provide for inspection of subcontractor components and materials at subcontractor plants.

- 18.9.10.2 Once a component has been approved at FAI, the subcontractor may begin shipment to the Contractor's facility. Source inspections shall be scheduled prior to each shipment in accordance with clause 18.9.2.
- 18.9.11 Receiving Inspection
- 18.9.11.1 The Contractor shall provide for the inspection of all incoming materials. The Contractor shall establish a receiving inspection procedure that shall specify the type of inspection employed for each item, either, sampling, statistical, or 100%.
- 18.9.11.2 The Contractor shall retain all material certifications and test reports used as a basis for accepting materials.
- 18.9.11.3 The materials that have been inspected, tested, and approved shall be identified as acceptable to the point of use in the manufacturing or assembly process.
- 18.9.12 In-process Inspections
- 18.9.12.1 The Contractor shall perform in-process inspections in order to monitor the effectiveness of manufacturing and assembly control processes.
- 18.9.12.2 The Contractor shall perform in-process inspections in accordance with procedures and checklists approved by its QA group.
- 18.9.12.3 The Contractor shall maintain and enforce a system for identifying the progressive inspection status of materials, components, assemblies, sub-assemblies, and car so that the inspection status is known and can be readily identified throughout manufacturing and testing.
- 18.9.13 Final Inspections
- 18.9.13.1 The Contractor shall schedule one day for CMRL's inspection of each car before each shipment. Before CMRL's inspection, the Contractor shall perform final inspection in conformance with written procedures. Workmanship items covered by prior inspection reports shall be corrected before final inspection begins.
- 18.9.13.2 The Contractor shall provide a qualified supervisor to accompany CMRL during final inspection to ensure that proper corrective action is taken. The Contractor shall provide labour and appropriate tools to remove or open and reapply covers and doors. All systems shall be operational during final inspection.
- 18.9.13.3 The Contractor shall provide to CMRL for review, prior to inspection, all documentation of inspection, test results, deviations, configuration control, list of open engineering changes, and Car History Book documentation.
- 18.9.13.4 If, in the judgment of CMRL's inspector, the car is complete, passes all inspection criteria, and complies with other agreed-upon conditions for shipment, the CMRL inspector shall issue the Contractor a "Certificate of In-Plant Inspection and Release for Shipment." The Contractor shall not ship any car without first having received such a certificate.
- 18.9.14 Retrofit Inspection
- 18.9.14.1 The Contractor shall provide a written procedure for tracking and inspecting retrofits or changes made to cars on CMRL's property. When the Contractor makes a retrofit or change on a single train, it shall be applied to the entire fleet.
- 18.9.14.2 The Contractor's Quality Control representative shall verify and document completion status of changes. Completed changes and retrofits shall be 100% inspected by the Contractor's quality control representative. Records of completed changes and retrofits and associated inspections shall be made available to CMRL.
- 18.9.15 Inspection by CMRL
- 18.9.15.1 All materials and each part or detail of the work shall also be subject to inspection and testing by the CMRL, at CMRL's request. The Contractor hereby consents to such inspection and testing. Upon request from CMRL, the Contractor shall furnish information to such persons as are designated in such request and shall permit such persons access to all parts of the work. The Contractor acknowledges and agrees that any additional inspection or testing of the work as described in the requirements or otherwise deemed necessary or advisable by CMRL may be done by CMRL.

- 18.9.15.2 CMRL shall at all times have access to the work whether it is in preparation or in progress and the Contractor shall provide proper facilities for such access and for inspection and testing. CMRL reserves the right to employ the services of professional consultants for any phase of the work as it may deem to be in the best interest of CMRL. The Contractor shall cooperate with CMRL and these consultants and shall provide access to the work and facilities for inspection and testing.
- 18.9.15.3 At each primary work location to which CMRL assigns a representative, the Contractor shall provide the CMRL and its consultants with access to an approved office space.
- 18.9.16 Authority of CMRL's Inspector
- The CMRL's inspectors shall have authority to inspect any and all work done and materials furnished. Such inspection may extend to all or any part of the work and to the preparation, fabrication, or manufacture of the materials to be used. The inspector will not be authorized to alter or waive the provisions of the Contract. The inspector will not be authorized to issue instructions contrary to the Requirements, nor to act as foreman for the Contractor; however, he or she shall have the authority to reject work or materials until a question at issue can be referred to and decided by the CMRL's Project Manager.
- 18.9.17 Notice of Inspections and Tests; Removal of Work
- 18.9.17.1 At all times before Final Acceptance of the Project, the Contractor shall remove or uncover such portions of the finished construction work as directed by the CMRL for the purpose of inspection and/or testing by the CMRL. After examination by the CMRL, the Contractor shall restore the work to the standard required by these provisions. If the work exposed or examined is not in conformance with the requirements of these provisions, then the cost of uncovering, removing and restoring the work and of recovery of any delay to any critical path occasioned thereby shall be at the Contractor's expense.
- 18.9.17.2 Furthermore, any work done or materials used without adequate notice to and opportunity for prior inspection by the CMRL (if applicable) may be ordered uncovered, removed, or restored at the Contractor's expense, even if the work proves acceptable.
- 18.9.18 Verification Tests
- The Contractor shall perform such tests as the CMRL may require verifying that corrective actions including redesign, repairs, and replacements comply with the requirements of the contract. All costs associated with such corrective actions and testing, including the removal, replacement, and reinstitution of equipment and materials necessary to gain access, shall be borne by the Contractor.
- 18.9.19 Plant Inspection
- 18.9.19.1 CMRL may undertake the inspection of materials at the source. Manufacturing plants may be inspected periodically for compliance with specified manufacturing methods. Material samples may be obtained for laboratory testing for compliance with materials quality requirements. This may be the basis for acceptance of manufactured lots as to quality.
- 18.9.19.2 In the event that a plant inspection is undertaken, the following conditions shall be met:
- a) The CMRL shall have the cooperation and assistance of the Contractor and the producer with whom it contracted for the provision of materials and equipment.
 - b) The CMRL shall have full entry at all times to such parts of the plant as may concern the manufacture or production of the materials being furnished. The CMRL shall have the unrestricted ability to photograph the manufacture or production of CMRL equipment.
 - c) If required by the CMRL, the Contractor shall arrange for approved office space for the use of the inspector; such space is to be located conveniently in or near the plant.
 - d) Adequate safety measures shall be provided and maintained.
- 18.9.19.3 CMRL reserves the right to retest materials that have been tested and accepted at the source of supply after the same have been delivered, and to reject materials that, when re-tested, do not meet the requirements of these Technical Provisions. The cost of re-testing (including the CMRL's & GC's travel and stay charges) in case of rejection shall be borne by the Contractor.

18.10 MANUFACTURING PLAN

- 18.10.1 The Quality Assurance Program Plan shall include a Manufacturing Plan. The Manufacturing Plan shall include a workflow block diagram showing each significant operation and the related control and hold points for inspections, examinations, and tests identified in the Quality Assurance Plan.
- 18.10.2 The Manufacturing Plan shall address the following:
- a) Hold points, as defined in clause 18.9.9.
 - b) Controls to ensure that special processes, including but not limited to welding, heat treating, and non-destructive testing, are accomplished using personnel and procedures qualified in accordance with industry codes and standards or the requirements of these Provisions. Certification credentials of suppliers, manufacturers, or personnel shall be provided when requested by CMRL.
 - c) The use of program effectiveness reviews and documented procedures to require evidence of corrective actions taken to preclude the recurrence of adverse quality conditions.
 - d) Control of all work instructions, procedures, and their revisions to ensure that manufacturing and processes are performed in accordance with Specification requirements.

18.11 CALIBRATION

- 18.11.1 The Contractor shall establish and implement approved control measures to ensure that tools, gauges, instruments, and other measuring and test equipment used on this Contract are calibrated in accordance with the Quality Assurance Program. The Contractor shall use MI-STD-45662 or equivalent standard as a guide to establish the procedure and control measures. Calibration standards shall be traceable to the National Bureau of Standards or the equivalent. Each device requiring certification of calibration shall bear a marking indicating current certification status and date.
- 18.11.2 When production fixtures, tooling masters, templates, patterns, and other devices are used as media of inspection, they shall be proved for accuracy at formally established intervals and adjusted, replaced, or repaired as required to maintain quality. The Contractor's Quality Assurance group shall ensure that accuracy and corresponding documentation are verified and maintained.
- 18.11.3 Evidence of compliance shall be readily available for CMRL inspection.

18.12 MANUFACTURING QUALITY RECORDS

- 18.12.1 The Contractor's Quality Assurance group shall ensure that all quality records and procedures are prepared and maintained in accordance with the Quality Assurance Program. Quality records shall include, but are not limited to:
- a) Material Certification
 - b) Test Records
 - c) Results of Examination
 - d) Inspections
 - e) FAls
 - f) Engineering Changes
 - g) Process Controls
 - h) Certification of Processes or Procedures
 - i) Certification of Personnel
 - j) Repair and Use-As-Is MRB Dispositions
 - k) Repair Procedures
 - l) Configuration.

- 18.12.2 Records shall be maintained complete and in an orderly and easily accessible manner. The records shall be stored to prevent damage or loss.

18.13 SITE AND SITE MANAGEMENT

18.13.1 Access to Site

The Contractor will be given access to the Site in accordance with Clause 2.1 of the General Conditions of Contract.

18.13.2 Site Facilities

- 18.13.2.1 ~~CMRL shall allocate approximately 100 square meter space to the Contractor at one of the Designated Depot(s) for erection of site the Contractor's Site Office. This land / space provision shall be provided to the Contractor on a free of cost basis without any rental charges.~~

1

CMRL shall allocate approximately 100 square meter open space / land to the Contractor, free of cost, at one of the Designated Depot(s) for erection of Contractor's Site Office.

Further space shall also be allocated to establish the Depot Stores facility.

Any buildings and/or structures needed to make the allocated space ready for occupation by the Contractor shall be constructed by the Contractor at the Contractor's own cost.

The Contractor shall submit architectural drawings to CMRL for all proposed buildings and/or structures for prior approval before construction begins. Proposed designs shall be sympathetic to their surroundings and entirely fit for the purpose of their planned occupation.

All buildings and/or structures shall be handed over to CMRL in good condition after the completion of the DNP Period.

- 18.13.2.2 The Contractor shall arrange its own furnishing, security etc. Charges for the electricity consumption (for the site office area only) shall be payable by the Contractor at the prescribed rates.
- 18.13.2.3 The Contractor shall also arrange for the constant and hygienic disposal of all effluent, sewage and rubbish from the buildings.
- 18.13.2.4 Firefighting equipment shall be provided in accordance with the recommendations of the Chennai City Fire Brigade.
- 18.13.2.5 Traction power at 25kV AC will be made available to the Contractor free of charge for testing and commissioning. The Contractor shall liaise with Designated Contractors for availing of the power and assuring compliance of all safety procedures. A test track is installed at each of the Designated Depot(s). It will be available for the testing of train. The Contractor will be allowed use of the test track free of charge.
- 18.13.2.6 The Contractor shall provide his own lifting facilities (preferably four point lifting system) for unloading of trains and any heavy equipment, at the port of arrival, trans-shipment point and at the Designated Depot(s). The Contractor shall however, be allowed to use any necessary existing Depot facilities free of charge for assembly, commissioning, inspection, repairs to EMU cars and equipment, subject to availability. CMRL shall, however, not be responsible for adequacy, reliability and safety of the facilities provided to the Contractor.
- 18.13.2.7 Reasonably lit access to the areas and to rail sidings will be provided by others. If Lighting is not provided in the specific areas allocated to the Contractor, he should make his own arrangements. The Contractor shall be solely responsible for the security and housekeeping of the area, plant and possessions allocated to him. The Contractor shall provide and maintain all facilities required by him in the area allocated for his exclusive use and all other work required to allow the Contractor to fulfil his obligations under the Contract.
- 18.13.2.8 The Contractor shall arrange at his own cost all Site services necessary and appropriate for the assembly, testing and commissioning of trains, which shall include, but not necessarily be limited to:
- (i) Electricity (for the site office area only).
 - (ii) Communication facilities (for the site office area only)

(iii) Instrumentation.

- 18.13.2.9 The Contractor shall be responsible for making applications or requests to the concerned Authorities for availing of the above facilities. In the event that electricity or water supplies are arranged by another Designated Contractor in the Designated Depot(s) area, the Contractor may avail himself of those supplies from the Designated Contractor, either directly on agreed terms and conditions. The Contractor shall comply with all regulations of the utility companies and Government departments concerned.
- 18.13.2.10 The Contractor shall allocate at his Works, and those of his major sub-contractors, adequate office space, furniture and equipment for the use of CMRL Representative's Inspection Engineers. Such accommodation shall include secure filing for Contractual and other sensitive documents, and secure telephone with net connectivity, computer and printer facilities. Such facilities shall apply equally to the overseas and the local building phases of the Works.
- 18.13.3 Site Management
- 18.13.3.1 The particular use to which the Site is put shall be submitted to CMRL for review within 120 days of the Date of Notice to Proceed. The Contractor shall:
- (i) Confine his use of the areas of the Site to purposes having been reviewed without objection by CMRL who reserves the right to extend, amend or restrict the uses to which areas of the Site will be put.
 - (ii) Where required under the Contract, provide and maintain fencing and lighting around and within the areas of the Site when or where necessary for the safety and convenience of the public or others or as directed.
 - (iii) Refrain from depositing rubbish or causing nuisance or permitting nuisance to be caused and, except where reviewed without objection by CMRL, depositing earth on or removing earth from areas of the Site.
 - (iv) Refrain from felling trees, other than those specifically identified in the Contract to be felled, and refrain from depositing earth around the trunks of trees and protect all trees remaining on Site to the satisfaction of CMRL.
 - (v) Except where otherwise provided, not permit any person to reside on the Site.
 - (vi) Unless otherwise stated, pay all rates and charges of any nature whatsoever arising out of his use of the Site and all work areas provided therein under the Contract.
 - (vii) Not use any part of the Site or Works for advertising purposes except with the acceptance of CMRL.
- 18.13.3.2 The Site shall be maintained in a clean and tidy condition. Materials, including those required for Temporary Works, shall be stored in an orderly manner. The Contractor shall, throughout the period of the Contract, provide a central collection point on Site, as reviewed without objection by CMRL, for collecting all empty cans, drums, packing and other receptacles capable of holding water. The Contractor shall ensure the regular collection and removal of such debris from the Site. After every shift of works, all work areas shall be cleaned and made tidy to the satisfaction of CMRL.
- 18.13.3.3 The Contractor shall ensure that gases, fuels, explosives and other dangerous goods are stored and handled in a safe manner and in accordance with the StatATOrY Regulations pertaining to their storage and handling. The Contractor shall be responsible for obtaining the requisite licenses at his own cost.
- 18.13.3.4 The Contractor shall provide all necessary protective clothing, safety equipment, hand tools, ladders, trestles, power supply, and replacement equipment for the staff engaged on Site maintenance.
- 18.13.3.5 Because of the multi-disciplinary nature of the Project, several different parties may require access to the same portion of the Site during the construction phase, for the installation, erection and testing of the Works.
- 18.13.3.6 To facilitate the organization and co-ordination of access and occupation requirements, the Contractor shall maintain a close liaison with other Contractors.

- 18.13.3.7 As soon as any or all of the Contractor's installations are no longer required for the execution of the Works, the Contractor shall remove those facilities and ensure that the area is left free of debris, excess materials, and obstructions.
- 18.13.4 Site Safety
- 18.13.4.1 CMRL will issue to the Contractor with the latest edition of CMRL Project Safety Manual. The Contractor shall, as a minimum, comply with the Safety Manual. However, this shall not relieve the Contractor of any of his Statutory duties, obligations or responsibilities under the Contract. CMRL reserves the right to order the immediate removal and replacement of any item of Contractor's equipment, which is deemed to be in an unsafe condition.
- 18.13.4.2 The Contractor shall submit, as part of his Safety Plan, a Site Safety Plan, and also designate a member of his staff as Safety Officer.
- 18.13.4.3 The Contractor shall establish and maintain and staff at all times when personnel are on site, a First Aid Post. Portable First Aid Boxes shall be maintained in a fully equipped state at each site work centre. The Contractor shall ensure that at least one employee on every working shift, is a trained First Aider, capable of administering First Aid competently until the arrival of professional help, in an accident situation.
- 18.13.4.4 The Contractor shall be fully responsible for the safety of the Works, his personnel, his Sub-Contractors' personnel, the public, and any persons directly or indirectly associated with the Works, or on or in the vicinity of the Designated Depot site(s). The Contractor shall treat safety measures as high priorities in all his activities throughout the execution of the work.
- 18.13.4.5 The Contractor shall submit to CMRL, regular Site Safety Reports, and shall notify immediately the occurrence of an accident involving his staff or that of his sub-contractors, or to any person within the area of the Designated Depot(s) for which the Contractor is responsible.

18.14 TRAFFIC, ROAD & APPURTENANCES

- 18.14.1 General
- 18.14.1.1 The Contractor shall conform to the applicable requirements of the Motor Vehicle Act – 1988 or latest. The Contractor shall ensure compliance with the requirements regarding the licensing of drivers and the registration of vehicles. Vehicle size and load limitations shall be in accordance with all statutory requirements.
- 18.14.2 Transportation to Site
- 18.14.2.1 The Contractor shall make all arrangements and assume full responsibility for transportation to the site at the Designated Depot(s) nominated for the delivery of passenger Rolling Stock, and all plant, equipment, materials and supplies needed for the proper execution of the Works. Procedures for access to and from the Site shall be coordinated with the relevant Authorities.
- 18.14.2.2 The Contractor shall use such routes and rights of entry to the Site as may be decided by CMRL from time to time. Routes for 'very large' or 'very heavy' loads shall be discussed with CMRL in advance and all arrangements thereafter shall be submitted to CMRL. In this context, the definition of the terms "very large" and "very heavy" refer to articles that cannot be transported by normal road vehicles or be handled by readily available methods. Where doubt exists, it shall be the responsibility of the Contractor to notify and discuss the nature of the load in question with CMRL for possible solutions.
- 18.14.2.3 The Contractor shall be responsible for obtaining permission from the relevant Traffic Police and other relevant authorities to move "very large" and "very heavy" loads and for arranging police escorts if required. The Contractor shall ensure that all roads and pavements, etc. leading to and around the Site are kept free from obstructions and shall not cause inconvenience or hindrance to traffic or persons either by its vehicle or its workmen, scaffolding, plant, materials, equipment, etc. All Workmen working on the road shall wear approved reflective safety vests at all times.
- 18.14.2.4 The Contractor shall repair damage caused to existing roads, footpaths, steps, cables, sewers, drains, etc. and shall reinstate the same at his own expense to the satisfaction of the relevant authorities.

18.15 STORAGE, PACKING, CRATING AND MARKING

18.15.1 General

- 18.15.1.1 The Contractor shall be fully responsible for the provision and maintenance of acceptable storage facilities for the Plant and any materials or equipment he intends to use for the carrying out of the Works.
- 18.15.1.2 The Contractor shall prepare, protect and store in a manner to be accepted by CMRL, all equipment and materials so as to safeguard them against loss or damage from repeated handling, from climatic influences and from all other hazards arising during shipment or storage on or off the Site. Secure and covered storage shall be provided for all equipment and materials other than those accepted by CMRL as suitable for open storage.
- 18.15.1.3 The Contractor shall provide all packing, crating and markings. In doing so, he shall comply with the following requirements:
- (i) All packing procedures shall be subject to acceptance by CMRL.
 - (ii) Spare parts shall be tropicalized in their packing for prolonged storage in accordance with BS 1133 or equivalent and shall be suitably labelled to indicate:
 - a) Ownership (CMRL)
 - b) Originating Company details
 - c) Shelf life.
 - d) Type of storage.
 - e) Total Description of all items and relevant part numbers.
 - f) Serial numbers of all items
 - g) Inspection Certificate numbers and batch numbers for all items, that is, the numbers allocated by the Contractor's Inspector at the time of manufacture or packing.
 - (iii) Protection requirements shall include but not be limited to:
 - a) Electrical and other delicate items or equipment shall be properly protected to CMRL acceptance.
 - b) Tube ends, cable ends, cable entry points into equipment and other similar terminations and openings shall be blanked off to prevent ingress of dirt, moisture, vermin or insects and to provide protection against damage.
 - c) Flanged ends shall be protected by adhesive tape or jointing material covered by a properly secured wooden blank not smaller than the flange itself. Plain tube ends shall be closed off with bungs or plugs or suitable materials firmly fixed in position.
 - d) Particular care shall be taken to prevent damage to or corrosion of shafts and journals where they rest on timber or other supports, which may contain moisture. At such points, wrappings impregnated with anti-rusting composition shall be used. Wrapping shall be of sufficient strength to resist chafing under the pressures and movements likely to occur in transit.
 - e) Spare ball and roller bearings and similarly protected items shall not be removed from the manufacturer's wrappings or packing.
 - (iv) Each case, crate or package shall be legibly and indelibly marked in large letters with the name (Chennai Metro Rail Limited), address, Contract Number, "right way up", opening points and other markings as necessary to permit materials and Plant to be readily identified and handled during transit and when received at Site. Each case, crate or package shall contain a comprehensive packing list showing the number, mark, size weight and contents together with any relevant drawings. A second copy of the packing list shall be enclosed in a watertight enclosure on the outside of each case for ready reference by CMRL.
 - (v) All items heavier than 100 kg shall be marked on the outside of the case to show the gross and net weights, the points for slinging, and where the weight is bearing.
 - (vi) Care shall be taken to prevent movement of equipment within cases, crates or packages by the provision of bracings, straps and securing bolts as necessary. Bags of loose items shall be packed

in cases and shall be clearly identified by well-secured labels on which the quantity and name of the part and its index or catalogue number have been stamped.

- (vii) In order to reduce fire risk and prevent obstruction, all empty cases, crates, or packages whether or not returnable shall be removed from the Site by Contractor as soon as possible. If this requirement is not complied with, after due notice, CMRL will remove them and the expenses for the activity will be charge to the Contractor.

18.15.1.4 If sea transportation of trains from manufacturer's works to site at Chennai is required, seaworthy packing/ treatment of Trains shall be carried out for the safe transportation of trains. It shall apply to sea transportation of spares and other materials also.

18.16 PUBLIC RELATIONS MATTERS AND PROGRESS PHOTOGRAPHS

18.16.1 General

- 18.16.1.1 The Contractor shall, in conjunction with CMRL, liaise with Public Relations Officer, CMRL on all press and public relations matters in connection with the Contract.
- 18.16.1.2 All press releases, press statements, articles or printed material prepared by the Contractor shall be submitted to CMRL, in consultation with CMRL prior to publication or release to the news media.
- 18.16.1.3 All press queries relating to the Contract received by the Contractor must be referred to CMRL for clearance, in consultation with CMRL. The Contractor is not allowed to be interviewed by the press or divulge any information freely to reporters without seeking clearance from CMRL.
- 18.16.1.4 Use of the CMRL logo in the Contractor's publications shall be subject to approval of CMRL.
- 18.16.1.5 The Contractor shall provide CMRL with prior schedules relating to night works, traffic diversions, closure of road etc. that may cause inconvenience to the public.
- 18.16.1.6 The Contractor shall extend to CMRL all the necessary assistance and cooperation with regard to requests for photo-taking, video-taking and visits to the Site by the CMRL's official photographer or appointed film-maker, in consultation with CMRL.
- 18.16.1.7 The Contractor shall include a section on matter concerning Public Relation in his monthly report to CMRL.
- 18.16.1.8 All hoardings and signboards at CMRL site put up by the Contractor shall be maintained in good condition.
- 18.16.1.9 All public complaints should be thoroughly investigated and acted upon by the Contractor on an urgent basis.
- 18.16.1.10 The Contractor shall give full support to all functions and events e.g. community talks for residents, Site visits for the media etc. organized by the CMRL during the period of the Contract.

18.16.2 Progress Photographs

- 18.16.2.1 After design, manufacturing and testing activities start, the Contractor shall furnish photographs showing the progress of the Works during the month. The actual number of photographs taken and the subjects photographed shall be as directed by CMRL.
- 18.16.2.2 Each photograph shall have a title block in the lower right-hand corner, which shall show the information like Contract no., Contract Name, Contractor, Photograph No., Date, Description:
- 18.16.2.3 Soft copies of all the photographs showing the progress of the work shall be submitted in the monthly meeting report.
- 18.16.2.4 Detailed photographs (date and time stamped) of each train on its arrival at the Designated Depot(s) and before introducing for revenue operation shall be archived and copies handed over to CMRL. The photographs must include all such items that are incomplete / defective etc. Complete set (soft copy) shall be submitted every month to CMRL.

19. MATERIALS AND WORKMANSHIP

19.1 NOT USED.

19.2 GENERAL

- 19.2.1 Materials for the construction of the Rolling Stock shall be in accordance with the stated specification or cited standard, unless the Contractor obtains approval for a substitution as specified in ERTS.
- 19.2.2 All materials shall perform safely and satisfactorily within their operating environment and in accordance with their intended function.
- 19.2.3 Workmanship shall conform to the best manufacturing practices in all respects. All work shall be performed by qualified personnel, using correct tooling and procedures, and be properly trained and skilled in the tasks they will be performing.
- 19.2.4 The Contractor shall maintain records that trace all materials to their manufacturers and shall help verify compliance with quality standards specified or cited in these provisions.
- 19.2.5 Whenever a commercial material is not covered by a specification or standard, the Contractor shall identify the material by the commercial trademark, name, and address of the supplier. The Contractor shall submit a description of the material composition for approval.
- 19.2.6 Use of substitute or single-source materials shall not be permitted unless approved by CMRL. Approval shall be determined on a case-by-case basis. Specification equivalency / benefit data for any substitution to a cited standard shall be submitted to CMRL for review and approval.
- 19.2.7 The following materials shall not be used in the construction of the car without CMRL's prior approval:
- (i) PVC
 - (ii) Asbestos
 - (iii) Cadmium, except in Ni-Cd batteries
 - (iv) Lead in brake shoes
 - (v) Urethane foam
 - (vi) Chlorinated fluorocarbons that may cause environmental problems or handling hazards
 - (vii) Materials that, in their normal installed state, emit products that are known to be toxic or irritative
 - (viii) Any material that produces combustion by-products which are known to be toxic.
 - (ix) Beryllium.
- 19.2.8 Carbody structural parts that are permanently covered and concealed after assembly shall not be made of copper, copper bearing aluminium alloys, brass, bronze, silver, or nickel.
- 19.2.9 Foreign matter, such as shavings, chips, etc., shall be completely removed from all parts of the car, its components, assemblies and subassemblies, whether hidden or exposed.
- 19.2.10 Surfaces exposed to passengers, crew, or maintainers shall be smooth and free of burrs, fins, sharp edges, and dangerous protrusions.
- 19.2.11 The Contractor shall submit to CMRL for approval material safety data sheets for all chemical materials used in the production, assembly, repair or maintenance of the cars, including, but not limited to paints, adhesives, sealants, compounds, solvents, and lubricants.
- 19.2.12 The Contractor shall submit for approval a material matrix for metals and non-metals, together with cited reference test reports and certifications (format as defined in MILSTD-454).
- 19.2.13 The Contractor shall submit to CMRL for approval joining and fastening data, specifications, and standards.
- 19.2.14 All name and rating plates shall be permanently attached using mechanical fasteners. Exceptions may be made for small components and circuit boards.
- 19.2.15 Not limited to: Welding, sealing, crimping, riveting, gluing, painting, torquing, etc. is considered as

special processes. The Contractor shall ensure process qualification and validation for these processes and records of the same shall be maintained for scrutiny and review by the CMRL.

- 19.2.16 Interior and Exterior shall be protected against damage caused by dirt, dust, moisture, etc. including during transport. The Contractor shall ensure that it is protected until the train is inducted into Revenue Operation.

19.3 UNITS OF MEASURE

- 19.3.1 Each car system shall be designed and manufactured to SI standard.
19.3.2 Only metric system parts shall be used.

19.4 STORAGE OF MATERIAL

- 19.4.1 All material subject to corrosion shall be protected so as to prevent corrosion due to moisture. All material subject to corrosion shall be protected by weatherproof and waterproof covers, coatings, or packaging so as to prevent corrosion.
19.4.2 Equipment covers, cable entrances, and openings shall be closed to prevent ingress of water or dirt.
19.4.3 All dated material shall have the expiration date clearly marked on the product and the exterior of the packaging. Expired material shall not be used.
19.4.4 Rejected or damaged material shall be clearly marked and stored separately from other production material.

19.5 LOW-ALLOY, HIGH TENSILE STRENGTH STRUCTURAL STEEL

- 19.5.1 Low-alloy, high tensile (LAHT) steel for the carbody end underframe shall comply with ASTM A242. Low Alloy, high tensile strength (LAHT) steel for structural and formed components shall comply with ASTM A242 and shall be anti-corrosive copper bearing steel for structural elements.
19.5.2 LAHT steel shall comply with ASTM A588 for structural shapes, plates, and bars.
19.5.3 LAHT hot-rolled and cold-rolled steel sheets and steel strips, with improved atmospheric corrosion resistance, shall comply with ASTM A606
19.5.4 Other LAHT steels meeting or exceeding the above minimum requirements may be proposed, but are subject to CMRL approval. The Contractor shall submit a test and inspection plan for all proposed alternate structural steel. All LAHT steel shall be applied according to their specified properties.
19.5.5 Proposed alternate welded LAHT steel shall develop at least 20 Joule Charpy V-Notch impact strength in the coarse grain heat affected zone, at 1 mm distance from the fusion area, at a temperature of –290C.

19.6 STAINLESS STEEL

- 19.6.1 Austenitic, stainless steel sheets, strips, plates and flat bars shall comply with ASTM A666 / EN 10088 / JIS G4305, except that the carbon content shall not exceed 0.03%.
19.6.2 Stainless steel shall be AISI type 201, 301, 301L, 301LN, 302, 304, 304L, 316, 316L or 347 in accordance with the intended function.
19.6.3 Stainless steel used in structural applications must be low carbon (“L” series) stainless steel with a maximum carbon content of 0.03% and shall conform to AAR “Specifications for the Construction of New Passenger Equipment Cars”, Section 2, paragraph (f).
19.6.4 All materials used in the carbody shall be the US or Metric standard gauge thickness with standard tolerances for the associated gauge. No alloys shall be used without prior approval.
19.6.5 General requirements for the delivery of stainless steel shall be as required by ASTM A 666 Section 15/ EN 10088/ JIS G4305, and this material shall be tested for susceptibility to inter-

granular corrosion in accordance with both Practice A and Practice E of ASTM A 262, latest revision. All material shall be free from precipitated carbides, scale or pickle last finish.

Surface imperfections or laminations of a magnitude that prevents meeting bending requirements shall not be permitted. For exposed surfaces, the colour and finish shall match samples.

- 19.6.6 Buffing and polishing of stainless steel, where required, shall be done in an approved manner and without the use of any composition containing iron or iron oxide.

19.7 STEEL CASTINGS

- 19.7.1 Steel castings shall be selected for the composition, heat treatment, and design best suited for the intended service. Castings shall be sound throughout and within specification requirements for intended use. Quality of casting (radiographic) for vital spares (like traction bars, etc.,) has to be ASTM Gr.1, or equivalent.
- 19.7.2 Welding repairs of castings shall be allowed, provided that repairs are performed in accordance with an approved written procedure, and by welders qualified to ASTM A488.
- 19.7.3 High strength castings shall be tested, inspected, and accepted in accordance with AAR requirements. High strength castings, and Low alloy nickel castings, shall comply with, and be tested, inspected, and accepted in accordance with AAR M-201.
- 19.7.4 General-purpose steel castings shall comply with ASTM A27, either Grade 65-35 / Grade 70-36.
- 19.7.5 Low alloy nickel castings shall comply with AAR requirements.
- 19.7.6 Steel castings shall be sound throughout. The manufacturer shall prove its manufacturing procedure by either destructive or non-destructive means. Following the establishment of a satisfactory procedure, quality control shall be maintained by testing one or more pieces of each lot at a frequency to be determined by CMRL, the Contractor and the foundry; and this frequency shall be influenced by the critical requirements of the part. If castings are found to be porous or otherwise unsound, the material shall be destroyed at no expense to CMRL.
- 19.7.7 All castings shall have all sharp or rough edges that are a result of the casting operation, removed. When grinding is used to dress surface defects or welds used to repair castings, care shall be exercised to ensure that no abrupt sectional changes result.

Each structural casting shall be identified, by permanent means, with the heat number of the steel and the serial and pattern number of the casting. Copies of the physical tests and the chemical analysis of each heat of steel shall be matched to individual castings and included in the appropriate Car History Book.

19.8 RIVET STEEL

- 19.8.1 Rivet steel shall comply with ASTM A31 or ASTM A502. Exposed rivets shall be concentric to the shank and free from rings, fins, pits, and burrs. All rivets removed and replaced shall have the holes reamed round to the size required such that the next larger rivet may be driven accurately. Rivets exposed to view shall be austenitic stainless steel or aluminium, as appropriate to the material being joined.

19.9 HEAT-TREATED ALLOY STEEL

- 19.9.1 Structural heat-treated alloy steel suitable for welding may be used for sub-structures not exposed to atmospheric corrosion. Heat treated alloy steel used for structural purposes shall comply with ASTM A514, Grade F. The use of all alloys is subject to CMRL approval.
- 19.9.2 Ultimate tensile strength shall be in accordance with the relevant standard(s).
- 19.9.3 Structures of heat treated alloy steel shall be so designed that the principle stresses to which any part is subjected shall not exceed the following percentages of yield strength of the material used, under full dynamic conditions with a maximum load.

	Bogie Frame	All Other
Tension and Compression	39%	50%
Shear	25%	31%
Bearing	62%	62%

Further reductions shall be made to compensate for fatigue where required.

- 19.9.4 Appropriate stress reductions shall be made for column or plate stability effects. Static test results may be submitted to justify the use of higher computed stresses.

19.10 ALUMINIUM

- 19.10.1 Aluminium alloy mill products shall be identified by designations prescribed by the Aluminium Association and shall comply with the requirements contained in the Aluminium Association publication, "Aluminum Standards and Data." Structural members shall be designed in accordance with the requirements of the Aluminium Association "Specifications for Aluminium Structures" and "Engineering Data for Aluminium Structures." Proper allowance shall be made for effects of fatigue, and for column and plate stability effects.
- 19.10.2 Aluminium alloy surfaces shall not make direct metal-to-metal contact with the surfaces of copper, brass, bronze, silver, nickel, nickel-plated parts, lead, tin, or alloys of any of these materials, except for electrical connections where appropriate joint compounds shall be used, subject to approval.
- 19.10.3 Extrusions, sheets and plate shall comply with Aluminium Association "Standards for Aluminium Mill Products" contained in "Aluminium Standards and Data."

The table below shows the properties of the materials for aluminium extrusions profiles and sheets / alloys data to be confirmed during design phase.

Table: Mechanical Properties of Materials for Extrusions

Material acc. To DIN EN 573-3	Thickness e [mm]	Yield Strength Rp0.2 [MPa] min.	Tensile Strength Rm [MPa] min	Ultimate Strength Elongation	
				A [%] min.	A50 [%] min.
EN AW 6005A T6 Profile; Open Section	< 5	225	270	8	6
	5 < e < 10	215	260	8	6
	10 < e < 25	200	250	8	8
EN AW 6005A T6 Profile; Hollow Section	< 5	215	255	8	6
	5 < e < 15	200	250	8	6
EN AW 6082 T6 Sheet	0.4 < e < 1.5	260	310	-	6
	1.5 < e < 3	260	310	-	7
	3 < e ≤ 6	260	310	-	10
	6 < e < 12.5	255	300	-	9
	12.5 < e < 60	240	295	8	-
EN AW 6082 T6 Profile; Open Section	25 < e < 50	260	310	-	8
EN AW 5083 H111	0.5 < e < 1.5	125	275	-	12

Material acc. To DIN EN 573-3	Thickness e [mm]	Yield Strength Rp0.2 [MPa] min.	Tensile Strength Rm [MPa] min	Ultimate Strength Elongation	
				A [%] min.	A50 [%] min.
Sheet	1.5<e<3	125	275	-	13
	3<e<6	125	275	-	15
EN AW 6060 T6 Profile	<3	150	190	8	6
	3<e<25	14	170	8	6

For structural aluminium castings the following materials are permitted according to DIN EN 1706:

- EN AC-42100 / EN AC-AISi7Mg0.3
- EN AC-21100 / EN AC-AICu4Ti

19.10.4 In certain areas (brackets, complex geometry) aluminium castings may be used.

The table below shows the properties of the materials for aluminium castings (data to be confirmed during design phase).

Material	Casting Process	Tensile Strength Rm [N/mm ²] min.	Proof Strength Rp0.2 [N/mm ²] min.	Elongation A5 [%] min.
AISi7Mg0.3	Sand casting	230	190	2
AISi7Mg0.3	Gravity die casting	250	250	3
AISi7Mg0.3	Investment casting	230	230	3
AlCu4Ti	Sand casting	250	180	2
AlCu4Ti	Gravity die casting	260	200	3

Note: Tension test acc. to DIN EN 10002-1, material properties acc. to DIN 1725-2, specin acc. to DIN 50125. The test specimen has to be marked distinctively at the front face with a stamping number.

19.10.5 Castings shall comply with ASTM B26, ASTM B85, or ASTM B108, or Aluminium Association “Standards for Aluminium Mill Products” alloy and temper 356-T6, 364-T5, or 356-T6 respectively, and shall be free from blowholes, cracks, shrinkage, and other defects. Unpainted interior aluminium castings shall be cast in alloy ASTM B275: GM70B.

19.10.6 The forming of aluminium parts, their joining by bolting, riveting, or welding, and protection of contact surfaces shall comply with ALCOA “Specification Covering Use of Aluminium in Passenger Carrying Railroad Vehicles.”

19.11 NON-METALS

19.11.1 Material specifications, including physical properties, and combustible property data (flame, smoke, toxicity, and heat content and release rate test results), for all materials, shall be submitted to CMRL for review and approval.

19.11.2 All non-metallic material shall be selected with due consideration for the specific needs, and environment, of the application. Materials shall not degrade within their service life in such a way as to diminish their performance, appearance, colour or intended function.

19.12 ELASTOMERS

- 19.12.1 Elastomeric parts may include hydraulic seals and gaskets, door and window seals, glazing strips, bogie stops and snubbers, structural and compressible gaskets, and mounting pads.
- 19.12.2 All elastomeric parts shall be composed from suitable elastomers compounded and cured to perform satisfactorily under the environmental conditions in which the car may be operated.
- 19.12.3 Gaskets shall comply with ASTM D1056. Foam gaskets shall comply with ASTM D1056, Class B.
- 19.12.4 Elastomeric materials shall be tested to verify compliance with performance requirements as given below. The Contractor shall submit certificates stating compliance with the requirements of the standards.
- 19.12.5 Elastomers shall pass tests indicated in Table 19-1 and the smoke/flame tests specified in TS19.61.
- 19.12.6 Interior decorative trim shall be coloured to harmonize with adjacent surfaces. All colours shall be as approved by CMRL.
- 19.12.7 Metal parts to which elastomeric materials are cured shall be made of SAE J403 hot rolled steel or equal, suitably cleaned for bonding.

Table 19-1: Testing For Elastomers

Physical Property	ASTM Test Method	Test Value
Hardness, Durometer A	D2240	45 ~ 75 (based upon application)
Tensile strength	D412	10342 kPa
Ultimate elongation	D412	300%, min
Ozone resistance	D1149	No cracks (0)
Oil aging resistance	D471	+80% change in volume max
Permanent-set resistance	D395	25%
Tear resistance	D624, method B	35 N/m
Brittleness temperature	D746 -40	-40°C
Resistance to heat aging	D573	-40% change in elongation -10% change in tensile strength ±5 change in hardness

19.13 GLASS

- 19.13.1 Laminated safety glass shall be used exclusively and shall conform to the following general, manufacturing, and finish requirements:
- Float glass shall be in accordance with FS-DD-G-451. Float glass shall be in accordance with ASTM C 1036, Type 1, Class 1, Quality q3 glazing select.
 - Glass shall be fully tempered in accordance with MIL-G-25667. If tempered glass is used in the laminate, it shall be fully tempered in accordance with SAE-AMS-G-25667
 - Edges shall be seamed and ground smooth per SAE J673, Edge no. 4, and sealed with aluminium tape or equivalent.
 - Any overlap of one sheet of glass with respect to the other at an edge shall not exceed 0.78 mm

- (v) The thickness tolerance of the individual sheets as supplied shall be held within 0.78 mm
 - (vi) When a sheet of glass is laid on a truly flat surface, the glass shall not exhibit a bow of more than 0.76 mm per linear foot.
 - (vii) The dimensional tolerance for the cut size dimensions of rectangular shapes, including squareness shall be according to ASTM C 1036 Table 1, but not to exceed (1.0mm). For other shapes, the cut size shall not exceed (1.6mm) of the dimension specified. Unspecified corners shall have a (1.6mm) radius.
 - (viii) Masking, if used, shall be applied between the laminated layers of the glass.
 - (ix) Manufacturers stamp shall be positioned in lower right hand corner as viewed from inside the car.
- 19.13.2 Window glazing shall be bonded with an approved type of plasticized polyvinyl butyral resin in the form of a membrane 1.14 mm $\pm$ 10% thick, which shall not be degraded by ultraviolet or visible light or temperatures that can be obtained by solar heating.
- 19.13.3 Group I glass shall:
- 1 (i) Be clear laminated safety glass used for all front facing glazing (i.e. windshields and ~~detrainment door~~). The Contractor is requested to follow IS 2553 or equivalent International Standard for Toughened Glass.
- (ii) Be coated, if required, to have maximum solar heat transmittance of 68%
- 19.13.4 Group II glass shall:
- (i) Be clear laminated safety glass used for operator cab side windows, passenger compartment windows, doors and draught screens.
- (ii) Be coated if required to have maximum solar heat transmittance of 68%.

19.14 FIBERGLASS-REINFORCED PLASTIC

- 19.14.1 Fiberglass-reinforced plastic (FRP) shall be polymeric-reinforced laminated material, composed of a gel-coated surface, fiberglass reinforcement, and a polyester, phenolic, or approved equal resin.
- 19.14.2 FRP shall be able to withstand, without any physical degradation or deformation, the stresses encountered in the environment where it is to be used. Fiberglass components shall be moulded, stored, and mounted in their final, designed, shape, and shall not be mounted in a deformed/stressed condition.
- 19.14.3 FRP shall be resistant to acids, mild alkalis, and cleaning solutions normally used in rail transit service.
- 19.14.4 Fiberglass reinforcement shall be mat, fabric, woven roving, continuous roving, chopped spun roving, or swirl mat, as required to meet physical and process requirements. Glass content by weight shall be minimum 20%.
- 19.14.5 Gelcoats shall be resistant to scuffing, fire, weather, perspiration, and cleaning agents and shall be pigmented to match approved colours. Gelcoats must contain UV inhibitors / stabilizers or be formulated to minimize any discernible yellowing or color degradation.
- 19.14.6 Gelcoat additives, fillers, monomers, catalysts, activators, inhibitors, pigments, or flameproofing materials shall be added to resin mixes to obtain finished products with required characteristics. No FRP panels shall be painted.
- 19.14.7 Mineral filler shall not exceed 28% of finished weight for preformed matched die moulding process.
- 19.14.8 FRP shall be manufactured by one of the following methods, or an approved equivalent:
- a. Method 1: Open melding, hand lay-up, or spray lay-up
 - b. Method 2: Matched die moulding or preform.
- 19.14.9 Production techniques shall ensure that the fiberglass reinforcement is distributed throughout the final product in such a manner as to preclude resin-rich or resin-starved sections.

- 19.14.10 Open-moulded parts shall be gel coated.
- 19.14.11 Surfaces shall be uniform, smooth, and free of porosity and crazing.
- 19.14.12 The Contractor shall submit for approval certificates verifying that reinforced plastic materials comply with the minimum requirements specified in Table 19-2. Pre-test conditioning of test specimens shall conform to ASTM D618.

Table 19-2: Minimum Requirements for Reinforced Plastic

Mechanical Property	ASTM Test	Open Moulding	Matched Die Moulding Preform
Tensile Strength	D638	89 MN/m ²	124 MN/m ²
Compressive Strength	D695	152 MN/m ²	221 MN/m ²
Flexural Strength	D790	145 MN/m ²	193 MN/m ²
Impact	D256	13.6Nm per 25 mm of notch	17.6 m per 25 mm of notch
Hardness	D2583	45 Barcol	45 Barcol
Heat	None	79°C	Continuous
Thickness	None	3 mm	3 mm min.
Gelcoat Thickness	None	14 mils, ± 2 mils.	[0.36mm ±0.05mm]

- 19.14.13 Fiberglass parts shall be fastened by bolting through metal joints or strips. Alternative methods are only permitted subject to CMRL approval.
- 19.14.14 Washers or similar inserts shall be bonded between fiberglass panels when joined.

19.15 THERMOPLASTIC MATERIALS

- 19.15.1 Thermoplastic materials shall comply with the requirements of Table 19-3.
- 19.15.2 Thermoplastic sheet shall be able to withstand, without any physical degradation or permanent deformation, the stresses encountered in the environment where it is to be used.
- 19.15.3 Thermoplastic sheet shall meet the relevant flammability, smoke emission and toxicity requirements as specified in TS19.61.
- 19.15.4 Thermoplastic sheet shall be homogenous and extruded from virgin stock, which does not include any regrind of vacuum formed parts. The exposed surface of this material shall be uniform in colour, texture and gloss. The colour and surface finish of parts manufactured from this material shall be approved prior to the production run of any parts.

Table 19-3: Thermoplastic Materials

Physical Property	STM Test	Method Performance Requirement Value
Specific Gravity	D792	1.20 to 1.36
Hardness, Rockwell	D785	90 to 100
Tensile Strength	D638 5	D638 38 MN/m ² minimum at 23°C
Flexural Modulus	D790	2206 MN/m ²

Physical Property	STM Test	Method Performance Requirement Value
		minimum elasticity at 23°C
Flexural Strength	ASTM D790	68,947.6 kPa minimum @ 23°C
Impact Strength (@ 73oF notched IZOD)	ASTM D256	6.6 foot pounds per inch of notch minimum
Heat Shrinkage	None	15% maximum, 10 minutes @ 193°C
Thickness	None	2.38 mm minimum

19.16 PLASTIC / COMPOSITE BODY FILLER MATERIAL

- 19.16.1 All body filling material shall be selected to effectively discourage flame propagation, smoke generation, and cracking.
- 19.16.2 The manufacturer's instructions shall be followed during application of body filler material.
- 19.16.3 The Contractor shall submit for approval material specifications, including flame and smoke test results, for all body fill material to be used on the car.
- 19.16.4 Maximum thickness shall be 3.175 mm.

19.17 NOT USED

19.18 SANDWICH PANELS

- 19.18.1 Sandwich panels include, but are not limited to, plymetal, honeycomb, or lumber-core panels, with metal or other approved facing material.
- 19.18.2 When finished, continuous edge reinforcement shall be incorporated if needed to facilitate transfer of stresses and to seal edges against moisture penetration and other damage.
- 19.18.3 The term "honeycomb panels" as used in these Technical Provisions refers to honeycomb material bonded to melamine or to metal.
- 19.18.4 Honeycomb-core panels shall comply with applicable requirements of MIL-C-7438, unless otherwise specified.
- 19.18.5 Bonding between the base material and the cover shall be sufficient to develop the full strength of the honeycomb material. Continuous edge reinforcement shall be incorporated if needed to facilitate transfer of stresses and to seal edges against moisture penetration and other damage. Where mechanical fasteners are used, threaded inserts shall be bonded into the panel.
- 19.18.6 Melamine laminates used in the construction of the car shall be two-ply laminated and shall consist of a hard plastic film facing permanently bonded to base sheet.
- 19.18.7 Contact adhesives shall not be used to bond the melamine to the base.
- 19.18.8 The final laminate assembly shall comply with NEMA LD-3 and shall be self-extinguishing.
- 19.18.9 Sandwich panels shall be fully balanced in construction.

19.19 NEOPRENE FOAM

- 19.19.1 Neoprene foam shall be high-resiliency foam latex. Base elastomer of latex shall be polymerized chloroprene (polychloroprene) and shall contain no reclaimed rubber.
- 19.19.2 The structure of the foam shall consist of a network of closed cells of uniform character.
- 19.19.3 The foam shall have a high resistance to flexing, tearing, wetting, and exposure to flame as specified in TS19.61.

- 19.19.4 The Contractor shall submit data on the physical and performance characteristics of the material for CMRL approval.
- 19.19.5 Dimensions of elastomers shall comply with ASTM D1055.
- 19.19.6 The elastomers shall have high resistance to ultraviolet radiation, weather, all car washing fluids, and the longest possible life consistent with the other characteristics specified. All elastomeric parts shall be resistant to ozone, oxidation, heat oil, grease and acid.

19.20 FLOOR COVERING

- 19.20.1 The floor covering shall be a proven material and floor system used in various railways for similar applications and will be subject to CMRL approval.
- 19.20.2 The flooring shall be non-staining, non-discolouring and non-oil extended, and contain additives to preclude damage or discoloring to UV light.
- 19.20.3 High-quality hard clay shall be used as a filler. No limestone shall be used in the compound.
- 19.20.4 The rubber flooring shall be fully homogeneous throughout.
- 19.20.5 The rubber flooring material shall comply with FS-SS-T-312 and the flame and smoke test requirements of clause 19.61.
- 19.20.6 The Contractor shall submit color / material 3 samples for approval.
- 19.20.7 Prior to the installation of the floor covering, any depressions, voids, or cracks in the sub-floor shall be filled and the sub-floor shall be leveled and smoothed with a CMRL approved leveling compound.
- 19.20.8 Bottom side of the flooring shall be sanded and then securely bonded to the subfloor panels.
- 19.20.9 The floor covering shall be permanently secured to the plymetal sub-floor with a CMRL approved adhesive and as recommended by the flooring manufacturer.
- 19.20.10 The floor covering and adhesive shall be resistant to solutions and solvents normally encountered in rail transit service.

19.21 CAULKING AND SEALING

- 19.21.1 The use of caulking and sealing compounds shall be minimized.
- 19.21.2 Caulking and sealing compounds shall be applied in accordance with the manufacturer's instructions and recommendations, shall be non-staining, and shall be supplied in colors closely matching those of adjacent materials and surfaces.
- 19.21.3 If butyl-type is used, it shall be extruded polyisobutylene sealer compound of 100% solids.
- 19.21.4 Caulking primers shall be quick-drying, colorless, non-staining sealers of a type and consistency recommended by manufacturers of caulking materials for the particular surface involved.
- 19.21.5 Packing (backstop) shall be non-staining, resilient material, such as fiberglass roving, neoprene, butyl, closed-cell foams, or other compressible materials compatible with the caulking compound used.
- 19.21.6 Caulking compound application shall be compatible with subsequent paint application.
- 19.21.7 Joints, spaces, and junctures to be packed and caulked or sealed shall be completely cleaned of dirt, dust, oil, and other foreign materials that would adversely affect caulking quality.
- 19.21.8 Surfaces shall be thoroughly dry before caulking compounds are applied.
- 19.21.9 When so stipulated by the sealant manufacturer, paint and other protective coatings shall be removed from surfaces to be caulked prior to priming and application of sealants.
- 19.21.10 Compounds shall be applied with pneumatic guns. Where the use of a caulking gun is impracticable, suitable hand tools shall be used.
- 19.21.11 Unless otherwise indicated, the entire perimeter of each opening shall be caulked.
- 19.21.12 The finish of caulking joints on flush surfaces and in internal corners shall be neatly pointed;

excess material shall be removed; and, where exposed, the caulking shall be free of wrinkles and uniformly smooth.

- 19.21.13 Application of polysulfide or silicone compounds shall be in accordance with the manufacturer's instructions and recommendations.
- 19.21.14 Compounds shall not be used when they become too gelled to be discharged in a continuous flow, and they shall not be modified by addition of liquids, solids, or powders. Compounds shall not be used when they have exceeded their stated shelf life.
- 19.21.15 Installation and working of compounds shall be completed within the maximum working times as follows; The application and working of caulking material shall be completed within 70% of the minimum "skin" time, considering application conditions. When two-part compounds are being used, only the amount of caulking that can be installed within 70% of the maximum recommended pot life shall be mixed.
- 19.21.16 When two-part compounds are being used, only the amount of caulking that can be installed within 4 hours shall be mixed.
- 19.21.17 Adjoining surfaces, finishes, and fixtures shall be carefully protected throughout caulking operations, and any stains, marks, or damage thereto as a result of caulking and sealing work shall be removed.

19.22 ADHESIVES

- 19.22.1 Adhesives to be used for installation of floor covering, panels, insulation, and vibration isolation materials shall have a satisfactory history of performance in a rail transit environment.
- 19.22.2 The Contractor shall submit for approval a list of all adhesives to be used on the car, with a description of the physical, chemical, and fire safety properties of each. This requirement does not apply to adhesives used in extremely small quantities, such as adhesives used to apply nameplates or markers.
- 19.22.3 Adhesive shall not be used when they have exceeded their stated shelf life and shall be installed within the manufacturer's defined temperature range.
- 19.22.4 Joining of components by adhesives shall be completed within the maximum working times as follows: The application and aligning of bonded components shall be completed within 70% of the adhesives maximum working time, considering application conditions. When two-part compounds are being used, only the amount of adhesive that can be used within 70% of the maximum recommended pot life shall be mixed.

19.23 UPHOLSTERY FABRIC

- 19.23.1 Upholstery fabric, if used shall be transit grade and shall be capable of withstanding all contaminants normally encountered in service, including water, grease, oil, grit, etc. The color of the upholstery fabric shall match with the interior color scheme and decoration of the passenger compartment. The upholstery, trim and other materials used for seat construction shall meet the fire, smoke and toxicity requirements of Chapter 19.61. The Contractor shall submit the List of compatible upholstery cleaning agents.

19.24 FASTENING TO STRUCTURAL MEMBERS

- 19.24.1 The Contractor shall ensure that any fastening or joining to structural members does not result in moisture accumulation within any structural member.
- 19.24.2 To this end, fastenings to structural members shall not be accomplished using drilled holes in the structural member.

19.25 THREADED FASTENERS

19.25.1 General

- (i) The number of different sizes and styles of fasteners used shall be minimized. A single standard, Metric standard (DIN/ISO), shall be adopted for the fasteners used. Fasteners shall be properly marked.
- (ii) All fasteners shall be stainless steel, dichromate, or zinc-plated steel, depending on the specific application. Zinc plating on steel fasteners shall conform to ASTM B 633 Type II – yellow, or equivalent standard, for non-exposed fasteners.
- (iii) Threaded aluminum fasteners shall not be used except in tapped holes in solid aluminum structures, subject to CMRL approval.
- (iv) When slotted or oversized holes are provided for installation tolerance, flat washers, of suitable size to cover oversized holes, or slots shall be used in all locations (that is, under bolt head and/or under nut). If slotted holes are provided as a means of adjusting a piece of equipment, a secure method of fastening, such as ribbed or toothed adjustment washers, must be used.
- (v) All threaded fasteners shall comply with ANSI B1.1 class 2 requirements, unless otherwise specified or approved.
- (vi) No protruding screws, mounting bolts, or similar items shall be permitted on the exterior of the car.
- (vii) On the car interior, all exposed screws shall be stainless steel with flat or oval heads.
- (viii) All exposed bolts and nuts shall be stainless steel, unless otherwise specified.
- (ix) Exposed screws shall be of tamper-proof type.
- (x) Fasteners not exposed to passengers on the car interior shall be of stainless steel or zinc-plated steel.
- (xi) Self-tapping screws shall not be used.
- (xii) Use of threaded inserts or special fasteners shall require approval.
- (xiii) At least 1½ threads shall be visible beyond all nuts but not more than 8 threads.

19.25.2 Locking Requirements

- (i) Threaded fasteners shall be self-locking or provided with locking devices, where practicable.
- (ii) Locking devices shall be either lockwire, lock washers or locknuts as appropriate for the application or service.
- (iii) Lockwire, if used, shall be stainless steel as specified in TS19.6.
- (iv) Locknuts shall be of the nylon collar insert type. Previously installed and removed locknuts shall not be re-used. High temperature applications may use metallic distorted thread locknuts upon CMRL approval. Locknuts shall conform to Military Standard MS-21044 and Military Specification MIL-N-25027, or equivalent.
- (v) Bolts for use with locknuts shall not be heated or drilled for cotter pins.
- (vi) All locknuts shall comply with the Industrial Fasteners Institute requirements regarding to locking ability.

19.25.3 Torque Marking/Indexing

- (i) The Contractor shall ensure the proper application of all threaded fasteners.
- (ii) Torque marks or stripes extending from the secured hardware shall be applied to all safety-related hardware, including, but not limited to, bogie, door, and brake equipment bolts.
- (iii) CMRL may require non-safety related hardware to have a tightening indication present.

19.25.4 Bolts and Nuts

- (i) All fasteners falling into this category used in this project shall require a submittal of Certifications of Compliance (C of C) with each shipment of hardware to the end user. The C of C shall be traceable to a manufacturer.

- (ii) Carbon steel bolts shall comply with ASTM A325. Alloy steel bolts shall comply with ASTM A354 or ASTM A490, as applicable.
- (iii) Nuts shall comply with ASTM A194.
- (iv) Stainless steel nuts and bolts shall be used for stainless-to-stainless joints.
- (v) Anti-seize compounds shall be used on all stainless-steel fasteners threaded into stainless steel, or using stainless steel nuts.
- (vi) All hardware used shall be a minimum of SAE Grade 5 / Metric Property Class 8.8, except that Phillips or slotted head screws ¼ inch in size, and smaller, may be SAE Grade 2 / Metric Property Class 4.8.
- (vii) SAE grade 8 or metric property class 12.9, hardware shall be used for mounting the traction motors to the bogie, and for all bogie mounted appurtenances, unless specifically allowed otherwise by CMRL.
- (viii) All structural or load-carrying bolts shall be a minimum of Grade 5. The design strengths for Grade 2 bolts and Class A nuts shall be used in sizing the mounting and attachment bolts for underfloor mounted equipment and equipment support structures or brackets.

19.25.5 Electrical and High Temperature Connections

- (i) Plated steel screws or bolts, nuts, flat washers, and lock-washers used in mounting and in making connections to resistors and other heat-producing apparatus shall be suitable for high temperatures without degradation of the strength of the hardware or its corrosion resistance.
- (ii) Flat washers shall be used on both sides of all electrical connections (that is, under bolt head and under nut).

19.25.6 Plating

- (i) After manufacturing, steel fasteners shall be electroplated, zinc with a yellow chromate conversion per ASTM B 633, Type II – Yellow, or equivalent standard, for non-exposed fasteners. (See table for thickness). Stainless steel fasteners shall be passivated.

Bolt size	US / SAE ASTM B633	Metric DIN 267	Thickness (µm)
Dia. up to M3 (#8)	-	A1L	(3µm)
Dia. >M3 (#8) to M8 (5/16")	SC1	A2C or A2L	(5µm)
Dia. >M8 (5/16") to M22 (7/8")	SC2	A3C	(8µm)
Dia. >M22 (7/8") to M33(1 1/8")	SC3	A4C	(13µm)
Dia. >M33 (1 1/8") and greater	-	A5C	(15µm)

- (ii) Steel fasteners for use in cosmetic locations may be chrome plated per ASTM B 456, class SC-3 – verify thickness criteria for threads, or specify heads only, w/ Cu or Ni on threads.
- (iii) Fasteners with hardness greater than or equal to 32 HRC (320 HV) are susceptible to hydrogen embrittlement when pickled and/or electroplated (i.e. US Grade 8, hardened steel washers, or spring washers). These fasteners and fastener components shall be mechanically zinc plated, with a yellow chromate conversion (Zinc Yellow Dichromate finish) per ASTM B 695 or equivalent standard, for non-exposed fasteners.

19.26 RIVETS AND RIVETING

- 19.26.1 Rivet holes shall be accurately located and aligned, and, when necessary, during assembly, holes shall be reamed round to the specified size in position.
- 19.26.2 Hand-driven steel rivets shall be driven hot and shall completely fill the holes.

- 19.26.3 Mechanically driven rivets may be driven cold.
- 19.26.4 Heads shall be concentric with the shank of the rivet.
- 19.26.5 Exposed heads shall be free from rings, fins, pits, and burrs.
- 19.26.6 Any rivet that is removed shall be replaced with the next larger size rivet, after the hole is reamed to the appropriate size.
- 19.26.7 Use of blind rivets shall require CMRL approval.
- 19.26.8 Aluminum alloy rivets shall comply with Aluminum Association “Standards for Aluminum Mill Products” alloys and tempers 6061-T6 or 6053-T61.
- 19.26.9 Steel rivets shall comply with ASTM A502.

19.27 CORROSION CONTROL

- 19.27.1 All materials used shall be either inherently corrosion resistant, or suitably treated to prevent corrosion. Equipment located in areas highly susceptible to corrosion shall be made from inherently corrosion resistant materials.
- 19.27.2 Areas exposed to corrosive fluids or cleaning solutions shall be protected with coatings resistant to those fluids. The Contractor shall be responsible for verifying that all such areas are protected.
- 19.27.3 Except as otherwise indicated, all aluminum exposed to view in finished work in the interior of the car shall have a protective anodized coating.
- 19.27.4 Dissimilar Metal Treatment
 - (i) The Contractor shall prepare a Corrosion Control Plan which shall locate all areas of dissimilar metal or other material joining which could result in galvanic action and material deterioration, and materials which require treatment to prevent corrosion due to atmospheric exposure. This plan shall document the methods used to preclude failure due to corrosion for any of the above conditions. The Contractor shall update this document as materials and treatments change. The Corrosion Control Plan shall be submitted to CMRL for review and approval.
 - (ii) Direct contact between electrically dissimilar metals is prohibited except for electrical connections between copper and aluminum where appropriate joint compounds are used as specified herein. Isolating and moisture proofing materials, appropriate to the materials being joined, shall be used at all times.
 - (iii) All metals used in the fabrication process shall be surface treated with corrosion resistant materials prior to assembly, with consideration being given to the severity of exposure to which the surface shall be subjected.
 - (iv) The joining of incompatible metals and materials shall be minimized as much as possible. When such metals must be joined, provision shall be made in accordance with MIL-STD-889 to prevent chemical reactions between the metals.
 - (v) Surfaces of aluminum alloy parts secured to ferrous parts shall be protected with one-part polysulfide or silicone sealant used as joint compound, or with joint material that is non-hygroscopic and is free from chlorides and heavy metal ions.
 - (vi) Fibrous joint material shall be impregnated with bitumen or other water-repellant substance that shall completely cover interfacing surfaces.
 - (vii) All ferrous metal surfaces, other than stainless steel, shall be protected by methods described in TS19.28, unless otherwise specified. Steel surfaces not requiring protection shall be galvanized by the methods and requirements described in ASTM A123.
 - (viii) Minor damage to galvanized coatings shall be repaired to recognized industry standards.
 - (ix) The Contractor shall submit for approval a description of the procedures and processes employed to prevent corrosion and to prevent corrosion arising from the use of dissimilar metals.

19.28 PAINT AND PRIMER

19.28.1 General

- (i) All paint must be compatible with local governing air quality management authority. The Contractor shall submit to CMRL for approval data on all paints, primers, and application processes or procedures to be used for the CMRL passenger car.
- (ii) All dents, roughness, or other surface imperfections shall be corrected prior to the application of the priming coat.
- (iii) Primer and finish paint shall be supplied as a system from a single manufacturer. All materials shall be stored according to the manufacturer's recommendations and used within the specified shelf life limits. In no case shall materials be used, if the specified shelf life, or 70% of the mixed pot life, has been exceeded. Paint shall be applied within the manufacturer's recommended temperature range, but at a temperature of no lower than 55°F.
- (iv) Preparation for paint application shall follow the paint manufacturer's recommendations.
- (v) As a minimum, prior to paint application, surfaces shall be cleaned to remove all traces of contamination, and properly treated to promote paint adhesion.
- (vi) Paint shall be applied evenly, and the finished surface shall be free of dirt, runs, "orange peel" or other imperfections. The Contractor shall submit to CMRL for approval a Paint Inspection Procedure, which defines testing plan, inspection procedure, achievable levels of cosmetic (appearance, gloss, surface imperfections) requirements and primer/paint adhesion requirements.
- (vii) At least two coats of paint shall be applied, with appropriate surface preparation between coats.
- (viii) Touch-up paint shall be identical in all respects to the original paint.
- (ix) Prior to assembly, all low-alloy steel areas shall be painted with one coat of an approved primer followed by one coat of an approved sealer to prevent rusting.

19.28.2 Underfloor

Exposed underfloor steel surfaces, after installation of welded-on bracketry, shall receive a minimum of two coats of primer and two coats of an approved paint. In areas where intermittent welding is used, the seam shall be completely sealed after paint application.

19.28.3 Equipment Enclosures

- (i) The exterior of all equipment enclosures shall be coated with an approved primer and coating. Final coat color shall be approved by CMRL.
- (ii) The interior of all equipment enclosures shall be coated with a primer and an approved white coating.

19.28.4 Not Used.

19.28.5 Apparatus and Underfloor Equipment

- (i) All underfloor apparatus (motors, control boxes, junction boxes, brake valves, and other equipment as specified) shall be primed and painted in accordance with the following requirements unless otherwise indicated. All other apparatus shall be painted in an approved color.
- (ii) Parts of undercar equipment enclosures made from plastic or fiberglass shall be painted in accordance with the above requirements for metal portions except that the paint system shall be compatible with the plastic used, and an insulating coating need not be applied.
- (iii) Painting Restrictions

Any equipment or parts of equipment which would be damaged or suffer impaired operation from painting shall not be painted and shall be corrosion resistant. The following items shall not be painted, Conduit fittings, Wire and cable, Power resistors, Heat transfer surfaces, Electrical insulators, Elastomeric portions of air, hydraulic and refrigerant lines, Grounding pads, Elastomeric parts, Grease fittings, Linkages, Threaded parts used for adjustments, Electrical equipment, Wearing surfaces.

19.28.6 Interior Painting

- (i) Interior surfaces requiring painting shall be coated with an approved thermosetting powder coating. Parts which are to be powder-coated shall be cleaned and prepared in accordance with the recommendations of the powder supplier and the substrate material being covered.
- (ii) The Contractor and its powder supplier shall supply a touch-up procedure and assure that a continued supply of touch-up paint in the proper colors suitable for spot application will continue to be available in India.

19.28.7 Corrosion Protection

Concealed surfaces capable of rusting or oxidation shall be properly cleaned, then primed with a rust inhibiting paint, and painted with an approved finish coat of paint. All joints between aluminum and steel shall be suitably insulated from each other to ensure that they will be free of corrosion.

19.28.8 Bogie frame

- (i) Before installation, the Bogie frame shall be cleaned by blowing off with compressed air and solvent-wiped to remove all dirt and grease.
- (ii) All bogie frame components shall then be sprayed with 1 coat of primer and 1 coat of an approved paint (a type that will not conceal cracks that may develop in service) and air-dried.

19.28.9 Paint Process Documentation

- (i) The Contractor shall prepare a paint coating and application submittal containing the procedures for surface cleaning and preparation, priming, surfacing, painting for the carbody and all equipment that is painted or powder coated.
- (ii) A detailed paint schedule showing the equipment painted, paint type and manufacturers, recommended thickness, and other pertinent information shall also be included. The documentation shall also detail the acceptable quality levels (including an 8" x 10" sample of each) for sags, runs, orange peel and foreign objects in the paint. This document shall also be included in the maintenance manuals.

19.28.10 Roof

- (i) The roof, if constructed of material subject to corrosion, shall receive a minimum of two coats of primer, a coat of surfacer, and at least two coats of a polyurethane paint and a clearcoat.
- (ii) Other roof materials shall be painted in areas exposed to public view from platform level.
- (iii) Roof walkway areas, either on the car structure or equipment containers, shall have an anti-skid material, coating or surface application to provide a safe walking surface when wet. Areas not capable of supporting weight of maintenance personnel shall be clearly marked with "no step".

19.28.11 Exposed Piping, Conduits and Wireways

- (i) Any exposed wireways, conduits, or piping made of material subject to corrosion shall receive a minimum of two coats of primer and two coats of an approved paint.
- (ii) This priming and painting can be accomplished either before or after installation of the item on the carbody.

19.29 WELDING

19.29.1 General

- (i) The Contractor shall be responsible for the quality of all welding and brazing, including the welding and brazing of its suppliers and subcontractors.
- (ii) All welding practice not specifically covered in this Chapter shall be in accordance with the applicable requirements and recommendations of EN-3834-2, EN 15085-1 to 5 or the American Welding Society (AWS), as contained in the latest revisions of the "Structural Welding Code" (AWS D1.1), "Aluminum Welding Code" (AWS D1.2), "Structural Welding Code -Sheet Steel" (AWS D1.3), "Recommended Practices for Resistance Welding" (AWSC1.1), "Railroad Welding Specification" (AWS D15.1) and the AWS "Welding Handbook" (AWS WHB). Where non-AWS welding is proposed, the supplier shall demonstrate equivalence.

- (iii) Prior to welding, all surfaces shall be thoroughly cleaned to remove corrosion, rust, scale, slag, grease, oil, water, paint, and other foreign materials in accordance with applicable parts of MIL-HDBK-132, "Protective Finishes", Section 2.
- (iv) Parts to be joined by welding shall be supported and held in position by tables, jigs, or fixtures to prevent warping.
- (v) Each weld shall be uniform in width and size throughout its entire length.
- (vi) Each welding pass shall be cleaned and free of slag before the next layer of weld material is deposited. Each layer of welding shall be smooth, free of cracks, pinholes, and undercuts and shall be completely fused to the adjacent weld beads and base metal.
- (vii) Chipping or grinding of welds shall be performed in a manner that will not gouge, groove, or reduce the adjacent base metal thickness.
- (viii) All grinding of welds shall be performed in the direction of the weld.
- (ix) All surface marks resulting from welding shall be treated in order to eliminate any visible defects in the finished surface.
- (x) The Contractor shall comply with the requirements of "Design of Welded Connections", and "Fabrication" sections of the applicable AWS Structural Welding Codes D1.1, D1.2, D1.3, and D1.6. If the Contractor cannot comply or takes exceptions, the Contractor is to provide a list of exceptions to these Codes to CMRL for review and approval.
- (xi) Welding symbols shall be those shown in the latest edition of AWS A2.4/ISO 2553, Symbols for Welding, Brazing, and Non-destructive Examination. Special conditions shall be fully explained by added notes or details. Other European or International Standards may be used upon approval by CMRL.
- (xii) Visible resistance welds shall cause a minimum of surface indentation, shall not cause permanent discoloration and shall be arranged in uniform patterns.
- (xiii) The Contractor shall submit welding specifications, procedures, and certifications to CMRL for approval.

19.29.2 Welder Qualification

- (i) Welders shall be tested to verify their proficiency for producing sound welds.
- (ii) Welder qualification tests and welder range of qualifications shall be in accordance with the applicable AWS Structural Welding Code (D1.1, D1.2, D1.3, and D1.6) or EN 287-1. Other European or International Standards may be used if the Contractor demonstrates equivalency of these standards to the AWS Structural Welding Codes. Welder qualification tests shall be performed in accordance with the applicable requirements of AWS standards, or other approved equivalent standards.
- (iii) Welder qualification tests for pressure vessel welding shall be in accord with applicable requirements of ASME Section IX, or other approved specifications.
- (iv) The Contractor and all suppliers and subcontractors shall retain records of welder qualifications and shall make these records available to CMRL upon request.
- (v) CMRL shall have the right to require the making of test welds by any welder, whether under the direct control of the Contractor or a supplier or subcontractor, to ascertain his/her competence and to determine the suitability of the welding procedure used.

19.29.3 Welding Procedures

- (i) All welding practices, Procedure Qualification Record (PQR) and Welding Procedures Specifications (WPS) not specifically covered in other sections shall comply with AWS-D1.1, AWS-D1.2, or AWS-D1.3 or AWS D1.6 and the AWS Handbook as appropriate. Other European or International Standards such as ISO 3834-2 may be used if the Contractor demonstrates equivalency of these standards to the AWS Structural Welding Codes.
- (ii) Weld joint configuration and fit-up tolerances shall comply with the requirements AWS D1.1, D1.2, D1.3, and D1.6, as applicable. Weld joint configurations which do not comply with these requirements must be tested in accordance with the applicable AWS welding code. Other

European or International Standards may be used if the Contractor demonstrates equivalency of these standards to AWS.

- (iii) Requirements for dynamically loaded structures shall be applied.
- (iv) Resistance welding shall be in accordance with MIL-W-6858. Resistance welding operations shall be undertaken using only equipment fitted with meters or readouts and adjustments for time, current, and pressure.
- (v) The method used in depositing weld metal shall be one that reduces warping and residual stresses. To achieve this, tack welding, offset welding, skip welding, and other devices and sequences well known to the craft shall be used where appropriate.
- (vi) The weld method shall be made to penetrate into the bottoms of angles and vees and ensure complete fusion at these points. Fillet welds shall be extended around the ends of members wherever practicable.
- (vii) Manual welds having a thickness greater than 6.35 mm shall be made with at least two passes.
- (viii) Machine welds of any thickness may be made with one or more passes as applicable.
- (ix) Accurate control of cleanliness, time, current, pressure, electrode size and shape to produce welds of specified strength shall be maintained.
- (x) The Contractor shall determine, experimentally or otherwise, the proper setting of the controls, and shall provide against unauthorized changes. Similarly, the shape, size, and surface conditions of electrodes required to give satisfactory welding and acceptable finish shall be determined, and a complete record made and kept.
- (xi) Processes shall be subject to CMRL approval, based on sample welds tested by either the shear-strength or the tear-test method.

19.29.4 Welding Electrodes

- (i) The choice of welding rod or wire filler metal shall be made with consideration of the make, type, size, composition, and suitability to the application and shall be in accordance with Chapter 94 of the AWS Welding Handbook.
- (ii) Procedures for structural welding of stainless steel to LAHT steel, or other combinations of metals or conditions not covered by AWS Specification or Code, shall be subject to CMRL approval.
- (iii) Austenitic stainless-steel electrodes or wire shall be used to join carbon or LAHT to stainless steel. Galvanized steel shall not be welded to stainless steel.
- (iv) Base metal, filler metal, and their combinations shall comply with the applicable AWS Structural Welding Code. Other European or International Standards may be used if the Contractor demonstrates equivalency of these standards to AWS Structural Welding Codes.
- (v) Welding electrodes for steel or manual shielded metal-arc welding shall comply with applicable AWS standards or shall be otherwise approved.
- (vi) Bare electrodes and granular flux used in the submerged-arc or gas metal arc process shall comply with AWS D1.1.
- (vii) Welding electrodes shall be stored in a dry, closed environment to prevent contamination.

19.29.5 Weld Repairs

Weld repairs shall be performed in accordance with approved procedures that comply with AWS D1.1. When a production weld has been determined to be substandard, all production since the previous acceptable production quality control test shall be segregated, and disposition shall be recommended to CMRL for approval. All parts with substandard welds shall be rejected or repaired by weld removal, re-weld, and inspection.

19.29.6 Welding Inspection and Examination

- (i) Welds shall be visually inspected to verify compliance with the approved drawings, these Provisions and the applicable AWS structural welding code requirements.
- (ii) The Contractor shall submit to CMRL for approval the critical weld areas and acceptable quality norms.

- (iii) The Contractor shall submit to CMRL for approval a Non-destructive Examination Plan for NDE procedures other than visual testing. Welds and welded joints that will be test by penetrant test, magnetic particle test, ultrasonic test, radiograph test or another NDE procedure other than visual test shall be clearly identified on the drawing in accordance with AWS A2.4.
- (iv) Welding inspection procedures and welding inspector qualifications tests shall be in accordance with AWS D1.1 and the applicable requirements of the AWS Welding and Brazing Handbook. The Contractor shall use and demonstrate the use of personnel qualified to perform weld inspection. An AWS Certified Welding Inspector (CWI) shall be utilized for inspection or oversight of welding inspection. Non-destructive examination procedures and qualifications of non-destructive testing personnel shall be in accordance with the applicable requirements of the AWS Structural Welding Codes & American Society for Non-destructive testing Recommended Practice No. SNT-TC-1A. Other European or International Standards may be used if the Contractor demonstrates equivalency of these standards.
- (v) Critical areas of all such welds shall be magnetic particle or dye penetrant or ultrasonic tested, and radiographic tests shall be used on a random sample basis.
- (vi) The following defects in excess of limits indicated or established in the approved procedures shall be cause for rejection of the work affected: cracks, regardless of length, magnitude or location; overlaps; lack of penetration; incomplete fusion; inclusions except if they do not materially affect the strength of the welded joint and do not indicate improper technique or an unsatisfactory procedure; undercuts; poor surface appearance; or improper size of weld.
- (vii) On the first structure or component, all full-penetration welds shall be non-destructively, volumetrically inspected (ultrasonic or radiographic methods). The Contractor shall specify a random weld sampling plan for volumetric inspection of subsequent full-penetration welds for approval by the CMRL.
- (viii) With the approval of the CMRL, destructive sectioning and metallurgical examination may be substituted for some or all of the required volumetric inspection requirements.

19.29.7 Heat Treatment

Where required by specifications or drawings, welded assemblies shall be stress relieved by heat treating in accordance with AWS D1.1.

19.30 BRAZING

- 19.30.1 The Contractor shall maintain a brazing program similar to the welding program specified in TS19.29.
- 19.30.2 All brazing, qualification of brazes, and repair of brazing defects shall be in accordance with the requirements and recommendations specified in the AWS Welding and Brazing Handbook.
- 19.30.3 The Contractor shall maintain quality control procedures necessary to ensure high quality brazing.
- 19.30.4 The Contractor shall submit brazing specifications, procedures, and certifications to CMRL for approval.

19.31 SOLDERING

- 19.31.1 Soldering of electronic equipment shall comply with requirements of MIL-STD-454 or equivalent
- 19.31.2 Soldering of mechanical equipment shall comply with requirements of DOD-STD-1866 or equivalent
- 19.31.3 The Contractor shall submit soldering specifications, procedures, and certifications for CMRL approval.

19.32 PIPING, TUBING AND PRESSURE VESSELS

- 19.32.1 Air or hydraulic hose applications shall not be permitted in locations where adequate visual inspections cannot be made. Air or hydraulic hose installations shall be located/arranged in such a manner as to prevent accidental cross connections to other hoses located in the same general

area.

- 19.32.2 Hose installations shall be such that kinking, rubbing, chafing, straining, and unnecessary swinging are precluded.

Rubber Items:

All rubber hoses, connecting pipes etc. used in pneumatic circuit shall not be required to be replaced before 5 years or major overhaul whichever is later. The rubber/ rubber- metal components used in suspensions shall not be replaced before 12 years or during major overhaul of the equipment, whichever is later. All rubber hoses shall be steel reinforced for better life and reliability.

- 19.32.3 Routing that requires other piping or cables as the sole means of support shall not be accepted.
- 19.32.4 The Contractor shall submit to CMRL piping, tubing, and pressure vessel specifications and data for approval.
- 19.32.5 Piping and Tubing
- (i) All brake piping shall be seamless stainless-steel pipe conforming to JIS3459 of SUS316LTP Steel or equivalent, as approved by CMRL.
 - (ii) Piping and tubing shall be adequately supported at least every 610 mm throughout its length and at connections, and must not interfere with the removal of or access to other components.
 - (iii) A minimum clearance of 3.175 mm shall be maintained between all piping and tubing used in the car.
 - (iv) Car body air lines, if required, shall be of stainless steel with suitable capacity.. Stainless steel piping shall meet the requirements of ASTM A 312 with flared fittings. All pipe flares shall be for 37-degree fittings meeting the requirements of SAE J533b or any better method of fitting.
 - (v) Copper tubing fittings shall be sweat type of wrought copper meeting the requirements of ANSI B1622.
 - (vi) Stainless steel or brass fittings shall be used with stainless steel piping and tubing. Forged steel fittings, zinc plated to ASTM B633, Type II, Yellow, SC3 / SC4, may be substituted upon CMRL approval.
 - (vii) All piping, tubing, valves, fittings, installation and testing methods, shall comply with ASME B31.1.
 - (viii) Joints that serve the sole purpose of connecting pipe lengths shall not be used in a straight run of pipe.
 - (ix) Unavoidable joints in piping shall be made in an approved manner.
 - (x) All inaccessible runs of tubing or piping shall be without joints.
 - (xi) All piping shall be securely fastened with zinc-chromate-impregnated core tape, or an approved equivalent, between the pipe and clamp to prevent chafing and vibration. Clamps shall not be welded, brazed or otherwise permanently fastened to any pipe or tubing.
 - (xii) Piping shall be deburred and blown out after cutting, and thoroughly cleaned and capped after installation.
 - (xiii) CMRL reserves the right to verify piping cleanliness to CMRL's satisfaction at any time during the production process.
 - (xiv) After installation of the piping, and before connection or installation of system components, piping shall be cleaned by approved methods.
 - (xv) The Contractor shall submit for approval proposed flushing and cleaning procedures for the piping and piping system.
 - (xvi) Following installation, piping systems shall be pressure tested in accordance with ASME B31.1 or other approved method.
 - (xvii) All leaks that appear during pressure testing shall be repaired to CMRL's approval and re-tested until acceptable under the approved test criteria.
 - (xviii) All hoses used shall comply with AAR Manual of Standards and Recommended Practices, Section E: Brakes and Brake Equipment. Brake system hoses shall be in compliance with AAR

M-618.

- (xix) All hose fittings shall be of a reusable type, where practicable, and subject to CMRL approval. Air hose fittings shall be in compliance with AAR M-927.
- (xx) All piping shall be installed in accordance with AAR 2518 as incorporated in Standard S-400 (AAR Manual E) and in such a manner as to provide drainage to prevent freezing.
- (xxi) All copper piping shall be joined using silver solder conforming to Federal Specification QQ-B-654, Class 1 or 3. Refrigerant tubing shall be filled with dry nitrogen or approved equal during soldering. Solder fittings shall be wiped and flux cleaned from tubing and fittings after soldering.
- (xxii) Air-conditioning refrigerant lines shall be of annealed seamless copper tubing per TS19.32.5.1, with sweat wrought type fittings per TS19.32.5.6. Joints shall be kept to a minimum and there shall be no inaccessible joints. Suction lines shall be designed and constructed without horizontal traps, and have a maximum of 3 pounds per square inch, pressure drop. The liquid line shall be sized adequately to prevent flashing due to pressure drop.
- (xxiii) All condensate drain lines and refrigerant piping shall be insulated. The insulating material shall be applied to the piping with suitable contact cement. All joints and directional changes in the insulation shall be appropriately mitred and sealed.
- (xxiv) Approved and surface sealed copper vibration isolators shall be used in piping connections to the air conditioning compressor unit(s). Flexible hoses may be used for this purpose and shall conform to EN 1057 and EN 378 standards.

19.32.6 Air Filters

- (i) The filtering capability, flow rate capacity, and overall size of filters shall be appropriate for the application so that the filter replacement interval shall be greater than 1 year except VAC.
- (ii) Access to the filter element for replacement purposes shall be possible without requiring the opening of any pipe fittings. Filters shall not be located in inaccessible locations for routine maintenance access.

2

- (iii) All the air filters shall be of metallic mesh construction and shall be made of stainless steel material. Any change in this shall require prior approval of the Engineer.

19.32.7 Pressure Vessels

- (i) Unfired pressure vessels shall comply with the ASME Boiler and Pressure Vessel Code for Unfired Pressure Vessels, Section VIII.
- (ii) A test report shall accompany each pressure vessel received by the Contractor, and a copy of the test report shall be included in the appropriate Car History Book.
- (iii) Each pressure vessel shall be stamped by the testing facility, whether it is the manufacturer or a third party, as verification of unit testing.
- (iv) Automatic Drain cocks along with manual operation shall be provided at the low points of all reservoirs.

19.33 BEARINGS AND LUBRICATION

- 19.33.1 All bearings and lubricants shall be readily available in the India
- 19.33.2 Standard grease fittings or plugs shall be provided for all bearings not internally splash- or bath-lubricated. All grease points shall be easily accessible and receive paint highlighting to enhance grease port visibility.
- 19.33.3 All rotary shafts shall be supported by sealed cylindrical or tapered roller or ball bearings where practicable.
- 19.33.4 Bearings subject to atmospheric or liquid contamination shall be sealed by labyrinth, lip or face seals. Bearings installed in a vertical application shall have suitable protection to prevent moisture or contaminants from accumulating on, or entering the bearing.
- 19.33.5 Not used

- 19.33.6 Bearings shall be installed and removed without major disassembly of related components, and in no case shall thrust be carried across the rolling elements in pressing a bearing into its seat.
- 19.33.7 Sleeve bearings shall be used for shafts with rotary motion of less than one full revolution. Alternative, service proven, designs will be considered. Sleeve bearings shall be adequately lubricated.
- 19.33.8 Sleeve bearings supporting ferrous shafts shall be composed of bronze, brass, or aluminium alloys as approved.
- 19.33.9 Sleeve bearings may be used to support rotary shafts if space limitations preclude the use of anti-friction bearings.
- 19.33.10 Self-lubricated bushings (sintered metal) shall be used in accordance with the manufacturer's recommendations but shall not be used for shafts with speeds greater than 500 rpm.
- 19.33.11 The Contractor shall submit bearing specifications and data for approval.
- 19.33.12 All lubricants shall be products approved by the supplier of the parts on which the lubricant is to be used.
- 19.33.13 All lubricants shall conform to applicable ANSI and ASTM specifications.
- 19.33.14 Multi-purpose lubricants shall be used where possible.
- 19.33.15 The Contractor shall submit for approval data on lubricants if any, recommended for bearings and bushings.

19.34 THERMAL AND ACOUSTIC INSULATION

- 19.34.1 Thermal insulation materials may be of the rigid, non-rigid, or spray-on type.
- 19.34.2 Insulating materials shall be fire-retardant, non-hygroscopic, resistant to fungus, and provided with a vapour barrier as required to prevent the entry of moisture, oil, gases, and dust.
- 19.34.3 The materials shall not absorb fluids and gases and shall possess the required properties to meet the noise and vibration requirements of clause 2.13 and 2.17.
- 19.34.4 The type of thermal insulation to be used shall not be susceptible to Mold or rot and shall not absorb water. Metals which are attached to the insulation shall not be corroded or settle under car vibration. The car thermal insulation shall not have an odour or be capable of absorbing odours and shall not sustain vermin. Urethane foam insulation is expressly prohibited.
- 19.34.5 Sound damping material used in the fabrication of the car shall be resistant to diluted acids, greases, gasoline, aliphatic oils, and vermin; must be resistant to fungus; and must not support combustion. The material shall not be affected by sunlight or ozone, and shall not become brittle with age.
- 19.34.6 Suitable acoustic insulation shall be provided on the carbody side and roof side to minimize the effect of reflected noise into the saloon. The car body shall be designed to have high thermal insulation to reduce the heat loss and heat transfer coefficient (K value) of the car body excluding glazing / windows shall be kept within 1.6W/(m²K). The calorific value of the insulation material used as well as the material used for fixing the insulation shall be bare minimum. Any insulation shall be protected against degradation, migration of particles into the car interior and shall be retained even when access panels are opened.
- 19.34.7 Thermal and Acoustic insulation measures sufficient to meet internal noise levels and VAC requirements of the car body shall be provided. The method of retention in the car shell, for all insulating materials, shall be subject to CMRL approval.
- 19.34.8 The Contractor shall submit for approval data on thermal and acoustic insulation materials and application processes.

19.35 WIRING GENERAL REQUIREMENTS

- 19.35.1 Wire sizes, insulation requirements, materials, shielding methods, and identification of wire and cable used for primary, auxiliary, control, and communications applications shall be based on the

- current carrying capacity, voltage drop, mechanical strength, temperature, and flexibility requirements of AAR, ASTM, ICEA, NFPA, MIL, or NFPA 70 specifications.
- 19.35.2 All wire and cable insulation shall meet the flame and smoke test requirements of clause 19.61 and shall be zero halogen.
- 19.35.3 The Contractor shall keep the number of wire types and sizes used in the car at a minimum.
- 19.35.4 All electrical wire and cable used in the car shall be approved by CMRL. The Contractor shall submit for approval samples and specifications of each size and type of wire and cable proposed for use in the.
- 19.35.5 The Contractor shall supply a motion and design suitability analysis for each case where wire and cable is used in flexing applications. This analysis shall include range of motion, clamping arrangement, wire/cable selection criteria, and expected number of cycles.
- 19.35.6 Wire location and spacing shall preclude any possible electrical interference (EMI, Transients, etc.) to any other wire, electrical equipment, or wayside equipment.
- 19.35.7 Braided copper wire shall be used in all ground strap applications. Flexible stranded copper wire is acceptable in other applications.
- 19.35.8 Aluminium braided wire straps shall not be used.
- 19.35.9 All unused conductors of multi-conductor cables shall be terminated at both ends.
- 19.35.10 All holes through which cables pass shall be fluted, or bushed, to prevent chafing and damage to insulation.
- 19.35.11 High and low voltage cables shall, wherever possible be kept separate. Where cables carrying voltages of greater than 200V between conductors are carried in the same jumper as other cables, they shall be run together only as far as the nearest junction box. Any such arrangement shall be submitted to the CMRL for review.
- 19.35.12 All cable shall be run in enclosed waterproof and dust-proof ducting.

19.36 CONDUCTORS

- 19.36.1 Maximum wire ampacities shall comply with EN 50343, except where otherwise specified or if the cable insulation material permits a higher temperature.
- 19.36.2 Where more than three conductors are routed in a conduit, Cable ducts or cable, the ampacities shall be de-rated as detailed in EN 50343.
- 19.36.3 Current capacities of conductors between traction motors and traction power control equipment shall be per IEEE 835 or NFPA 130, Chapter 4.3.3. Current capacities of all other primary power conductors shall be per EN 50343.
- 19.36.4 Current capacities may be per ICEA 110° C ratings where cable type and construction are appropriate.
- 19.36.5 Low voltage control and auxiliary power circuits operating below 240 V shall use minimum 600 V cable. Propulsion power circuits operating at or above 240 V shall use minimum 2,000 V cable.
- 19.36.6 A minimum of 4 mm² Cross sectional area of conductor shall be used for wire pulled through conduits. Any changes in minimum wire size will be considered during design review.
- 19.36.7 Wire for control and auxiliary circuits shall not be smaller than 4 mm² Cross sectional area of conductor 4 mm² Cross sectional area of conductor except for high temperature, public address, and intercom applications. Any changes in minimum wire size will be considered during the design review.
- 19.36.8 0.08 mm² Cross sectional area of conductor of minimum shall be used for wire in electronic units and card racks.
- 19.36.9 When bundled, 1.5 mm² Cross sectional area of conductor wire may be used in circuits where the current is low and physical strength is not required, or when laid in wire troughs or its equivalent.
- 19.36.10 Except as otherwise specified, conductors shall be of soft, annealed, tinned copper stranded in accordance with ASTM B33.

- 19.36.11 Stranding and conductor construction for all wires and cables 0.75 mm² Cross sectional area of conductor and larger shall comply with NEMA-WC7. Stranding and conductor construction for all wires and cables of 0.75 mm² Cross sectional area of conductor and larger shall comply with AAR S-501 or ICEA S-66-524, as is appropriate for the application, Class I or equivalent for general-purpose Car body wire, and ASTM B174, Class K for flexible wire between the Car body and electric coupler or bogie-mounted equipment
- 19.36.12 Stranding and conductor construction for wires and cables of 0.5 mm² Cross sectional area of conductor and of 0.34 mm² Cross sectional area of conductor shall be of 19-strand construction as appropriate for the usage requirements.
- 19.36.13 Fire resistant cables shall be proposed for circuits, which should survive for long periods during fire, as per applicable international standards. As a minimum, the cables and wires for Battery Circuit, Public Address System, CCTV system, emergency lighting, door system, any other circuit related to Passenger Safety and warning systems shall be fire resistant in compliant to EN 50200 PH120.

19.37 APPLICATION AND INSTALLATION

- 19.37.1 All wiring shall be performed and directed by experienced personnel using appropriate tools for stripping insulation, cutting, soldering, and attaching mechanical crimp-type terminals with correct dies.
- 19.37.2 All car wiring connected to a given piece of electrical apparatus shall be insulated for the highest voltage supplied to that apparatus. Wires operating with potential differences of 50 volts or more shall not be cabled or routed together. Signalling, LVDC, AC, and HVDC wiring shall be separated.
- 19.37.3 Wiring for any communications system equipment or for cab signalling shall be done in an approved manner to conform to the requirements established by the supplier of that equipment.
- 19.37.4 All circuits shall be adequately protected and insulated from ground. All circuits and branches must be separable to isolate their grounds when trouble-shooting is required.
- 19.37.5 Wiring shall be fabricated into standard harnesses and installed in prefabricated groupings and standardized locations in the cars.
- 19.37.6 Car wiring shall comply with EN 50343, and with the AAR Manual of Standards, Section F, S-538, "Wiring Practice and Rolling Stock Standard," except where otherwise specified.
- 19.37.7 Circuit protection shall comply with EN 50343.
- 19.37.8 Electrical circuits and associated cabling shall be designed with clearance and creepage distance between voltage potentials and Car body ground in accordance with the environmental conditions to which the circuits and cabling will be subjected, and in accordance with NFPA 130, Chapter 4.
- 19.37.9 The layout of wiring shall be designed in advance of its installation and in cooperation with those furnishing the related equipment.
- 19.37.10 The Contractor shall submit a cabling plan to CMRL for approval.

19.38 WIRE AND CABLE INSULATION

- 19.38.1 Each conductor shall be separately covered with insulation. Flat cables are prohibited, except for specific data/communications applications where other arrangements are impractical. Shall comply with EN 50306, EN 50305, EN 50264, NFF 16101 & NFPA130.
- 19.38.2 Rubber, thermosetting, irradiated, cross linked polyolefin and thermoplastic-insulated wire and cable shall comply with the electrical and physical requirements of NEMA WC3, NEMA WC5, and NEMA WC7.
- 19.38.3 Wires within enclosed equipment or suitably protected locations shall comply with MILW-81044, or as otherwise approved.
- 19.38.4 For general-purpose wire and cable, the insulation shall be of heat and moisture proof material suitable for use at conductor temperatures of 90°C minimum in dry and wet locations. For high-

temperature applications, such as connecting to heaters and resistors, the insulation shall be suitable for a maximum conductor temperature of 110°C and short circuit temperature up to 250°C.

- 19.38.5 Asbestos, urethane, and polyvinyl chloride (PVC) based insulations or jacket materials shall not be used.
- 19.38.6 Outer jacket material of multi-conductor cable shall be the same as that used to insulate individual conductors, unless physical considerations indicate different material with superior characteristics.
- 19.38.7 Multi-conductor cables shall provide at least 10% spare wires and at least one spare of each wire type and size.
- 19.38.8 Shielding shall be used over multi-conductor cable for safety-critical circuits. Shielding material shall be woven wire providing not less than 60% coverage and shall be soft, annealed, tinned copper of an area equal to or greater than the largest conductor.
- 19.38.9 Non-conducting separators and fillers may be applied between conductor and insulation on conductor sizes greater than 16.8 mm² Cross sectional area of conductor
- 19.38.10 Leakage between primary wiring and car body shall be measured in accordance with IEEE 11. The leakage shall be at least 10 mega ohms when measured with 1,000-volt mega ohmmeter.
- 19.38.11 Di-electric test for all Control & Power cables shall comply with IEC 61133 & IEC 60077.
- 19.38.12 General Car body wiring insulation shall be flame-retardant, halogen-free, extra-flexible, cross-linked polyolefin material, phosphorus, sulphur, and nitrogen combined to less than 1% by weights and shall comply with EN50264, EN50382, EN50306 and EN45545. The contractor shall submit the details for review and approval by the Engineer during the design phase.

19.39 GENERAL PURPOSE CABLE AND WIRE

- 19.39.1 General Car body wiring insulation shall be flame-retardant, extra-flexible, cross-linked polyolefin material.
- 19.39.2 Wire and cables up to and including of 10mm² Cross sectional area of conductor-shall pass the test specified in of AAR S-501, Section 5.9.4.
- 19.39.3 16 mm² and larger shall pass the test specified in IEEE 383, Section 2.5.

19.40 HIGH VOLTAGE POWER CABLES

- 19.40.1 High voltage power cables (with the exception of cables passing through or above the floor) that are of 16 mm² Cross sectional area of conductor-or larger shall be cleated in place.
- 19.40.2 ~~The cleats, as specified in clause 19.47, shall be positioned at intervals no greater than 257 mm, and adequate clearance shall be maintained between cables and any structural members, components, or items of equipment.~~
The cleats, as specified in ERTS19.47, shall be positioned at intervals no greater than 300mm for horizontal mounting and 500mm for vertical mounting, and adequate clearance shall be maintained between cables and any structural members, components, or items of equipment.
- 19.40.3 Where mechanical protection is required, short lengths of conduit complying with clause 19.46 may be employed, one conduit per wire, subject to approval.
- 19.40.4 Except for heater circuits, high voltage cabling shall not be run through the Car body interior.

19.41 CABLE CONNECTORS

- 19.41.1 All cable connectors shall be of watertight design, unless enclosed in interior watertight cabinets and approved by CMRL, with removable crimp contacts of the correct size for the wire being terminated.
- 19.41.2 Cable connectors shall be equipped with sealing gaskets for both the front and back of the connector. Extension bodies shall be used if necessary to ensure that there is sufficient room to

terminate the cable wires within the connector body.

- 19.41.3 The cable jacket shall extend within the body, shall be held by a clamp, and shall have a gasket seal at the entrance.
- 19.41.4 Unused connector pin positions shall be sealed with either connector contacts or plastic sealing plugs designed for that purpose.
- 19.41.5 Adjacent connectors shall either use different inserts or different insert orientations to prevent erroneous connections.
- 19.41.6 Connectors shall comply with MIL-C-5015 or approved equal.
- 19.41.7 No straight connectors shall be used for joining live cables.

19.42 TERMINALS

- 19.42.1 Terminations and connections throughout the car shall be with insulated ring tongue connectors of the compression (crimp) type.
- 19.42.2 Quick-disconnect (fast-on) terminals with locking features may be used, subject to CMRL approval.
- 19.42.3 Terminals shall not utilize PVC insulation.
- 19.42.4 Terminals shall be attached to the wiring with the crimping tools and dies recommended by the connector manufacturer.
- 19.42.5 The crimp terminal shall be rated to match the wire conductor diameter and the insulation diameter.
- 19.42.6 Conductors that will be subjected to motion relative to the terminal shall be protected to prevent breakage of the conductor at or near the terminal.
- 19.42.7 Spare terminals shall be provided for each terminal assembly in an amount equal to at least 10% of all terminals, with at least one spare terminal provided for each terminal size.
- 19.42.8 Except for electronic equipment, all cable terminations shall be of the crimped type in accordance with BS 4579: Part 1: 1988, Compression Joints in Copper Conductors, or other service proven type. Soldered connections will not be accepted.
- 19.42.9 Low voltage cables up to 6.0 mm² conductor cross sectional area shall preferably be fitted with terminals conforming to BS4579 Pt.1 or equivalent. Alternatives shall be submitted for CMRL review.

19.43 HIGH-TEMPERATURE WIRE AND CABLE

- 19.43.1 Insulation for all wires in high-temperature applications, such as those connecting with Heaters and resistors shall conform to the following:
 - a. For wire sizes 1.5 mm² Cross sectional area of conductor and larger, cables shall be fire retardant and shall comply with EN 50306-1 to -4, EN 50264-1, EN 50267-2-1. Cables used for Emergency circuits and fire survival circuits shall comply with EN50200.
 - b. For wire sizes 0.75 mm² and smaller, the insulation shall be abrasion resistant extruded PTFE Teflon meeting MIL-W-22759/6B. When used for interconnecting pieces of apparatus, this type of wire shall be bundled and shall have a protective covering.
 - c. Fuses (shall comply with IEC 60947 & IEC 60077) may be used where specified in these Technical Specifications and with the approval of CMRL. No fuse shall be used in protection circuits, MCBs are to be provided.

19.44 COMMUNICATIONS WIRE AND CABLE

- 19.44.1 Communications wire and cable shall consist of twisted pairs of not less than 0.75 mm² Cross sectional area of conductor soft annealed, tinned copper.
- 19.44.2 Each twisted pair shall have a woven wire shield providing not less than 85% coverage. Shield

wire shall be soft annealed, tinned copper.

2

19.44.3 Stranding shall be at least ~~26 strands~~ 19 strands.

19.44.4 All communications wire and cable shall be installed in Cable ducts or as otherwise approved.

19.45 UNDERCAR AND ROOF WIRING INSTALLATION

- 19.45.1 Wiring of 10mm² or smaller shall be run in insulated metal Cable ducts and wire ducts with securely fastened but easily removable metal covers.
- 19.45.2 Wire and cable shall be securely anchored in an approved manner in the ducts to prevent chafing from relative motion.
- 19.45.3 The wire ducts and conduits shall be of waterproof construction and shall be presented to CMRL during design review for approval.
- 19.45.4 When physical strength is required, 16 mm² Cross sectional area of or larger wires may be used and supported in place without any type of enclosure by using moulded rubber cable support blocks. This method is also acceptable in protected areas subject to damage or vandalism.
- 19.45.5 Wires or cables shall not pass over or through the battery compartment.
- 19.45.6 Floor wiring shall be run in conduits or ducts and may be run through partitions, but only if suitable bushings are provided at such points of passage.
- 19.45.7 In no case shall wires or cables carrying high voltage be tied to or directly supported by conductive members at ground potential. The wires or cables shall be securely anchored in an approved manner and shall be covered at the point or points of contact with an approved insulating material.
- 19.45.8 Sufficient slack and wire length shall be provided to prevent breaking or pulling out of bushings or terminals, and to allow for a serviceability loop long enough for three re-terminations.
- 19.45.9 Drip loops shall be provided where appropriate.

19.46 CONDUIT AND CABLE DUCTS REQUIREMENTS

- 19.46.1 Open metal Cable ducts and their elbows, couplings, nipples, bushings, locknuts, universal joints, expansion joints, and other conduit fittings shall be so designed that the sections can be mechanically and electrically coupled, while the wires are protected from abrasion.
- 19.46.2 High voltage wiring, (i.e., wiring in excess of 120 volts) shall not be run in the same cable ducts, conduits, or Cable ducts as low voltage wiring.
- 19.46.3 All conduits shall be arranged to prevent moisture traps and shall drain toward control boxes, and shall be supported to the Car body at least every 610 mm.
- 19.46.4 Wires in conduits, ducts, and Cable ducts shall be free of kinks, insulation abrasions, and insulation skinning.
- 19.46.5 Conduits that contain three or more conductors shall be sized such that the sum of the cross-sectional area of the wires and cables does not exceed 40% of the cross sectional area of the conduit. For two conductors, a limit of 30% shall be used. For a single conductor, a limit of 53% shall be permitted.
- 19.46.6 Where conduits with a length not exceeding 610 mm, and without bends of more than 15 degrees, are used between enclosures, a maximum fill of 60% shall be permitted.
- 19.46.7 If a conduit is designed to come through the flooring of the car and into equipment boxes located at the passenger compartment level, the conduit must extend 4-inch [25 mm] above floor level to prevent water or cleaning chemicals from draining onto the below-floor cables.
- 19.46.8 All the cables which are traversed from underframe to coach, coach to roof & vice-versa shall be adequately provided with cable glands and seals such that it shall prevent the ingress of water, vermin, dust, fire, noise to interior of the saloon from exterior environment.
- 19.46.9 Process of cable laying in various cable ducts inside train, underframe & roof cable ducts shall be proposed to CMRL for approval.

- 19.46.10 The connecting hoses, jumper cables and other electrical conduits between cars shall be secured with adequate spacing between the adjacent train components, adjacent cables/conduits/hoses to prevent chafing during train operating and coupling/un-coupling conditions.
- 19.46.11 The entry of the car-car/rake-rake jumper cables including HV power cables, auxiliary power cables, battery voltage supply cables, train-line control circuit conduits, pneumatic hoses, etc., between under-frame to car body interior shall be effectively sealed for ingress of water, dust and fire.
- 19.46.12 Any inter car or inter rake hoses/conduits/AC-cables/DC-cables shall have sufficient clearance from the top-most surface of the track level considering the full wheel wear diameter, operating levels of the primary suspension and failure of air suspension.
- 19.46.13 There shall be at-least 10% spare wires with connected terminals for each category of type of purpose inside each electrical conduit and 20% of spare wires for Trainlines. These categories of wires could be audio, Ethernet, trainlines, various train networks, other serial & parallel communications and all types of car lines or trainlines which are passing through the jumper conduits. It shall be possible for CMRL to utilize these free cables which are within the train conduits without impacting other functionalities of the train at a later stage.
- 19.46.14 All metallic boxes, cases and enclosures containing electrical equipment, including cable ducts & conduits which are not intended to be part of the live circuit shall be properly earthed with an insulated flexible earth bond to the relevant earth bar. All the locations accessed by passengers and maintenance personnel shall be properly earthed.

19.47 CLEATING

- 19.47.1 All cable and wiring not installed in conduits shall be cleated by split block cleats of moulded neoprene rubber or an approved equivalent.
- 19.47.2 A non-flammable insulating material with a durometer reading of 50 to 60 shall be used for cleating.
- 19.47.3 The holes in the cleat shall be sized for the individual wires and cables.
- 19.47.4 Each cleat shall have a stiffener on the side away from the mounting bracket that will act to spread the bolt clamping force over the entire length of the cleat.
- 19.47.5 Bolts shall have lock nuts of approved design.
- 19.47.6 Cable and wiring using cleating shall be supported to the Car body at least every [610 mm].

19.48 JUNCTION BOXES AND FITTINGS

- 19.48.1 Pull-boxes, outlets, and junction boxes shall be provided specifically for application with the conduit and cable systems with which they are to be used.
- 19.48.2 Boxes, covers, and fittings of ferrous metal shall be galvanized inside and outside after fabrication.
- 19.48.3 Screws and other hardware shall be made of stainless steel.
- 19.48.4 All undercar and roof-mounted junction boxes shall be waterproofed and vented and shall protect enclosed equipment and connected conduits from water seepage.
- 19.48.5 The interiors of all junction boxes shall be protected with insulating light colour paint.

19.49 SPLICING AND TAPING

- 19.49.1 Splicing and taping shall not be allowed unless approved by CMRL on a case-by-case basis.

19.50 MOTOR STARTERS (if used)

- 19.50.1 Auxiliary motors shall be equipped with individual starters and 1 ϕ protection, as required by design.
- 19.50.2 Starters shall be rated for continuous duty at service indicated. The operating coils shall be

energized by battery voltage and shall be rated for continuous duty. Starters that could normally be energized during engine cranking operation must be of a type having a very low dropout voltage. Application and device data must be submitted to CMRL for approval. Starters having “pick” and “hold” coils will not be acceptable.

- 19.50.3 Starters shall be equipped with sufficient auxiliary contacts to comply with requirements for annunciator circuits, as indicated.
- 19.50.4 Thermal overload protection shall be provided. Service proven design standards shall apply.
- 19.50.5 3 ϕ starters shall have three-poles.

19.51 CIRCUIT PROTECTION

- 19.51.1 Circuit breakers shall be moulded-case type, single- or multi-pole, with frame size suitable for continuous current and interrupting duty.
- 19.51.2 Each pole shall be equipped with a trip mechanism consisting of an inverse time element for overload protection and an instantaneous magnetic element for short circuit protection.
- 19.51.3 Each pole shall be equipped with adequate means of arc extinction to prevent flashover.
- 19.51.4 Multi-pole breakers shall operate contacts simultaneously.
- 19.51.5 Breaker current rating shall be clearly visible after installation and shall comply with NEMA AB1, ANSI C37.13, C37.14, or C37.16.
- 19.51.6 Continuous current rating shall be selected in accordance with EN 50343 for load and type of service indicated.
- 19.51.7 Electrically controlled breakers shall be equipped for operation from the LVPS.
- 19.51.8 Circuit breakers shall be properly coordinated with other protective devices.
- 19.51.9 Other than high speed circuit breakers (HSCBs) used for HVDC circuits, circuit breakers shall not be used for protection on HVDC circuits.
- 19.51.10 Fuses may be used where specified in these Technical Specifications and with the approval of CMRL.
- 19.51.11 Indicator-type fuses shall be permitted within electronic assemblies and special applications with approval.
- 19.51.12 A properly marked spare fuse-holder equipped with a spare fuse shall be provided in all locations where fuses are utilized.
- 19.51.13 Where practicable, fuse holders shall be designed to preclude incorrectly rated fuses from being inserted.
- 19.51.14 High voltage circuits and low voltage circuits should not be earthed together and separate earthing shall be arranged. All earthing pads shall be readily visible and accessible for inspection and trouble-shooting.
- 19.51.15 The Contractor shall produce a complete earthing scheme, which shall prevent traction return current passing through motor and axle bearings, gearboxes, bogie centre bearings, couplers, or any path other than the designed path. The earthing scheme shall be submitted to the CMRL for review.
- 19.51.16 Miniature circuit breakers (MCB's) shall be used only for the protection and isolation of the DC control voltage and AC auxiliary circuits. MCB's shall be of a robust design suitable for use in the railway environment as detailed in IEC 61133
- 19.51.17 All grounding and bonding jumpers and straps shall either be with copper cables or copper braids of adequate size to handle fault currents and lightning discharge currents, for which the voltage drop shall not exceed 25V. All earthing connections shall be colour coded as per relevant International Standards.
- 19.51.18 Earthing
An earth fault detection system shall be proposed by the Contractor for review. Protective devices shall also prevent fires resulting from short circuits, or other electrical defects.

- 19.51.19 The Earth Concept shall such that requirement in audio frequencies used in signalling track circuits is met.
- 19.51.20 All electrical circuits shall be fully insulated from the superstructure on both the positive and negative sides and the super-structure shall not be used as any portion of an earth return circuit.
- 19.51.21 Earth fault protection shall be provided on control, auxiliary and traction power circuits, so that it shall be possible to continue operation for a limited period even where there is one earth fault on the circuit. For this purpose, the earthing of the circuits may be provided through the coils of earth fault detection relays and the supply battery.
- 19.51.22 All electrical and electronic equipment shall be protected against surge or transient voltages caused by switching (internal or external to the Rolling Stock), lightning discharges and line voltage disturbances by the provision of suitable filters or surge suppressors.

19.52 RELAYS AND CONTACTORS

- 19.52.1 Contactors and relays shall meet or exceed IEC 60077.
- 19.52.2 Low-current relays (less than 10 Amp per pole) shall have silver-alloy contacts.
- 19.52.3 Very low current relays (1 Amp and less) shall have gold-plated, silver-alloy contacts.
- 19.52.4 Low-current and very low-current relays that have not been proven in rail service shall comply with MIL-R-5757.
- 19.52.5 Higher-current relays and contactors that have not been proven in rail service shall comply with MIL-R-6106.
- 19.52.6 Relays shall be capable of at least one million electrical operations at rated contact capacity.
- 19.52.7 Plug-in relays shall be secured in their sockets by mechanical restraint.
- 19.52.8 Relay and contactor coils shall be suppressed to mitigate transient voltage spikes, with the suppressing network mounted as close to the coil as possible.
- 19.52.9 Contractor shall use Mors Smitt BK-400 / [equivalent reputed make](#) relays [with approval of CMRL](#) for all Safety Functions (like, Cab active, Rear cab active, Zero velocity, Door System, Brake control, Emergency brake circuit, coupler, etc).
- 19.52.10 Relays used in safety-critical circuits shall comply with the AAR Signal Manual, Volume 2, Section 6, unless otherwise approved.
- 19.52.11 Contactors used to interrupt HVDC circuits shall be equipped with blowout coils or other means of arc suppression in accordance with Chapter 9 and Chapter 10.
- 19.52.12 Features of Relays and Sockets:
- All relays must have a transparent cover to ensure visual inspection and must be equipped with LED based visual indication for coil activation.
 - All relays must be mounted in a socket ensuring easy swapping of relays in the installation without the use of any tools. The socket or relays must be equipped with a retaining clip or snap lock ensuring proper mechanical installation under IEC 61373 conditions.
 - The relay sockets shall be suitable for panel, rail or front mounting style. The wire connection shall be twin connection per relays pin with spring terminal.
- 19.52.13 Relay Testing Kit:
- The Contractor shall provide two (02) portable Relay Testing Kit to quickly identify the relay condition in RS Maintenance Depot. It shall be capable of testing instantaneous and timer relays on correct functionality (no jammed contacts), minimum operating voltage, contact quality, operating time and delay time.
 - The relay testing kit shall be suitable for various types of relays used in the Rolling Stock and shall also be able to electrically clean relays contacts
- 19.52.14 Extension of Relay base:
- The Contractor shall provide two (02) tools in RS Maintenance Depot for extension of each type

relay base (i.e. duplicating all the relay pins) for unattended system monitoring (measurement of current and voltage) without affecting the train electrical system in any way.

- b. The tool for extension of relay base of all type of relays shall be able to fit in tightly packed relay panels and small cabinets. It shall operate unattended once fitted in electrical cabinets, enabling normal passenger operating service. The tool kit consists of:
 - A Test Block -which shall be put between existing relay socket and the plug-in relay.
 - Break-Out Box – All the relay pins from the Test Block shall be wired to this box for the duplication of
 - relay pins.
 - Data Monitoring and Logging Device –which shall be connected to Break Out Box for the monitoring of relay pins (i.e. measurement of voltage, current etc.).

19.52.15 Dummy Relay (test switch):

- a. The Contractor shall provide a dummy relay (test switch) for each relay type in each of the Designated Depot(s)
- b. For testing, commissioning and fault finding purpose Plug-in test switch shall be able to simulate relay operation in an electrical installation, with latchable manual.
- c. operation and voltage presence indicator.

19.53 PUSHBUTTON SWITCHES AND INDICATORS

- 19.53.1 Switches shall be heavy-duty, with electrical characteristics, ratings, and accessories as required for circuit application.
- 19.53.2 Pushbutton (including illuminated) switches shall have silver-plated or silver-alloy terminals.
- 19.53.3 Indicators and pushbutton switches shall have insulation resistance of at least 1 Mega Ohms to case at 500V DC.
- 19.53.4 Indicators shall be LED type.
- 19.53.5 All push buttons and indicators shall be uniform in style and shall be arranged, size, label properly as far as possible all push buttons and indicator lamps shall be of the same manufacturer. All push button shall be of push to light type.
- 19.53.6 Contacts of critical push buttons shall be duplicated for improving reliability.

19.54 ELECTRONIC COMPONENTS

- 19.54.1 Electronic components shall be free of storage and handling damage. Components shall be clearly and permanently labelled with values or type identification.
- 19.54.2 Carbon resistors shall not be used on printed circuit boards, unless otherwise approved by CMRL
- 19.54.3 All Electronic equipment shall comply with IEC60571 and/or EN50155 and additionally type tested for,
 - (i) Dry heat test: The dry heat test shall be conducted for class T3 and temperature shall be considered 80°C against 70°C specified in IEC/EN. An extra performance check at 95°C shall also be carried out for 10 minutes over temperature value. LCD / LED display units may be tested at 70°C and an extra performance check at 85°C shall also be carried out for 10 minutes over temperature value
 - (ii) Salt Mist test (ST3 category)
 - a. Cyclic Humidity tests (IEC 60571).
 - b. Dust and sand test & Mold growth tests: The tests shall be done as per IEC 60068 & IEC 60721. The dust settlement rate shall be taken as 6gm/m²/day and dust particle size shall not be larger than 100 microns.
- 19.54.4 Electronic equipment shall not be damaged, nor shall malfunction when subjected to direct spikes and surges on the supply and indirect burst transients as defined in IEC60571 / EN50155.

19.55 PRINTED CIRCUIT BOARDS

- 2 19.55.1 Printed circuit boards (PCBs) shall be of glass epoxy construction, complying with IEC 60721-3-3/ANSI/IPC-4101 and PCB's shall generally comply with IEC 60326-3: 1991 Printed Boards – Part 3: Design and Use of Printed Boards.
- 2 19.55.2 PCBs shall be uniformly coated. The coating shall be 3C3 conformal coating (minimum) against sea salt, SO₂, H₂S, Cl, HCl, HF, NH₃, O₃, and Nox.
- 19.55.3 Conductor materials shall be determined on the basis of current carrying capacity.
- 19.55.4 Edge connectors and boards shall be keyed to prevent insertion of any board in a wrong position, and mounted for ease of board removal and replacement.
- 19.55.5 To the greatest extent practicable, component labelling shall be provided on PCBs. PCB's shall be connected to the case or rack wiring using multi-pin connectors, which shall have a successful service history in rail applications. Details shall be provided in any electronic rack system, the failure of any one module or individual circuit board shall neither cause loss of the electronics power supply within the rack, nor cause subsequent failure of circuits on other PCB's or modules. PCB's shall have mechanical polarisation to prevent insertion into a wrong socket. The use of PCB edge connectors is not permitted unless reviewed by CMRL, on a case by case basis. PCB's and modules shall be positively retained in the rack or case by a fastener or spring loaded locking pin. All PCBs shall be adequately lacquered to isolate from environment pollution.
- 19.55.6 The Contractor shall furnish the following information in respect of printed circuit boards as part of contract:
- a) Voltage and/or waveform expected at each critical test point.
 - b) Instructions for carrying out testing and troubleshooting and the function of each circuit block.
 - c) Block Diagram and functional descriptions of the PCBs.
 - d) Connection or interfacing diagrams for the printed circuit boards and assemblies.

19.56 SEMICONDUCTOR / INTEGRATED CIRCUITS REQUIREMENTS

- 19.56.1 The Contractor shall be responsible for ensuring that all electrical and electronic circuitry, including those of suppliers and subcontractors, as a minimum meet the criteria for the use of semiconductors and/or integrated circuits listed in this section, unless otherwise approved.
- 19.56.2 Suppression devices shall be provided to protect the devices and limit the circuit voltage.
- 19.56.3 All semiconductors shall be JEDEC registered and numbered and shall be available from at least two different manufacturers unless otherwise approved by CMRL. Non-JEDEC registered devices may be used, provided that the Contractor obtains CMRL's prior approval based on submission of appropriate justifications. These shall include, but not be limited to the complete procurement specifications, details of each semiconductor device, evidence of available alternative replacements as well as any applicable diagnostic connectors / capability that would otherwise be offered by JEDEC compliant devices.
- 19.56.4 Non-JEDEC registered devices which carry more than 100 Amps may be used with prior CMRL approval, based on submission of complete procurement specifications defining each such device and evidence of availability from two or more manufacturers.
- 19.56.5 All semiconductor/integrated circuits shall be rated to properly perform in the range 25° to +85° C unless otherwise approved by CMRL.
- 19.56.6 The Contractor shall not utilize obsolete components, or components for which the manufacturer is intending to discontinue manufacture. The Contractor shall make reasonable efforts to verify this requirement with each sub-supplier/manufacturer.

19.57 MICROPROCESSOR-BASED SYSTEM REQUIREMENTS

- 19.57.1 Microprocessor-based components, assemblies, and power supplies shall be provided with voltage/current regulation and protection to ensure proper operation.
- 19.57.2 All interfacing wiring shall be protected against interference from other on-car or wayside electrical radiation.
- 19.57.3 The microprocessor shall be of a family shown to be suitable for the rugged environmental conditions encountered in rail applications, and shall be supported by software development language and diagnostic programs which are acceptable to CMRL.
- 19.57.4 The microprocessor assembly shall be housed in an enclosure that shields the microprocessor assembly and the surrounding circuits from EMI radiation and interference. Incoming and outgoing cables shall be shielded.
- 19.57.5 All integrated circuits shall be screened for defects. The Contractor shall submit for approval screening methods based on a minimum of a 24-hour burn-in for the completed assembly.
- 19.57.6 The burn-in shall be performed with the equipment operational and with all input signals and loads (output signals) connected to simulate normal operating and power dissipating conditions within the devices and system.
- 19.57.7 The microprocessor shall have external buffers provided and shall be protected from external voltage and current transients and EMI.
- 19.57.8 The Contractor shall not utilize obsolete components, or components for which the manufacturer is intending to discontinue manufacture. The Contractor shall make reasonable efforts to verify this requirement with each sub-supplier or manufacturer.
- 19.57.9 Microprocessor based systems in safety critical systems such as friction braking, shall contain suitably placed “watchdog” timers to protect against a system getting hung in a loop or otherwise failing. Failure of the friction brake microprocessor system shall result in the application of friction braking. Other microprocessor-based systems shall fail to a known, safe state.
- 19.57.10 Microprocessor systems shall incorporate self-test and diagnostic facilities to locate and indicate faults within the system. The system shall have sufficient built-in diagnostic capabilities to automatically identify all system faults.
- 19.57.11 Faults occurring during system operation shall be logged, the information being stored in a non-volatile memory. LED's shall be used to indicate faulty modules, to allow rapid fault diagnosis and maintenance.
- 19.57.12 Microprocessor system hardware block diagrams shall be provided.

19.58 NOT USED

19.59 GROUNDING

- 19.59.1 Grounding connections shall be made through stainless steel / copper or bronze pads, tinned, and silver soldered to the Car body and/or equipment box.
- 19.59.2 All ground pads shall be readily visible and accessible for inspection and troubleshooting.
- 19.59.3 All equipment enclosures and shock-mounted equipment shall be grounded with tinned, braided copper, flexible “strap” grounding leads bolted to a Car body grounding pad.
- 19.59.4 Ground cables and shunts shall be extra-flexible, tinned, non-insulated, stranded copper cable meeting the additional requirements in clause 19.36, and shall be terminated by approved crimped ring terminals on both ends.
- 19.59.5 Ground cables and shunts shall be sized to withstand, without failure, the maximum failure current which could be anticipated should the return wiring totally fail.
- 19.59.6 In no case shall the size of a ground cable or shunt be less than 6 mm².
- 19.59.7 The Contractor shall ensure that all metal parts inside and outside the car that could be touched by passengers or operating personnel, including equipment boxes, panels, and test receptacles

in the passenger or operator areas, shall never exceed Car body potential.

19.60 WIRE AND TERMINAL MARKING

- 19.60.1 All electrical conductors, whether individual wires or cables, shall be marked in accordance with assigned circuit designations for the entire car.
- 19.60.2 Contractor shall submit the wire numbering plan for CMRL approval.

19.61 FLAMMABILITY AND SMOKE EMISSION

- 19.61.1 Materials used in the car shall comply with the flammability, smoke emission, toxic gas, and fire retardation requirements specified herein, as well as 49 CFR Part 238, Appendix B.
- 19.61.2 Those materials and products generally recognized to have high toxic products of combustion shall not be used.
- 19.61.3 Materials used in the cars shall be substantially free of halogen in addition to meeting the low smoke requirements specified below.
- 19.61.4 All materials used in the car, except for materials used in small quantities that would not contribute significantly to fire propagation or to smoke or toxic gas generation, shall be highly fire resistant and shall produce as little smoke emissions and toxic products of combustion as possible in conjunction with other required qualities. Toxic gas generation shall be tested to BS-6853 and shall not exceed the following values:

Toxic Gas	Maximum Concentration
Carbon monoxide (CO),	3500 ppm
Hydrogen Fluoride (HF),	200 ppm
Nitrogen dioxide (NO ₂),	100 ppm
Hydrogen Chloride (HCL),	500 ppm
Hydrogen cyanide (HCN),	150ppm
Sulphur dioxide (SO ₂),	100 ppm

ppm = parts per million

- 19.61.5 As a minimum, all materials used in the construction of the car shall meet the requirements of NFPA 130 or BS 6853, in particular the flammability and smoke emission values in Table 4-2.4.
- 19.61.6 Not Used
- 19.61.7 Not used
- 19.61.8 The Contractor shall furnish a list of materials used in the cars showing heat load per car in BTU (or heat release rate (HRR)), flame spread, and flashpoint. The Contractor shall submit laboratory test results per ASTM E163 for each test for approval. The Contractor shall furnish a combustible material matrix including all combustible materials used in the cars showing all combustible properties, heat load per car in BTU (or heat release rate (HRR)), flame spread, and flashpoint, and documentation references. The Contractor shall submit laboratory test results per ASTM E2010 for each test for approval.
- 19.61.9 Copies of prior test results showing that proposed materials have complied with the specified standards and tests may be submitted for CMRL approval. Assurance may be required that the material presently being considered for use is the same composition as that previously tested.
- 19.61.10 A material matrix showing the total weight of all materials, where the material is used, all flammability and smoke data, test requirements, results and quantity of the products of combustion shall be submitted by the Contractor during final design review.
- 19.61.11 General Requirements

- a) All materials shall have a maximum flame propagation index (IS) of 35, when tested in accordance with ASTM E162, Radiant Panel Test, except as indicated otherwise.
- b) All materials shall have a maximum (DS) of 100 at 90 seconds and 200 at 4 minutes, when tested in accordance with ASTM E662 in both flaming and non-flaming modes, except as indicated otherwise.
- c) All materials shall have a maximum (DM) of 300 within 4 minutes, when tested in accordance with ASTM E662.
- d) The following materials shall meet the requirements of this general paragraph for flame and smoke characteristics:
 - (i) Seating components (frames, shrouds, cushions, and arm rests)
 - (ii) Panels (walls, ceiling, partitions, and windscreens)
 - (iii) Equipment boxes, including shrouds/covers
 - (iv) Battery cases
 - (v) Other materials not specified elsewhere.
- e) Specific materials shall meet the combustibility properties in Table 19-7.

19.61.12 Fabrics and Upholstery

- a) Fabrics that may be machine washed or dry-cleaned shall also comply with the following, as applicable:
 - (i) FED-STD-191, Textile Test Method 5830
 - (ii) After dry-cleaning according to AATCC 86
- b) Woven upholstery fabrics for car seats shall meet the following requirements:
 - (i) In non-flaming portion of test, DS shall not be greater than 50 (in 90s) and 100 (in 4 min)
 - (ii) In flaming portion of test: DS shall not be greater than 75 (in 90s) and 100 (in 4 min)

19.61.13 Floor Covering

Floor covering shall have a (DS) of no greater than 100 at 90s, and 200 at 4 min, when tested in accordance with ASTM E662.

19.61.14 Windows and Diffusers

Windows and lighting diffusers shall have a flame propagation index (IS) of 100 or less when tested in accordance with ASTM E162; and shall have a (Ds) of 100 or less at 90s and 200 or less at 4 min when tested in accordance with ASTM E662.

19.61.15 Elastomers

- (i) Elastomers shall meet the requirements of NFPA 130 or BS 6853.
- (ii) In addition, when tested in accordance with ASTM E662, elastomers shall have a (DS) of no greater than 100 at 1.5 minutes and 200 at 4 minutes.

Table 19-7: Material Combustibility Properties

Function of Material	Test Procedure Performance Criteria	ASTM E 1354 Requirements
Wall Panels, Ceiling Panels, Partition Panels, Windscreens, Fiberglass, Plastics, Diaphragms, Non-sealing Elastomers, etc. (All car materials & components except as otherwise noted)	ASTM E 162-98 Is ≤ 35 ASTM E 662-97 Ds (1.5) ≤ 100, Ds (4.0) ≤ 200	0180 ≤ 200 kW/m2 σf(Avg) ≤ 500 m2/kg
VAC Ducting	ASTM E 162-98 Is ≤ 35 ASTM E 662-97	-

	Ds (4.0) $\leq$ 100	
Lighting Diffusers / Plastic Glazing	ASTM E 162-98 Is $\leq$ 100 ASTM E 662-97 Ds (1.5) $\leq$ 100, Ds (4.0) $\leq$ 200	0180 $\leq$ 300 kW/m2 σ_f (Avg) $\leq$ 500 m2/kg tig $\geq$ 100s
Thermal and Acoustical Insulation	ASTM E 162-98 Is $\leq$ 25 ASTM 662-97 Ds (4.0) $\leq$ 100	0180 $\leq$ 50 kW/m2 σ_f (Avg) $\leq$ 50 m2/kg
Flexible Cellular Foams	ASTM D 3675-95 Is $\leq$ 25 ASTM E 662-97 Ds (1.5) $\leq$ 100, Ds (4.0) $\leq$ 175	0180 $\leq$ 200 kW/m2 σ_f (Avg) $\leq$ 500 m2/kg
Elastomers – Lock strip gaskets	ASTM C 542 Pass criteria in table 1 ASTM E 662-97 Ds (1.5) $\leq$ 100, Ds (4.0) $\leq$ 200	0180 $\leq$ 200 kW/m2 σ_f (Avg) $\leq$ 500 m2/kg
Elastomers – Other gaskets or Seals	ASTM C 1166-00 100mm (4.0in), maximum ASTM E 662-97 Flame propagation Ds (1.5) $\leq$ 100, Ds (4.0) $\leq$ 200	0180 $\leq$ 200 kW/m2 σ_f (Avg) $\leq$ 500 m2/kg
Structural – Floor, Roof	ASTM E 119 Pass (30 Minutes minimum endurance at AW3 loading)	-
Floor Covering	ASTM E 648-97 CRF $\geq$ 0.5 W/cm2 ASTM E 662-97 Ds (1.5) $\leq$ 100, Ds (4.0) $\leq$ 200	0180 $\leq$ 200 kW/m2 σ_f (Avg) $\leq$ 500 m2/kg
Seat Cushion	ASTM D 3675 Is $\leq$ 25 ASTM E 662-97 Ds (1.5) $\leq$ 100, Ds (4.0) $\leq$ 175	0180 $\leq$ 200 kW/m2 σ_f (Avg) $\leq$ 500 m2/kg
Seat Frame, Seat Shroud	ASTM E 162-98 Is $\leq$ 35 ASTM E 662-97 Ds (1.5) $\leq$ 100, Ds (4.0) $\leq$ 200	0180 $\leq$ 200 kW/m2 σ_f (Avg) $\leq$ 500 m2/kg
Upholstery	FAR 25.853 Flame Time $\leq$ 10 sec. (vertical) Burn Length $\leq$ 150 mm, (6"). ASTM E 662-97 Ds (4.0) $\leq$ 200	0180 $\leq$ 100 kW/m2 σ_f (Avg) $\leq$ 500 m2/kg
Wire Insulation	Flammability IEEE Std 383-1974 - Pass	-

	ASTM E 662-97 Ds (4.0) ≤ 50	

19.61.16 VAC Ducting

In accordance with NFPA 130, ducting used for VAC shall have an (IS) of no greater than 35 when tested in accordance with ASTM E162, and shall have a (DS) of no greater than 100 at 4 minutes when tested in accordance with ASTM E662.

19.61.17 Electric Wire Insulation

- (i) Electrical insulation on wire and cables shall meet the flammability requirements of IEEE 383.
- (ii) Electrical insulation shall have a (DS) not greater than 50 within 4 minutes when tested in accordance with ASTM E662.

19.61.18 Paint and Coatings

All paint and coatings shall conform to the fire-retardation requirements of ASTM D1360. Waivers for coatings less than 0.004 inch [0.1 mm] thick will be accepted, providing full details are submitted for approval.

19.61.19 Plastics

All plastic materials shall be capable of passing ASTM E162 Radiant Panel Test with (IS) not exceeding 100.

20. SOFTWARE MANAGEMENT REQUIREMENTS

20.1 NOT USED

20.2 INTRODUCTION

20.2.1 General

- i) The purpose is to define main principles that the Contractor shall implement to manage the production of software systems and products throughout the Project.
- ii) These principles shall apply to any Contractor / Sub-contractor involved in software development, modification, configuration, re-use and adoption of COTS software.
- iii) The goals of software management activity are to obtain software which is Fit for purpose & Safe.
- iv) Therefore, this document covers technical, safety & quality and managerial aspects of the software systems.

20.2.2 Scope

- i) It covers both the Design and Construction stages of the Project.
- ii) The principles defined within this chapter shall apply to all software developments of Rolling stock Works.
- iii) Generally, the Contractor shall demonstrate and implement its ability to conform to all phases of the software management process from the design stage to the Burn in testing phase. The maintenance requirements defined by EN 50128 shall also be met.
- iv) In order to picture this, the appendix of this document proposes a model for the software development lifecycle. The appendix also gives the corresponding Projects responsibilities based on the standards.
- v) This document shall be read in conjunction with the System Assurance Requirements issued with Tender Documents by the CMRL.

20.2.3 Relationship with EN 50128

This document makes extensive reference to the European standard EN 50128 in defining the software management guidelines. It should be noted that this document sets some principles which EN 50128 leaves to the discretion of the Project. In this respect, these Software Management principles shall take precedence over EN 50128.

Abbreviations

COTS	Commercial Off The Shelf
EN	European Norm
ISO	International Organization for Standardisation
IswA	Independent Software Assessor
O&M	Operation & Maintenance
PLC	Programmable Logic Controller
RAMS	Reliability, Availability, Maintainability and Safety
SIL	Safety Integrity Level
SwDS	Software Development Status
SwSIL	Software Safety Integrity Level

20.2.4 Definitions

Assessment	Process of analysis to determine whether the Design Authority and the Validator have achieved a product that meets the specified requirements and to form a judgement as to whether the product is fit for its intended purpose.
Assessor	Person or agent appointed to carry out the assessment.
Contractor	Any company(ies) contracted by the Client to perform design and construction of the Rail Systems / Sub-systems.
Design Authority	Body responsible for the formulation of a design solution to fulfil the specified requirements and for overseeing the subsequent development and setting to work of a system in its intended environment.
CMRL	As defined in the Conditions of Contract
Modified Software	A Proprietary Software Product, which has been modified for the Project.
New Software	A Software Product that has been developed specifically for the Project.
O&M Contractor	The entity that will be responsible for the O&M of the Project. It may be done by CMRL in-house also.
Proprietary Software	An existing Software Product that is used without any modification, except for minor parameterisation. Proprietary Software includes system level software such as operating systems, networking software, software libraries and language compilers.
Safety	Freedom from unacceptable levels of risk.
Safety Authority	Body responsible for certifying that the safety-related system is fit for service and complies with relevant statutory and regulatory safety requirements.
Safety-related software	Software which carries responsibility for safety.
Software Component	The lowest identifiable item of software, for example a procedure, function or subroutine.
Software Development Status	A classification assigned to the software to indicate the level of change or development that must be undertaken to produce software which meets the technical requirements. The status can be Proprietary, Modified or New.
Software Module	A discrete piece of code, which is a logically separable part of a Software Product. A module contains one or more software components.
Software Product	A Software Product is a high-level stand-alone item. It may be commercially available, such as an operating system or network service, or it may be developed specifically for the project.
Software Safety Integrity Level	A classification number which determines the techniques and measures that have to be applied in order to reduce residual software faults to an appropriate level.
Verification and Validation	Activity of determination, by analysis and test, that the output of each phase of the lifecycle fulfils the requirements of the previous phase and the activity of demonstration, by analysis and test, that the product meets, in all respects, its specified requirements.
Verifier/ Validator	Person or agent appointed to carry out verification/validation.

20.3 TRANSPORTATION SYSTEM SOFTWARE

The requirements set for software management are divided into the following items:

- i. Software General requirements: Setting the main principles that shall govern all the other requirements,
- ii. Organisational requirements: Setting the main principles that shall govern the roles and responsibilities of the Contractor,
- iii. Technical requirements: Setting the main principles that shall govern the software development activity to be undertaken by the Contractor,
- iv. Deliverables requirements: Summarising the main documents that shall be produced by the Contractor.

All these items are detailed in the next Chapters.

20.4 SOFTWARE GENERAL REQUIREMENTS

The software general requirements are defined as mentioned below:

- i. Systems containing software: Indicating the principles for identification of the systems including software,
- ii. Software breakdown: Indicating the principles that shall follow the hierarchical decomposition of the software,
- iii. Software Development Status: Indicating whether the software is New, Modified or Proprietary,
- iv. Software Safety Integrity Level: Indicating from 0 to 4, whether the software is “Non Safety-Related” to “Very High”,
- v. Software quality assurance: Indicating the link with ISO 9001 and ISO 9000-3,
- vi. Software lifecycles: Mandating the concept of double V-cycle,
- vii. Software documentation: Setting the classification between development documentation and safety documentation.

All this is detailed in the following sections.

20.4.1 Systems containing software

All systems that contain software and which are either part of train or which interface with the train will be part of the rail Systems. If, however other systems are identified these should also be indicated by the Contractor.

The requirements defined in this document shall apply to all software used on the Project. Software used on the Project are, for example, application software and software tools.

For application software (including all data and all protocols), it is the Contractor's responsibility to provide them and hand them over to the CMRL without any restrictions. Application software shall remain under the Contractors responsibility during O&M.

For train systems' software and their software tools, either bespoke or COTS (Commercially Off the Shelf) software, it is the Contractors responsibility to ensure the CMRL has full right to use them with perpetual licence access to all the train systems' software and software tools used in the Rolling Stock.

The Software of all train sub-systems shall meet the criteria defined in Chapter 14.

20.4.2 Software breakdown

20.4.2.1 The Contractor shall provide the CMRL with the functional breakdown of the Rail Systems. This breakdown shall indicate:

- i. For Rail Systems, the Contractor will present the functional level specifications breakdown for the Systems namely Rolling Stock, Signalling, Telecommunication, Power Supply, etc.
- ii. The interfaces between Rail Systems and their environment,

- iii. The interfaces between Systems constituting the Rail Systems.

The Contractor shall set a SIL at functional level and functional modules level.

The Contractor will present the technical breakdown of the software in the software level specifications.

20.4.2.2 The technical breakdown will be done according to the following pattern:

- i. Software Product, the highest level of the software breakdown,
- ii. Software Modules, the middle level of the software breakdown,
- iii. Software Component, the lowest level of the software breakdown.

The Contractor shall set a Software SIL at Software Product level and at Software Module level.

For each Software Product delivered, the Contractor shall provide its software Product Breakdown Structure. This shall indicate the Software Development Status and Software SIL as defined in the further details.

20.4.3 Software Development Status

The Contractor shall assign a Software Development Status (SwDS) to all Software Products indicating the degree to which the delivery of a Software Product depends upon new development.

The Contractor shall define and justify the development status for each Software Product and provide it to the CMRL.

The Software Development Status shall normally have been defined as part of the tender submission.

The Software Development Status shall have three possible values: Proprietary, Modified & New

20.4.3.1 Proprietary Software

- i. The term 'Proprietary Software' shall be used to classify an already existing Software Product. Software shall only be classified as Proprietary if the following criteria are met:
 - a) The software is unchanged.
 - b) The structure of parameters is unchanged.
 - c) No refinement or restructuring of a database takes place.
- ii. Features of Proprietary Software, which are not covered in official user manuals, or are not supported by its owner or the Contractor shall not be used.

20.4.3.2 Modified Software

- i. The term 'Modified Software' shall be used to classify an existing Proprietary Software Product that is to undergo modification of any software component or database structure.
- ii. If more than 30% of the modules in an existing Software Product are expected to be or have been changed then the software shall be deemed to be New Software.
- iii. Large-scale population of databases and parameterisation beyond simple configuration shall be considered as either Modified or New Software.
- iv. All software to be developed or modified (re-engineered software) shall follow the standardisation requirements of EN 50128. The Contractor shall define within the Software Quality Assurance Plan what techniques and measures are to be applied for software development

20.4.3.3 New Software

- i. The term 'New Software' shall be used to classify a Software Product that is being developed specifically for the project, or an existing Software Product that has been modified for the Project.
- ii. New Software shall include the large-scale definition and parameterisation of data for a database application. New Software shall also include major initial system configuration and set-up requirements to otherwise Proprietary Software.

20.4.4 Software Safety Integrity Levels

The standard EN 50128 specifies five Software Safety Integrity Levels (SwSIL). The required Software Safety Integrity Level shall be decided on the basis of the level of risk, defined in the document related to RAMS requirements, associated with the use of software in the system and the system integrity level.

The Contractor shall assign to all Software Products a Software Safety Integrity Level.

The Contractor shall propose design and implementation techniques or measures depending on the SwSIL of the function to be performed by each individual system or equipment. These techniques or measures shall be based on the tables in Appendix A of the standard EN 50128.

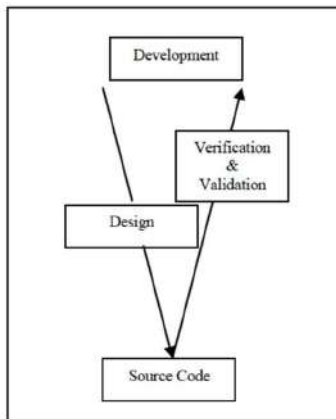
20.4.5 Software quality assurance

As a minimum, the Contractor shall implement for software Quality the relevant sections of ISO 9001 standard in accordance with the guidelines of ISO 9000-3 and with the EN 50128 standard.

The Contractor shall provide a Software Quality Assurance Plan covering all software systems, whatever their SwDS and a Software Development Plan for each Software Products (Modified or New Software).

20.4.6 Software life cycles

To control both quality and safety of the software, the Contractor shall implement the concept of the Double V-cycle which comprises:

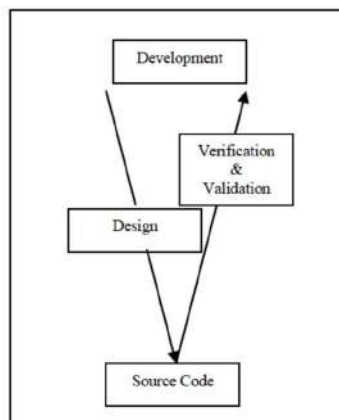


This V-cycle is detailed in the appendix of this document that illustrates the various steps of the software design and the software verification & validation. Each step is then detailed in a table. This is compliant with chapter 7 of EN 50128.

The Contractor may propose a different software development lifecycle provided that a clear mapping between the adopted phases, including the combination of individual phases, and the phases defined in the appendix is given in the Software Quality Plan. Where phases are combined, then the Contractor shall ensure that all of the requirements for the individual phases are collectively met.

- i. The Development V-cycle,
- ii. The Safety V-cycle.

Development V-cycle



To control quality, the software shall be developed, verified and validated according to a strictly defined Development V-cycle. An overview of this V-cycle is given in the figure.

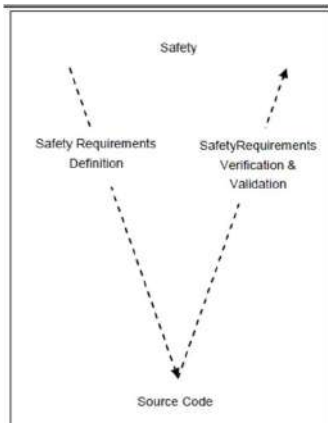
This V-cycle is detailed in the appendix of this document that illustrates the various steps of the software design and the software verification & validation. Each step is then detailed in a table. This is compliant with chapter 7 of EN 50128.

The Contractor may propose a different software development lifecycle provided that a clear mapping between the adopted phases, including the combination of individual phases, and the phases defined in the appendix is given in the Software Quality Assurance Plan. Where

phases are combined, then the Contractor shall ensure that all of the requirements for the individual phases are collectively met.

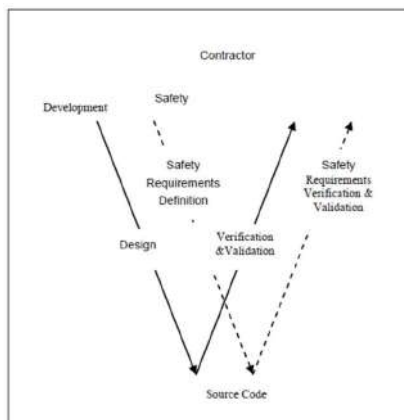
Safety V-cycle

1



To control safety, the software shall be designed, verified and validated according to a defined Safety V-cycle. An overview of this V-cycle is given in the figure shown

1



In parallel with the Development V-cycle followed by any software, the safety related software must also follow a Safety V-cycle as shown above. Therefore, the safety-related software must follow a Double V-cycle as shown,

Thus, for each step of the Development V-cycle a safety step must be undertaken. This double V-cycle must be followed by the Contractor. The Contractor must ensure a strict independence between the Development team and the Safety team.

The Contractor shall provide the CMRL with a Software Safety Plan describing the implemented Safety V-cycle and link with the Development V-cycle.

20.4.7 Software documentation

The Contractor shall provide a Software Documentation Submission Schedule which shall list all the software related documentation to be produced by the Contractor. This schedule shall define when the documentation is to be submitted with status for each document in the lifecycle i.e., for information, review and acceptance).

All documentation shall be controlled as defined by the Contractors Software Configuration Management Plan. Any divergence between the documentation in the standard EN 50128 and that provided by the Contractor shall be identified and clearly recorded, giving reasons for the difference.

The software documentation produced by the Contractor shall be of two different types:

- i. The Development documentation, written by the Contractor's Software Development teams. Typically, this documentation will be constituted by the Software Specifications, the Software Validation Plan, the Software Test Specifications, and the Software Test Reports.
- ii. The Safety documentation, written by the Contractors Safety team. Typically, this documentation is constituted by the various Safety Cases but also by any detailed safety study supporting these Safety Cases.

20.5 ORGANISATIONAL REQUIREMENTS

20.5.1 Roles and responsibilities

As far as the building and demonstration of the software safety of the Project is concerned, the Contractor shall produce the various Safety Cases of the technical systems (excluding O&M Procedures), according to the standard EN 50129,

The Contractor is responsible for the Safety of the software it provides.

The Contractor shall put into place a Safety Team able to address the software safety aspects.

20.5.2 Contractor's Safety Team

The Contractor shall carry out the building of system Safety. At the same time, the Contractor shall carry out the building of software safety which is a sub-set of the building of system Safety.

The Contractor's Safety Team shall have a technical point of view of software safety.

The Contractor shall give all required access to information and premises for the following:

- i. The CMRL shall carry out Software Audits at the Contractors premises if and when it deems it necessary. If deemed needed, the CMRL can carry out any Software Review on the top of those planned by the Contractor in its Safety Programme.
- ii. An Independent Software Assessor (ISwA) with appropriate skills may be appointed by the CMRL. The ISwA shall be given adequate means to perform the Software Assessment tasks.
- iii. The ISwA shall carry out the Software Assessment Audits at the Contractors premises when he deems it necessary.
- iv. If deemed needed, the ISwA can carry out some technical reviews which are not as formal as the audits and focus on particular technical issues, especially when some documentation, for whatever reasons, are not provided to the CMRL.

20.6 TECHNICAL REQUIREMENTS

The technical requirements that are described below shall be detailed by the Contractor in a document called Software Quality Assurance Plan. This Software Quality Assurance Plan shall detail the technical requirements according to the SwDS and shall be part of the tender documentation.

The Contractor shall obtain the acceptance of the Software Quality Assurance Plan by the CMRL.

The technical requirements are defined in terms of:

- i. Software requirements,
- ii. Development lifecycles and documentation,
- iii. Review, testing, verification & validation,
- iv. Specific software requirements,
- v. Expansion and sizing,
- vi. Management requirements.

These items are detailed in the following sections.

20.6.1 Software requirements

The Contractor and any Subcontractor(s) providing train subsystem which include software scope shall follow the relevant guidelines, principles and processes of ISO 9001, ISO 9000-3, EN 50128 and any other applicable standards throughout the project period. It is clarified, however, that ISO 9001 certification shall form part of validation (which will be applicable at FDR stage).

The Contractor shall produce a Software Safety Plan that indicates, according to both the SwSIL and SwDS, which software safety techniques and studies will be implemented to meet the Project's Safety Targets. As per EN 50128, SwSIL1 shall be processed as SwSIL2 and SwSIL3 shall be processed as SwSIL4.

These two plans shall follow the following pattern, this table shows that the Contractor shall put a 'Very High' level of development into a New SwSIL4 software when a 'Fair' level of development will be sufficient for a SwSIL0 software, whatever its SwDS.

	Proprietary	Modified	New
SwSIL0	Fair	Fair	Fair
SwSIL2	Medium	Medium	Medium
SwSIL4	High	High	Very High

It is important to highlight that only the higher SwSIL (SwSIL4) justifies a graduation of the development effort according to the SwDS, See below:

- i. For SwSIL0 and SwSIL2 software, which has none or an indirect impact on safety, the tasks comprising their V-cycle will require justification. Therefore, it is not economical to distinguish between the various SwDS. In terms of tests for example, these software will all be processed as New software,
- ii. For SwSIL4 software, which has a direct impact on safety, the tasks comprising their V-cycle require an important amount of justification. Therefore, it becomes economical to distinguish between the various SwDS. In terms of tests for example, Proprietary software will be re- tested, a Modified software will be tested on its relevant parts only and a New software will be thoroughly tested.

20.6.2 Development lifecycle and documentation

All the phases constituting the development V-cycle implemented by the Contractor shall be detailed in terms of:

- i. Objectives of the phase,
- ii. Methodologies used to carry out the phase,
- iii. Input documentation,
- iv. Output documentation.

Software Assessment shall also be described in Software Quality Plan since this phase shall be undertaken by lswA.

20.6.3 Review, Testing, Verification and Validation

20.6.3.1 Reviews

- i. The Contractor shall perform formal reviews at the end of each conducted lifecycle phase and as requested by the CMRL. The review activities shall be defined in a Review Programme to be prepared by the Contractor.
- ii. If the system/software development is partitioned into several sub-systems, performed by different Contractors/ subcontractors, then the Contractor shall perform individual reviews for each sub-system in addition to the overall system level reviews.
- iii. Records of reviews shall form part of the project documentation.
- iv. At any time during the development lifecycle, the CMRL reserves the right to perform reviews on the Contractor or any of its Contractors/ subcontractors.

20.6.3.2 Testing

- i. As a minimum, the tests that will be performed during the verification and validation phase will be made up of the testing methods as recommended in the standard EN 50128.
- ii. The Contractor shall define the testing strategy and requirements in terms of Regression Testing, Test Software and Simulators, Metrics and tests documentation.

20.6.3.3 Verification

- i. Refer to EN 50128

- ii. Software Verification Plan shall be produced by the Contractor during the software development and updated as required to ensure the management of the verification activities. The Contractor shall produce a Verification Report at the end of each verification exercise.
- iii. The Contractor shall produce and maintain a Traceability Matrix that demonstrates that all requirements have been achieved and no untraceable material has been included.

20.6.3.4 Validation

- i. Refer to EN 50128
- ii. The Contractor shall demonstrate that the software (or system) is compliant with the safety, functional, performance and interface requirements. This demonstration shall be achieved through the use of verification, testing, and analysis techniques appropriate to the particular software integrity level.
- iii. Software Validation Plan shall be produced by the Contractor during software development and updated as required to ensure the management of the validation process.
- iv. The validation activities will define each step and each intermediate production of the software development cycle so as to detect and to correct functionality and/or design concepts which can drive the software and by consequences the system into a state where safety is no more ensured.
- v. The Contractor shall produce a Software Validation Report at the end of Software Validation and Site Acceptance phase.

20.6.4 Specific software requirements

The Contractor shall specify the specific software requirements in terms of:

- i. Systems configured by application data,
- ii. Software languages,
- iii. Compiler / code generator certification,
- iv. Databases,
- v. Software licences and ownership,
- vi. Coding standards,
- vii. Software revisions
- viii. Development methodologies,
- ix. Software delivery,
- x. Interface definition,
- xi. Irrelevant software.

These items are detailed in the following sections.

- i. Systems configured by application data (Refer EN 50128)
- ii. Software Languages (Refer EN 50128). The Contractor shall write the software using high-level, strongly typed programming languages.
- iii. Compiler / Code Generator Certification (Refer EN 50128). The Contractor shall use a recognised compiler / code generator. The Programming language extensions specific to a particular compiler that are not contained within an International standard for that language shall not be used.
- iv. Databases: Where a proprietary database system is employed, it shall provide an ISO compliant Structured Query Language interface. During the system and software design phases the Contractor shall define database structures using approved Normalised Form representations.
- v. Software Licences and Ownership

The Contractor shall:

- a) Ensure that all licences for products and associated tools shall be transferred to the CMRL prior to software delivery to-site. All licences shall be transferred to the CMRL following site acceptance; and

- b) Deliver all documentation for the software to the CMRL and ensure that the CMRL has full rights to change the software following acceptance of the initial product.
- vi. Coding Standards
 - a) Refer EN 50128
 - b) The Contractor shall write software in accordance with a Coding Standard. The Coding Standard shall define software-structuring rules to be used for all source code.
 - c) Features of Proprietary software which are not covered in its official user manuals or are not supported by its owner, or the Contractor shall not be used.
 - d) Software shall be written in a modular form and all components shall be of low structural complexity.
 - e) Comprehensive comments shall be included within the code and there shall be clear references to the relevant design documentation for each set of software.
- vii. Software revisions
 - a) Throughout the operational life of the system, it may be necessary to introduce changes due to either a new requirement from the CMRL or a fault fix / product enhancement by the Contractor.
 - b) Software shall therefore be designed to allow revisions to be introduced without:
 - Incompatibility problems with other existing system software and hardware,
 - Disruption to the system availability caused by the installation process; and
 - High number of changes being made to other system software or data.
- viii. Development Methodologies
 - a) The Contractor shall use a recognised and proven structured analysis and design methodology for the clear unambiguous definition of system requirements.
 - b) As an alternative to structured design techniques the Contractor may use a recognised object-orientated method. The design will then be implemented in a programming language with inherent data structures for Classes, Objects, Operations and Inheritances.
 - c) For the detailed design of PLC software, the Contractor shall use structured methods such as Functional Block and Ladder Logic definitions.
 - d) PLC designs shall ensure that operation is not dependent on a specific manufacturers PLC and standard communications protocols are used, such that the PLC can be replaced by another manufacturer's device with the minimum of reprogramming.
 - e) Only PLC designs and programming tools that have a proven history of reliability may be used.
 - f) The Contractor shall use formal methods and proofs, where specified as techniques for particular Software Safety Integrity Levels.
- ix. Software delivery
 - a) All software delivered to site shall be accompanied by suitable release certification which shall clearly identify the software version and, if applicable, the identification of modifications since the previous version. The reference to the tests covering these modifications shall be indicated, along with the reference to the results of these tests.
 - b) Following Site Acceptance Tests, no software shall be installed, modified or updated without the written authorisation from the CMRL. The Contractor is responsible for ensuring that all certification, affected documents and records are updated to reflect changes, modifications and updates to software and that the software is retested to the level originally specified.
 - c) All delivered software shall be accompanied by evidence that demonstrates the media is free of viruses.
- x. Interface definition
 - a) For each interface to an external system, only a single interface specification document shall

exist.

- b) The Contractor shall state during the Software Requirements Specification phase whether the Contractor is responsible for the definition of a particular interface.
- c) Reference to all interface specifications used shall be made from the design documentation against which verification and validation shall be made.
- d) The Contractor shall define the precise table of contents of the Interface Requirements Specification.

xi. Irrelevant Software

Software that does not contribute to the fulfilment of the specified requirements shall not be included in any formal or informal build of a Software Product or System.

20.6.5 Expansion and sizing

- i. The Contractor shall specify the software requirements in such a way to allow for future expansion that has not been foreseen during the development of the system.
- ii. The requirements shall provide resources for future input/output expansion, database expansion and hardware spare capacity.

20.6.5.1 Software Expansion Requirements

- i. The Contractor shall develop/supply software with consideration to possible future expansion provision or porting to other hardware/software environments.
- ii. The software design shall allow for further input/output dialogues, peripheral equipment and controlling equipment to be added.
- iii. Software databases shall be designed to allow for ease of expansion. Where new database structures are implemented with fixed sizes then at least 25% spare capacity of each entry type and attribute shall be provided.

20.6.5.2 Hardware spare capacity

- i. Spare capacity requirements shall apply to memory, disk storage, communication links/ports, input/output capacity. Minimum figures for spare capacity are given here below.

Resource	Spare Capacity
Memory	50%
Disk Storage	50%
Communication Links / Ports	50% 15%
Input / Output Capacity	Min. 10% (End of DNP)

20.6.5.3 Hardware resource loading

- i. For virtual memory systems, the Contractor shall show that processor loading and contractual system performance can be achieved with the proposed amount of memory spare capacity.
- ii. The Contractor shall demonstrate at Factory Acceptance Test that the contractual performance can be met with the Main Processor Loading not exceeding the figures given here below. Peak loading for the main processor is defined as an average of the measured load over an agreed period, for example one minute.
- iii. For Local Area Networks or Wide Area Networks, the loading shall not exceed the figures given here below

Resource	Loading Not Exceeding	
	Mean	Peak
Main Processor	50%	80%

Local and Wide Area Network	10%	40%

20.6.6 Management requirements

20.6.6.1 Software quality assurance plan

- i. The Contractor shall provide its Software Quality Assurance Plan which will describe how the requirements of EN 50128 are addressed.

20.6.6.2 Software quality assurance

- i. The objective of the software quality assurance is to ensure that the development of software is performed in such a way the desired quality has been achieved. This is performed by creating a process which notably provides a clear framework for the Software Assessment activity.

20.6.6.3 Software configuration management

- i. The Contractor shall define its software configuration management process in accordance with the requirements of ISO10007 for the configuration management of the software and documentation; the Contractors configuration management processes shall be extended to manage the software configuration of its subcontractors of any tier.
- ii. The Contractor shall produce a Software Configuration Management Plan to cover changes that occur during the development phases and to monitor the software configuration.
- iii. The software configuration management activity shall be carried out by the Contractor and will comply with the principles depicted in the Software Configuration Management Plan.
- iv. The Software Configuration Management Plan shall address the configuration management for configuration item identification, change and version control, configuration status accounting, audit, problem reporting, media control and configuration management tools.

20.6.6.4 Project management

- i. The Contractor shall provide a detailed Project Management Plan to the CMRL for his approval and acceptance.
- ii. It is the Contractors responsibility to ensure the system is developed, tested and delivered on time. The Contractor shall create and maintain a Detailed Work Schedule, which shall identify critical paths, slippages and resource issues.
- iii. The Contractor shall supply periodic (to be defined in consultation with the CMRL) Progress Reports for the transportation system.
- iv. The CMRL shall have full access to the Contractor and all subcontractors involved in the Project.

20.6.6.5 Security

The Contractor shall define procedures to ensure the security of all hardware, software, communication protocols, architecture, networks and data acquisition concepts of Rolling stock & its sub-systems during both the development and operation stages.

Other than just procedural control, built-in security facility / function (e.g., access control, anti-virus, firewall, any computer security standards) to comply with aspects to be considered include and shall not be limited to:

- i. Sabotage: The Contractor shall describe measures taken to protect all hardware, software, communication protocols, architecture, networks and data acquisition concepts of Rolling stock & its sub-systems against sabotage during the development and operational phase. This description shall define the physical restrictions as well as procedural measures and specific tests to be carried out on the train.
- ii. Unauthorised Access: The Contractor shall describe measures taken to protect all hardware, software, communication protocols, architecture, networks and data acquisition concepts of Rolling stock & its sub-systems against unauthorized access and subsequent modification. The description shall define both physical and procedural methods.
- iii. Virus: The Contractor shall ensure software which is susceptible to viruses is developed in environment certified free from computer viruses. To achieve this, the Contractor shall use

propriety virus detection software and suppression tools, as reviewed by CMRL. Approval of the software tools by CMRL shall not relieve the Contractor of his obligations to ensure that the software is free of viruses.

Other manipulation may be caused by malicious activity like intrusion, hacking, phishing, wireless signal jamming, physical tampering, damaging critical communication cable or nodes, accident or natural disaster.

Security Levels shall be declared by RS contractor for all software used in Rolling stock.

20.6.6.6 Security Plan:

The Contractor shall submit the Security Plan to CMRL describing all the precautions mentioned above taken for the security of all hardware, software, communication protocols, architecture, networks and data acquisition concepts of Rolling stock & its sub-systems.

The Contractor shall comply IEC62443 and TS50701 (or any other International Standards) and prepare the Security Plan including Operational & Technical precautions / procedures taken as also incorporated in the system design to ensure necessary safety of the complete Rolling Stock sub-system including both Hardware & Software. The Contractor shall ensure that all the computer based systems in network are provided with latest anti-virus protection.

This Security Plan must be regularly reviewed, updated and accepted through a process of security certification, access control, gateway security, communications security, physical security, accreditations and certifications.

The RS Contractor must demonstrate practically, the ability of the system to proactively detect, contain, eradicate and recover from a security breach in a real-time basis. The RS Contractor shall define procedures for assured operations and continuous monitoring of the security controls.

The Contractor shall submit the Final Cybersecurity Case, including evidence of compliance with applicable railway cybersecurity standards, at least four (4) months prior to the commencement of service trials of the Prototype train.

1

20.7 DOCUMENTATION TO SUBMIT:

Below mentioned plans and details shall be submitted (for all Rolling Stock Sub-systems) as part of document submission:

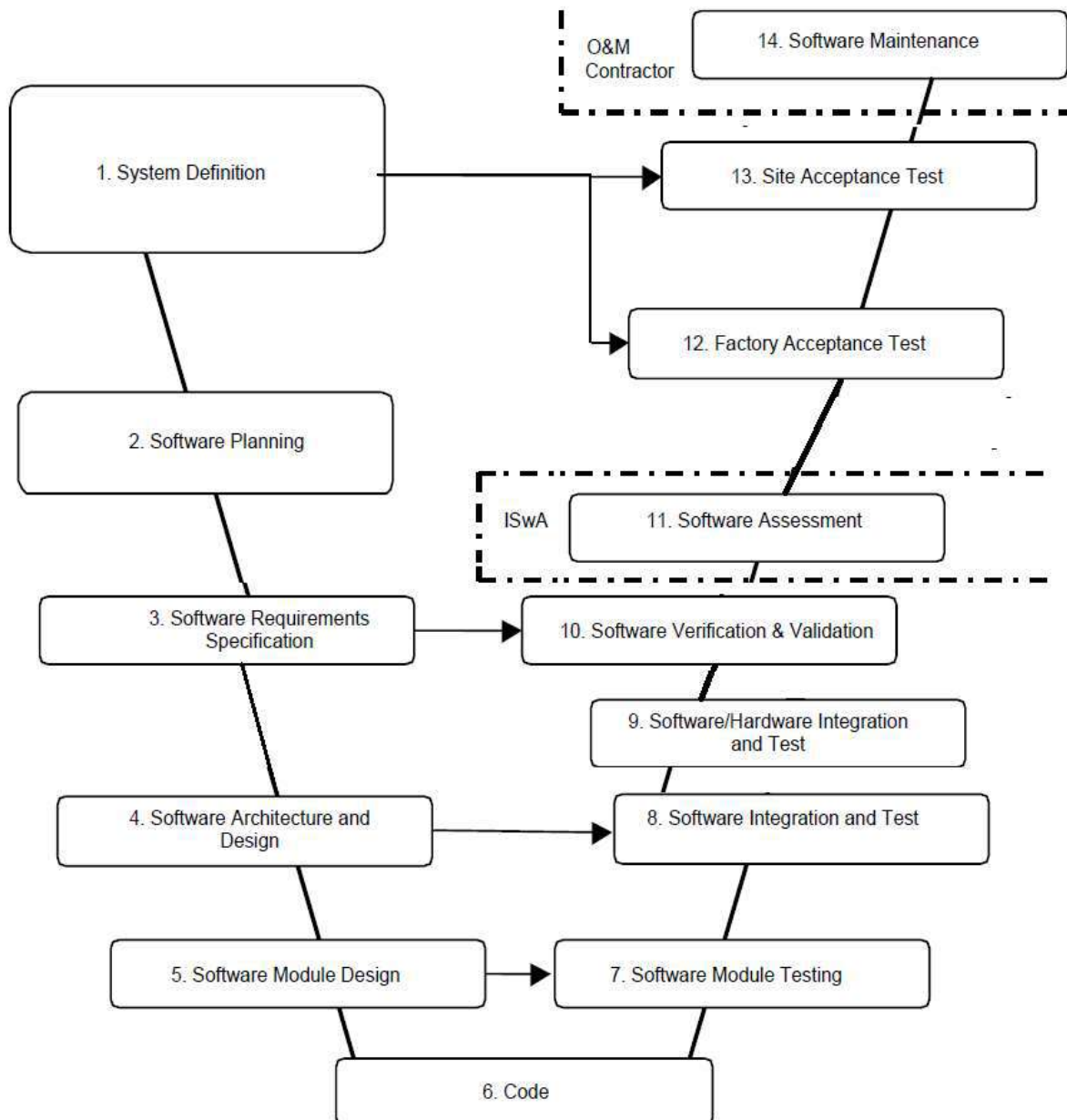
- i. Detailed Work Schedule
- ii. Product Breakdown Structure
- iii. Software Documentation Submission Schedule
- iv. Review Programme
- v. Traceability Matrix
- vi. Software Development Plans
- vii. Software Specifications
- viii. Software Verification Plan
- ix. Software Verification Report
- x. Software Validation Plan
- xi. Software Test Specifications
- xii. Software Test Reports
- xiii. Software Validation Report
- xiv. Safety Cases
- xv. Supporting Documentation
- xvi. Software Quality Assurance Plan
- xvii. Final Cybersecurity case (To be submitted 4 month prior to Burn-in Trials)

1

APPENDIX A1: DETAILED SOFTWARE DEVELOPMENT V-CYCLE

The following Software Development V-cycle is proposed by the standard EN 50128:

All phases are to be performed by the Contractor, except O&M Contractor and ISwA phases as shown below. A detailed description of each phase is given next section.



Appendix A2: DESCRIPTION OF THE SOFTWARE DEVELOPMENT PHASES

The following Software Development V-cycle is proposed by the standard EN 50128:

Lifecycle Phase	Works Description	Responsibility	Deliverables	Remark
1 System Definition	To determine and define the system requirements and the system architecture according to the CMRLs contractual and technical requirements. Configuration or parameterization of proprietary products shall be classified following the user requirements and shall be documented accordingly. To define tests for use during the Software/ Hardware Integration Tests, the Factory Acceptance Tests and the Site Acceptance Tests.	Contractor	As per EN 50128 as a minimum.	Activities performed during System Definition shall be in accordance with EN 50126 & EN 50129
2 Software Planning	To establish the mechanisms and support documentation by which the development of software will be controlled.	Contractor	As per EN 50128 as a minimum.	
3 Software Requirements specification phase	To define the software requirements from the system documentation. To verify that the output of this phase correctly implements the requirements of the input system documents. To define the tests needed to validate the requirements during Software Validation.	Contractor	As per EN 50128 as a minimum.	Refer to EN 50128
4 Software Architecture and Design Phase	To define the architecture of the software needed to meet the detailed requirements identified in the Software Requirements Specification. To define the tests and analyses needed to validate the architecture during the Software Integration and Test phase. To verify that outputs of this phase correctly implement the requirements defined by the Software Requirements Specification.	Contractor	As per EN 50128 as a minimum.	Refer to EN 50128
5 Software Module Design Phase	To define the processing to be performed by the individual software modules. To define the tests required to demonstrate the correct operation of these software modules during the Software Module Testing phase. To verify that outputs of this phase correctly implement the requirements defined by the Software Architecture and Design phase.	Contractor	As per EN 50128 as a minimum.	EN 50128 is applicable
6 Code phase	To code the software modules in accordance with a specific programming language Coding Standard. All new and modified modules shall be subjected to static analysis.	Contractor	As per EN 50128 as a minimum.	Refer to EN 50128

Lifecycle Phase	Works Description	Responsibility	Deliverables	Remark
	To verify that outputs of this phase correctly implement the requirements defined by the Software Module Design phase.			
7 Software Module Testing phase	To test each module. Such tests shall demonstrate that a module provides the processing specified in the associated design documentation. Software produced by code generators shall be tested to an 'appropriate level'. The term 'appropriate level' shall be agreed with the CMRL for each code generator. All new and modified components shall be subjected to dynamic analysis. Tests shall ensure the proper functioning of each software component under normal conditions and degraded scenarios. They shall be capable of analysing the behaviour within limits as well as outside limits. Testing with sub-system not working properly shall also be tested.	Contractor	As per EN 50128 as a minimum.	A Software Module Test Report shall be produced during this phase
8 Software Integration and Test Phase	To integrate and test the software modules to produce complete software items or products. The tests shall be conducted in accordance with the Software Integration Test Plan and Software Integration Test Specification. Dynamic analysis shall be used to demonstrate that the agreed test coverage has been achieved. Deviations from the agreed test coverage shall be justified and agreed with the CMRL.	Contractor	As per EN 50128 as a minimum.	Refer to EN 50128
9 Software/Hardware Integration and Test phase	To integrate and test the software with the hardware to form a complete system. The tests shall validate the system design. Software/hardware integration shall be performed in progressive stages starting with the integration of the hardware and software of one element of the system and ending up with the complete working system. At each stage, the interfaces between the integrated items shall be tested. Integration tests shall cover both functionality and performance. The testing performed shall be in accordance with the Software/ Hardware Integration Test Plan and Software/ Hardware Integration Test Specification. To submit the software system to endurance tests. These endurance tests shall demonstrate the ability of the system to work over a prolonged period of time using data and events that represent likely operating conditions. Endurance tests shall cover varying load conditions.	Contractor	As per EN 50128 as a minimum.	Refer to EN 50128

Lifecycle Phase	Works Description	Responsibility	Deliverables	Remark
	To perform load testing to demonstrate the ability of the system to handle contractual performance limits under agreed loading conditions. Loading shall include peak and avalanche loading using the full system configuration together with simulation equipment for proving interfaces with external systems.			
10 Software Validation phase	To validate that the integrated system is compliant with the agreed software requirements. The validation activities shall be in accordance with the Software Validation Plan. The results of the validation activities will be documented in the Software Validation Report and should form an input into the overall System validation and Product/Application specific Safety Cases as defined in the RAMS requirements.	Contractor	As per EN 50128 as a minimum.	Refer to EN 50128
11 Software Assessment phase	To assess whether the software is of the specified Software Safety Integrity Level and is fit for purpose. The outcome of the software assessment shall be documented in the Software Assessment Report.	Independent Software Assessor	As per EN 50128 as a minimum.	Refer to EN 50128
12 Factory Acceptance Test phase	To perform the tests specified in the Factory Acceptance Test Specification in accordance with the Factory Acceptance Test Plan. To configure a system (hardware) platform to test and accept the software prior to delivery to site. The test platform shall, where possible, be identical to the target hardware platform and use a full system configuration. The Contractor may use test software and hardware to simulate communications with external systems and also where large numbers of remote equipment exist within the Contractors scope of supply. For high integrity software, tests of all interfaces shall be made using the actual (target) software for all interface dialogues. The Contractor shall perform testing which demonstrates that all functional requirements have been met. Factory testing shall demonstrate all fault handling, recovery and resilience provided. A Factory Acceptance Test Report shall be produced during this phase	Contractor	As per EN 50128 as a minimum.	Refer to EN 50128
13 Site Acceptance	To deliver to site and integrate the system with the other systems. To perform the tests specified in the Site Acceptance Test Specification in	Contractor	As per EN 50128 as a minimum.	Refer to EN 50128

Lifecycle Phase	Works Description	Responsibility	Deliverables	Remark
e Test Phase	accordance with the Site Acceptance Test Plan. The Contractor shall ensure that the complete system functions correctly within the whole site environment. The test shall demonstrate the integration, performance and resilience of operation with other systems.			
14 Maintenance phase	After successful site acceptance to implement a controlled cycle of procedures for software maintenance.	Contractor	As per EN 50128 as a minimum.	Refer to EN 50128

21. ASSET MAINTENANCE MANAGEMENT SYSTEM (AMMS)

21.1 GENERAL

- 1 21.1.1 The purpose of the AMMS solution is to provide effective Asset Management capabilities for **CMG Rolling Stock** Assets. The system shall aid in reduction of maintenance down time and optimize capacity utilization of the Designated Depot(s).
- 21.1.2 The Contractor shall ensure that the proposed AMMS complies with and supports the concepts of ISO 55000 and has been proven for metro rolling stock application (e.g., IBM Maximo, SAP, Trimble R2M / E2M etc.) during at least two similar projects during the last 10 years.
- 21.1.3 The Contractor shall ensure that the proposed AMMS system is fully installed, tested & commissioned before delivery of the Prototype Trainset. The primary objectives are as follows but not limited to:
- 1
- i) Storage of fault data from **CMG Rolling Stock** Assets (including wayside Hot Axle measuring system data) for at least 35 years.
 - ii) To eliminate the need for human intervention / manual download of fault data recorded by **CMG Rolling Stock** Assets through automated data transfer with interfaced systems.
 - iii) To provide early identification of emerging failure trends.
 - iv) To predict operational failures through aggregation of TCMS fault data with historic / emerging failure trends. The system shall generate service and/or maintenance work orders on an automated basis, without user intervention.
 - v) To automate decision making process in job card or work order creation through implementation of rules that can generate Job cards and work orders automatically for most tasks, semi-automatic with approval in exceptional cases and occasional manual job card creation for rare conditions.
 - vi) Full access to display, analyze and generate reports from remotely acquired data in real-time and also on demand of the maintenance, faults and condition of rolling stock assets, work orders or stock status.
 - vii) Streamline Maintenance process at Depot by seamless integration of remote data acquisition, creation of job cards, processing of work orders, tracking of all assets of depot, inventory and material data management at stores automatically and without human intervention.
 - viii) Reduce downtime of trains at depot by automatically processing rules for optimizing the duration of stoppage at depot by diagnosing and recommending repairs, replacements and other service requirements while the train is running and keep resources such as maintainers and spare parts ready well ahead of train reaching the depot for Corrective or Scheduled maintenance.
 - ix) Optimize the number of maintenance interventions at the depot by synchronizing the Corrective, scheduled / preventive maintenance based on the severity, urgency and availability of train based on automated diagnostic rules engine with minimal human intervention.
 - x) Record all requests from the Operations Control Centre, stations, trackside and depot sources for non-scheduled maintenance work;
 - xi) Produce on request a current list of items outstanding and work in progress;
 - xii) Record materials and spares withdrawn from stores for each maintenance activity;
 - xiii) Output on a daily basis to maintenance supervisory and management personnel as required a list of outstanding maintenance items by engineering discipline and length of time outstanding.
 - xiv) Record the time a maintenance item is completed; record the cause or circumstances of each failure and the corrective action taken.
 - xv) AMMS shall improve the availability of assets by using predictive maintenance and the Internet of Things (IoT) to take early corrective actions.
 - xvi) AMMS server shall collect data from Rolling Stock server.

21.2 SCOPE OF WORK

21.2.1 Hardware Deployment:

- i) The Contractor shall provide all equipment hardware (including main server, backup server, desktop computer and laptops for user interface etc)

21.2.2 Interfaces:

- i) The Contractor shall interface with other designated Contractors for matters including, but not limited to Space, Power, UPS, Data communication, etc.
- ii) The Contractor shall also interface with the Signaling and Telecoms Contractors for transfer of TCMS and wayside Hot Axle measuring system data through their network to the AMMS server.

21.2.3 Maintenance Management Module:

- i) Automatic work order / Job card creation based on the fault data acquired from the train sets and Depot M&P's.
- ii) Automatic work order / Job card creation for the Preventive maintenance activities of the Rolling stock assets based on the mileage / running hours / time period and Depot M&P.
- iii) Maintaining the configuration (Up to each Line Replaceable Unit level) of all the Rolling stock assets and Depot M&P.
- iv) Maintaining warranty information for all Rolling stock Assets and Depot M&P
- v) Tracking the maintenance campaigns (Software / Hardware Changes).

21.2.4 Material Management Module:

- i) Tracking inventory including repair and return items.
- ii) Tracking material inside the stores by barcoding and its location.
- iii) Generating Pos

21.2.5 The Contractor shall procure / provide sufficient number of licenses to operate, manage & monitor the AMMS. The Contractor shall transfer the licenses to CMRL at the end of the **CMG Project** period which shall be further valid for the period of at least one year after completion of **CMG Project**. In addition, the Contractor shall also provide TWO fully functional AMMS terminals (Latest version laptop) to CMRL maintenance personnel to access the real time information of maintenance and enable CMRL for the generation of reports. CMRL shall also be able to generate service requests from their terminals. The Contractor shall make suitable arrangement to securely store the database of AMMS system.

21.2.6 The Contractor shall provide all complete Hardware and Software equipment's enabling the system to download all the stored TCMS data and its linked files if any through from Rolling Stock and Fault data from Depot M&P's to AMMS server through the Signalling Contractor provided network. The Signalling Contractor will provide network for data transfer. The downloading shall be real time / time interval actuated / fault actuated / manual triggered and shall be stored on a central server.

21.2.7 The Contractor shall be responsible for the complete set up and commissioning and satisfactory working of the system till the **expiry of CMG end of project**. The integrity of the data shall not be affected during remote download and in case of any interruption or otherwise the data shall be suitably secured and retrievable. Apart from normal downloading the system should also have intentional / forced download by authorized CMRL personnel.

21.2.8 The Contractor shall provide logbook for each Rolling Stock and Depot M&P's which shall be progressively updated to record details of the status of the Vehicle at all stages of production and testing up to the point at which routine maintenance is commenced and subsequent modifications and maintenance actions are recorded by the Maintenance Management System.

21.3 MAINTENANCE MANAGEMENT SYSTEM

- 21.3.1 The core functionality of the Maintenance Management system is to automatically capture all information from TCMS system in real-time, process it through a Diagnostics Rule engine and seamlessly integrate to the Maintenance system for Job Cards / Work order creation without the need of human intervention.
- 21.3.2 Job card / Work Order: All maintenance activities shall be organized, planned, and reported through job cards / work orders. A work order refers to the maintenance tasks and creates a link between:
- i) A basic action or group of basic actions
 - ii) A subsystem function or component.
 - iii) According to maintenance task nature, the work order shall have different consequences.
 - iv) Equipment unavailability, needing immediate intervention.
 - v) Equipment dysfunction, needing a planned intervention.
- 21.3.3 Work Order Triggering, Planning and Closure
- i) Both preventive and corrective maintenance activities shall be managed through work orders.
 - ii) Preventive work orders shall be automatically generated according to:
 - a) Technical Maintenance Plans (TMP) milestones (related to counters)
 - b) Pre-defined allocation by an entity in charge of it (internal or external)
 - c) Pre-defined resources engagement according to standards (Human Resources, major maintenance equipment, spare parts, etc.).
 - iii) Maintenance Department ability regarding the workload and resources to be engaged.
 - iv) Different timescales shall be visualized based on the planning horizon.
 - v) Corrective work orders shall also be created by either Operations or Maintenance stakeholders, according to operational disfunction or technical report needing maintenance intervention, if required.
 - vi) Whatever the trigger is, Work Order description shall be based on:
 - a) Automatically generated Work Order number.
 - b) Asset assignation according to asset register files.
 - c) Event context (date, hour, location, operator details etc.).
 - d) Codified Work Order origin (maintenance regime, TMP reference if preventive maintenance, etc.).
 - e) Entity assignation according to the process described previously.
 - f) Expected duration of the maintenance task (related to preventive standards or failure codes).
 - vii) Whatever the WO is, the system shall support the following information size but not limited to allow the WO closure:
 - a) Identification of the entity (division, shift, etc.)
 - b) Intervention beginning/end.
 - c) Description of the technical intervention
 - d) Selection of the sub system (and breakdown level) subject of the WO
 - e) Selection of the intervention cause related to the sub system according to a pre-defined terminology (worn, broken, fouled, ...)
 - f) Selection of the intervention nature according to a pre-defined terminology (check, measurement, exchange, cleaning, ...)
 - g) Selection of the failure code in case of corrective action

- h) Measurements registration (according to “online templates”)
 - i) Resources engagement (human resources, spare parts, third party, tools, and equipment)
 - j) Considering technical, organizational or workload issues, a WO shall be transmitted from one entity to another one.
- viii) If, during a maintenance intervention, several elementary actions are conducted, the initial work orders (“parent work orders”) shall be broken down in several ones (“child work orders”).
- ix) AMMS shall allow the complete maintenance process (planning, initiation, execution, and closure) to be implemented without the use of any paper form or print out. Thus, all steps of the process must be tracked within the system for records and reporting purposes.
- 21.3.4 Specific Follow Up and Investigations
- i) For any technical issue or need to monitor a specific sub system population, etc, the process to collect and register information will be based on the Rolling stock Remote Diagnostics and Maintenance Management System.
 - ii) The initiative shall be backed by specific WO generation allowing:
 - a) Pre-defined equipment/sub systems samples (asset specific designations)
 - b) Pre-defined timescales (beginning/end of the follow up)
 - c) Intervention triggering “rule,” eventually diverging from the generic TMP.
 - d) Specific reports
 - iii) As this type of work order is close to the preventive one's concept, the planning process will be the same, dedicated to the Maintenance Planner.
 - iv) AMMS shall be fitted with functionalities to send specific alert/warning messages to defined persons based on adjustable parameters (i.e. based on MTBF levels, failures rates...)
- 21.3.5 Maintenance Documentation
- i) Updated maintenance documentation shall be accessible from AMMS. Two types of documentation shall be available and displayed:
 - a) Relating to elementary maintenance actions
 - CMRL Maintenance procedures and manuals
 - Reports and forms to be filled in, etc.
 - b) Relating to functions and components technical documentation
 - Technical notes
 - Charts, pictures, and drawings
 - Assembly / removal process, etc.
 - ii) As maintenance operations shall be executed mostly on the field (track, stations...), access and viewing of this documentation via handheld devices shall be possible.
- 21.3.6 Operations / Maintenance Integration
- i) Equipment Operational Engagement and State: From Real Time to Forecast
 - ii) The system will collect in real time from Remote Diagnostics system and transfer the specific usage data, especially distance running, usage period, energy consumption and operation cycles for equipment and sub systems equipped with counters. This data shall be allocated individually to the different assets and related sub systems.
 - iii) Maintenance planning (short and long term) will be based on extrapolation of this data (according to individual or grouped trends) and shared (via pre-defined reports) by Maintenance Planner with Operations employees enabling them operations planning.
 - iv) Concerning the Rolling Stock, the AMMS will enable, through real-time collection of data, short- & long-term planning, the definition of the daily mileage target per train to ensure that maintenance

activities are evenly spread in time.

- v) In case of an equipment failure, AMMS Remote Diagnostics system shall be the interface between Operations and Maintenance to raise the malfunction, generate and send necessary reports and thus enable corrective action to be undertaken.

21.3.7 Joint Maintenance Effort

- i) The maintenance staff shall be able to raise requests for maintenance to the operating staff such as requests to get a train set in a particular depot at a particular time etc.
- ii) Maintenance activities that are to be done, such as internal train cleaning etc., during non-revenue hours shall be planned and tracked using AMMS. The Maintenance requests shall be represented in a user-friendly form to ease usability. AMMS shall be capable of storing these requests and activities and analyzing the data for different performance parameters.

21.3.8 Safety

- i) The system shall raise pre-alerts and alerts to maintenance planning in case of an impending maintenance milestone or expired milestone. In case of an alert, the situation shall be considered according to two modes:
 - a) Standard situation: work order requiring an immediate intervention (and consequently the equipment unavailability) is initiated,
 - b) Derogation implementation: planned work order requiring a specific survey is put in place with the approval of the safety department, no immediate intervention is planned.

21.3.9 Not used.

21.3.10 AMMS shall provide a comprehensive view of any specific vehicle faults and identify any potential faults that may arise through color codes that are configurable. For example, critical faults shall be highlighted in Red, Medium in Orange, Less critical in Yellow etc. and shall be dynamic with a real time refresh of live train data.

21.3.11 AMMS shall also have the capability to analyze and detect anomalies in specific on-vehicle component behavior and use this information to identify the health and status of both the individual component and the possible impact that this behavior may have on the vehicle and to the overall fleet.

21.3.12 AMMS shall also have the capability to retrieve reports after an incident or fault has occurred to replay the history of events and the condition and behavior of the vehicle that led to the fault or incident, with the user's capability to visualize time, distance, location etc. on a graphical / map based system.

21.3.13 Addimap-based display of real time diagnostic data in the display unit of maintenance control center.

21.3.14 TCMS data of all trains in operation or in depot shall be made visible in a single dynamic view that is constantly refreshed within 5 second intervals to display each train, its cars, Location, Speed, List of faults with color coding configurable by user, Live Events window of every fault captured in real-time from every running train on the system.

21.3.15 The system shall also have the capability to decipher the TCMS codes and protocols to correctly display the relevant system detail, state and values.

21.3.16 The system shall have the capability to allow the user to have a detailed train level, subsystem level, component level data, Channel data, Location data and TCMS display values along with meter and counter values in real-time.

21.3.17 The Live display window shall also allow users to select, query and drill down to individual train sub systems in real-time to monitor and analyze current condition of individual equipment, signal values, events etc. continuously.

21.3.18 All the display dashboards, values, tables and meters on the live view shall have clear color coding based on criticality and condition that is configurable by the users.

- 21.3.19 The display and views shall also have the capability to do a time-based study and analysis as and when required without affecting live data acquisition.
- 21.3.20 The system shall have the capabilities for role-based and user-based access and display for the following functionalities, as a minimum requirement but not limited to:
- i) Interactive and predictive fault detection with configurable coding and alerts from Diagnostics rule engine.
 - ii) Interface where new alerts and rules can be defined and added to the system without affecting the vehicles in service.
 - iii) Real-time cross fleet performance monitoring identifying trends as they occur within the fleet.
 - iv) Real-time schematic view of key subsystems as the train is in service.
 - v) The system shall be capable of real-time vehicle and fleet location tracking through mapping software, with the option for the user to select and view individual fleet and condition data.
 - vi) Replay fault events to accurately diagnose root cause and repair actions during maintenance with rule-based diagnostics enabling automation.
 - vii) Rule engine for diagnosis shall recommend maintenance repair actions to the fleet maintainer, based on the data received from the on-board systems.
- 21.3.21 The rule-based diagnostics and alerts trigger system shall allow the user to define, modify and configure rules at any point of time without the need to approach the solution provider.
- 21.3.22 The rule editor interface shall be intuitive and user friendly, allowing any authorized user to quickly modify rules by adding any remote diagnostic data, train alerts, channel data, meter values and condition data in any combination with logical / Boolean operators to define further actions, alerts, messages, trigger other activities or reports.
- 21.3.23 The result of the Remote diagnostics Rule engine shall be capable of enabling the following functions, as a minimum requirement but not limited to:
- i) Job card / Work order creation
 - ii) Events and Alerts with color coding and prioritization
 - iii) Reports and messages
 - iv) Email / SMS alerts
 - v) Sub system events for further rule processes
 - vi) Alert Escalation process
- 21.3.24 Based on predefined / configurable rules, from a rule-based diagnostics engine, the maintenance alerts are triggered, and an interactive maintenance scheduling is enabled based on the availability of workshop, machinery, skillsets and existing plan schedules.
- 21.3.25 Not Used
- 21.3.26 A job card is created and shared automatically to the designated maintenance teams based on the maintenance scheduling on a maintenance planner's approval window.
- 21.3.27 The job card / work order is circulated to related maintenance stake holders based on activity, workflow, and roles.
- 21.3.28 Not used
- 21.3.29 Not used
- 21.3.30 Solution provider shall take necessary precautions for not deleting the data from the original fault logger in rolling stock, at any point of time.
- 21.3.31 All the logs shall be stored in a server, hereinafter referred to as data server, to be installed in Koyambedu depot by the Contractor. The maintenance management solution shall be capable of fetching respective asset maintenance manuals for a specific maintenance intervention.
- 21.3.32 Configuration Management

- i) The solution will be a full-featured asset configuration management system for all equipment in metro rolling stock and depot M&P's.
- ii) The configuration management solution shall consist of a tool for managing engineering rules and physical build and provide a tool for managing operational status.
- iii) The configuration management tool shall provide conflict detection and resolution, unlimited backdated changes to Install / Remove and Usage records, and on-the-fly historical at-the-time asset build and component life views.
- iv) The system will include a rule engine to support true alphanumeric serial effectivity and system-on-system functionality.
- v) The system will be able to define all maintenance programs as part of the configuration management capability as master data that is utilized by all applicable assets (based on the rules)
 - a) Create a network of maintenance requirements that links maintenance requirements to one or more related maintenance items that are triggered on related actions (completion, install, remove etc.).
 - b) Link maintenance resources to the Maintenance items (bill of materials, labor, tools and services).
- vi) The system will provide for the ability to view an audit trail, since asset creation on the system, and to view and status changes, including life usage, components fitted and maintenance program status.
- vii) The system will support Technical Records with the ability to define all technical record types, such as Engineering Orders, Service Bulletins, Modifications and Service Instructions, service Technical Instruction etc. within a single application that enables both technical records effectively and embodiment to be effectively managed.
- viii) The Technical Record capability shall dynamically link to the maintenance program (preventive maintenance) and work order applications.
- ix) The system will support Fleet Management definition, such as a fleet of metro rolling stock and depot M&P's, based on attribute values that may change over time.
- x) The system will support Work Packaging requirements for maintenance inputs based on planned maintenance activities.
- xi) The system will support configuration management attributes throughout the logistics applications.
- xii) The system will provide in service 'Event Management' capability to record all in service events based on retrospective recording / configuration validation of all associated actions to provide robust 'Service Lifecycle Management'.

21.4 OTHER REQUIREMENTS OF AMMS

- 21.4.1 The AMMS is expected at the minimum to allow seamless, unattended and automated flow of diagnostics, condition and channel data from rolling stock and Depot M&P to Remote diagnostic system, Diagnostics Rule Engine, Maintenance management system, Display and reporting systems, Job card / Work order systems, Maintenance Rule Engine, Maintenance planning system and individual/common display devices in real-time with a refresh rate of not exceeding 5 seconds under ideal connectivity condition.
- 21.4.2 The system shall also have options on demand for Manual intervention, manual approvals and manual data entry as and when required.
- 21.4.3 The AMMS solution shall allow for multiple repairs to be recorded for each component.
- 21.4.4 The AMMS solution shall be capable of using metro railway industry standard codes.
- 21.4.5 The AMMS solution shall be capable of recording industry standard codes for labor and materials on job card / work orders and purchase order.

- 21.4.6 The AMMS solution shall be able to create and track OEM, Extended and aftermarket warranties by Item, Industry Code, and Manufacturer.
- 21.4.7 The AMMS solution shall be capable of processing warranty claims based on tracked warranty items.
- 21.4.8 The AMMS solution shall generate a warranty items report identifying items that were replaced under warranty by a given period.
- 21.4.9 The equipment or asset record in the AMMS system shall display warranty information.
- 21.4.10 The AMMS solution shall generate claims against warranty items.
- 21.4.11 The AMMS solution will provide a warranty system to manage reimbursement in money, replacement parts, credits and other conditions.
- 21.4.12 The AMMS solution shall be capable of generating a warranty alert prior to the end of the asset's warranty period.
- 21.4.13 The AMMS solution will provide a template for assigning warranties to multiple assets within a group or fleet.
- 21.4.14 The AMMS solution shall provide a capability that allows defined work types to be excluded from warranty validation, eliminating additional alerts when a work type is not eligible for warranty recovery.
- 21.4.15 The AMMS solution shall have a tracking system to track s for manufacturer recalls, changes in government regulations and internal engineering orders and changes.
- 21.4.16 The AMMS solution's tracking system shall be capable of defining a as a set of job or task plans for one or more assets.
- 21.4.17 The AMMS solution's system shall be able to select multiple assets for the setup.
- 21.4.18 The system of the AMMS solution shall create a job card/work order hierarchy for each job or task plan for each equipment, and the ability to track the progress.
- 21.4.19 The AMMS solution shall be able to perform inspection and servicing activities, such as daily inspections, car cleaning and external washing that can be recorded for multiple assets on a single work order.
- 21.4.20 The AMMS solution shall allow for meter adjustments for broken items such as odometers and hour meters.
- 21.4.21 The AMMS solution shall have a built-in capability to import and validate multiple readings from external systems in future.
- 21.4.22 The AMMS solution shall be capable of recording meter history & allow correction of previous readings.
- 21.4.23 The AMMS solution shall have the capability of tracking an unlimited number of meters readings with history.
- 21.4.24 The AMMS solution shall have a built-in meter import capability for all continuous meters such as odometers and hour meters in future when requirement arises.
- 21.4.25 The AMMS solution shall allow users to setup rules in the rule Engine, that enable to issue work orders / Job Cards, alerts, or early preventive maintenance (PM) work orders when a meter threshold is exceeded in the Rule settings automatically.
- 21.4.26 The AMMS solution shall provide a capability to automatically capture a meter reading on the main page of a work order based on the asset's primary meter, defined by asset type (mileage, hours, cycles, etc.) that is captured live from the Running Train including timestamp, Location etc. within 5 seconds from the Remote diagnostics data.
- 21.4.27 The AMMS solution shall have a specifications capability in the Asset Management system to list a multilevel hierarchy in the asset record with attributes at various levels in the hierarchy.

- 21.4.28 The AMMS solution will support measurement points that can be defined in a new asset template that will create a measurement tab or fields in work orders for associated assets to allow for multiple measurements to be recorded on the work order.
- 21.4.29 The AMMS solution shall support serial number changes of equipment, component and parts.
- 21.4.30 The AMMS solution shall include inventory tracking and purchasing functionality as part of a single application.
- 21.4.31 The AMMS solution will provide a capability for the setup and management of inventory and cycle counting.
- 21.4.32 The AMMS solution shall be able to make work assignments through a supervisor screen or window.
- 21.4.33 The AMMS solution shall have a screen or window to allow maintainers to see their assignments, select work orders and start, pause and stop labor hours.
- 21.4.34 The AMMS solution will have the capability to capture training and certifications, and verify technicians are qualified for safety or special training assignments within the application and alerts expiry of certifications.
- 21.4.35 The AMMS solution shall have the capability to create multiple asset and equipment records using a template.
- 21.4.36 The AMMS solution shall be able to generate multiple Preventive Maintenance schedules using a template.
- 21.4.37 The AMMS solution will have a preventive maintenance (PM) system that will provide relationships that can be used to have one PM schedule activate, inactivate, or complete another PM.
- 21.4.38 The AMMS solution will provide for a detailed view of the preventive maintenance (PM) events of the asset throughout its life.
- 21.4.39 The AMMS solution shall be able to track out of service, available and operational status of all assets.
- 21.4.40 The AMMS solution shall have the capability to define expected life, depreciation schedule, current condition & repair cost limits and manage repair or replacement decisions.
- 21.4.41 The AMMS solution shall be able to record and manage items and components by position that is captured through the Remote Diagnostics system in real-time.
- 21.4.42 The AMMS solution will be able to alert the user of recent or repeat repairs, to include the display of a user configurable recent or repeat history of the asset on the current work order.
- 21.4.43 The AMMS solution shall have the capability to manage outsourced maintenance work on components and assets through job cards.
- 21.4.44 The AMMS solution will provide detailed history of component and asset movements based on parent-child relationships.
- 21.4.45 The AMMS solution shall provide straight forward access to full work order history, including preventive maintenance history, charges for labor, material, tools, and services, warranty work history, meter readings, status, condition changes, moves, and usage history chronologically. The displayed data shall be in real-time based on changes updated from Remote Diagnostics system.
- 21.4.46 The AMMS solution shall have the capability for integration of remote data acquisition and wayside condition monitoring equipment to drive emergency work orders and preventive maintenance inspections as part of a future requirement.
- 21.4.47 The AMMS solution shall be capable of integrating to telematics systems for health or condition monitoring to track parameter information and receive diagnostic data and have seamless link to other systems down the line.
- 21.4.48 The AMMS solution will provide a capability for flexibility for asset numbering, allowing customers to define an unlimited number of different asset numbers (aliases) for each asset

- 21.4.49 The AMMS solution shall be capable of triggering alert for scheduling job cards / work order which are waiting for spare / material and train availability in depot.
- 21.4.50 If any system in AMMS fails, the restoration time shall not exceed 30 minutes under any circumstances.
- 21.4.51 The AMMS solution shall be capable of functioning with local server as well as with cloud (i.e.,- remote server)
- 21.4.52 The AMMS solution shall not affect the existing functionality of any assets to which AMMS is incorporated.
- 21.4.53 The AMMS shall also be capable of manually raising job cards/ work orders as and when required.
- 21.4.54 The AMMS shall allow handling of additional rolling stock and depot M&P machines by CMRL.
- 1 21.4.55 All the hardware and software support for AMMS shall be available for 10 years post [AMC DLP Completion](#).
- 21.4.56 The AMMS solution shall be capable of protecting its system from all malwares, viruses and any other potential threats throughout its service life.

21.5 MATERIAL MANAGEMENT SYSTEM

- 21.5.1 The core functionality of the material management is to provide a fully integrated, comprehensive capability for requisitioning, procurement, warehousing, distributing and inventory tracking for all the spare parts, materials and components with seamless integration to the Maintenance Management of AMMS.
- 21.5.2 The material management shall be a Windows / Web application-based solution with Bar coding capability for effective material management.
- 21.5.3 The material management shall also be mobile based, compatible for viewing on tablets and smaller screen sizes.
- 21.5.4 The material management shall provide the following functionalities as minimum requirements.
- 21.5.5 Automatic identification and data capture: The system shall consist of a Barcode station which will facilitate unique identification, categorization and labeling of all the store components which shall be tracked individually at any given point in time.
- 21.5.6 Master Data Maintenance for Procurement Planning: The material management shall capture and store vendor transaction details and other purchase related information including automated vertical storage system and provide an interface to other modules with in AMMS solution enabling it to collect the necessary details that can be used to create inventory transactions and Purchase orders. The same details shall be available for tracking of warranty, service periods and related information.
- 21.5.7 Warehousing (Storekeeping): The system shall automatically determine the distribution of the store materials, including those that are available in automated vertical storage system and other locations where these stocks are maintained, stacked and handled. The material management shall define and enforce a standard procedure for receipt, inspection, issue and accounting of materials and so on.
- 21.5.8 Inventory Control: The material management shall maintain stock of materials at the correct level under all circumstances, providing automatic stock level updates and sending notifications to concerned departments when Re- Order Level (ROL) is reached. The material management shall handle Inward Material Rejection, WIP Material Status and Tracking and management of parts with defects which also encompasses warranty information tracking with scheduled synchronization to Material Management system of AMMS.
- 21.5.9 Surplus / Obsolete / Scrap Disposal: The material management shall provide the functionality to actively track, decommission and dispose of store materials and components that are either obsolete, dead surplus or scrap. The disposed materials shall not be available anywhere else in

- the system and the serial number management is to be handled accordingly to eliminate ambiguity.
- 21.5.10 Business Intelligence based Reporting for Value analysis and cost optimization.
- i) The material management shall provide Insightful Business Intelligence reports that effectively cover all aspects of store management such as inventory tracking etc., The material management reports shall be visually illustrative, easy to comprehend and easy to generate.
 - ii) The user shall also be able to generate custom reports based on the data available in the system.
- 21.5.11 The minimum requirement in terms of reports from material management are but not limited.
- i) Category Based Location Mapping
 - ii) Materials at or below Reorder Level
 - iii) Materials Currently within Warranty Period
 - iv) Category Wise Stock availability of Components
 - v) Category wise Movable Surplus quantities
 - vi) Component wise useful Life
 - vii) Category wise Storage Space Availability
 - viii) Annual Inventory Snapshot comparison (Current and previous)
 - ix) The reports shall be provided with drill-down capabilities, enabling the user to view the data at both a summarized and detailed view.
- 21.5.12 The material management system is expected to address the following areas:
- 21.5.13 Supplier contacts
- i) The system will enable direct interface between Maintenance Management/Supply Chain Management
 - ii) Spare parts “pre-reservation” during the planning process
 - iii) Stock levels automatic updating according to spare parts picking (cf. WO)
 - iv) Purchasing proposition if minimum stock level is reached.
- 21.5.14 Spare-parts consumption forecast (considering preventive planning and corrective aspects). At any time, AMMS shall provide a vision of real inventory according to assets, locations, warranty duration, maintenance department and financial breakdown.
- 21.5.15 According to spare-parts rotation rates, the system shall be able to
- i) Propose updated stocking levels.
 - ii) Control stock lifetime compliance (for goods with specified lifetime) and alert in case of risk of non-compliance.
 - iii) AMMS shall be able to handle logistic processes based on bar codes.
- 21.5.16 Purchasing
- i) The system will enable launching, endorsement, monitoring and reporting of the purchasing process. Spare parts and services (third party) purchasing shall both be considered.
 - ii) Process shall be engaged following a recommendation automatically generated or a punctual need.
 - iii) Analyze Supplier performance when ordering a part.
 - iv) Once validated, a purchasing proposition shall raise a purchasing order to be endorsed (endorsement rules according to the purchasing amount).

21.6 REPORTS, ANALYSIS AND KPIS

21.6.1 To ease reporting and analysis, all the configuration and recorded data shall be exportable to commonly used file format (e.g., MS Excel). A set of regular reports shall be designed considering all the aspects of maintenance activities and according to various breakdowns (equipment, sub-system, component, location, etc.,)

- Planned vs. Unplanned work.
- Detailed fault / cause analysis
- Repeat defect analysis.
- Resources (history and forecast)
- Technical (reliability and availability)
- Assets utilization (counters state)
- Costs

AMMS shall be fitted with data management tools allowing easy set-up of customized reports related to all available data. These report building facilities shall neither require IT skills nor intervention of the software provider.

21.6.2 As a minimum but not limited to, the following KPIs shall be tracked:

S. No	Area	KPI	Description
1	Inventory	% Inactive stock items	Percentage of all stock items that have had no activity in the past 12 months.
2		Total inventory value	Total dollar value of all inventory items in stock.
3		% Annual stores investment used	Percentage of the inventory value that is used annually.
4		Inventory turnover ratio	The value of total orders for inventory items annually, divided by the total value of inventory.
5		% Non-critical spares as a % of total inventory value	Percentage of all inventory items that are considered non-critical to the operation.
6		% Critical spares as a % of total inventory value	Percentage of all inventory items that are considered critical to the operation.
7	Assets	% Total downtime	Percentage of the total operating hours resulting in downtime for all causes.
8		% Maintenance downtime	Percentage of the total operating hours resulting in downtime for maintenance reasons.

9	Assets	% Unscheduled downtime	Percentage of unscheduled downtime
10		% Downtime caused by breakdowns	Percentage of downtime that was caused by breakdowns.
11		Mean Time Between Failure (MTBF)	A measure of the typical duration between any failures for a critical asset (breakdown).
12		Mean Time To Repair (MTTR)	A measure of the average time it takes to correct failure on an asset.
13		% Repetitive asset failures	Percentage of asset failures that are repeat failures.
14	Planned activities	% of Planned Maintenance Work	Percentage of work orders that were planned.
15		Weekly Plan Attainment %	Measure of the successful completion of the maintenance plan on a weekly basis
16		Unplanned %	The level of unplanned maintenance activities against available time.
17	Work order	% Work orders waiting on parts	What percentage of work orders are waiting on parts.
18		% Preventive work labor hours	What percentage of all work orders were PMs.
19		% Corrective work labor hours	What percentage of all work orders were Corrective
20	Preventive maintenance	% Corrective work orders generated from PM inspections	What percentage of all corrective work orders is generated from PM inspections annually.
21		% PM tasks audited annually	What percentage of PMs is audited!
22		% PM inspections overdue	What percentage of PMs was not completed before the due date.

21.6.3 As a minimum but not limited the following reports shall be generated:

Report	Description
Details of an Asset's Failures	Summarizes the failures, by problem code, for an asset between the specified dates. Links are available to view these failures graphically. Problem codes are linked to the Drilldown into Asset's Failures report.
Drilldown into Asset's Failures	Displays problem causes and remedies for the selected problem code.
Summary of Asset Failures by Location	Displays the total number of failures reported against the selected assets during the specified time period.
Accident/Incidents	For the staff/ Assets in depot and mainline
	For all EIR/ECP
Scheduled reports	Such as rolling stock / depot machine's daily report, weekly report, monthly reports, train running hours, train set wise / TO login details etc.,

21.7 USER ADMINISTRATION

- 21.7.1 Several user profiles will be implemented according to various access privileges (“user groups”) defined during design stage. According to users’ functions and missions, these privileges will allow them to (the following list is given for illustration purpose and will be further defined during design):
- i) Allocate tasks.
 - ii) Create reports.
 - iii) Seize data (in partly or complete AMMS access).
 - iv) Consult data (in partly or complete AMMS access).
 - v) Generate purchase orders.
 - vi) Approve purchase orders.
 - vii) Part of these “user groups” shall be external ones, such as sub-contractors (cleaning operations, etc...) or suppliers (especially during the defect liability period).
- 21.7.2 The software user licenses shall not be restricted to the number of users of the solution.
- 21.7.3 The solution shall be capable of producing different user groups with specific privileges. There shall be flexibility to change user groups and privileges as desired by CMRL.
- 21.7.4 At any given point of time of the entire lifecycle of the solution without restrictions on number of users, profiles, user groups, roles or capabilities.

21.8 PROJECT MANAGEMENT

- 21.8.1 The Solution provider shall provide on-going project management for the responsibilities, to provide a framework for project planning, communications, reporting, procedural and contractual activity. This activity is composed of the following tasks:
- i) Develop and maintain the master implementation plan and set project standards
 - ii) Report to steering committee and program management.
 - iii) Ensuring and auditing the quality, clarity and comprehensiveness of documentation of all KPIs, business process functional requirements, technical requirements, configuration setups, data migration scripts, roles & responsibilities and access rule etc.
 - iv) Control project performance
 - v) Conduct regular meetings and/or updates with other project team members
 - vi) Assist project Manager and change manager to implement organizational change management plan
 - vii) Review work products produced by project members.
 - viii) Ensure system fully tested prior to cut over to production
 - ix) Risk Management
 - x) Project status reporting
 - xi) Scope Management /Delivery of project
 - xii) Ensure external consultant’s obligations on the project are completed on time
 - xiii) Co-ordinate with various IT/business groups in organization to ensure the success of implementation of project
 - xiv) Confirmation of quality server setup, start of UAT, Go-Live check and confirmation from CMRL for Go-live.

21.9 SYSTEM ACCEPTANCE CRITERIA

21.9.1 System Integration Testing

- i) System Integration & Testing (SIT) process brings together individual elements of software under implementation and tests the system as an integrated whole. All the systems that were not available and untested during Solution Mapping, Application Development and Data Conversion are brought together at System Integration Test environment.
- ii) This activity is composed of the following tasks:
 - a) Prepare Test Environment
 - b) Prepare Test plans.
 - c) Prepare Test Specifications
 - d) Load sample data
 - e) Execute test.
 - f) Bug fixing and Regression testing.
 - g) Document Test Results
- iii) Deliverables:
 - a) System Integration Test Plan
 - b) System Integration Test Specification with test cases
 - c) System Integration Test Results
- iv) Completion Criteria: Upon the submission & Physical signoff of the above-mentioned deliverables.
- v) Performance Testing
- vi) Peak-Load Performance Testing needs to be carried out for all the processes below, individually as well as collectively.
 - a) Extracting Rolling stock asset logs from the DATA server manually.
 - b) Automatic Work order creation from the logs available in the DATA server.
 - c) Manual and automatic Records creation/ updates by application as well as via integration
 - d) Tasks/ Jobs assignment and notification
 - e) Work Order creation through PM schedules and manually
 - f) Work Order updating through Mobiles as well as manually
 - g) Material request and approval procedure through mobiles as well as manually.
- vii) Deliverables
 - a) System Performance Test Plan
 - b) System Performance Test Specification
 - c) System Performance Test Results
- viii) Completion Criteria: Upon the submission & Physical sign-off of the above-mentioned deliverables.

21.9.2 User Acceptance Testing (UAT)

- i) This Testing will be based on Acceptance Test Plan and test specifications. CMRL will issue acceptance certificate upon completion of the testing. This activity is composed of the following tasks:
 - a) Create UAT Environment
 - b) Prepare for Acceptance Test
 - c) Prepare test plans.

- d) Validate Test Plan and Sign Off
- e) Prepare test specifications.
- f) Execute test.
- g) Bug fixing and Regression testing.
- h) Obtain user acceptance.
- ii) Deliverables:
 - a) Acceptance Test Plan
 - b) Acceptance Test Specification
 - c) Acceptance Test Results
 - d) Acceptance Certificate (From CMRL)
- iii) Completion Criteria: Upon the submission & Physical signoff of the above-mentioned deliverables.
- iv) UAT Acceptance Criteria: The UAT Plan would clearly and unambiguously spell out the plan to test the following final acceptance criteria, the fulfillment of which would complete the implementation phase. The problems reported during the UAT would be categorized according to these severity codes.
 - a) Severity 1: Critical and high severity problems that include problems that would in a production environment, cause disruption of the work.
 - b) Severity 2: Medium severity problems that include problems such as certain functions not working as per the documented functionality, but which in a production environment would not cause total disruption of the operations.
 - c) Severity 3: Low severity problems that include problems that have been circumvented at operational levels and/or not disrupting the normal operations.
 - d) Severity 4: Cosmetic problems and others that have no impact on the functionality of the system.
- v) Deployment Acceptance Criteria is considered complete and accepted when it meets the following criteria:
 - a) There shall not be any failures of Severity 1 or severity 2 or severity 3 for three months (System stability period) from the date of completion of UAT test.
 - b) If the failures of Severity 1 or severity 2 or severity 3 are found during the system stability period, then solution provider shall immediately address the failures. After rectifying the failures stability period shall be started again from Day 1.
 - c) The remaining errors (Severity 4) may be addressed during the ~~Support period (AMC)~~ **DLP period**. All sign-off deliverables would be treated as accepted when the system goes live. However, this does not include the deliverables, which may be open in the UAT stage before the system goes live.

21.10 GO-LIVE

21.10.1 The Go-Live process encompasses transition to deployment readiness, production planning, testing, production, and post-production support. When planning for deployment the following issues are addressed.

- i) Infrastructure readiness
- ii) Organization (change) readiness and adoption
- iii) CMRL Business users' readiness
- iv) Deployment Strategy
- v) Post Implementation support from Solution provider

vi) Joint post implementation review

21.10.2 This activity is composed of the following tasks:

- i) Prepare Production Environment
- ii) Data Collection
- iii) Load data (100%)
- iv) Develop Transition Management Plan
- v) Migrate Configurations from Test to production system.
- vi) Go Live

21.10.3 Completion Criteria

- i) Upon the submission & Physical signoff of the above-mentioned deliverables
- ii) System Go live signoff shall be taken from CMRL.

21.11 TRAINING

21.11.1 Skill transfer is critical to the implementation of the project at CMRL. The training will be carried out separately for each section's users (like Rolling stock maintainers, stores team, etc.,).

21.11.2 The training for various groups (maintainers and stores) shall be conducted separately. Solution provider shall provide training for four weeks to CMRL. The number of trainees will be decided by CMRL.

21.11.3 Three sets of training material, hard copy and soft copy shall be provided to CMRL.

21.11.4 Deliverables

- i) End user Training
- ii) Training material

21.11.5 Completion Criteria: Upon the submission & Physical signoff of the above-mentioned deliverables.

APPENDIX A: ABBREVIATIONS

A.1 GENERAL

A.1.1 Various abbreviations used in this document are set out in alphabetical order in the below table

Abbreviation	Full name
AAR	Association of American Railroad
AASHTO	American Association of State Highway And Transportation Officials
AC	Alternating Current
AFC	Automatic Fare Collection
AFTC	Audio Frequency Track Circuits
AGC	Associated General Contractors
AIS	Association of Information System
ANSI	American National Standards Institute
AREMA	American Railway Engineering and Maintenance-of-way Association
ARS	Automatic Route Setting
ASHRAE	American Society for Heating, Refrigeration and Air-conditioning Engineers
ASP	Audio and Selection Panel
ASS	Auxiliary Sub-Station
ASTM	American Society for Testing and Materials
ATC	Automatic Train Control (ATO+ATP+ATD)
ATD	Automatic Train Driving Mode
ATO	Automatic train Operation
ATP	Automatic Train Protection
ATR	Automatic Train Regulation
ATS	Automatic Train Supervision
BCC	Backup Control Centre
BIS	Bureau of Indian Standards
BS	British Standards
BCP	Brake Cylinder Pressure
BP	Brake Pipe
CATC	Continuous Acting Train Control (system)
CAD	Computer Aided Design
CADD	Computer Aided Design and Draughting
CBTC	Communications Based Train Control
CCTV	Close Circuit Television
CCITT	Consultative Committee on International Telegraphy and Telephony
CD	Commencement date

Abbreviation	Full name
CEB / FIP	Comite Euro – Internationale du Beton (Euro-International Concrete Committee) and Federation Internationale de la Pre-contrainte (International Federation of Prestressed Concrete)
CENELEC	European Committee for Electro technical Standardization
CER	Communications Equipment Room
CIBSE	Chartered Institution of Building Services Engineers
CI	Converter Inverter
CIE	International Commission on Illumination
CMC	Comprehensive Maintenance Contract
CMD	Control Train Driving Mode
CM	Coded Manual (Driving Mode)
CPU	Central Processing Unit
CPWD	Central Public Works Department
CPM	Critical Path Method
CS	Control Superintendent
CSC	Contactless Smart Card
CVMS	Central Voice Mail System
CVRS	Central Voice Recording System
CWR	Continuously Welded Rail
DC	Direct Current
DCC	Depot Control Centre
DCA	Design Certificate Application
DCC	Design Certificate (of) Consent (Sheet)
DFF	Direct Fixation Fastener
DIN	German Industrial Standards
DG	Diesel Generator
DLT	Direct Line Telephone
DLP	Defect Liability Period
DM	Driving Motor Car
DMD	Depot Manual Driving mode
DOD	Direct Outward Dial
DPR	Detailed Project Report
DRCA	Design Review Certificate Application
DSO	Depot Security Office
DTS	Data Transmission System
DVAS	Digital Voice Announcement System
DVR	Digital Video Recorder
E&M	Electrical and Mechanical

Abbreviation	Full name
EC	Engineering Controller
ECMS	Equipment Control and Monitoring System
EIA	Energy Information Administration
EIG	Electrical Inspector of Government
EMC	Electro-magnetic Compatibility
EMI	Electro-magnetic Interference
EMU	Electric Multiple Unit
EN	Euro Norm (European) Standard
EP	Electro-Pneumatic
ETP	Effluent Treatment Plant
FAT	Factory Acceptance Tests
FFT	Fast Fourier Transform (method)
FIDS	A Flat-Panel Interactive Display System
FRLS	Flame Retardance Low Smoke Emission
FRLSOH	Fire Retardant Low Smoke Zero Halogen
FRP	Fiber Reinforced Plastic
FMEA	Failure Modes Effects Analysis
FMECA	Failure Modes Effects and Criticality Analysis
FRACAS	Failure Reporting And Corrective Action System
GCC	General Condition Of Contract
GoA	Grade Of AATOMation
GPS	Global Positioning System
GS	Employer's Requirements : General Specification
GUI	Graphical User Interface
HDPE	High Density Poly Ethylene
HSCB	High Speed Circuit Breaker
VAC	Ventilation and Air Conditioning
Hz	Hertz (Frequency)
HV	High Voltage (as per Indian Electricity Rules)
IABSE	International Association for Bridge and Structural Engineering
IC	Integrated Circuit
IE	Independent Engineer
IEC	International Electro technical Commission
IEEE	Institution of Electrical and Electronic Engineers
IES	Illumination Engineering Society
IGBT	Insulated Gate Bipolar Transistor
IRC	Indian Roads Congress

Abbreviation	Full name
IRS	Indian Railway Standards
IS	Indian Standard
ISA	Independent Safety Assessor
ISBT	Inter –State with Bus Terminus
ISO	International Standards Organization
IT	Information Technology
ITU-T	International Telecommunications Union–Telecommunication Standardization Sector
JIS	Japanese Industrial Standards
KMPH	Kilometres per hour
LAN	Local Area Network
LCD	Liquid Crystal Display
LCP	Local Control Panel
LCX	Leaky Coaxial
LED	Light Emitting Diode
LRU	Least Replaceable Unit
LOMA	Limit Of Movement Authority
LV	Low Voltage (as per Indian Electricity Rules)
LWR	Long Welded Rail
M&P	Machinery and Plant
M C	Motor Car
MCB	Miniature Circuit Breaker
MCBF	Mean Cycle Between Failures
MDBF	Mean Distance Between Failures
MCC	Mains Circuit Control
MDB	Main Distribution Board
MIS	Management Information System
MMI	Man-Machine Interface
MMIS	Maintenance Management Information System
MMS	Maintenance Management System
MOSRTH	Ministry of Shipping, Road Transport and Highways
MRTS	Metro Rail Transport System
MSS	Maximum Safe Speed
MTBF	Mean Time Between Failures
MTTR	Mean Time To Restore
MWI	Maintenance Works Instruction
NBC	National Building Code (of India)
NEMA	National Electrical Manufacturers Association

Abbreviation	Full name
NFPA	National Fire Protection Association
NMS	Network Management System
NTP	Notice to Proceed
O&M	Operation and Maintenance
OA	Officer Accommodation
OCC	Operations Control Centre
OCS	Overhead Catenary System
OHE	Over Head Electrical System
OMPD	Operating Modes and Principles Document
PA	Public Address (System)
PABX	Private Automatic Branch Exchange
PAS	Public Address System
PC	Personal Computer
PCB	Printed Circuit Board
PEA	Passenger Emergency Alarm
PCM	Pulse Code Modulation
PIC	Passenger Inter Communication
PIDS	Passenger Information Display System
PIS	Passenger Information System
PLC	Programmable Logic Control
PMD	Protected Manual Driving Mode
PSB	Platform Supervisor Booth
PSD	Platform Screen Doors
PSG	Platform Screen Gates
PSSS	Passenger Saloon Surveillance System
PSTN	Public Switched Telephone Network
PTCC	Power and Telecommunication Consultants Committee
PTFE	Poly Tetra Fluoro Ethylene
PTZ	Pan/Tilt/Zoom
PWD	Public Works Department
PWM	Pulse Width Modulation
RAM	Reliability, Availability and Maintainability
RASTI	Rapid Speech Transmission Index
RCC	Reinforced Cement Concrete
RCP	Radio Control Panel
RDW	Radio Dispatch Workstation
RF	Radio Frequency

Abbreviation	Full name
RI	Ride Index
RJT	Return Journey Ticket
RMDT	Reliability, Maintainability Demonstration Testing
ROW	Right of Way
RSS	Rectifier Sub Station
RS	Rolling Stock (Passenger Cars)
RH	Relative Humidity
RM	Restricted Manual (Driving Mode)
RSC	Rolling Stock Controller
RTU	Remote Terminal Unit
S&T	Signalling and Telecommunications
SAT	Site Acceptance Tests
SATRA	Shoe and Allied Trade Research Association
SBD	Safe Braking Distance
SCS	Safety Cut-out Switch
SCC	Special Condition of Contract
SC	Station Controller
SCADA	Supervisory Control and Data Acquisition
SCIL	Safety Critical Items List
SCR	Station Control Room
SDH	Synchronous Digital Hierarchy
SEJ	Switch Expansion Joint
SER	Signalling Equipment Room
SECP	Software Engineering Change Proposal
SIL	Safety Integrity Level
SINAD	Signal plus Noise plus Distortion (ratio)
SJT	Single Journey Ticket
SMS	Station Management System
SMD	Surface Mounted Devices
SOD	Schedule of Dimensions
SPL	Sound Pressure Level
SS	Sub Station
STM	Standard Telecom Mode
SV	Stored Value
T	Trailer Car
TCMS	Train Control Management System
TR	Train Radio

Abbreviation	Full name
Train ID	Train Identification Number
TC	Traffic Controller
TCCP	Train Cab Communication Panel
TDR	Train Data Recorder
TEP	Track Earthing Panels
TER	Telecommunications Equipment Room
TETRA	Terrestrial Trunk Radio
TNS	Three phase and Neutral system
TO	Train Operator
TOM	Ticket Office Machine
TP	Traction Power
TPS	Traction Power Substation
TSR	Train Service Regulator
TSS	Traction Sub-station
TVM	Ticket Vending Machine
TVS	Tunnel Ventilation System
UD	Usage Data
UIC	Union Internationale des Chemins de Fer (International Union of Railways)
UPS	Uninterrupted Power Supply
VAC	Ventilation and Air Conditioning
VCC	Vehicle Control Circuit
VCB	Vacuum Circuit Breaker
VCR	Video Cassette Recorder
VDU	Video Display Unit
VDU	Visual Display Unit
VVVF	Variable Voltage Variable Frequency
WAN	Wide Area Network
XLPE	Cross Linked Poly Ethylene
ZVR	Zero Voltage Relay

APPENDIX B: INTERNATIONAL STANDARDS

1 GENERAL

- 1.1 During the design phase, the Contractor shall provide original copies of the latest standards used, with transfer of permanent rights to CMRL as part of the Contract.
- 1.2 All the standards listed in tables B 1.1 to B 1.19 as well as those that are referred to elsewhere in the Contract or in the Contractor's design submissions; shall be submitted to CMRL in a searchable PDF format. Known standards shall be submitted no later than Preliminary Design Stage and shall always be of the latest released version on the date of submission.
- 1.3 Standards are set out in alphabetical order of the Standards Organization (in English) in tables B 1.1 to B 1.19. Any other latest equivalent standards may be followed subject to approval of CMRL.
- 1.4 Where international or national standards are quoted and specified in the Contract, the Contractor may propose to work to latest equivalent internationally or nationally recognized standards. Not systematically, but if necessary, CMRL can require the Contractor to prove the equivalence between the European and other standards. Submission for Approval are to be supported by a copy of the proposed standards, a detailed comparison of the quoted and proposed standards and, where applicable, an English translation of the proposed standard;
- 1.5 In cases where a particular standard is superseded by a more recent and/or applicable standard, such substitution shall be proposed for CMRL consent.
- 1.6 All sub-systems including major equipment, assemblies and complete car/train must comply with the latest international standards.
- 1.7 Wherever updated standard is released, the same shall be applicable.

Standard Organization	Standard Reference Number	Title or Description of the Standard
B 1.1: American Society for Testing and Materials Standards		
ASTM	A 480	Standard specification for general requirements for flat rolled stainless and heat resisting steel plates.
ASTM	B 280	Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
ASTM	A 380	Standard Practice for Cleaning, Descaling, and Passivation of Stainless Steel Parts, Equipment, and Systems
ASTM	A 666	Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar
ASTM	B743	Standard Specification for Seamless Copper Tube in Coils.
ASTM	D 2563	Standard Practice for Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts ¹ .
B 1.2: British Standards Institution		
BS	88	Cartridge Fuses for Voltages up to and including 1000V AC and 1500V DC.
BS	476-7	Flame Spread Requirements for Paint

Standard Organization	Standard Reference Number	Title or Description of the Standard
BS	476-15 : 1993 ISO 5660-1 : 1993	Fire Test on Building Materials and Structures: Method of Measuring the Rate of Heat Release of Products.
BS	857:1990	Specification for Safety Glass for Land Transport.
BS	1571 : Pt. 2 1984	Methods for Simplified Acceptance Testing of Air Compressors and Exhausters : Part 2 : Simplified testing of reciprocating and rotating types, including permissible deviations pressure and temperature measurements and arrangement of tests, form of test report and gives adjustment of test result to guarantee conditions.
BS	1006	Methods of Test for Colour Fastness of Textiles and Leather
BS	1725 Pt. 1	Domestic furniture - Beds and mattresses - Safety requirements and test methods.
BS	3100:1991	Specification for Steel Castings for General Engineering Purposes. Chemical Composition Heat treatment and Mechanical Properties of Cast Steels.
BS	3429	Size of Drawing Sheets
BS	3682 Pt.1: 1994	Specification for Compressed Air Brake Hose.
BS	3900:1980	Methods of Test for Paint.
BS	4066	Cable Tests in Fire Conditions.
BS	4360 :	Steel Used in Welded Structures.
BS	4579: Pt.1 1988	Compression Joints in Copper Conductors. Covers requirements for the performance of general application compression joints for use with copper and copper alloy conductors up to 1000mm ² cross sectional area operating below 85°C.
BS	4743	Specification for Safety Requirements for Electronic Measurement Apparatus.
BS	4870	Specification for Approval Testing of Welding Procedures
B 1.3: British Standards Institution / Euro Norms		
BS-EN	3	Portable Fire Extinguishers.
BS-EN	286-3:1995	Simple Pressure Vessels designed for Air Braking and Auxiliary Pneumatic Equipment for Railway Rolling Stock.
BS-EN	286-4:1995	Simple Unfired Pressure Vessels Designed to Contain Air or Nitrogen. Aluminium Alloy Pressure Vessels for Air Braking Equipment and Auxiliary Equipment for Rolling Stock.
BS-EN	287-1 : 1992	Specification of Approval Testing of Welders Working to Approved Welding Procedures: Pt. 1 Fusion

Standard Organization	Standard Reference Number	Title or Description of the Standard
		Welding of Steel.
BS-EN	288-3 : 1993	Fusion Welding of Steel
BS-EN	10025-1 to 5	Hot Rolled Products of Non-Alloy Structural Steels. Technical delivery conditions. Requirements for long and flat products.
BS-EN	10210	Hot Finished Structural Hollow Sections of Non-Alloy and Finer Grain Structural Steels.
BS-EN	24014 : 1992	Hexagon Head Bolts. Product grades A, B.
BS-EN	24017 : 1992	Hexagon Head Machine Screws. Product grades A and B.
BS-EN	30042 : 1994	Arc Welded Joints in aluminium and its Weld able Alloys. Guidance on quality levels for imperfections.
BS-EN	50081	Electromagnetic Compatibility. Generic emission standard.
BS-EN	60529 :1992	Specification for Degrees of Protection Provided by Enclosures (IP Code). Gives uniformity in methods of describing protection provided by enclosures and in tests to prove protection. Provides an optional extension of the IP code by an additional letter A – D, if the actual protection of persons against access to hazardous parts is higher than that indicated by the first characteristic numeral
B 1.4: CISPR		
CISPR	16 am1 (1997-08)	Specification for Radio Disturbance and Immunity Measuring Apparatus and Methods : 1 Radio Disturbance and Immunity Measuring Apparatus
B 1.5: Defence Standards		
DEF-STD-	00-56	Hazard Analysis
B 1.6: German Standards / Deutsches Institut fur Normung		
DIN	2353 : 1998	Compression fittings and couplings
DIN	52306	DIN 52306 1990 Edition, March 1990 Complete Document Ball drop test on safety glass for vehicle glazing
B 1.7: Euro Normes		
EN	438-2	High-pressure decorative laminates (HPL) - Sheets based on thermosetting resins (Usually called Laminates) - Part 2: Determination of properties
EN	779	Particulate air filters for general ventilation - Determination of the filtration performance
EN	1288	Glass in building. Determination of the bending strength of glass
ECE	Regulations-43	Uniform provisions concerning the Approval of safety glazing and glazing materials

Standard Organization	Standard Reference Number	Title or Description of the Standard
EN	10088-1 to 3	Technical delivery conditions for sheet/plate and strip of corrosion resisting steels for general purposes
EN	10089	Hot rolled steels for quenched and tempered springs - Technical delivery conditions
EN	10155	Structural Steels with improved atmospheric Corrosion
EN	12663	Railway applications Structural requirements of railway vehicle bodies
EN	13103	Railway applications – wheel sets and bogies Non-powered axles – Design method
EN	13104	Railway applications – wheel sets and bogies Powered axles – Design method
EN	13260	Railway applications – Wheel sets and bogies – Wheel sets – Product requirements
EN	13261	Railway applications –Wheel sets and bogies Axles – Product requirements
EN	13262	Railway applications - Wheel sets and bogies - Wheels - Product requirements
EN	13272	Electrical Lighting in Rolling Stock
EN	13287	Personal protective equipment – Footwear – Test method for slip resistance
EN	13452	Railway applications - Braking - Mass transit brake systems
EN	13452-1	Railway applications - Braking - Mass transit brake systems : Performance Requirements.
EN	13452-2	Railway applications - Braking - Mass transit brake systems : Performance Requirements
EN	13749	Railway applications - Wheel sets and bogies method of specifying the structural requirements of bogie frames
EN	14363	Railway applications. Testing and Simulation for the acceptance of running characteristics of railway vehicles. Running Behavior and stationary tests
EN	14750-1	Railway applications - Air conditioning for urban and suburban Rolling Stock Part 1: Comfort parameters
EN	14750-2	Railway applications - Air conditioning for urban and suburban Rolling Stock Part 2: Type tests
EN	14750:2005	Railway applications - Body side entrance systems
EN	14752:2015	Railway applications - Body side entrance systems for Rolling Stock.
EN	15085-1 to 7	Railway applications – Welding of railway vehicles and components
EN	15152	Railway applications- Front windscreens for train cabs.

Standard Organization	Standard Reference Number	Title or Description of the Standard
EN	15227	Railway applications - Crashworthiness requirements for railway vehicle bodies.
EN	15663 : 2009	Railway applications - Definition of vehicle reference masses
EN	16286-1	Railway applications - Gangway systems between vehicles - Part 1: Main applications
EN	16286-2	Railway applications - Gangway systems between vehicles - Part 2: Acoustic measurements
EN	45545 Part 1 to 7 (Category 4-A, Hazard level HL3) latest edition	Railway applications – Fire protection on railway vehicles – Part 1- 7.
EN	50082	EMC
ENV	50121	Railway Application – Electro Magnetic Compatibility – Rolling Stock
EN	50121-1 : 1996	Railway Application – Electro Magnetic Compatibility Part 1. General
ENV (DD)	50121-2 : 1996	Railway Application – Electro-Magnetic Compatibility Part 2. Emission of the Whole Railway System to the Outside World.
EN	50121-3	Railway Application – Electro Magnetic Compatibility – Rolling Stock
EN	50122-1	Railway Applications - fixed installations - part 1_ protective provisions relation to electrical safety and earthing
EN	50264	Railway Application- Railway Rolling Stock cables having special fire performance
EN	50125-1	Railway applications – Environmental conditions for equipment –Part 1: Equipment on board Rolling Stock
EN	50126-1	Railways applications – Specification and demonstration of dependability, reliability, availability, maintainability and safety - Basic requirements and generic process
EN	50126	Railway Application – Specification and Demonstration of RAMS
EN	50121-3-1	Railway Application – Electro-Magnetic Compatibility – Rolling Stock Pt. 3–1 : Train and Complete Vehicle. traction stock, train sets and independent hauled stock. Covers the frequency range DC to 400GHz.
EN	50121-3-2	Railway Application – Electro-Magnetic Compatibility – Pt. 3–2 : Rolling Stock Apparatus. Specifies emission and immunity requirements for electrical and electronic apparatus for use on Rolling Stock. Covers the frequency range DC to 400GHz.
EN	50124-1	Electrical Enclosures

Standard Organization	Standard Reference Number	Title or Description of the Standard
EN	50124-2	Railway applications- Insulation Coordination- Part 2: Overvoltage's and related protection
EN	50126-2	Railway Applications – Dependability for Guided Transport System - Pt. 2 : Safety
EN	50128	Railway Applications : Software for Railway Control and Protection Systems
EN	50129	Safety Related Electronic Railway Control and Protection Systems
EN	50132-7	Alarm systems - CCTV surveillance systems for use in security applications - Part 7: Application guidelines.
EN	50155	Railway Application - Electronic equipment used on Rolling stock.
EN	50159	Railway applications - Communications, signalling and processing systems
EN	50163	Lightning Arrestors.
EN	50180	Bushings above 1 kV up to 52 kV and from 250 A to 3,15 kA for liquid filled transformers
EN	50181	Plug-in type bushings above 1 kV up to 52 kV and from 250 A to 2,50 kA for equipment other than liquid filled transformers
EN	50200-PH-15	Fire Resistant Cables
EN	50200-PH-90	Fire resistant LSZH cables
EN	50207	Power Converters for Rolling Stock
EN	50264 1 to 3	Railway Applications - Railway Rolling Stock Power and Control Cables having special fire performance.
EN	50306 Part 1 to 4	Railway Rolling Stock cables having special fire performance.
EN	50311	Railway applications – Rolling Stock – D.C. supplied electronic ballasts for lighting fluorescent lamps
EN	50343	Railway applications – Rolling Stock – rules for installation of cabling
EN	50388	Railway Applications. Power supply and Rolling Stock. Technical criteria for the coordination between power supply (substation) and Rolling Stock to achieve interoperability.
EN	50405	Railway applications - Current collection systems - Pantographs, testing methods for carbon contact strips.
EN	50533	Railway applications - Three-phase train line voltage characteristics.
EN	50547	Railway applications. Batteries for auxiliary power supply systems.
EN	55011	Industrial, scientific and medical equipment radio-frequency equipment – disturbance characteristics –

Standard Organization	Standard Reference Number	Title or Description of the Standard
		limits and methods of measurement.
EN	55101	Immunity of information Technology Equipment.
EN ISO	2813	Determination of specular gloss of non- metallic paint films.
EN ISO	266	Acoustics. Preferred frequencies
B 1.8: International Electro-technical Commission		
IEC	1133	Electric traction-Rolling stock-Test methods for electric and thermal/electric Rolling Stock on completion of construction and before entry into service.
IEC	300-3-3	Dependability management – Part 3: Application guide Section 3: Life Cycle costing.
IEC	60034-1 : (1996-12) 60034-1 : am1 (1997-06)	Rotating Auxiliary Machines : Pt. 1 Rating and Performance Amendment No.1
IEC	60034-7	Rotating Auxiliary Machines : Pt. 7 Rating and Performance.
IEC	60034-14	Rotating electrical machines - Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher - Measurement, evaluation and limits of vibration severity
IEC	60038	Standard voltage
IEC	60044	Instrument transformers.
IEC	60044-1	Instrument transformers – Part 1 Current transformers.
IEC	60044-2	Instrument transformers - Part 2- Inductive voltage transformers.
IEC	60056 (1987-03) 60056 am3 (1996-10)	High Voltage Alternating Current Circuit Breakers Amendment No.3
IEC	60068-2	Environmental Testing.
IEC	60076	Power Transformers.
IEC	60077	Railway applications. Electric equipment for Rolling Stock. Electro technical components. General rules
IEC	60077 -1 to 5	Railway applications – Electric equipment for Rolling Stock
IEC	60077 (1968-01)	Specification for Electric Traction Equipment. Motive power units of 600-3000V DC or high-voltage AC or independent power source, also for control trailers or multiple unit trains. Can be applied to DC Rolling Stock at voltages below 600V.
IEC	60077-1	Railway applications-Electric equipment for Rolling Stock- Part1 – General service conditions and general rules.

Standard Organization	Standard Reference Number	Title or Description of the Standard
IEC	60077-2	Railway applications-Electric equipment for Rolling Stock-Part 2 - Electro technical components-General rules.
IEC	60077-4	Railway applications- Electric equipment for Rolling Stock Part 4: Electro technical components Rules for AC circuit breakers
IEC	60099-4 (1991-11)	Surge Arrestors – Pt.4 Metal Oxide, without Gaps for AC Systems.
IEC	60115-1	Smaller Resistors.
IEC	60146	Semiconductor convertors - General requirements and line commutated convertors
IEC	60228	Cables.
IEC	60268-1 (1985-01) 60268-1 60268-1 (1988-01)	Sound System Equipment : Pt. 1 General. Amendment 1 Amendment 1
IEC	60268-16 Part 16	The Objective Rating of Speech Intelligibility in Auditoria by the "RASTI" Method
IEC	60269-1 (1998-12)	Low Voltage Fuses Pt. 1 : General Requirements.
IEC	60269-2 am1 (1995-11)	Low Voltage Fuses Pt. 2 : Supplementary Requirements for Fuses for Use by Authorized Persons (Fuses mainly for Industrial Applications).
IEC	60300-1 (1993-04)	Dependability Management – Pt. 1 Dependability Programmed Management.
IEC	60300-2 (1995-12)	Dependability Management – Pt. 2 Dependability programmed Elements and Tasks.
IEC	60300-3-1 (1991-11)	Dependability Management – Pt. 3 Application Guide Sct. 1 Analysis Techniques for Dependability. Guide on Methodology
IEC	60300-3-2 (1993-10)	Dependability Management – Pt. 3 Application Guide Sct. 2 Collection of Dependability Data from the Field.
IEC	60300-3-3 (1996-09)	Dependability Management – Pt. 3 Application Guide Sct. 3 Life Cycle Costing.
IEC	60300-3-5	Dependability management – Part 3-5: Application guide – Reliability test conditions and statistical test principles.
IEC	60310 (1991-11)	Traction Transformers and Inductors.
IEC	60319 1978-01	Presentation of Reliability Data on Electronic Components (or Parts).
IEC	60322	Railway applications -Electric equipment for Rolling Stock - Rules for power resistors of open construction.

Standard Organization	Standard Reference Number	Title or Description of the Standard
IEC	60326-3 : 1991 BS 6221 : Pt.3 : 1991	Guide for the design and use of printed wiring boards. Design and application of printed boards, irrespective of their method of manufacture. Recommends design, specification, and application.
IEC	60332-1 1993-04	Tests on Electric Cables under Fire Conditions – Pt.1 :Test on a Single Vertical Insulated Wire or Cable
IEC	60332-3 1992-03	Tests on Electric Cables under Fire Conditions – Pt.3 : Tests on Bunched Wires or Cables.
IEC	60349 1991-12	Electric Traction. Rotating Electrical Machines for Rail and Road Vehicles.
IEC	60349-1	Electric Traction – Rotating Electrical Machines for Rail and Road Cars.
IEC	60349-2 1993-04	Electric Traction – Rotating Electrical Machines for Rail and Road Vehicles Pt. 2 Electronic Convertor-fed AC Motors.
IEC/TR2	60349-3 1995-08	Electric Traction – Rotating Electrical Machines for Rail and Road Vehicles Pt. 3 Determination of the Total Losses of Convertor-fed Alternating Current Motors by Summation of the Component Losses.
IEC	60384-1	Electrolytic Capacitors.
IEC	60384-4	Electrolytic Capacitors.
IEC/TR	60411-2 (1978-01)	Power Convertors for Electric Traction Pt. 2 Additional Technical Information.
IEC	60494 (1974-01)	Rules for Pantographs of Electric Rolling Stock.
IEC	60494-2	Railway applications - Rolling stock - Pantographs Characteristics and tests -Part 2: Pantographs for metros and light rail vehicles.
IEC	60502	High Voltage Cables.
IEC/TR	60505 (2004)	Guide for the Evaluation and Identification of Insulation Systems of Electrical Equipment.
IEC	60529	IP Codes, etc.
IEC	60563	Permissible Limiting Temperatures in Service for Components of Electrical Equipment of Traction Vehicles.
IEC	60571 Latest version	Electronic Equipment Used on Rail Vehicles.
IEC	60571-1	Electronic Equipment Used on Rail Vehicles.
IEC	60571-2	Electronic Equipment Used on Rail Vehicles.
IEC	60571-3	Electronic Equipment Used on Rail Vehicles.
IEC	60605	Reliability and maintainability Requirements in Equipment.

Standard Organization	Standard Reference Number	Title or Description of the Standard
IEC	60617	Graphical Symbols For Diagrams.
IEC	60617-1 (1985-01)	Graphical Symbols For Diagrams : Pt. 1 General Information, General Index. Cross Reference Tables.
IEC	60617-2 (1996-05)	Graphical Symbols For Diagrams : Pt. 2 Symbol Elements, Qualifying Symbols and Other Symbols Having General Application.
IEC	60617-3 (1996-05)	Graphical Symbols For Diagrams : Pt. 3 Conductors and Connecting Devices.
IEC	60617-4 (1996-06)	Graphical Symbols For Diagrams : Pt. 4 Passive Components.
IEC	60617-5 (1996-06)	Graphical Symbols For Diagrams : Pt. 5 Semiconductors and Electron Tubes.
IEC	60617-6 (1996-05)	Graphical Symbols For Diagrams : Pt. 6 Production & Conversion of Electrical Energy.
IEC	60617-7 (1996-05)	Graphical Symbols For Diagrams : Pt. 7 Switch gear, Control gear, and Protective Devices.
IEC	60617-8 (1996-05)	Graphical Symbols For Diagrams : Pt. 8 Measuring Instruments, Lamps and Signalling Devices.
IEC	60617-9 (1996-05)	Graphical Symbols For Diagrams : Pt. 9 Telecommunications Switching & Peripheral Equipment.
IEC	60617-10 (1996-05)	Graphical Symbols For Diagrams : Pt. 10 Telecommunications Transmission.
IEC	60617-11	Graphical symbols for diagrams - Part 11: Architectural and topographical installation plans and diagrams.
IEC	60617-12	Graphical symbols for diagrams - Part 12: Binary logic elements.
IEC	60617-13	Graphical symbols for diagrams – Part 13 : Analogue elements.
IEC	60622	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Sealed nickel-cadmium prismatic rechargeable single cells
IEC	60623 1990-03 60623 am1 1992-04 60623 am2 1992-07	Vented Nickel Cadmium Prismatic Rechargeable Single Cells. Amendment No. 1 Amendment No. 2
IEC	60631	Electro-dynamic Braking.
IEC	60664	Surface Cree page and Electrical Clearance.
IEC	60721	Classification of environmental Conditions - Part 1: Environmental parameters and their severities.
IEC	60747-6	Electrical Type Test.

Standard Organization	Standard Reference Number	Title or Description of the Standard
IEC	60749	Mechanical and Climatic Test Methods.
IEC	60754-1 1994-01	Tests on Gases Evolved During Combustion of Materials from Cables Pt. 1 : Determination of Amount of Halogen Acid Gas.
IEC	60754-2 1991-08 60754-2 1997-04	Tests on Gases Evolved During Combustion of Materials from Cables Pt. 2 : Determination of Amount of Halogen Acid Gas. Amendment No. 1
IEC	60815	Guide for the selection of insulators in respect of polluted conditions
IEC	60850 (1988-03)	Supply Voltages for Traction Systems.
IEC	60871-1 (1997-10)	Shunt Capacitor for AC Power Systems having a Rated Voltage above 1000V – Pt. 1 General Performance, Testing and Rating – Safety Requirements – Guide for Installation and Operation.
IEC	60913 (1988-12)	Electric Traction Overhead Lines.
IEC	60947-1 (1998-11)	Low Voltage Switch Gear and Control Gear Pt.1 General Rules.
IEC	60947-2 (1998-03)	Low Voltage Switch Gear and Control Gear Pt.2 Circuit Breakers.
IEC	60947-3	Circuit Breakers
IEC	60947-4	Circuit Breakers
IEC	60993 (1989-08)	Electrolyte for Vented Nickel-Cadmium Cells.
IEC/TR3	61000-1-1 (1992-05)	Electro-magnetic Compatibility (EMC) Pt. 1 : General
IEC	61000-3-6	Electromagnetic Compatibility (EMC) - Part 3-6: Limits - Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems.
IEC	61000-4-2 (1995-01) 61000-4-2 am1(1998-01)	Testing and Measurement Techniques Pt. 4, Sct. 2 : Electrostatic Discharge Immunity Test. Amendment No. 1
IEC	61000-4-3 (1995-03) 61000-4-3 am1(98-06)	Testing and Measurement Techniques Pt.4 Sct 3 : Radiated Radio Frequency Electromagnetic Field Immunity Tests. Amendment No. 1
IEC	61000-4-4 (1995-01)	Testing and Measurement Techniques Pt.4 Sct. 4 : Electrical Fast Transient/Burst Immunity Test.
IEC	61000-4-5 (1995-03)	Testing and Measurement Techniques Pt.4 Sct. 5 : Surge Immunity Test.
IEC	61000-4-6 (1996-04)	Testing and Measurement Techniques Pt.4 Sct. 6: Immunity to Conducted Disturbances Induced by Radio Frequency Fields.
IEC	61000-4-8 (1993-06)	Testing and Measurement Techniques Pt.4 Sct.8:

Standard Organization	Standard Reference Number	Title or Description of the Standard
		Power Frequency Magnetic Field Immunity Test.
IEC	61000-4-9 (1993-06)	Testing and Measurement Techniques Pt.4 Sct. 9 : Pulse Magnetic Field Immunity Test.
IEC	61000-4-10 (1993-06)	Testing and Measurement Techniques Pt.4 Sct. 10: Damping Oscillatory Magnetic Field Immunity Test.
IEC	61000-4-11 (1993-06)	Testing and Measurement Techniques Pt.4 Sct. 11: Voltage Dips, Short Interruptions and Voltage Variations Immunity Test.
IEC	61000-4-12 (1993-06)	Testing and Measurement Techniques Pt.4 Sct. 12 : Oscillatory Waves Immunity Test.
IEC	61000-5-1 (1996-12)	EMC Pt. 5 :Installation and Mitigation Guidelines Sct. 1 General Considerations.
IEC	61000-5-2 (1996-12)	EMC Pt. 5 :Installation and Mitigation Guidelines Sct. 2 Earthing and Cabling.
IEC	61034	Cables.
IEC	61071-1	Power Electronic Capacitors.
IEC	61131	Programmable controllers.
IEC	61133 (1992-11)	Electric Traction – Rolling Stock – Test Methods for Electric and Thermal/ Electric Rolling Stock on Completion of Construction and Before Entry into Service.
IEC	61287-1 (1995-07)	Power Converters Installed on Board Rolling Stock – Part 1 Characteristics and Test Methods.
IEC	61287-2 Latest Version	Power convertors installed on board railway Rolling Stock – Part 2: Additional technical information.
IEC	61348	Possible safety and health hazards in the use of alkaline secondary cells and batteries. Guide to equipment manufacturers and users.
IEC	61371	Shocks and vibrations standards.
IEC	61373	Requirements for Vibration and Shock Testing of Equipment for Railway Cars.
IEC	61375-1	Electronic railway equipment – Train Communication Network – Part 1: TCN Communication Network General Architecture.
IEC	61375-2-5	Electronic railway equipment - Train Communication Network - Part 2 - 5: ETB - Ethernet Train Backbone.
IEC	61375-3-4:2014	Electrical equipment and systems for railways.
IEC	61377 (1996-05)	Electric Traction – Rolling Stock –Combined Testing of Inverter Fed Alternating Current Motors and their Control.
IEC	61508-1 1998-12	Functional Safety of Electrical / Electronic / Programmable Electronic Safety-Related Systems : Part 1. General Requirements.

Standard Organization	Standard Reference Number	Title or Description of the Standard
IEC	61508-3 1998-12	Functional Safety of Electrical / Electronic / Programmable Electronic Safety-Related Systems : Part 3. Software Requirements.
IEC	61881	Power Electronic Capacitors used on Rolling Stock.
IEC	62313	Railway applications - Power supply and Rolling Stock - Technical criteria for the coordination between power supply (substation) and Rolling Stock.
IEC	62290-1, 2 & 3 (2014)	Railway applications –Urban guided transport management and command/control systems – Part 1: System principles and fundamental concepts.
IEC	62278	Railway applications - Specification and demonstration of reliability, availability, maintainability and safety (RAMS)
IEC	62973	Railway applications - Rolling stock - Batteries for auxiliary power supply systems - Part 4: Secondary sealed nickel-metal hydride batteries
IEC	61099:2010	Insulating liquids - Specifications for unused synthetic organic esters for electrical purposes
IEC	61203:1992	Synthetic organic esters for electrical purposes - Guide for maintenance of transformer esters in equipment
IEC	61672-2	Electroacoustics - Sound level meters - Part 2: Pattern evaluation tests
B 1.9: Institution of Electrical and Electronics Engineers		
IEEE	16	Standard for Electrical and Electronic Control Apparatus on Rail Vehicles.
IEEE	1474.1	Communications-Based Train Control (CBTC) Performance and Functional Requirements.
IEEE	304	Thermal Endurance of Insulation.
IEEE	429	Sealing Against Moisture.
IEEE	519 – 1992, 2014	IEEE Recommended Practice and Requirements for Harmonic Control in Electrical Power Systems.
B 1.10: Not used		
B 1.11: Indian Standard		
IS	2553 (Part 1 & 2)	Safety Glass - Specification Part 1: General Purpose Part 2 : For Road Transport
IS	8148	Packaged air conditioners - specification.
B 1.12: International Standards Organization		
ISO	281/1	Steel for Railway Wheels.
ISO	1553	Methods of the Determination of Copper, Lead, Iron, aluminium and Nickel in Copper Alloys.
ISO	1554	

Standard Organization	Standard Reference Number	Title or Description of the Standard
ISO	1810	
ISO	1217:1996	Displacement compressors - Acceptance Tests.
ISO	2439	Flexible cellular polymeric materials – Determination of hardness (indentation technique).
ISO	2553	Welding & allied processes- Symbolic representation on drawing's- Welded joints
ISO	2631 -1(1997)	Mechanical Vibration and Shock – Evaluation of Human Exposure to Whole Body Vibration
ISO	2631-4(2001)	Mechanical vibration and shock- Evaluation of human exposure to whole- body vibration- Part 4: Guidelines for the evaluation of the effects of vibration and rotational motion on passenger and crew comfort in fixed- guide way transport systems.
ISO	3095	Acoustics – Measurement of Noise Emitted by Rail bound Vehicles 1st. Edition.
ISO	3381	Acoustics – Measurement of Noise Inside Rail bound Vehicles 1st Edition.
ISO	4126	Safety devices for protection against excessive pressure -- Part 4: Pilot-operated safety valves
ISO	10005	International Standard: Quality management – Guidelines for the quality plans.
ISO	10007	International Standard: Quality management – Guidelines for configuration.
ISO	1005 pt. 3	Railway Rolling Stock material -- Part 3: Axles for tractive and trailing stock -- Quality requirements
ISO	4649	Rubber, vulcanized or thermoplastic- Determination of Abrasion resistance using a rotating cylindrical drum device
ISO	7626-5	Vibration and shock - Experimental determination of mechanical mobility.
ISO	8573	Compressed air quality standard.
ISO	9000	Design Management and Control. Quality Systems : Model for Quality Assurance in Design, Development, Production, Installation and Servicing .
ISO	9001	
ISO	9002	
ISO	9003	Software engineering – Guidelines for the application of ISO 9001:2000 to computer software
ISO	9126-1	Software engineering - Product quality - Quality model
ISO	9126-2 to 4	Software engineering - Product quality - External metrics and Quality in use metrics
ISO	9614-2	Acoustics - determination of sound power levels of noise sources using sound intensity - part 3_ precision method for measurement by scanning.

Standard Organization	Standard Reference Number	Title or Description of the Standard
ISO	9662	Information Processing – Volume and File Structure of CD-ROM for Information Exchange.
B 1.14: Japan Industrial Standards		
JIS	G 3114	Hot rolled atmospheric corrosion resisting steels for welded structure.
JIS	G 3459	Stainless steel pipes.
JIS	G 4305	Cold rolled stainless steel plates, sheets and strip 50126.
B 1.15: Military Standards		
MIL-HDBK-	454 (1)	General Guidelines for Electronic Equipment.
MIL-I-	46058	Insulating Compound (for Coating Printed Circuit Assemblies).
MIL-STD-	882 C	Hazard Analysis.
MIL-STD-	883 E (1)	Test Methods Standard Microcircuits.
MIL-STD-	889 B (3)	Dissimilar Metals.
B 1.16: French Standards (Normes Françaises)		
NF-F	16-101	Rolling stock. Fire behavior. Materials choosing.
NF-F	16-102	Railway Rolling Stock. Fire behavior. Materials choosing, application for electric equipment's.
NF-F	16-103	Rolling stock. Fire protection and firefighting. Design arrangements
NFPA	130	Standard for Fixed Guide way Transit and Passenger Rail Systems
NF-F	31-101	Rolling stock. Dimensional characteristics and tolerances for the underframes and body-shells of passenger coaches, vans and self-propelled units
NF-F	31-112	Railway Rolling Stock - Protection in Relation to Graffiti - Tests Procedures and Methods of Valuation, Behavior of Materials and Products of Expulsion
NF-F	31-119	Behavior of seats at static, fatigue, vibrations and impact stresses
NF-F	01-281	Fiber reinforced thermosetting plastics
NF-F	63-808	Halogen Free Cables for Low Voltage Applications
NF-F	63-826	Halogen Free Cables for High Voltage Applications
NF	T51-113	Plastic Materials Determination of Resistance to Scratching
B 1.17: Research and Study Organization (ORE)		
ORE	C116/RP8	DB WZ Ride Index : Frequency Weighting Curves
B 1.18: International Railway Union		

Standard Organization	Standard Reference Number	Title or Description of the Standard
UIC	410 O	Composition and Calculation of the Weight and Braking of Passenger Trains
UIC	505 1 to 5	Railway Transport Stock - Rolling Stock Construction Gauge
UIC	510-2 OR	Trailing stock: wheels and Wheel sets. Conditions concerning the use of wheels of various diameters
UIC	512	Rolling Stock - Conditions to be Fulfilled in Order to Avoid Difficulties in the Operation of Track Circuits and Treadles
UIC	515 OR	Passenger Rolling Stock trailer bogies - running gear
UIC	515-3 OR	Rolling Stock – Bogies – Running gear – Axle design calculation method
UIC	515-4 O	Passenger Rolling Stock – Trailer bogies – Running gear – Axle design calculation method
UIC	518 OR	Testing and Approval of railway Vehicles from the Point of View of their Dynamic Behavior, Safety, Track fatigue and Ride Quality.
UIC	534 OR	Signal lamps and signal lamp brackets for locomotives, railcars and all tractive and self-propelled stock.
UIC	541	Brakes- All UIC 541 Standards
UIC	541-05 OR	Brakes- Specifications for construction of various brake parts- Wheel Slide Protection device (WSP)
UIC	541-5 OR	Brakes – Electro pneumatic brakes for passenger trains and freight trains.
UIC	541-6 OR	Brakes – Electro pneumatic brakes test programmes for passenger trains and freight trains.
UIC	553	Heating, ventilation and air-conditioning in coaches
UIC	555 OR	Electric lighting in passenger Rolling Stock.
UIC	555-1 OR	Transistorized inverters for supplying fluorescent lamps (1).
UIC	556	Information transmission in the train (train-bus)
UIC	560 OR	Doors of coaches and luggage vans.
UIC	564-2 OR	Regulations Relating to Fire Protection and Fire Fighting Measures in Passenger Carrying Railway Vehicles.
UIC	565-3	Indications for the layout of coaches suitable for conveying disabled passengers in their wheelchairs
UIC	566 OR	Loadings of coach bodies and their components.
UIC	615 OR	Tractive units-Bogies and running gear.

Standard Organization	Standard Reference Number	Title or Description of the Standard
UIC	615-1 OR	Tractive units – Bogies and running gear – General conditions applicable to component parts.
UIC	615-4 OR	Motive power units - Bogies and running gear – Bogie frame structure strength test
UIC	644	Warning devices used on tractive units employed on international services
UIC	651	Layout of driver's cabs in locomotives, railcars, multiple unit trains and driving trailers.
UIC	811-1 OR	Technical Specification for the Supply of Axles for Tractive and Trailing Stock
UIC	812-2 OR	Solid Wheels for Tractive and Trailing Stock Tolerances (1).
UIC	812-3	Technical Specification for the Supply of Solid Wheels for Trailing Stock.
UIC	813 O	Technical Specification for the Supply of wheel sets for Tractive and Trailing Stock: Tolerances and Assembly.
UIC	861-3	Standard 60 kg/m rail profiles.
UIC	S1002	Standardization of wheel profile.
B 1.19: Miscellaneous		
ASHRAE	37	Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment.
ASHRAE	55	Thermal environmental conditions for human occupancy.
ASHRAE	62	Ventilation for Acceptable Indoor Air Quality.
ARGE Guidelines		Fire detection in Rolling Stock.
ANSI/AMCA	204	Balance Quality and Vibration Levels for Fans.
ANSI	B 31.5	Refrigeration Piping and Heat Transfer Components.
ANSI	S 1.6	Preferred Frequencies And Filter Band Centre Frequencies For Acoustical Measurements
ANSI	S 1.11	Specification For Octave-Band And Fractional-Octave-Band Analog And Digital Filters
ANSI	S 1.13	Measurement Of Sound Pressure Levels In Air
Railway Group Standard	GM/RT 2130	Vehicle Fire, Safety and Evacuation.
Railway Group Standard	GM/RT 2472:2002	Requirements for Data Recorders on Trains.
	GM/RT2100 latest issue	Requirements for Rail Vehicle Structures.

Appendix C – INTERFACE

1 INTRODUCTION

1.1 General

- 1.1.1 The Rolling Stock (RS) Contractor shall interface the design, manufacture and supply related to trains and their related interface systems with that of the Designated Contractors and Other Contractors. The Contractor shall keep CMRL fully informed of the status of such interfaces, by providing information to CMRL in the manner, format and at the intervals that are stated in the Contract or as otherwise directed by the CMRL during the course of the Works.
- 1.1.2 Corridor 1 & Corridor 2 will be extended. Hence, Rolling Stock shall be compatible for such extensions in all aspects (Design, Operations, Interface, etc.,).

1.2 Interface Responsibilities

- 1.2.1 The allocation of responsibility for specifying and provisioning the requirements necessary for to interface the Works with the scope of other Designated Contractors' has been tabulated in the corresponding sections of this document. ~~The Rolling Stock (RS) Contractor shall be the Lead Contractor and Other Designated Contractors will be the Participating Contractor. The list of Other Designated Contractor shall be intimated by CMRL to RS Contractor during Design Stage.~~
- 1.2.2 Each section is intended to describe the interface requirements between Designated Contractors with RS Contractor.
- 1.2.3 This document shall be read in conjunction with the relevant clauses of the Employer's Requirements Technical Specifications – Rolling Stock (ERTS-RS) and its Appendices.
- 1.2.4 This document outlines the interfacing requirements that are likely to arise during the execution of the Works. However, the RS Contractor remains responsible to ~~ensuring~~ ensure that all interface requirements arising from the scope of the Rolling Stock ERTS-RS) and its Appendices are properly identified; including any which may not have been listed within this Chapter. In such cases, the RS Contractor shall inform CMRL and the respective Designated Contractor.
- 1.2.5 The requirements specified herein are by no means exhaustive and it remains the Contractors responsibilities to develop and jointly execute an Interface Plan after the commencement of the Works and throughout the execution of the Works, to ensure that:
- All interfacing issues between the two Contracts are satisfactorily resolved.
 - Supply, installation and testing of equipment and software are fully co-ordinated.
 - That all equipment supplied under the Contracts is fully compatible with each other, whilst meeting the requirements of the respective Technical Specifications.
 - All the construction tolerances at the interface shall meet the requirements of the respective specifications relating to the interface points
 - Interface Contractors shall mutually respect each other's project timelines with respect to the interface requirements.
 - Interface Contractors shall finalize their respective interface equipment only after clear agreement on interface requirements with the other designated Contractors.
 - Interface Contractors shall ensure that in any case, no equipment of their system shall be put into production or installation without meeting the interface requirements spelt out in this Appendix or in the Technical Specification.
 - Test procedures, troubleshooting manuals and any other documentation shall be updated with technical details from of each Contractor and shall be submitted to CMRL.
- 1.2.6 Where details of Rolling Stock design are required to enable the Designated Contractor to implement Interface Works, RS Contractor shall provide the Designated Contractors with the necessary information including, but not necessarily limited to, those described in the sections

below. The level of information provided shall be in sufficient detail to enable the Designated Contractors to design and/or construct the required Interface Work.

- 1.2.7 RS Contractor shall take a lead in developing the Interface Management Plan (IMP), which will be prepared in conjunction with the Designated Contractors to cover all aspects of the implementation of the Interface Works required. The Plan will define the interface Works necessary to complete all the Works in this contract and shall not be limited only to those that are listed in the [summary](#) table under clause no. 2.13.1 below.

- 1.2.8 The IMP shall fully conform to the Works Programme and shall, in respect of the Contractor and each of the Designated Contractors, show and be in logical agreement with Key Dates and Handover Dates for Rolling Stock. The IMP shall indicate dates for the commencement and completion of each principal activity by each Contractor, and delivery and installation of principal items of equipment.

- 1.2.9 The IMP shall be submitted by the RS Contractor to CMRL and thereafter, the IMP shall be updated by the Contractor at regular intervals and shall be presented during Monthly Meetings. These updates shall be agreed with Designated Contractors and the status of such agreements shall be reflected in the submission [to CMRL](#).

- 1.2.10 Should it appear to CMRL that any reporting on the scope or progress of the Works Programme does not conform to or align with the IMP, then the Contractor shall be required to resolve the misalignment and resubmit the respective documents.

- 1.2.11 RS Contractor shall review the details of interface Works and notify CMRL of any amendments to the summary table required in the process of his Works. Unless such requests are reviewed without objection by CMRL, RS Contractor shall design and construct Rolling Stock Works in accordance with the provisions outlined in this Appendix and along with the requirements of Section VI A ERTS-RS.

1.3 Scope of Work of Integrated Management Plan

- 1.3.1 The information and scope of work to be provided by RS Contractor include but may not necessarily be limited to those listed in this document. This document only defines those tasks at the interface point and is not a complete itemisation of the Scope of Work.
- 1.3.2 The Designated Contractors shall liaise with the RS Contractor in the design, installation, testing and acceptance of Rolling Stock Works.
- 1.3.3 RS Contractor shall provide all access and attendance necessary in accordance with the Contract requirements to enable the Designated Contractors to complete those activities defined under the summary table attached to this interface specification in a timely manner.
- 1.3.4 Where RS Contractor Works are identified as failing to meet the requirements of the Contract and are likely to impact the Designated Contractor's Works, the RS Contractor shall propose remedial measures by submitting details to CMRL for review. The same shall be copied to the Designated Contractors.

2 SIGNALLING & TRAIN CONTROL CONTRACT:

2.1 General

- 2.1.1 This Chapter describes the interface requirements between Rolling Stock (RS) Contract and Signalling & Train Control (STC) Contractor.

- 2.1.2 The existing Signalling & Train Control system has been Designed & Commissioned by M/s Siemens Aktiengesellschaft, Germany and Siemens India Consortium. For the scope of new trains, the Signalling & Train control system contract will be awarded separately, based on a Communication-Based Train Borne Control (CBTC) system solution fully enabled for GoA4.

- 2.1.3 The Contractors shall ensure that all the requirements of the Metro Railway General Rules 2020 [or latest](#) are duly met by incorporating appropriate alarms, remote commands and other features.

- 2.1.4 The Contractors as above shall ensure that all requirements of the Specification pertaining to interfaces are properly satisfied.
- 2.1.5 All Interface Meetings, unless specifically approved by CMRL shall be held at CMRL site and they shall be given sufficient notice to attend the meeting.
- 2.1.6 Each Contractor shall be responsible for interface identification, establishment, construction and testing works either in the capacity as the Lead Contractor or Participating Contractor.
- 2.1.7 RS Contractor shall provide equipment, software, functionalities etc. of the RS part of the Train to meet the requirement of Interface. STC Contractor shall provide on board signalling equipment, software, functionalities etc., to meet the requirements of STC part of the interface. The requirements specified herein are by no means exhaustive and it remains the responsibility of the Contractors to develop and execute an interface plan during execution of the work to ensure that:
- All interface issues between the different contracts are satisfactorily resolved
 - Supply, installation and testing of equipment and software are fully co-ordinated
 - All equipment supplied in the contract are fully compatible with each other
 - ATØ UTO mode of operation, ~~Non-ATØ Non UTO~~ modes of operation and all other degraded mode of operation shall be achieved with all its inherent features in the mainline and in all Designated Depot(s) of the CMRL Phase 1 & Phase 1 Extn. network.
 - All the system tolerances at the interface shall meet the requirements of the respective specifications relating to the interface points
 - Interface Contractors shall mutually respect each other's project timelines with respect to the interface requirements.
 - Interface Contractors shall finalize their respective interface equipment only after clear agreement on interface requirements with the other designated Contractors.
 - Interface Contractors shall ensure that in any case, no equipment of their system shall be put into production or installation without meeting the interface requirements spelt out in this Appendix or in the Technical Specification of respective contracts.
 - Test procedures, troubleshooting manuals and any other documentation shall be updated with technical details from of each Contractor and shall be submitted to CMRL
- 2.1.8 The Automatic Train Protection (ATP) system shall issue the braking commands to Rolling Stock when safety limits are exceeded or when over-speed is detected. The removal of traction power and the correct application of brakes in train shall be the responsibility of RS Contractor. The ATP system shall be responsible for monitoring of speed and the issuing of braking commands when safety speed limits are exceeded.
- 2.1.9 Parking brakes shall be provided by RS Contractor. The parking brakes shall be capable of holding a fully loaded stationary train on a 4% gradient under all track conditions, indefinitely.
- 2.1.10 The trains shall be designed, tested and commissioned such that they will be operated in ~~ATØ mode from the initial stage of passenger service~~ UTO conforming to GoA4 and ATO conforming to GoA 2. The Trains shall be operated in GoA2 (ATO) mode during the initial stage of revenue operations and in GoA4 (UTO) subsequently. ~~Hence, there is no dedicated operator cabins in the train.~~
- 2.1.11 An Operator's Desk shall be provided ~~in the centre of the cab~~ inside both the extreme ends of the train. This Operator's Desk shall be suitable for operation of train in GoA1, GoA2, ~~GoA3 and GoA4 (UTO)~~ and other degraded modes.
- ~~ATO / GoA2 shall be the predominant mode of train operation from the initial stage of passenger operations. In case CMRL does not engage ATO for any reason during any stage of operation, the train operator / train attendant shall operate the train under GoA1 / ATP / Manual Mode or under Restricted Manual Mode or any other degraded mode or rescue operation or depot shunting purposes or during testing & commissioning.~~
- ~~During GoA4 & GoA3 operation, the Operator's Desk shall be concealed by aesthetically matching covers (material, colour, and texture matching with car interiors). The covers shall have~~

1

sufficient structural strength, be vandalism proof, compatible with fire performance standards and suitably locked & secured. During the non UTO operation, only authorized personnel shall be able to open the covers and operate the train which shall be recorded as an event and shall be transmitted to the RSC consoles of OCC, BCC and DCC.

Refer to Section VI A clause 3.4.3.8 for compliance.

All the panels of the operator's desk shall be mounted such that, there shall be easy access to the internal equipment. There shall not be requirement to remove any rigid mountings to access any equipment inside the operator's desk

1

2.1.12 UTO mode of operation and other Non-UTO modes shall be achieved by all Designated Contractors right after the commissioning of train by the Rolling Stock Contractor.

2.1.13 All the trains of the CMRL phase 1 project shall be operated within the specific sections of Corridor 1 and Corridor 2 and also inter-corridor between Corridor 1 and Corridor 2 of CMRL Phase 1 project. The trains shall be capable of operating in Bi-directional way during passenger services & during commissioning in all these corridors, in the related depots and other related lines. All the systems and Interface Contractors shall design their equipment for the same.

2.1.14 Brief Description of the Existing signalling system

1

The CMRL Phase 1 and Phase 1 Extn. Signalling system including the currently operated 4car trains are equipped with Siemens LZB 700M Train control System. The LZB 700M continuous automatic train control system covers many components. ATP and ATO functions are implemented in separate subsystems. The ATP wayside unit is interconnected to the interlocking system and to the platform screen doors (PSD). Track circuits are used for track vacancy detection by the interlocking and for data transmission to the ATP train borne units by the LZB system.

The train to track communication is effected via the PTI function. The data processing required on board the train is carried out by the ATO train borne unit, the transmission of PTI telegram is under the release control of ATP system. At stations, IMU loops in the track are used for receiving the commands for platform screen doors from the train, which are affected via the IMU train-borne antenna and carried out by the ATO train borne unit. The LZB 700M ATC train borne equipment consists for each cab of one ATC train borne unit (including ATP - redundant and ATO), operating and display devices (Human Machine Interfaces HMI), two ATC antennas as well as two odometer pulse generators (OPG) and one IMU antenna.

The LZB 700 M System covers the technical equipment for supervising, controlling and safeguarding the train service. The LZB is generally made up of the two following subsystems:

ATP Automatic Train Protection and

ATO Automatic Train Operation including Display and covers functions as follows:

- Train Detection
- Determination and Supervision of Speed Profiles
- Direction Supervision
- Distance Supervision
- Train Door Release, Supervision and Controlling
- Platform Screen Door Release, Supervision and Controlling
- Emergency Stop
- Operation at Stations
- Operation in Depot and at Depot Borders
- Service and Diagnostic
- providing data for ATS
- motoring & braking in ATO mode

All these functions are divided into vital and operational parts. Vital parts are managed by ATP, operational by ATO.

a) ATP train borne unit

- One ATP train borne unit is provided for each cab.

- The ATP carries out comprehensive safety-relevant functions.
- For a highly availability the ATP train borne unit is designed with two ATPs (2*2v2).
- Each ATP of the ATP train borne unit processes the data from the same odometer
- pulse generators and the incoming data from the same ATP antennae.

Furthermore, each ATP is linked to the same ATO and HMI (display unit) of the LZB700 M. The ATP train borne unit supervises the train's movement and, if required, initiates emergency braking.

b) Odometer pulse generator

There are two odometer pulse generators per ATP train borne unit. They are mounted on separate axles one on the left and the other one on the right side of the train and supply pulses in proportion to the distance travelled. These pulses are passed via two channels in parallel to both ATPs to determine the travelled distance, the speed and the direction of travel.

c) ATP antennas

The ATP antennas are placed beneath the train, in front of the first axle, above the rail. They receive the audio phase modulated track circuit signal carrying the data to be transmitted from the ATP trackside unit in form of encoded telegrams. The received telegrams are passed to the ATP train borne unit for further processing. Each antenna consists of two coils and a serial connection of every one coil of each antenna is connected to one ATP.

d) IMU antenna

The IMU antenna is placed centric beneath the train in front of the first axle. It is used from ATO to send the open/close commands to the platform screen doors.

e) ATO train borne unit

One ATO train borne unit is provided for each cab. On the basis of data, transmitted from both ATPs (ATP1 and ATP2), ATS and TCMS, it automatically runs the train by controlling propulsion and braking, sends some ATC status information to ATS and controls the train doors and PSDs in the relevant door mode.

f) Operation Modes

The operation modes determine the operation of the train and thus the action of the vehicle (train). The operation modes set the active monitoring functions for the different operational situations (e.g. speed supervision, supervision of backward rolling, supervision of telegram failure times). The beginning, the course and the end of the operation modes are determined for instance by the driver's actions or information from the ATP trackside unit. One operation mode is finished at the start of a new one. This means that at any moment no more than one operation mode can be active. If the ATC system is switched off by means of the fault switch, the train can be controlled under sole responsibility of the driver. This Cut Out Mode (Fault Mode) is not an ATC operation mode, because the ATC system is switched off.

2.2 Interface Management

2.2.1 **The STC Contractor shall be the Lead Contractor.** The Lead Contractor shall be responsible to initiate, plan, coordinate and produce jointly with the Participating Contractors all the required interfaces and interface design documents and interface progress reports for submission to CMRL for acceptance. The Lead Contractor will also prepare and issue all interface meeting of minutes after incorporating Participating Contractors comments within 3 days of the meeting and provide bi-weekly interface progress reports to all the Participating Contractors for information. Later, forwarding of issued minutes of meeting and bi-weekly interface progress reports to concerned Contractors shall be lead Contractor's responsibility.

2.2.2 **RS Contractor, Telecommunications Contractors and PSD Contractors will be the participating Contractors.** The Participating Contractors ~~shall fully cooperate with RS Contractor~~ shall collaborate fully with the Lead Contractor in the development and finalization of the interface design, joint production of the interface documents and interface progress reports.

2.2.3 All the participating Contractors shall ensure that copy of the Interface design documents

submitted to CMRL of the STC Contractor shall also be submitted to the concerned team (will be intimated by CMRL) to participate in the Interface Meetings.

- 2.2.4 The costs for all interface design and testing works shall be deemed to be included in the Contract sum of respective contracts regardless of the actual extent of effort required or expended by the Contractor.
- 2.2.5 The Contractors shall be fully responsible for the management and control of his Subcontractors in relation to all interfacing activities carried out under the Contract.
- 1 2.2.6 The interface design shall be for ~~6-car and~~ 6 car rake configuration. The system capability, interface design, the Input output points, Data communication telegram fields, Communication network bandwidth designs etc shall be designed ~~The~~ for 6 car rakes will have the following configuration
6-car rake: DMC + TC + MC + MC + TC + DMC (67% Traction power)
- 1 2.2.7 The STC Contractor shall provide necessary support and modifications in their system as part of the contract, to resolve all pending or interface related issues arising during the operation of the trains which are under the scope of the contract till completion of RS Contractor's defect notification period. The cost of these support and modifications shall be part of the actual cost of the STC contract. RS Contractor shall provide necessary support and modifications in their system as part of the contract, to resolve all pending or interface related issues arising during the operation of trains which are under the scope of the contract till completion of STC Contractor's defect liability period/defect notification period for the respective corridors and inter-corridors of the CMRL Phase 1 and Phase 1 Extn. The cost of these support and modifications shall be part of the actual cost of the RS contract.
- 2.2.8 STC Contractor in close coordination with the RS Contractor shall ensure that ATO / DTO / UTO modes of operation designed and optimized for least energy consumption in all corridors.
- 1 2.2.9 Both RS and STC Contractors shall ensure that complete and detailed logs of the signals exchanged between Train borne signalling system & TCMS shall be retrievable locally and on demand for diagnostics from the OCC, BCC and DCC control panels.
- 2.2.10 STC Contractor shall be responsible for slow speed wash movement on the Automatic Wash Plant (AWP) in the mainline and in all the Designated Depot(s) of the CMRL Phase 1 and Phase 1 Extn. network. Separate Interface will be required to be done by STC and RS Contractors with the AWP supplier for ATO & UTO modes. RS Contractor shall provide wash mode activation facility inside the trains for other manual modes like ATP / RM / ROS / Cut-out mode, etc.
- 1 2.2.11 Emergency brake application validation at slow speed (less than or equal to 25 kmph) shall be achieved as a part of the wake up procedure as finalized by the STC Contractor. STC Contractor shall prepare and submit the train wake up procedure with the inputs from RS Contractor. RS Contractor shall make sure that the equipment of train shall comply with this procedure.
- 2.2.12 Wherever requirements of OCC are mentioned in this section, the same shall mean to be implemented for both Operations Control Centre (OCC) and Backup Control Centre (BCC) for all the corridors.
- 2.2.13 STC Contractor as Lead Contractor, shall prepare a comprehensive Operating Modes and Principle Document (OMPD). RS, PSD and Telecommunications Contractor will provide required inputs to the STC Contractor in preparation of the document. The traction Contractors and Tunnel Ventilation Contractors will also assist STC Contractor in preparation of the documents. CMRL will provide necessary inputs such as standard operating procedure. The document shall establish the principles related to system and interface design under normal, degraded and emergency modes of operation. For each operating principle, the document shall describe the scenario, action to be taken by operator and system in a structured process flow chart. The additional requirement generated while preparing OMPD document shall be treated as the requirement within the contract without any cost implication.
- 2.2.14 STC Contractor and the RS Contractor shall coordinate and prepare the necessary interface inputs for FMECA, RAMS documents, Hazard analysis incl. interface hazards etc. A joint interface safety case for each phase of the interface (design, commissioning etc.) shall be prepared by the

Contractors and submit to CMRL. Both the Contractors shall provide adequate support for CMRL (as interface designs, installation checks, test documents, technical information etc.) for liaison with the Independent safety assessors (ISA) and with other statutory regulators.

- 2.2.15 STC Contractor and the RS Contractor shall prepare a joint compliance matrix for this interface specification which includes the relevant clauses of the Metro Railway General Rules 2020 or latest, especially in ~~ATQ~~ UTO and Non-UTO operation related and submit to CMRL for review.

2.3 Train Operating Modes

General System Description

- 2.3.1 The train-borne Automatic Train Control (ATC) system will consist of Unattended Train Operation (UTO), Driverless train operation (DTO), Automatic Train Operation (ATO) system and Automatic Train Protection (ATP).

- 2.3.2 Rolling Stock shall be fitted with all ~~ATP & ATQ~~ ATP, ATO, UTO system. The ATO system shall conform to Grade of Automation 2 (GoA2) and UTO system shall conform to Grade of Automation 4 (GoA4) as defined in IEC 62290-1.

- 2.3.3 The Automatic Train Control (ATC) System shall be supplied by the STC Contractor, who shall be required to liaise closely with RS Contractor, in regard to the installation, testing and commissioning of the STC Equipment.

The below mentioned modes of operation shall be made available from STC Contractor.

- 2.3.4 Unattended Train Operation (UTO Mode)

UTO mode of operation consists of full driverless unmanned operation. Train shall be operated completely unmanned in GoA4. This UTO mode shall be available everywhere on the mainlines and the depots of all corridors of CMRL phase 1 and phase 1 extn. except for inside the workshop lines of depots. UTO mode shall also have all the advantages and features of ATO & ATP modes described above. The trains shall be designed such that they will be automatically controlled remotely from OCC / BCC / DCC in UTO mode. UTO operation shall be compliant to IEC 62290-1 or latest and IEEE1474-1:2008 or latest.

- a) The Trains shall operate in Unattended Trains Operation (UTO) mode when the mode selector is at "UTO" position.
- b) Information of the operation of the equipment shall be transmitted to the OCC via the Signalling & train Control system. Complete information of trains shall be transmitted to OCC/BCC/DCC to enable the OCC to determine the status of the equipment, sub-systems, and systems of the Trains and to issue the required control commands to the Trains via Signalling & train Control system and via RTR-DMS system of RSC workstation to monitor, control, reset, isolate any of the equipment or circuit of train to meet the safety and reliability requirements specified in this specification.
- c) All radio communication equipment and Signalling equipment of the Trains shall be maintained in active status, ready to receive or transmit any data to and from the OCC.
- d) All equipment shall be provided with self-diagnostics function and the health status shall be transmitted to the OCC via the Signalling & train Control system
- e) Under UTO mode, the train departure, train running, train stopping, train doors opening & closing, PSD doors opening & closing shall be controlled by Signalling & train control system. Trains shall achieve a station stopping accuracy of $\pm 300\text{mm}$ with 99.98% times of the station stopping
- f) UTO shall also provide "All-Out Mode" of train operation to make up time loss to the extent possible by reducing the coasting period in case train is not running in accordance with Time-Table. This shall be conducted in online during train operation.
- g) To enable the OCC to handle "Undershoot or Overshoot" situations at station stopping point, the OCC shall be able to command the Trains to perform inching movement via the Signalling system
- h) The trains shall be capable of travelling at maximum 3 Kmph for train washing mode (under Signalling control) to enable exterior cleaning at the Automatic wash plant. The Contractor

shall submit the details during design phase. The location of wash plant shall be either in mainline or in depot. Also, the wash plant shall be placed on a ramp gradient or on level tangent track.

- i) Automatic opening of doors on the appropriate platform side(s) when the train is berthed. When the dwell time has elapsed, the Train
- j) doors shall be closed automatically with PA and chimes prior to the door close operation. Necessary information of doors shall be communicated to Rolling stock for operation of doors and Passenger announcement.
- k) The trains under UTO operation shall always remain under ATP protection
- l) The UTO mode shall include Automatic Turn back of train at any locations which includes, mid-section between stations, the terminal stations, the intermediate turn back locations etc. The Automatic turn back facility will be without train operator or attender.
- m) During occurrence of wheel Slip in train during UTO at various locations of Phase 1 & Phase 1 Extn network, UTO shall receive the online Wheel Slip information from train and shall act according to the reduced tractive effort provided by the train's TCMS. UTO system shall support the RS system efforts to mitigate the wheel slip occurrence.
- n) During occurrence of wheel Slide in train during UTO at various locations of Phase 1 & Phase 1 Extn network, UTO shall receive the online Wheel Slide information from train and shall act according to the reduced braking effort provided by the train's TCMS. UTO system shall support the RS system efforts to mitigate the wheel slide occurrence.
- o) UTO shall be capable of operating train with wet speed profile being selected from OCC through ATS to minimise the wheel slip/slide occurrence. RS Contractor may provide necessary inputs to the STC Contractor for the design of the wet profiles.
- p) UTO shall control commands to TCMS to restrict Jerk (up-to max. 0.75 m/s³) in train in various locations of Phase 1 & Phase 1 Extn network. It shall monitor the Jerk during Station Start, Station Stop and during train running conditions. The STC system and the RS system shall jointly ensure that the jerk is limited within the range.
- q) During Un-attended Train Operation modes, all the audio-visual alarms of RS, STC, TETRA equipment inside the Operator's desk shall be kept in mute.
- r) Under UTO operation, it shall be possible for the Signalling system or the OCC / DCC / BCC to remotely set the Trains to operate in any of the following operation modes:
 - i. Sleep Mode

ATC may initiate automatic train sleep function when trains are not required to be operated in mainline or in the Designated Depot(s). Whenever sleep command is initiated by Train Operator / OCC / DCC, TCMS shall shutdown the relevant equipment except for control supply to necessary equipment.
 - ii. Wake Up Mode

All systems of train shall be initialized and a self-check to be carried out to confirm the health status.

The Trains shall be put in a state ready for service.

The OCC / DCC / BCC and the Signalling system shall be notified when the Trains is ready for service.
- s) In the event the Trains fails to complete the shutdown / initialization process, sufficient details of the failure shall be transmitted to the OCC / DCC / BCC to enable the determination of appropriate actions to be taken.

2.3.5 Driverless Train Operation (DTO Mode)

- a) In DTO mode, all the functionalities of UTO, as in Para 2.3.4 shall be applicable.
- b) This mode shall be selected by the roving agent using a selecting rotary device, operated using suitable key, placed outside the Emergency operator panel (in appropriate position as decided in Design phase).
- c) The indication of DTO mode activation shall be transmitted to OCC by STC system in safe and reliable manner.

2.3.6 Automatic Train Operation (ATO Mode)

The on board equipment shall provide for Automatic Train Operation (ATO). In this mode, the train's speed, motoring, coasting and braking within the parameters dictated by the ATO system shall be performed by the on-board STC equipment without the train operator's intervention. Train's Dead Man protection shall not monitor in ATO mode. This operation shall include:

- a) Automatic operation of trains between stations.
- b) The ATO system shall provide control for acceleration, deceleration and coasting of trains in such a manner that the specified schedule speed is achieved with minimum energy consumption. The minimum energy consumption of trains specific to the complete individual corridor shall be recorded in a joint verification with STC and RS Contractors with CMRL.
- c) ATO shall also provide "All-Out Mode" of train operation to make up time loss to the extent possible by reducing the coasting period in case train is not running in accordance with Time-Table. This shall be conducted in online during train operation.
- d) Receipt of coasting request and passing of request to traction power equipment and also provide for acceleration and deceleration of the train.
- e) Under ATO mode, the train departure, train running, train stopping, train doors opening, PSD doors opening shall be controlled by Signalling & train control system. Trains shall achieve a station stopping accuracy of $\pm 300\text{mm}$ with 99.98% times of the station stopping.
- f) Automatic opening of doors on the appropriate platform side(s) when the train is berthed.
- g) Prevent the train from starting if train doors / Platform Screen doors are detected "not closed".
- h) Receipt and implementation of control to skip one or more stations.
- i) The trains under ATO operation shall always remain under ATP protection. Transfer from ATP to ATO mode shall only be possible at standstill; However, transfer from ATO to ATP mode shall be possible at any time and in any mode of train operation.
- j) The ATO mode shall include Automatic Turn back of train at any locations which includes, mid-section between stations, the terminal stations, the intermediate turn back locations etc. The Automatic turn back facility will be without train operator or attender.
- k) During occurrence of wheel Slip in train during ATO at various locations of [Phase 1 & Phase 1 Extn network three corridors](#), ATO shall receive the online Wheel Slip information from train and shall act according to the reduced tractive effort provided by the train's TCMS. ATO system shall support the RS system efforts to mitigate the wheel slip occurrence.
- l) During occurrence of wheel Slide in train during ATO at various locations of [Phase 1 & Phase 1 Extn network three corridors](#), ATO shall receive the online Wheel Slide information from train and shall act according to the reduced braking effort provided by the train's TCMS. ATO system shall support the RS system efforts to mitigate the wheel slide occurrence.
- m) ATO shall be capable of operating train with wet speed profile being selected from OCC through ATS to minimise the wheel slip/slide occurrence. RS Contractor may provide necessary inputs to the STC Contractor for the design of the wet profiles.
- n) ATO shall control commands to TCMS to restrict Jerk (up-to max. 0.75 m/s^3) in train in various locations of [Phase 1 & Phase 1 Extn network three corridors](#). It shall monitor the Jerk during Station Start, Station Stop and during train running conditions. The STC system and the RS system shall jointly ensure that the jerk is limited within the range.
- o) Any of the supervision functions detects violation of the corresponding limiting values, emergency braking is initiated by the Train borne unit.
- p) Information about the position of neutral zones will be taken out of the track data stored in the ATO.
- q) ~~Simultaneously the ATO sends PSD open command. the driver operates the door close button the ATO train borne unit closes the doors and platform screen doors.~~
- r) ~~Train control system shall make use of the running time information to the next station, as provided by the ATS, to achieve accurate stopping at designated station positions.~~

2.3.7 Automatic Train Protection (ATP or Coded Manual Mode)

The on board STC equipment shall provide Automatic Train Protection (ATP) on all lines / sections. In this mode, the train operator shall perform the control of the train speed and braking within the parameters dictated by the ATP system. The ATP mode shall include:

- a) Identification and enforcement of maximum speed at which the train may operate, shall be in accordance with the maximum design safe speed of 90 kmph.
- b) Identification and display of actual speed, target speed, target distance, and the operating speed.
- c) Provision of an audio-visual warning to the train operator in non-ATO modes, when the system identifies that the train is operating at a speed in excess of the maximum safe speed; recognition of a delay of 2s for the train operator to react, and service brake application should the train operator fail to reduce the speed below the maximum safe speed in a specified time. However, it shall be possible to cancel this Service Brake by the train Operator from train HMI in case of operation of train is under control. In the event of the service braking rate being inadequate, an irrevocable Emergency Brake application shall be made, automatically.
- d) Identifying the platform side of the train with the train berthed at a station. The system shall then enable the doors to be opened on that side.
- e) Receipt of a door closed signal indicating that all train doors and PSD doors are closed and locked before the train may start. Loss of this signal shall cause the ATP system to initiate a brake application.
- f) ~~The ATP train borne unit prevents the ATO train borne unit from controlling the train. ATP-M is identical to ATO-M with respect to ATP supervision functions and also used for normal service.~~

2.3.8 Automatic Train Reversal Operation - AR Mode

This mode is used to reverse the running direction of a train automatically. AR-M is only possible in defined areas of the system, assigned for this operation. Principally two types of reversal operations have to be distinguished:

- a) Reversal operation utilizing a reversal track
- b) Reversal operation without reversal track (changing cabs at standstill in the station).
- c) Reversal operations utilizing a reversal track can be carried out by the driver. In this case the driver either controls the train himself using the motoring/braking lever (ATP-M operation), or he operates the ATO start button to initiate ATO controlled outward / return running (ATO operation).
- d) To permit the train to immediately run fully supervised by ATP after reversing the running direction, the data about the train position has to be referenced to the other train 'head', while the train is at standstill.

2.3.9 Restricted Manual (RM) and Run on Sight (ROS) Mode

- a) In RM mode, the maximum train speed shall be controlled by the on-board ATP, to a limit not exceeding 25 kmph. This mode shall be available only when the on-board ATP equipment is operational.
- b) ROS mode of operation shall be selectable by suitable means. In this mode, the maximum train speed shall be controlled by the on-board ATP, to a limit not exceeding 25km/h. This mode shall be available only when the on-board ATP equipment is operational. The running monitoring shall be the same as for RM. The ATP shall give cab signal indications as soon as the train reaches a track position where normal running can be resumed. The ATP authorizes the ROS request.
- c) In Restricted Manual Mode, when the Train Operator uses the Permissive Door Button (PDB), the PSD also shall Open and close along with train doors using the direct communication path designed for PSD Open / Close commands from train borne signalling in a safe manner.
- d) Reverse operation shall be possible by bringing the Mode Selector in RM(R) position with ATP protection. It shall be possible to run in reverse direction under ATP protection on mainline. The maximum permissible speed of the train shall not exceed 10 kmph in reverse mode for a predefined distance. This predefined distance shall be designed by the Contractor and submitted to CMRL for Approval.

2.3.10 Cut-out (or By-pass) Mode

- a) By-pass Mode shall be provided for use in the event of failure of the ATP system. In this mode, the train speed shall be controlled entirely by the train operator, to a limit speed as 25 kmph as “Low speed Cut-Out” and 40 kmph as “High Speed Cut-Out”. RS Contractor shall provide equipment and means to ensure that the maximum train speed remains within the above-mentioned limits when the Cut-out Mode is in effect, under all circumstances. This shall be considered as Low speed cut out (25 Kmph) and High speed cut out (40 Kmph).
- b) The ATP Cut-out (By-pass) Mode shall be initiated by the train operator operating a sealed Safety Cut-out Switch (SCS) and simultaneously breaking its seal. The operation shall be recorded by the on-board digital counter and TCMS, OCC/BCC & DCC. The SCS shall be provided by RS Contractor and the on-board digital SCS counter shall be provided by the STC Contractor. RS Contractor shall record the individual operations for High Speed SCS selection and Low speed SCS selection in TCMS and this data to be shared to STC upon Onboard ATC system activation.
- c) In this mode, the train doors shall only be enabled and controlled manually by train operator.
- d) The availability of power supply to the ATC system during this mode will be decided during the design finalization.

2.3.11 Standby Mode (ready), Immobilized mode etc.

- a) A fully initiated train in standstill condition.
- b) Traction control shall be inoperative and brake shall be applied during this mode.
- c) The details of the mode will be finalised during design stage.

2.3.12 Based on operational requirement, rakes may have to be operated in GoA2 mode with driver / in GoA3 mode with attendant / in GoA4 (UTO). However, the rakes are planned with operations in GoA2 (ATO) during the initial passenger service and subsequently in GoA4 (UTO).

2.3.13 Identification: Train Operating Mode, Train Description and Next Station Information, etc.

- a) Positive train Identification (PTI): STC Contractor shall take the lead to develop a common PTI. The PTI shall be able to be entered by the OCC operator or by Train driver in manual modes, through the HMI in train. The PTI shall include as a minimum the following:
 - i. Train identification number (Train ID)
 - ii. Physical car numbers
 - iii. ATC number
 - iv. Crew number
 - v. Passenger destination
 - vi. Service number
 - vii. Schedule number Communication between the ATS and Train shall be identified through this number.
 - viii. Operating corridor with details of start station and destination station.
- b) STC Contractor shall provide Train Identification Number (Train ID) to RS Contractor. This Train ID shall indicate and identify a destination station, originating corridor, destination corridor, door operating platform details of all stations and the service. Train ID shall be allocated to train at suitable place and shall be maintained until it finishes its service. It shall be possible by CMRL to amend and/or modify the Train ID, subsequently, to suit the operational requirements. STC and RS Contractors shall provide necessary equipment and means for the same. RS Contractor shall provide suitable arrangement for Train Operator to view this information displayed on the Frontal display provided on front and other display information inside the train from the operator's emergency desk.
- c) Route related passenger information and announcement system:
- d) STC Contractor shall provide below mentioned information to RS Contractor during RM, ATP, ATO, DTO, UTO modes of operation, as a minimum but not limited to,

- i. The starting station
- ii. The destination station / destination code
- iii. The train number.
- iv. Corridor number of operation
- v. Corridor of start station
- vi. Corridor of Destination station
- vii. The current station
- viii. The next station
- ix. Current station Platform number
- x. Next station platform number
- xi. Distance to the next station
- xii. Distance travelled from the current station
- xiii. Skip station info
- xiv. Next station door opening side.
- xv. Information for RS door inhibition announcement and display.
- xvi. Non-passenger train
- xvii. End of the trip
- xviii. Advance information for door opening warning lamp (in ATO)
- xix. Advance information for door closure warning lamp (in ATO)
- xx. Dwell time of each current station
- xxi. Cumulative Distance travelled from start station to destination station
- xxii. Service loop is provided between C1 and C2 near Alandur station and OTA-Nanganallur Station (Refer the track alignment). This service loop will be used for the movement of Rakes as well as for the movement of passenger trains. The On-board PAPIS system and the Interface provided by signalling system shall be designed to cater for this inter-corridor operation of trains. The strategy for displaying unambiguous information for the train borne passengers shall be proposed jointly by the Contractors to CMRL for approval.

The RS Contractor shall accordingly use the relevant above mentioned information and provide audio and visual information to the passengers which includes exterior displays, saloon displays, indication lights, announcements etc.

Implementation of the automatic route related announcement system of trains shall be functioned by using signalling variables available in train as a main function. RS Contractor shall interface with STC Contractor for this information. RS Contractor shall design the software for passenger information announcements such that it shall be possible by CMRL to conduct any changes in the software for change in route or additional information or new sections or new announcements. RS Contractor shall provide necessary equipment and means for the same.

The RS Contractor shall also have an independent automatic route related announcement system in trains for redundancy purpose. This redundant system shall be functional in all ~~ATO, non-ATO~~ UTO, non-UTO and degraded modes of train operation and shall be designed to have all the functions of the Automatic Passenger announcement system in all the sections of all the corridors 1 & corridor 2 of CMRL Phase 1 & Phase 1 Extn. project. It shall be possible by CMRL to modify the parameters in this announcement system to suit the requirements of passenger operations and new passenger information required.

- e) RS and STC Contractors shall exchange information identifying the effective mode, the active or non-active status of each cab, the door status etc. The inputs shall be categorised as vital and non-vital. The levels and form of these inputs shall be coordinated between the two Contractors.
- f) RS Contractor shall provide necessary inputs to the STC Contractor identifying the required mode

and status of active cab etc. The levels and form of these inputs shall be coordinated between the two Contractors.

- g) RS system shall automatically record the log each time the mode is changed using the on-board Signalling.
- h) In By-pass / Cut-out Mode, immobilization mode or any other mode, external indication light shall flash or occult (in distinct and distinguishable manner). Details shall be finalized during design stage.
- i) For ~~ATO~~ UTO and Non-UTO operation, necessary train command digital inputs signals shall be provided by the STC Contractor. The ATP/ATO/UTO initiated signal demands shall be redundant. The redundancy shall also be provided on TCMS side by RS Contractor. The form of these inputs shall be coordinated between RS and STC Contractors.

2.4 Interface Requirements

2.4.1 The STC Contractor shall provide the RS Contractor with a list of equipment to be supplied by the STC Contractor and installed by the RS Contractor on the Rolling Stock. The list of equipment shall include, but not be limited to the following:

- a) Train-borne ATP/ATO equipment
- b) Communication Based Train Control (CBTC) modules
- c) Various types of antennas
- d) Speed / acceleration measuring devices including tachogenerators, accelerometers, event recorder and data logger, etc., as appropriate.
- e) Signalling driving console display with buzzer

2.4.2 The train-borne signalling equipment shall consist of separate compact modular sub-rack for each function, readily replaceable and mounted on the train-borne signalling equipment rack located in the ATC compartment provided in the train.

2.4.3 The STC Contractor shall submit drawings showing the recommended placement of their train borne ATP/ATO equipment in the train. This is in addition to specifying the locations where the exterior equipment has to be mounted for optimal performance.

2.4.4 The RS Contractor shall ensure that ATC compartments shall be compatible with the car interior design and decor. The complete assemblies shall be capable of being mounted in a suitable position. The assemblies shall be secured from passenger interference but shall be easily accessible for inspection and maintenance when required. The ATC equipment shall be installed in the saloon. The Signalling driving console (HMI) display shall be mounted in the appropriate position in Operator's Desk considering the overall ergonomics for the Train Operator / ~~Roving attendant~~.

2.4.5 ~~The interface shall be designed between the STC Contractor and the RS Contractor in a manner that the Hardware design of the on-board ATP/ATO system (including the tachometer, Antennas, Driver display units) shall be maintained the same to the extent possible, with the existing Rolling stock operated in CMRL Phase 1.~~

2.4.6 STC Contractor shall supply at RS Contractor factory pre-wired equipment racks with appropriate connectors for all wiring terminating inside ATC, including wiring between ATC racks. STC Contractors, with the details provided by RS Contractor shall ensure that the exterior finish and colours of the respective equipment suitably harmonize with that of the cab and the vicinity.

2.4.7 There shall be 3 separate radio systems for communication between Train and wayside. The system will broadly cater to Train Radio (TETRA), CBTC Radio and CCTV Radio (Non-CBTC Radio). The radio system (TETRA) for Train Radio traffic shall be provided by the TETRA Contractor primarily for voice communication and for limited system alarms and controls. CBTC radio is for train control functionalities as well as for certain remote-control facilities of the train with ATS which shall be provided by STC Contractor. CCTV traffic is for video streams, alarms and status to ATS as well as for RTR-DMS. CCTV radio shall be provided by STC Contractor.

The design of the respective wireless networks, its antennas, its relative positions, other wireless network parameters etc shall take the influence of other radios into consideration.

- 2.4.8 Interfacing wiring for each module provided by STC Contractor including the interfacing wiring between their equipment shall terminate in a quick disconnect robust plug connector suitable for traction applications, with direct cable connection as far as possible. All cable connectors shall be identified within the cubicle using robust cable markers with distinctive colours for identification of e.g. safety function cables.

- 2.4.9 The Signalling and RS Contractors shall develop and produce detailed descriptions of interfaces, as follows (Not exhaustive):

- a) Signalling equipment cubicle environment requirements.
- b) Signalling equipment internal temperature.
- c) Vibration and shock.
- d) Humidity.
- e) Ventilation requirements.
- f) All equipment dimensions, mounting arrangements and necessary clearances.
- g) Cable size / type / routing and specifications.
- h) Electro-magnetic interference protection.

In addition to the above, the STC Contractor shall provide the following information (Not exhaustive)

- a) Weights and dimensions
- b) Quantity
- c) Equipment layout and clearances relative to the rack enclosure, including envelopes for operation, installation and removal.
- d) Models of all train-borne equipment with fixing holes and cable connectors together with installation details and layout details
- e) Fixing details
- f) Smoke and toxicity level release information.
- g) Enclosure performance, IP rating

- 2.4.10 The STC and RS Contractors are required to develop in more detail the electrical interfaces, not limited to, as follows:

- a) Type and Number of Interface Points - includes all data required by both parties, to display equipment operating status, including failure conditions to the Trains' DDU and to the OCC ATS via the Signalling communication path. If relays are to be used for interface, only voltage-free contact shall be used.
- b) Signalling System Outputs and Train Control Interfaces
- c) Power Supply Interface - The power supply wiring between the Train power supply and the signalling termination board shall be supplied and connected by RS Contractor. The STC Contractor will specify the power requirements. For the power supply distribution from the battery of RS systems for the STC systems, the detailed interface wiring diagram needs to be agreed between the STC & RS Contractors.
- d) Train Power Supply Isolation – The STC Contractor shall co-ordinate with the RS Contractor to ensure that all electronics can withstand the voltage spikes at the input of the ATC equipment, as specified in EN50155.
- e) Transient Suppression – The STC Contractor shall interface with the RS Contractor for the required details where STC Contractor can produce the design of the Signalling's relay coils spike suppression circuit to eliminate the possible interference due to disconnection of power from the ATC system.
- f) Earthing Requirements - The earthing shall be designed to minimise the noise voltage generated

and to avoid creating earth loops susceptible to magnetic field and differences in potential. The STC Contractor shall specify the earth impedance required for the earthing point.

- g) Train Lines – The STC Contractor shall liaise with the RS Contractor on the required number of Train lines to fulfil the functional requirements of Signalling. They will be verified and validated jointly during Testing & Commissioning phase. A provision of redundancy (100 % redundant with path diversity) and adequate spares shall be provided for train lines post DLP (at least 10%). The RS Contractor shall ensure that the connectors used in train line shall be of proven type with very high reliability and availability so that no momentary or permanent disconnection occurs when the train travels in high speed or in sharp curves.
 - h) Train-borne Communication Protocol – The STC Contractor shall comply with train-borne communication protocol to be proposed by the RS Contractor.
- 2.4.11 The STC and RS Contractors shall coordinate with each other to ensure all Works are carried out seamlessly. The following split (Not limited to) of installation Works are envisaged between the Signalling and RS Contractors:
- a) STC Contractor Responsibilities:
 - i. Supply of the train-borne signalling equipment rack containing the signalling equipment, fully wired and tested.
 - ii. Train-borne signalling equipment rack supplied with anti-vibration pads which shall be installed by RS Contractor
 - iii. Junction box, where signalling cables terminate
 - iv. Signalling Cables (exclude cables from termination board to junction box and between termination boards) from the signalling equipment rack to termination board.
 - v. Signalling cables between junction box and undercarriage equipment, to RS Contractor for installation / mounting.
 - vi. Supply of all cabling, free mating connectors and plug couplers for wiring from ATC termination board to the ATC cubicle for installation by RS Contractor
 - vii. Provide equipment such as antennas, tachometer, sensors, relay coils, etc related to the Signalling system.
 - viii. Provide the non-resettable digital counter for cutout mode operation.
 - ix. Mounting details and dimensions of junction box and the exterior equipment.
 - x. Suitable coupling for connection to the ATC system, if applicable.
 - xi. Specification of the cables from the junction box to the termination board and specify the allowable length for these cable runs.
 - b) Rolling Stock Responsibilities:
 - i. Provide all supports, brackets braces, mounting holes, etc. to ensure proper mounting and to allow adequate maintenance access to the train-borne signalling equipment.
 - ii. Provide adequate supports and stress relieving provisions for the cabling of signalling equipment after these are mounted to ensure that cables are not fouling, chaffing or unduly stressed with other equipment.
 - iii. Good ventilation facilities (e.g., ventilation louvers/ openings) in the train-borne signalling compartments shall be provided to allow air into the train-borne signalling equipment rack and to prevent condensation.
 - iv. Shall install each of Train exterior Signalling equipment.
 - v. Mounting brackets for junction box housing.
 - vi. Suitable support or clamping arrangement on the bogie for the flexible conduit to ensure that the connectors or cables shall not work loose or break due to the movement of flexible conduit even during the most adverse operation of the Trains. Such support / clamping arrangement shall ensure non-chaffing with other equipment or create undue stress on cables or connectors.

- vii. Mounting plates and brackets for the exterior equipment
- viii. Suitable push buttons for Door open close, Permissive Door Button, AATO Reversal etc.
- ix. Rotary switches (or other suitable alternatives) for the cutout mode operation.
- x. The rack ~~will~~ shall be shock-mounted and easily removable, so that maintenance personnel can quickly substitute equipment in case of failure. Connections between this rack and car wiring will be by plug connector with captive thumbscrews.
- xi. The RS Contractor shall locate and mount the rack so that it is readily accessible from within the driver's cab and passenger compartment.
- xii. The Contractor shall ensure that adequate space is provided and that the ATP/ATO/UTO equipment is easily accessible for visual inspection.

~~xiii. The exact dimensions and weight will be made available to the contractor at the time of preliminary design.~~

2.4.12 It shall also be noted that changes in the interface specifications such as key alarms, remote commands, interface signals and GUI specifications etc., are to be expected throughout the project execution stage and shall extend even after commencement of UTO operation based on operational and passenger requirements. Requirements identified in the Testing & Commissioning phase of various stages of train borne system needs to be factored in as a part of the contract. Likewise, ~~in respect of UTO Operation only~~, the changes required from an operational perspective, need to be carried out as part of the Contractual obligations, if notified before the completion of DLP of the last stage. Beyond these periods, change request with reasonable EoT and Cost compensation will be considered. However, this is not applicable to rectification of snags identified during the DNP period of various stages, in respect of compliance with Performance & RAMS requirements of the Contract. STC Contractor and RS Contractor system design shall be capable of accommodating these changes without major modification in the systems. Necessary spare interface points, communication band widths etc shall be incorporated into the design from the beginning of the design phase itself to accommodate these future requirements.

2.4.13 All installation of train-borne signalling equipment shall be ruggedized and be able to withstand train and track vibrations in accordance with IEC 61373 standard and EN 13749 for bogie mounted equipment. Once complete, STC Contractor will jointly verify with the RS Contractor of the completed installation.

2.4.14 As a minimum, all electronic equipment to be mounted on Rolling Stock, including those provided by STC Contractor shall comply with EN 50155 and IEC 60571, for design, manufacture and testing, and shall use components purchased against an internationally recognised quality assurance and reliability certification procedure.

2.4.15 The screened cables used for the train-borne signalling equipment shall be properly terminated so that no return loops are formed to cause an electrically noisy environment within the train-borne signalling equipment cubicle wiring.

2.4.16 STC Contractor shall certify the procedure of fixation of relevant connections, cables to on-board STC equipment after their assembling in first train at RS Contractor's premises. This procedure shall be agreed between STC Contractor and RS Contractor and the same shall be followed for all the subsequent trains of the manufacturing. STC Contractor shall conduct random inspections in RS Contractor's manufacturing unit, if required, to ensure proper procedure is followed in all trains Any change to the agreed procedure based on the subsequent supplier recommendations, or failure observed in previous trains, modification in the design, mounting arrangements shall be incorporated in complete fleet of trains.

2.4.17 Any re-installation, replacement of cables, connectors, equipment, antennas or modifications in mounting arrangements etc because of failures, damages, replacement because of quality issues, during the installation, T&C as well as DLP period, shall be taken up by the respective Contractors, who was responsible for the supply or for the installation as per the original work. These replacements are included in the scope of this interface.

- 2.4.18 For compatibility, Rolling Stock and the train detection system (track circuits / axle counters), shall conform to EN 50238.
- 2.4.19 Vehicle control circuits shall be developed by the RS Contractor. During the design stage, all the vehicle control circuits incorporating the identified interfaces shall be provided to STC Contractor. STC Contractor shall provide specific observations on these circuits to RS Contractor. RS Contractor shall suitably incorporate these observations in the design.
- 2.4.20 The STC Contractor and RS Contractor shall liaise with each other regarding the electrical requirements on the TCMS interface. The RS Contractor shall advise STC Contractor on the protocol of communication with the TCMS and the response time.
- 2.4.21 The data to be transmitted from the train borne ATC equipment to the TCMS and from the TCMS to the train borne ATC equipment shall be determined mutually by both RS Contractor and STC Contractor and submitted to CMRL for review and approval.
- 2.4.22 Both STC & RS Contractors to ensure that all input and output signals exchanged between Rolling Stock equipment and on-board signalling equipment shall be recorded and shall be available for retrieval on demand for analysis/record. All signals (import / export between RS & STC) shall generally be routed through TCMS.
- 2.4.23 RS Contractor to ensure that all doors related and other safety / train control related signals including brakes, position of safety cut out switches, direction related relays, suspensions, obstruction on track, derailment, coupler status etc. are communicated to the STC Contractor.
- 2.4.24 Door control circuit design shall allow opening of doors in stand by position of mode selector under manual responsibility in case of non-availability of door opening authorization from ATP without losing the ATP mode.
- 1 2.4.25 Provision of "Jog and Creep mode" operation with command to operate the train at specified reduced speed under degraded condition (e.g. aligning train in case of undershoot / overshoot of Normal Stopping Point within a limit) shall be addressed in the interface.
- 2.4.26 STC Contractor to ensure the automatic speed restrictions imposed by Rolling stock during the occurrence of failure scenarios such as event of train deflated condition, bogie brakes isolated in cars, or any major failures of train which shall require a slower speed operation. The list of these failures shall be provided by RS Contractor to STC Contractor during the interface so that the STC Contractor shall implement in a safe manner.
- 1 2.4.27 RS & STC Contractor will jointly finalize a list of actionable command and responses for UTO & Non-UTO modes of operation which shall be available at Communication Based Train Control (CBTC) system at OCC as well as Local Train Supervision system at Station Control Room (SCR), if applicable. The two Contractors shall also finalize the list of alarms and events for Rolling Stock monitoring and troubleshooting which shall be displayed on Rolling Stock Controller monitor of ATS system at OCC as well as on other suitable terminals.
- 1 2.4.28 The key alarms, which are related to the events of operation, safety etc. and critical/serious in nature shall be displayed to both Traffic Controller as well to Rolling Stock Controller. All other alarms and events shall be displayed to Rolling Stock Controller and traffic controllers according to the requirements of ERTS of respective contracts.
- 1 2.4.29 The list of alarms, equipment status events and remote control commands shall be proposed by RS Contractor and approved by CMRL. The implementation of alarms, events and remote control commands shall be ensured by both the Contractors in ATS system. The packet size should have margin to accommodate additional requirement for future.
- 1 2.4.30 The high critical alarms shall be transmitted to ATS through the CBTC channel itself. The list of high critical shall be decided in design phase, e.g.: Derailment, Obstruction detection, unauthorized Door loop Open etc.
- 2.4.31 The continuous train location information shall be communicated from Signalling system to Rolling Stock. The location information shall consist of the track chainage, as provided in the design phase by the tracks department, corridor number, direction of travel and the line (UP or Down). RS Contractor shall use the same for different distance based algorithms provided in the RS. The

resolution / accuracy of the distance, its error especially owing to processing delay, transmission delay, reception delays etc shall be agreed by both the Contractors in the interface.

- 2.4.32 The interface shall ensure that TCMS receives necessary inputs from the on-board ATP system to enable TCMS to synchronize its clock with the system master clock. All the microprocessor / micro-controller based on-train systems shall synchronize respective clocks with TCMS clock.

- 1 2.4.33 The Train Data Management System (TDMS) / ATC is Signalling Scope and it is the subsystem that provides the interface to Rolling stock Train Control & Management System (TCMS). It shall provide the health monitoring, Train event recording and control of the Train initialization functions.

- 2.4.34 To prepare Trains for the mainline service and depot movements, Train shall be initialised to assume a certain readiness state. The Automatic Train Supervisory (ATS) system shall issue the required readiness state to the assigned Train either in the mainline or depot for compliance. Upon receipt of the readiness state command, the TDMS / ATC shall then initiate to prepare for the requested readiness state. TDMS / ATC shall initiate the same command to TCMS and Telecomm's equipment (via TCMS) for their respective preparation for the requested Train readiness state. Depending on the readiness state command, the individual system shall prepare itself with tasks such as self-check, static departure test, Train service facilities, public address announcement etc. The ATC / TDMS shall confirm the readiness state of the assigned Train back to the ATS system when the overall preparation is satisfactory. If the preparation is not satisfactory, the respective fault code and diagnostic messages shall be transmitted by the ATC / TDMS to the ATS system.

The Train readiness states shall include:

- 1
- a) Train Readiness State 1: Sleep
 - b) Train Readiness State 2: Initialisation
 - c) Train Readiness State 3: Wake Up
 - d) Train Readiness State 4: Standby
 - e) Train Readiness State 5: Mainline Off Service
 - f) Train Readiness State 6: Mainline On Service
 - g) Train Readiness State 7: Depot Movement
 - h) Train Readiness State 8: Train Wash
 - i) Train Readiness State 9: Shut down

- 2.4.35 RS Contractor shall supply and install the hardware and software for Rolling Stock Controller (RSC)'s workstation in OCC, BCC and in DCC of each Designated Depot(s) in the CMRL Phase 1 & Phase 1 Extn. network as a part of Real Time Remote Diagnostic Monitoring System (RTR-DMS). This workstation is in addition to the Rolling Stock work stations to be provided as a part of ATS system and ATS-CCTV system by the STC Contractor. This RSC display shall provide the access for viewing of all train related real time remote fault diagnostic data & RSC display shall also provide the access for controlling of all train related functions in real time during UTO mode as described in Section VI A Chapter 14.11 & 14.13 of RS contract. The GUI of this RSC display shall be similar to the Train TCMS-DDU. Operating related safety signals of train shall be controlled through Signalling system ATS Work station. This shall not be directly controlled through RTR-DMS work station.

- 2.4.36 The RSC workstation (provided by RS Contractors) shall be connected to the Central server data placed in OCC supplied by RS Contractor as a part of Real Time Remote Diagnostic Monitoring System (RTR-DMS). RS Contractor shall interface with Signalling Contractors for the installation and network configuration for this RSC console in OCC, BCC and in DCCs of all Designated Depot(s) of the CMRL Phase 1 & Phase 1 Extn. network. Any other GUI(s) in OCC / BCC / DCC except RSC console shall not be in the scope of RS Contractor. RS Contractor shall ensure to connect the RSC work station with the network provided by STC Contractor. The installation of the RSC work station, the RTR-DMS Server, its wiring to power connection and data switch of signalling is the responsibility of RS Contractor.

- 2.4.37 STC Contractor shall provide wireless communication network to connect the RTR-DMS server

to the TCMS (or suitable interfacing RS equipment on-board) for the transmission of the diagnostic data from all trains to this central server at OCC location. The Signalling Contractor shall provide network connectivity to the RSC workstation in OCC, BCC, DCC of all Designated Depot(s) of the CMRL Phase 1 & Phase 1 Extn. network from this central server. The RS Contractor shall conduct necessary interface with Signalling Contractors for this purpose and RS Contractor shall be responsible for complete set up, testing, commissioning and satisfactory working of the system until during train warranty period.

- 2.4.38 The wireless network bandwidth availability for the remote diagnostic data for RTR-DMS shall be part of the overall network design of the signalling Contractor (maximum of 1- 2 mbps envisaged per train). Necessary data compression techniques shall be adopted by the RS Contractor to optimize the data network bandwidth requirement.
- 2.4.39 The RTR-DMS system shall utilise the same allotted band width for uploading files like multimedia advertisements from the RTR-DMS server to the on-board equipment like passenger display systems.
- 2.4.40 Ground based hot axle box detection for monitoring of axle box temperature shall be provided in mainline by Rolling Stock Contractor and shall be installed specific to each corridor. The ground equipment shall be provided by RS Contractor. The server for storage of the information shall be placed by RS Contractor at the nearest station's Telecom Equipment Room. This ground based hot axle detection system shall be integrated with RTR-DMS by the RS Contractor. The communication network path from the station server to the OCC shall be provided by the STC Contractor. The power from UPS as well as network cabling from the equipment to the Signalling network switch is the responsibility of the RS Contractor.
- 1 2.4.41 RS Contractor shall provide CCTV cameras in the trains which will cover cab, saloon, front of train, rear view camera, area for passenger-initiated alarm, platforms of each station etc. Also the view from real-time CCTV view , integrated with inbuilt video analytics functions to continuously monitor the track, OHE, pantograph, and surrounding environment. The CCTV cameras video shall be recorded in suitable NVR on board train for a minimum ~~seven~~ thirty (30) continuous days of recording.
- 2.4.42 SIG Contractor shall provide the Communication Infrastructure to Transfer and display of CCTV streams from on-board to work stations at OCC, BCC, DCC & SCR (within one station vicinity of the train on either ends).
- 2.4.43 RS Contractor and STC Contractor shall interface for control and data transfer of CCTV images from the train to OCC, BCC, DCC & SCR (within one station vicinity of the train on either ends), on the ATS terminal and Large Video Screen. The hardware/software interface shall be furnished and installed by RS Contractor. The CCTV signal shall be provided by RS Contractor at a suitable port on board to STC Contractor for transmission.
- 2.4.44 Predefined /operator defined camera views shall be continuously streamed in OCC & DCC SCR (within one station vicinity of the train on either ends) consoles. The CCTV workstations provided by the STC Contractor shall be capable of live streaming camera feeds in sequence modes of switching between the cameras, manual selection of camera, as well as auto popup facility based on the onboard as well as any way-side trigger.
- 2.4.45 It shall be possible to select any camera on-board and perform the following activity at CCTV terminal/workstation at OCC, BCC, DCC & SCR.
- a) Live view
 - b) Play back of recorded video
 - c) Export / Download recorded video to the workstation
- 2.4.46 RS and STC Contractors shall interface to ensure that at least but not limited to following emergency / Operational conditions should result in the event based auto popup of CCTV images of a camera or a predefined set of cameras via CCTV network on OCC, BCC, DCC & SCR (within one station vicinity of the train on either ends). The detail implementation shall be finalized during interface with the approval of CMRL. The utilization of bandwidth of CCTV network shall be managed dynamically.

- a. PEI activation
- b. Bogie's Obstacle Detection Device activation
- c. Train Side Door Obstacle detection
- d. Fire/Smoke Detection inside or outside the train
- e. CCTV Emergency Button Activation
- f. Driving console cover open
- g. Withdrawal of train from mainline
- h. Train to train coupling in mainline
- i. Passenger to OCC communication or during Vice versa operation
- j. Door Open - Long stop request operated by any passenger from inside the train (with Long stop request, increase in the dwell time shall be implemented)
- k. Pantograph integrity/obstacle detection
- l. Permissive door button activation
- m. Derailment alarm
- n. Unplanned stoppage of trains owing to on-board or way-side failure.
- o. Long stoppages in between stations
- p. Trains scheduled to depart to depot/siding from passenger platform for stabling
- q. Mismatch between Train door and PSD door working.
- r. Abnormality and Alarms observed in OHE, Track and the environment detected by the video analytics cameras fitted in the Train.

2.4.47 The integrated CCTV system shall support transmission of video streams (from multiple cameras / NVR live or recorded) from train and shall support for changing the video frame rate and resolution for good image quality and in limited bandwidth available for CCTV transmission (80 to 95 mbps approximate). Recording of CCTV footages in train's NVR shall be at minimum 1920 x 1080 and minimum 30 frames per second.

Live Streaming : Dynamically allocated based on the viewing requirement from OCC SW

2.4.48 The Levels and protocols for this interface shall be proposed by the STC Contractor and agreed by the RS Contractor in compliance with open interoperability standards in CCTV industry (e.g.: ONVIF). The onboard and wayside equipment of this interface (Cameras, NVR, video management software's etc) shall implement band width optimisation techniques like multicast transmission, modern codecs (e.g. H.266 or higher) for the efficient and reliable use of wireless network bandwidth available.

2.4.49 Coupling of trains for call-on or push out shall normally be performed in RM mode.

2.4.50 RS & STC Contractors shall implement automatic 'sleep', 'wake-up', 'testing and dispatch etc. (pertaining to UTO mode of operation)' of trains stabled at depot/siding/main line. Rolling stock will send suitable signal through signalling interface for display of indication and alarm at OCC, BCC, SCR & at DCC level.

2.4.51 Train Event Recorder shall be provided by the RS Contractor according to Section VIA Chapter 14.10, designed to resist tampering, that monitors and records data on train speed, direction of motion, time, distance, throttle position, brake applications and operations (including service brake, emergency brake) equipped, cab signal aspect(s) etc. STC Contractor shall provide the requisite signal to RS for the storage purpose.

2.4.52 In case of resumption of traction supply after failure / otherwise and when number of trains are standing in the section, ATS shall be capable of issuing sequential / staggered power on command and sequential/staggered starting of the train to avoid overloading of the traction supply.

2.4.53 During train movement in Depot, Air conditioning and Lighting shall be switched off automatically through interface between Signalling and Rolling Stock. Percentage of required switch OFF VAC & Lighting will be finalized during detailed design stage.

2.4.54 For the train getting delocalized because of a momentary external failure/ breakage, shall be able to resume the UTO operation with full speed once the interruption ceases.

2.4.55 Sleep mode functions shall be implemented, the details of which will be finalized during detailed

design stage.

1 2.4.56 STC Contractor shall provide location based trigger command for Neutral Section Detection in various sections of CMRL Phase 1 & Phase 1 Extn; the requirement for the trigger points / locations shall be suitably interfaced. The detection of neutral section shall be transmitted to train based on each unit for operation of VCB of each unit. In manual mode like Cut out / RM / ROS modes, RS Contractor shall generate a trigger command for Neutral section detection. The details shall be shared to CMRL for their review and approval. RS Contractor shall interface with STC Contractor for the same.

1 2.4.57 EB shall be applied on detection of obstruction by the Obstruction Deflection Device (ODD). The information shall be transmitted to OCC through Signalling system. EB shall not be released unless the removal of obstruction is acknowledged by OCC or locally on the train.

1 2.4.58 No train with defective safety equipment's, cab signalling, leading cab controls, interior lighting, ventilation, brakes or doors, including emergency doors, shall remain in passenger service, and it shall be removed from service at the earliest opportunity as per special instructions. Failure of these equipment's shall generate indications and/or alarms and/or messages at Operations Control Centre for above defects. Remote commands (where provided) shall isolate the defective equipment in safe manner.

2.4.59 PSD & train Door control – Both the Signalling and RS Contractor shall submit a full list of all control and monitoring functions, operations and fault data that shall be required between the PSD and Train Door interface. This control shall include as a minimum, door inhibition of PSD / RS because of faulty RS / PSD door.

1 2.4.60 During UTO, DTO, ATO & ATP operation, STC system shall be able to detect roll back of train at any location of CMRL network when train roll backs. Similarly, STC equipment shall prevent the train from rolling back in mainline and CMRL network including all gradients during the all modes of train operation. The actual distances for this purpose shall be finalized in the design phase.

2.4.61 STC and RS Contractors shall jointly sign off the interface design being proposed, the details of design interface requirements expected from each other, interface details of manufacture of prototype etc., which are required for clear understanding of CMRL.

2.4.62 The car wise passenger load of the train shall be continuously communicated to the signalling system by the Rolling Stock system, in a continuous manner with a defined level of accuracy (less than 3% deviation). The signalling system shall use this data along with train number and location details for various data analysis and information displays.

2.4.63 The external ambient air temperature of the train shall be continuously communicated to the STC system by RS system. The STC system shall use this data along with the location details for various data analysis and information displays.

1 2.4.64 Rolling stock Contractor shall interface with STC Contractor for Operation of Train's VCB's in Neutral section by using commands from on-board ATP as primary method. This function shall be a vital output from on-board ATP. However, RS Contractor shall provide a back-up software logic in train for operation of VCBs during all modes of train operation while passing in Neutral section region

The VCB operation facility by signalling shall work in UTO, DTO, ATO, ATP mode of operation irrespective of the classification of train in ATS (time tabled, non-time tabled, with/without train ID, passenger-non-passenger etc).

1 2.4.65 Door Loop Monitoring: If any door or emergency exit door on a Train is detected to be unlocked while the Train is in UTO / DTO / ATO / ATP / Signalling RM mode in motion, on-board signalling system shall apply emergency brake to stop the train.

2.4.66 The RS Contractor shall provide interface controls, inputs, magnet valves, or other devices necessary to enable the cab-Signalling system to initiate irretrievable full-service penalty-breaking and, separately, irretrievable emergency braking functions.

1 2.4.67 RS Contractor shall provide a sealed switch in each cab. This switch will be incorporated into the cab-Signalling circuitry so that it may be used to bypass a defective ATP/ATO/UTO function

caused by a failure in the carborne ATP/ATO/UTO equipment. When activated, this switch shall illuminate the light required.

- 2.4.68 For train control circuits the Signalling and Train control, Contractor shall respectively identify the voltage free contacts to be provided by the Rolling Stock Contractor, including the number and type of electrical signals required between the ATP/ATO/UTO equipment and the equipment provided by the Rolling Stock Contractor. The contractor shall co-ordinate to agree on levels and protocols for each such signal

- a) UnderFrame ~~Signalling equipment ATP & PTI Antenna~~—The Signalling and Train control Contractor shall identify, bogie-, and underframe-mounted antennae, and associated disconnection box mounting brackets and location requirements to identify cable and conduit routes required to antennae, as applicable.
- b) The Signalling and Train control Contractor for their respective scope, shall supply the necessary disconnection boxes, terminal blocks, cables and adaptation mounting brackets, flexible conduit assemblies complete with connectors and cables from antennae to the junction boxes.
- c) The Rolling Stock Contractor shall provide the antenna mounting brackets, conduits, support or clamping arrangements to ensure security and reliability.
- d) The antenna system shall not contravene the kinematic envelope and fully meet the radio coverage requirements both for normal and reverse directions of train working.
- e) ~~The RS Contractor shall install pick-up coils on the leading and rearmost cars of each 6-car train in front of the leading and rearmost axles and over each running rail. Pilot bars, as specified, shall protect the pick-up coils from track debris.~~
- f) ~~Junction boxes furnished by Signalling contractor shall be installed on the bogies and underframe for connecting receiver coil leads.~~
- g) ~~The RS Contractor shall make provisions for mounting receiver coils to bogie. The receiver coils shall be installed such that they are clear from any ferro-magnetic material by at least 6 inches.~~
- h) ~~The ATP/ATO equipment will select the correct receiving coils, depending on which Operator cab is active. The RS Contractor shall provide suitable contacts and indications for the carborne ATP/ATO equipment to determine this.~~
- i) ~~The PTI antenna installed in the underframe works with a corresponding fixed wayside equipment. As the same wayside equipment works for both 4cars / 6 cars the position of the PTI antenna needs to be installed to match the wayside equipment.~~

2.4.69 Speed Measurement Devices

- a) For each UTO/ATO/ATP equipment set (per driving cab), the Signalling and Train control contractor shall supply to the Rolling Stock Contractor for installation, axle mounting speed measurement devices and couplings, to be configured, and the data from them processed in such a way as to achieve the objectives described below in fail safe manner.
- b) The speed measurement devices shall be mounted on one axle for each driving cab, which shall be non-powered / powered as proposed by the Signalling and the Train control contractor equipped with a device to prevent the wheel from slip/slide during acceleration / braking; used for emergency brake application, whenever required.
- c) The Signalling and Train Control contractor shall ensure that the speed measurement devices produce a signal which reflects the true speed of the train (within ± 1.0 km/h) under any operational, weather and track conditions including gradient, curvature, wheel spin/slide and error in the speed measurement due to wear in wheel diameter.
- d) The Signalling and Train Control contractor shall supply the necessary disconnection and terminal blocks, device mounting brackets and plates, flexible conduit assemblies complete with connectors and cables from speed measurement devices to the junction boxes.
- e) The Rolling Stock Contractor shall provide for each speed measurement device mounting brackets, support or clamping arrangements to ensure security and reliability
- f) The Signalling and Train Control contractor shall provide speedometer indicating the actual

speed, and with maximum safe speed.

- g) The Automatic train Protection (ATP) system shall issue the braking commands to the-rolling stock when safety limits are exceeded or when over-speed is detected. Removal of traction power and the correct application of brakes shall be the responsibility the Rolling Stock Contractor. The ATP system shall be responsible for monitoring of speed and the issuing of braking commands when safety limits are exceeded.
- h) Parking brakes shall be provided by the Rolling Stock Contractor. The parking brakes shall be capable of holding a fully loaded stationary train on a 4% gradient under all track conditions, indefinitely.
- i) The signalling and Train Control contractor shall furnish the Rolling Stock Contractor with full mounting details, apertures, fixing holes, etc

2.5 Integrated Testing and Commissioning:

- 2.5.1 RS, STC, Telecom and PSD Contractors shall jointly setup an integrated test bed at CMRL premise to arrange for the integration testing of various subsystems, as a minimum but not limited to ATS, ATO, on-board CCTV management system by signalling Contractor, On-board passenger information system, on-board driver display units, TCMS, On-board NVR, RTR-DMS by RS Contractors, station passenger information systems etc of the Telecom Contractors. The test bed shall have provision for testing the actual software over the actual hardware. Necessary train running mimicking simulator shall be provided by the SIG Contractor to simulate a train running. RS Contractors shall provide necessary simulators to simulate various failure and operational scenarios in the TCMS pertaining to the Interface data.
- 2.5.2 This integrated test bed shall be designed in a manner that it mimics the real-world test scenario.
- 2.5.3 This test bed can share the hardware from the hardware test bed, if envisaged in respective contracts. The tests for vital interface tests and the tests pertaining to the driving parameters of the train or ATO are excluded from this test bed scope.
- 2.5.4 This test bed shall be used for the initial preliminary type tests of the interface, regression tests, software tests after modifications, preliminary interface tests pertaining to stage integration etc. This test bed shall not completely replace the original testing using the train.
- 2.5.5 RS, STC, Telecommunications & PSD Contractors shall work jointly to perform static and dynamic mainline Integrated Testing. It shall include but not limited to traction and braking control, precision stopping, turn back, jog function, door operation, PSD, train wake up and PAPIS functioning test remote command & control for Rolling Stock monitoring & troubleshooting from OCC to train and safety related test etc. All Contractors shall jointly produce a protocol document for Integrated Testing & Commissioning.
- 2.5.6 Integrated Testing of each train shall comply with the accepted international standards agreed between the Contractors and agreed with the CMRL.
- 2.5.7 Integrated Testing specific to each train shall be done at the Rolling Stock factory, Designated Depot(s) and on the main line of the CMRL Phase 1 & Phase 1 Extn. network to ensure satisfactory performance of all train control, STC, telecommunications and PSD interfaces. ~~Integrated Testing specific to each train shall be done at the Rolling Stock factory, depot and main line of CMRL to ensure satisfactory performance of all train control, STC, telecommunications and PSD interfaces.~~
- 2.5.8 Integrated Testing shall subsequently shall be signed-off jointly by the Rolling Stock, Signalling & Train Control, Telecommunications and PSD Contractors.
- 2.5.9 For each stage of RS - STC interface testing, Contractors shall jointly sign off test reports which need to be approved by CMRL.
- 2.5.10 RS Contractor shall complete the train's static & dynamic testing, reports to be approved by CMRL RS and further RS Contractor shall hand over the train to STC Contractor to conduct the STC portion of tests in train.
- 2.5.11 STC Contractor after completion of all Interface testing shall hand-over the train back to RS

Contractor.

2.5.12 For ~~ATO~~ UTO and other ~~non-ATO~~ non-UTO modes of operation, the Integrated Testing between the RS, STC, Telecommunications and PSD Contractors shall include tests on mainline to confirm below minimum features:

1

- a) realization of demanded acceleration rate, deceleration rate, Jerk in all ~~ATO~~ UTO and ~~non-ATO~~ non-UTO modes of operation.
- b) train stopping accuracy in stations, wet rail conditions / adhesion levels.
- c) synchronization with PSDs.
- d) automatic train operation with all the train controls from OCC / DCC of all depots.
- e) ~~Train RTR-DMS data transmission to OCC server and display of fault information at OCC and Depot controller console.~~
- f) Verification of alarms and other vital information transmission from train to OCC and vice versa.
- g) ~~Passenger to OCC communication and vice versa.~~
- h) ~~Train radio verification Automatic passenger announcements in train~~
- i) OCC triggering of automatic passenger announcement messages (via Train Radio) and manual PA announcements by OCC staff.
- j) Pre-recorded and manual announcement from OCC.
- k) ~~Streaming of CCTV videos of train in OCC & DCC~~
- l) Automatic route related passenger announcements in train.

1

2.5.13 Any other tests necessitated by the technical specification of the interfacing Contractors. RS Contractor shall highlight any other required interface testing in the test plan. All the above requirements shall be tested in Corridor 1 & Corridor 2 and their extensions if any.

2.5.14 Based on operational requirement, rakes may have to be operated in GoA2 mode with driver / in GoA3 mode with attendant / in GoA4 (UTO). However, the rakes are planned with operations in GoA2 (ATO) during the initial passenger service and subsequently in GoA4 (UTO). Contractor shall develop and submit the detailed scheme for tests (in addition to the tests mentioned in Appendix C Clause 2.5.1) required to be done for the safe and reliable operation in UTO mode. Contractor shall successfully conduct these tests. CMRL shall witness these tests. These above tests mentioned shall be completed before the start of the Rolling Stock Burn-in trials for each train individually.

1

2.5.15 ~~In accordance with Part 2 – Section VI A: ERTS Clause 17.9.12, the RS Contractor shall work with the STC, Telecom and PSD Contractors to identify any additional Joint Integration Tests which may be required for the running of trainsets in 6-car Multi-Consist Mode. These tests may need to be conducted separately from other Joint Integration Tests and shall be performed Contractor if and when requested by CMRL.~~

1

2.6 Rolling Stock Characteristics to be used by STC Contractor

2.6.1 Signalling system will work on CBTC moving block principle and the system shall be designed to meet the headway requirements of 4 car train set and 6 car train set, based on the characteristics of the vehicles to be furnished and the track geometry. The back-up (line-side) signalling (in ROS / RM / cut-out mode) shall use the same track circuits / axle counter or any advanced system as designed for the ATP working.

1

2.6.2 RS Contractor shall provide traction and braking characteristics of the actual vehicles. The continuous controllability and linearity in the brake system shall be provided by the RS Contractor in electrical as well as air braking period, including blending period for the STC Contractor to achieve higher stopping accuracy.

2.6.3 STC Contractor must co-ordinate to fine-tune the system design based on the traction and braking characteristics of the actual vehicles furnished. Acceptance tests of the signal system will use the actual vehicles supplied. Brake capacity of Rolling Stock shall be used optimally to ensure its

maximum utilization when full brake equipment is operational. In case of isolation of any brake system or bogie / car, RS Contractor shall furnish requisite information to STC Contractor. However, Guaranteed Emergency Brake Rate (GEBR) shall never be compromised.

Train composition (6 car train)	~~DM-T-M-M-T-DM~~ DMC+TC+MC+MC+TC+D MC
Minimum Design Average Acceleration rate for fully loaded (seating plus standees @ 8 passengers / m2) train on level tangent track shall be as under:	
0 kmph to 40 kmph	1.0 m/s ²
0 kmph to 60 Kmph	0.6 m/s ²
0 kmph to 80 Kmph	0.3 m/s ²
Minimum Operational Average Acceleration rate for (seating plus standees @ 6 passengers / m2) loaded train on level tangent track shall be as under:	
0 kmph to 35 kmph	1.2 m/s ²
0 kmph to 60 Kmph	0.65 m/s ²
0 kmph to 80 Kmph	0.35 m/s ²
Minimum Average Acceleration rate for AW4 loaded train on level tangent track 0 kmph to 30 kmph	0.82 m/s ² + 5%
Minimum Average Service braking rate from 80 kmph to standstill for AW4 loaded train on level tangent track	1.0 m/s ²
Minimum Average Service braking rate from 80 kmph to standstill for fully loaded (seating plus standees @ 8 passengers / m2) train on level tangent track	1.0 m/s ²
Minimum Average Service braking rate from 80 kmph to standstill for - (seating plus standees @ 6 passengers / m2) train on level tangent track	1.1 m/s ²
Minimum Average Emergency braking rate from 80 kmph to 0 kmph for AW4 loaded train on level tangent track	1.3 m/s ²
Jerk rate #	~~0.70 + 0.05 m/s³~~ ≤ 0.75 m/s ³
The following maximum brake operating timing shall be achieved on all cars of a train. The maximum time for a brake application from initiation of brake application command from Brake control unit to 90% of full Brake Cylinder Pressure (BCP) and for brake release from initiation of brake release command from Brake control unit to 10% of BCP shall not exceed the following:	a) Service Brake Application : 2.0 sec (Maximum) b) Emergency Brake Application : 1.5 sec (maximum) c) Service and Emergency Brake Release : 2.5 sec (Maximum)

	Time delay from TCMS reception to Air Brake Unit or Electric traction/braking reception	< 300 ms
1	Train electric brake transient response overshoot or undershoot of the ATO / UTO effort	< 10%
	Train electric brake transient response duration	< 0.3 s
1	Train electric brake permanent response overshoot or undershoot of the ATO / UTO effort	< 5%
1	Train air brake transient response overshoot or undershoot of the ATO / UTO effort	< 20%
	Train air brake transient response duration	< 0.5 s
1	Train air brake permanent response overshoot or undershoot of the ATO / UTO effort	< 10%
	Brake system controllability & linearity during fading zone	Within the above limits of electric & air braking (continuous controllability required)
	Weight compensation by the train from empty train to fully loaded train	Yes
	Sum of braking effort (air brake + electric braking) during this transition	effort $\pm 10\%$
	Hold brake response delay from switch off to on and from on to off	< 0.5s
	Maximum wheel diameter	860 mm
	Minimum wheel diameter	780 mm
	Train Design speed	90 kmph
	Door opening and closing times	Open 2.5 s (Max.) Close 3.5 s (Max.)
	No of axles per Car	4
	Presence of non-service brake and non-powered axles: All DM & M axles are powered while axles of T cars are non-powered. All axles are equipped with friction brake mechanism.	
	Axle Load	16 tonne
	Train length – 6 Car Train	135.6 m
	Length of cars	22,350 mm
	Driving Motor Car	21,850 mm
	Trailer Car & Motor Car	
	Width over Body	2900 mm

Note:

1. All of the data in the above table should be confirmed between the Contractors. The above

data is not exhaustive, and full co-operation between Contractors is required.

2. For the items marked *, the maximum timings are for a brake application from initiation of brake application command from BECU to 90% of full Brake Cylinder Pressure (BCP) and for brake release from initiation of brake release command from BECU to 10% of BCP.
 3. For the item marked #, RS Contractor as well as STC CONTRACTOR shall comply with EN 13452-1 or equivalent international standards for jerk determination and methodology shall be finalized during design stage with the approval of CMRL.
- 2.6.4 When operating in ATP Mode, a delay of 2s (programmable) shall be provided for the Train Operator to acknowledge a reduction in speed and begin to apply the brakes.
- 2.6.5 The model for calculating the Safe Braking Distance (SBD) shall identify and take into account various system's response times and Train Operator's reaction times and shall be in accordance with IEEE 1474.1 standard. **The design of CBTC system shall also take into account the effect of track geometry, of the traction and braking characteristics.** RS Contractor shall furnish the guaranteed braking rate at the normal braking efficiency, including brake deterioration to STC Contractor. RS Contractor shall also provide the speed Vs acceleration curves and speed Vs tractive effort curves, for all passenger loading conditions.
- 2.6.6 RS Contractor shall furnish as minimum Rolling Stock parameters to be used by STC Contractor for designing the **STC CBTC** system, as set out in the below section (Interface – Division of Responsibility). RS Contractor shall also furnish a reasonable tolerance band for the identified performance parameters. RS Contractor shall ensure that all the trains supplied perform within the tolerance band.
- 2.6.7 RS Contractor shall provide optimized energy efficient run curve pattern of Train's traction system to STC Contractor for incorporation in the ATO / **UTO** mode of operation. All associated information as requested by STC Contractor shall be duly handed over by RS Contractor. The efficacy of the finalized run curves shall be jointly demonstrated by means of simulations as well as main line trials.
- 2.6.8 Optimization of energy efficient mode shall consider different TE (Tractive Effort) /BE (Braking Effort) curve for different loads as well. Contractor shall demonstrate optimization of energy with respect to different TE (Tractive Effort) / BE (Braking Effort) curve for different loads.
- 2.6.9 Rolling Stock Contractor shall furnish guaranteed braking rate at the normal braking efficiency, and at the lowest braking efficiency permitted in service, including brake deterioration.

2.7 STC system details to be used by RS Contractor

- 2.7.1 The following data shall be provided at minimum to RS Contractor by STC Contractor:
- a) The maximum power consumed by STC Contractor equipment from the 110V DC supply under all specified operating conditions.
 - b) The number of train wires/ Ethernet connections required, and the function of each.
 - c) All control logic outputs.
 - d) Electrical characteristics of the interconnection cabling and wiring.
 - e) Sensitivity levels and frequencies which must be avoided.
 - f) The specific heat load for air conditioning purposes and ventilation requirements if any.
 - g) The EMC / EMI requirements including the limiting value of psophometric current, to obviate interference in the operation of other on-board equipment
 - h) Details of the provisions required to enable the bi-directional transference of data from the train to the wayside.
 - i) Physical dimensions of the equipment's to be fitted on Rolling Stock.

2.8 Train operator's Display - HMI

2.8.1 The STC HMI equipment on driver's console used for **UTO / DTO / ATO / ATP / RM / ROS** modes shall be ergonomically placed. This HMI shall be provided by STC Contractor per cabin side of each train.

2.8.2 Indications to the train operator shall be displayed on the ATC HMI Cab Display supplied by STC Contractor. The train operator's HMI display will be composed of an integrated display screen. It shall incorporate as a minimum, but need not be limited to the following information:

- a) Train description (ID) including crew identification
- b) Target Distance
- c) Target Speed and Actual Speed
- d) Service and Emergency Brake Initiation
- e) Train docked
- f) Train hold status
- g) Station dwell time available
- h) Departure order
- i) In ATP zone or not
- j) ATP / ATO / **UTO** failure indications
- k) Skip Stop indication
- l) Train Door & PSD Open, Close, Lock & Unlock Indication
- m) Maximum Permissible Safe Speed (MSS) in ATP, ATO and **UTO** Modes
- n) Train stopped outside of expected stopping window
- o) Depot indication, when the train is identified as being in a depot
- p) Axle locked indication, for axles on which ATC speed sensors are mounted
- q) Door release available; indicating which side(s) of the train the doors may be opened.
- r) Operating Mode
- s) Axle slip indication
- t) Axle slide indication
- u) Neutral Section

2.8.3 The DMI shall display following text messages in the event of EB for the below. It shall incorporate as a minimum, but need not be limited to the following information:

- a) **EB: Train doors unlocked**
- b) **EB: Train hold applied**
- c) **EB: Over Speed**
- d) **EB: Fatal Fault**
- e) **EB: safety immobilisation not obtained**
- f) **EB: signal overrun**
- g) **EB: roll back**
- h) **EB: changing mode while running**
- i) **EB: Requested by ATS**

2.9 Interface between TCMS and on-board signalling Equipment and OCC

2.9.1 Rolling Stock Contractor shall provide an on-board Diagnostic Monitoring System (DMS), to log the information from the ATP/ATO/**UTO** equipment supplied by the Signalling and Train control Contractor.

- 1 2.9.2 All the vital commands by the on-board ATP and ATO and UTO systems, to Rolling Stock equipment and the responses of the rolling stock equipment to these commands shall also be recorded in TCMS.
- 1 2.9.3 The signals to be supplied from the TCMS to the equipment of the Signalling and Train control and the Telecommunications Contractor shall be decided jointly between the Contractor. In Phase-1 and Phase-1 Extn existing trains, MVB protocol is being used.
- 2.9.4 TCMS shall be able to communicate data to OCC using a data link supplied by the Telecommunications Contractor'. The data shall contain identified train alarms. The Rolling Stock and the Telecommunications Contractor shall interface to make the data available to its destination in OCC.
- 2.9.5 The interface shall ensure that TCMS receives necessary inputs from the on-board ATP system to enable it to synchronize its clock with the system master clock. All the microprocessor/ micro-controller based on-train systems shall synchronize respective clocks with TCMS clock.
- 2.9.6 The Signalling System Outputs and Train Control Interfaces typically consist of the following;
- a) Output from Trains, not limited to, as follows:
- i. Cab Occupied Relay
 - ii. Motoring Command
 - iii. Automatic Mode
 - iv. Protected Manual Mode
 - v. Restricted Manual Mode Forward
 - vi. Restricted Manual Mode Reverse
 - vii. Cut-out (Bypass) Mode
 - viii. Train door Closed and Locked
 - 1 ix. Emergency Detrainment Doors status
 - x. Emergency Brake Activation
 - xi. Zero Velocity Brake Activation
 - xii. Auto Coupler Switch
 - xiii. Traction Inhibit Applied
 - xiv. Off Mode
 - xv. Open Doors Push-Buttons Right Side in PM / RM
 - xvi. Open Doors Push-Buttons Left Side in PM / RM
 - xvii. Close Doors Push-Button Right Side in PM / RM
 - xviii. Close Doors Push-Button Left Side in PM / RM.
 - xix. Service brake command
 - xx. Directional door display (left or right side)
 - xxi. Advance door close warning.
 - xxii. Advance door opening warning.
 - xxiii. Train departure
 - xxiv. Train sleep
 - xxv. Train wake up
 - xxvi. Train wash mode
 - xxvii. Target speed
 - xxviii. Over speed warning
 - xxix. ATC system fault

- xxx. Jog mode indication
- xxxi. Creep mode indication
- xxxii. Evacuation direction (to be displayed on the Dynamic Route Map) Control Output from Rolling Stock
- b) Output from Signalling, not limited to, as follows:
- i. Cab Selection Relay
 - ii. Emergency Brake Relay Drive
 - iii. Door Enable (Right side and Left side)
 - iv. Emergency ~~detrainment~~ Doors Locked
 - v. Forward direction for traction control in AM
 - vi. Reverse direction for traction control in AM
 - vii. Emergency Brake Reset
 - viii. Traction Inhibit Request
 - ix. Target Speed – Analogue / Digital Output
 - x. Actual Speed - Analogue / Digital Output
 - xi. Creep mode - low speed velocity relay – Speed range need to be defined
 - xii. Door Open Command by ATO in AM
 - xiii. Door Close Command by ATO in AM
 - xiv. ATO Start relay given ATO in AM
 - xv. Motoring Demand Relay in AM
 - xvi. Motoring / Braking command in AM - Analogue Output
 - xvii. Braking Demand Relay in AM
 - xviii. Light Braking Demand activation in AM mode
 - xix. Jog - reduce tractive effort
 - xx. Restricted Manual Mode (Forward and Reverse)
 - xxi. Wash Mode
 - xxii. Traction detection
 - xxiii. Brake Active
 - xxiv. Emergency Brake
 - xxv. Train stationary (zero velocity)
 - xxvi. Train depart readiness
 - xxvii. Train wake-up readiness
 - xxviii. Passenger door status – Open / Close
 - xxix. Manual door release request
 - xxx. Train preparation pass / fail status
 - xxxi. Passenger Emergency Call
 - xxxii. Rolling Stock Alarms Passenger Door / Platform Screen Door
 - xxxiii. Pantograph & VCB control command
 - xxxiv. High beam & Horn Command
 - xxxv. Saloon Lighting control
 - xxxvi. Air-condition ON/ OFF/ Control command

The details shall be submitted by the Contractors as a joint interface document for CMRL review

1

2.9.7

Remote Control from OCC in ATS work-station: The Signalling and Train Control Contractor and Rolling Stock Contractor shall coordinate to allow the following functions, as a minimum, to be performed remotely from OCC in ATS work-station under UTO mode but not limited to the following functions. CMRL shall request a few other operational requirements during the project execution stage.

1

- i Train Door Open / Close
- ii Emergency Brake Reset
- iii Passenger Alarm Handling
- iv Smoke Alarm Reset
- v Wake up/ Sleep
- vi Pantograph & VCB control
- vii Inching movement
- viii Parking Brake apply/Release
- ix BLCOS (Brake loop cut-out)
- x DPLCOS (Door Proving loop cut-out)
- xi Low speed control as washing mode
- xii DCU Isolation control
- xiii VAC mode and temperature control
- xiv VAC Reset Control
- xv Damper Reset Control
- xvi Interior Light Control
- xvii Stop all trains
- xviii ATC reset
- xix Start-up tests
- xx MCB reset
- xxi Door open in Mid section
- xxii Door Enable (DE)
- xxiii PEA Reset
- xxiv Flasher light On/ Off
- xxv Horn On/Off
- xxvi Exterior light control (flasher, stop, headlight etc.)
- xxvii Compressor control (on / off / isolation)
- xxviii High pressure and low pressure values of HVAC
- xxix Wash mode (set / reset)
- xxx Brake pipe (BP) pressure switch relay (set / reset)

2

1

The details shall be submitted by the Contractors as a joint interface document for CMRL review. Addition and deletion of alarms and remote control based on the experience in the T&C phase, based on recommendations from statutory authorities, experience in the initial phases of revenue operation shall be included in the scope of this interface. This review shall be taken up in certain intervals and the modifications can be clubbed along with other software snag closure to minimise the efforts from the Contractors.

2.9.8

Signalling Contractor and RS Contractor shall interface to make the functionality available to execute certain critical remote commands from OCC (ATS system) to TCMS through TETRA radio system, in addition to the functionality through CBTC Wi-Fi radio. This facility will be utilised by the ATS when the signalling Wi-Fi radio transmission network is not available because of any reason for a particular train. Adequate reliability and availability shall be built into this functionality by suitable measures (e.g.: message duplicated telegrams, acknowledgements, message counters, time stamps etc). Emergency door release is one such remote command under this

1

interface. The detail list of critical alarms & remote commands from ATS to Rolling stock through TETRA shall be finalised by RS, Signalling and TETRA Contractors in the detail interface design phase in consultation with CMRL.

2.10 Power Supply and Earthing Arrangements

- 2.10.1 Independent 110V DC power supply circuits, including positive and negative poles (at least three numbers) for ATC Equipment shall be provided by RS Contractor and there shall be no physical or electrical links between these power supply circuits. STC Contractor shall have independent voltage protection devices for the on-board STC equipment.
- 2.10.2 RS Contractor shall provide dedicated earthing arrangements for the train borne ATC equipment. STC Contractor shall specify the earth impedance required.
- 2.10.3 The power supply cable between the train power supply and the ATC train borne equipment shall be segregated, as short as possible and directly connected to the supply without any intermediate connection.

2.11 Factory Installation and Testing

- 2.11.1 All the special equipment associated with the train borne ATC system, including the interface cables / wires between the train borne ATC and Train Radio shall be designed and supplied by STC Contractors, as applicable, to RS Contractor factory. Each Contractor shall be aware of the locations of manufacturing plants, which could concurrently be manufacturing cars.
- 2.11.2 STC Contractor shall be responsible for providing all data and training of RS Contractor staff in all aspects of ATC installation and verification wherever applicable. Necessary training material shall be provided to CMRL RS and RS Contractor for this purpose. The first set of ATC equipment shall be installed by RS Contractor, under the supervision of STC Contractor representatives, including the wiring for the interface of the ATC equipment with Rolling Stock.
- 2.11.3 STC Contractor while handing over the STC equipment to RS Contractor for train fitment in manufacturing facility, shall provide the equipment fitness certificates and quality assurance certificates for all the equipment being handed over to RS Contractor.
- 2.11.4 STC Contractor has to provide the material list, Part numbers, unique serial numbers for all the STC components of all trains in a digital medium so that RS contract shall incorporate the same in their material management system.
- 2.11.5 RS Contractor shall be responsible for installing wiring and equipment and STC Contractor shall conduct the confirmation testing on each car at the factory itself.
- 2.11.6 Testing of each car shall comply with the accepted international standards agreed between the Contractors and CMRL. Initial integration tests (static) shall be done at Rolling Stock factory and carried out by the test personnel of respective Contractors jointly. Further main line integration tests (static and dynamic) will be required to be carried out to ensure all STC train control functions and telecommunications between OCC and Train which will be required to be done jointly by RS, Signalling and Telecommunication Contractors at site in Chennai. The test reports subsequently shall be issued jointly by RS, STC & Comm Contractors. The procedure will pertain to the respective areas of the Contractor's responsibility and shall be decided during the interface.
- 1 2.11.7 RS Contractor shall provide facilities for comprehensive static and interface tests between RS, & STC & Telecom systems at his premises. Signalling and Telecommunication Contractors shall be responsible for the provision of special test equipment and instrumentation.
- 1 2.11.8 In case of UTO & ATO, the Integrated Testing between RS and STC Contractors shall include tests on mainline to confirm the realisation of demanded acceleration and deceleration rate by the UTO / ATO under various conditions.
- 2.11.9 Should the need arise for modifications in the configurations of respective equipment or systems as a result of Integration Test or otherwise, the scope of work and division of responsibility shall be jointly agreed amongst the Contractors and detailed procedure shall be developed. RS Contractor shall provide the requisite manpower to monitor and/or implement the modifications

on Rolling Stock for work involving scope as identified in above clause.

- 2.11.10 RS Contractor and STC Contractors shall fully associate and render all necessary support during type testing of the respective systems. Rolling stock type tests may require “All-Out” mode of operation in GoA4 & GoA2 as per approved test specifications, RS & STC Contractor(s) will jointly finalize such test plan and schemes/operational modes and ensure the satisfactory completion of type tests.

2.12 EMC / EMI Interface

- 2.12.1 Regarding electromagnetic interference, STC Contractors shall provide a list of working frequencies and other sensitive requirements to the RS Contractor, to enable RS Contractor to avoid such frequency bands in design, and to provide devices to isolate the source of emission wherever required. STC Contractor will have first right of use for radio frequency bands in 2.4 GHz and 5-8 5 GHz for CBTC application.
- 2.12.2 RS, STC & Comm Contractors shall ensure that the emission and immunity level of their respective equipment meet the requirements of EN50121-3-1 & EN50121-3-2.
- 2.12.3 RS Contractor shall ensure that the return current in the track at the specified frequencies does not exceed the value specified by STC Contractor.
- 2.12.4 RS and STC Contractors shall also jointly develop a test plan for verification of electromagnetic compatibility of Rolling stock with signalling systems. The Contractors shall work together to assure that all electronic and electrical equipment on Rolling Stock Works properly without interfering with signalling sub-systems.
- 2.12.5 The cable layout of the signalling system in the cable ducts provided by RS Contractor shall be jointly agreed. The separation between signalling cables and power cables of 25kV, 415 V 3 ϕ AC, 230 V AC 1 ϕ , 110 V DC and further other DC voltages rating shall be in accordance with accepted international practice and jointly agreed.
- 2.12.6 The cable ducts shall be earthed at notionally at every 2 m and also at the ends and shall be in accordance with accepted international practices.
- 2.12.7 The psophometric current of one 6 car train at full rated power, at all degraded modes of traction operation at various speeds up to maximum speed shall not exceed 5 amperes. Psophometric current of train shall be measured according to the requirements of EN 50121-3-1 and ITU-T O.41.

2.13 INTERFACE- Division of Responsibility

- 2.13.1 RS Contractor shall coordinate with STC Contractors in order to achieve the functional and operational requirements of the system. The roles and activities of the Contractors shall broadly include minimum but not limited to those mentioned in table below. Apart from the below table, RS and STC Contractors shall also adhere to all the requirements of Appendix C and their referred sub-clauses of Section VI A ERTS-RS mentioned in this Appendix C.
- 2.13.2 Interface description brief
- Installation of ATC in the Train at the rolling stock factory.
 - Provision of Power supply and Earthing arrangements to ATC and Telecommunication equipment by rolling stock.
 - Interfacing between Train information management system(TCMS) and ATC & Telecommunication equipment
 - Physical Testing, verification of wiring between rolling stock and S & T equipment.
 - The joint functional testing between on-board ATC equipment and Rolling stock system on the test track.
 - Rolling stock contractor shall be the in charge of Interface Management Plan (IMP)

S. No	Item	STC Contractor	RS Contractor
1	On board VATC	To supply the equipment,	To provide space in the vehicle

S. No	Item	STC Contractor	RS Contractor
	equipment		
2	Antennae for ATP, ATS and TWC	its mounting details to the RS Contractor's Works as per manufacturing schedule of RS Contractor.	design for fixing and installation at the manufacturer's facility, by the RS Contractor, under the supervision of STC Contractor.
3	Speed measuring sensors and speedometer for non-ATC mode.	furnish the mechanical interface details like weight, dimensions, space required, mounting and fixing requirements etc., to install ATC cubicles, ATP/ATO/UTO antennas, axle mounted speed sensors, speedometer, cab display, ATC alarm indications and other ATC equipment	The speed measuring sensor(s) and odometer(s) for non-ATC mode will be provided by RS Contractor.
4	ATC Cab Displays (Train operator MMI) including special cables etc.		Design the mechanical interface with space proofing, mounting and fixing arrangements to install ATC cubicles, ATP/ATO/UTO antennas, axle mounted speed sensors, speedometer, cab display, ATC alarm indications and other ATC equipment.
1	5	Antennae for CBTC, CCTV including special cables etc.	To supply the equipment to the RS Contractors Works.
	5 6	Train lines / Ethernet connection	To provide space in the vehicle design for fixing and installation at the manufacturer's facility, by the RS Contractor, under the supervision of STC Contractor.
1			To provide train lines and Ethernet Connection as per STC Contractors requirement.
			To provide CPS to STC Contractor.
			Design the cable routing and fixation.
1	6 7	Not used. Design	
		a. Provide detailed characteristics of the signalling system pertaining to train acceleration and braking functions	a. Incorporate the RS characteristics to design the ATO/UTO functions
		b. Incorporate the STC S & T requirements in the overall design of the driver cab	b. Furnish the requirements of cab signalling functions and control panel details.
		c. Additional technical details for the Interface are provided in clause No. 2.6.3	c. Additional technical details for the Interface are provided in clause No. 2.6.3
		d. design to suit the technical parameters of trains and stopping accuracy required in its performance Specification	d. provide Kinematics envelope (K.E), Train door dimensions and Train door opening and closing time of trains.

S. No	Item	STC Contractor	RS Contractor
7 8	Power supply and earthing for on board ATP/ATO/UTO equipment.	Furnish the load characteristics, required voltage values and earthing requirements to RS Contractor for respective scope. To review the earthing scheme, prepared by RS Contractor.	To provide the required voltages and earthing. To provide earthing scheme to STC Contractor.
8 9	Logging of on-board information from ATP / ATO/UTO All the Contractors shall log / record all the input and output signals in their equipment separately.	STC Contractor to co-ordinate with RS Contractor for signal levels and protocols. All the input and output signals in Signalling equipment shall be logged by STC Contractor.	Provide the on board data logger TCMS. All input and output signals shall be logged in TCMS.
9 10	Interface between ATP / ATO/UTO with train braking and Propulsion systems for automatic braking, acceleration and deceleration.	~~ZVR & redundant EBR relays to be supplied by the STC Contractor.~~ To ensure the same braking and traction performance in all the mode (ATP/ATO/ ATO UTO) of operation for 6 car and 6-car Train consists. Furnish the requirements for the automation of acceleration and braking system of the car.	ZVR & redundant EBR relays to be supplied by the STC Contractor. RS Contractor shall co-ordinate with the STC Contractor to agree on levels and protocols for interface signals. There shall be no delay in braking from RS during the transition from ED to friction brake at slow speed. Design the interface for automation of acceleration and braking system of the car
	ATO/UTO Operation requirements specification.	STC Contractor shall prepare detailed requirements document related to ATO/UTO.	RS Contractor shall comply and meet the requirements for ATO/UTO.
10 11	System master clock	STC Contractor to provide necessary inputs. Provide necessary inputs to synchronise the TCMS clock with master Clock	RS Contractor to synchronize its clock with the system master clock. Design all the on-train system and TMS TCMS clock to synchronise with master clock
11 12	On board next station information to the passengers	Shall provide necessary signals on-board to RS Contractor.	Shall provide for necessary hardware interface, display for on-board P.A and PIS system inside the cars.
12 13	Climatic requirements for on board ATP / ATO /	STC Contractor to specify at an early date, the total heat load wattage, and	RS Contractor to provide Cab Air Conditioning to maintain a nominal temperature of 25°C.

S. No	Item	STC Contractor	RS Contractor
	UTO equipment.	maximum permitted temperature	Suitable ventilation shall be provided by the Contractor for the backside area of the console. RS Contractor to provide conditioning air from the saloon to all relevant signalling installations to maintain a nominal temperature of 25°C. Conditioned air ventilation shall be provided by the Contractor for the console.
~~13~~ 14	EMI / EMC interface between the Rolling Stock and Signalling and Train Control, and Telecommunications.	STC Contractor shall advise EMI/EMC plan, requirement, specification and test reports for ATP/ATO/ ~~ATO~~ UTO equipment to RS Contractor at early date.	RS Contractor shall ensure the compliance of the requirements of STC Contractors for on board ATP/ATO/UTO. prepare the EMI / EMC plan and ensure the compatibility of Rolling stock equipment with ATC equipment
~~14~~ 15	Train Integrity Information	On-board ATC shall take appropriate action on the basis of information provided by RS Contractor	Train integrity information will be provided by RS Contractor to ATC on-board.
~~15~~ 16	Data transmission methodology for control command	STC Contractor to interface with RS Contractor for selection of best suited methodology i.e. bit by bit, code (1 byte) or any other.	RS Contractor to provide details from TCMS to ATC communication.
~~16~~ 17	The polling cycle and delay times assessment between OCC / BCC and on-board VATC / CCTV	The STC Contractor shall assess and furnish to RS Contractor the polling cycle time, data transmission time(rate) between OCC / BCC and onboard VATC / CCTV under best and worst case scenarios for both CBTC and CCTV networks.	The RS Contractor to provide TCMS to VATC / CCTV interface requirements to STC Contractor to comply with functionality as specified in the Rolling Stock contract.
18	Standalone door operation	Signalling to give standalone door operation command to allow driver/cleaning staff to enter/exit the train from designated door in designated Depot area/Main line siding.	RS Contractor shall give the necessary support to the STC Contractor
19	Graphical User Interface (GUI) for RS controller	STC Contractor shall be responsible for providing necessary support during	RS Contractor shall be responsible for development of the GUI (including hardware) for

S. No	Item	STC Contractor	RS Contractor
		interface finalization to the RS Contractor	the RS controller (RSC) in the OCC, BCC & DCC. Any other GUI(s) in OCC/BCC/DCC shall not be the scope of RS Contractor
~~16~~ 20	Guaranteed Emergency Brake Rate (GEBR)	STC Contractor shall share the logics used for GEBR	RS Contractor shall furnish value of GEBR to STC Contractor.
~~17~~ 21	Emergency Brake application validation at low speed (≤ 25 kmph) as a part of wake up procedure	STC Contractor shall validate the EB Test based on details furnished by RS Contractor.	RS Contractor shall furnish the pass/fail criteria based on the speed achieved and gradient of the track to STC Contractor.
~~18~~ 22	Signals for neutral section	STC Contractor will protect from the stoppage of train in neutral section in ATP/ATO/ ~~ATO~~ UTO mode. Also, will provide necessary signal to TCMS for Panto management around Neutral Section.	In case, signal for Panto management fails, the RS Contractor will ensure that the an independent information about neutral section is available on TCMS.
~~19~~ 23	Platform Screen Doors	STC Contractor shall be the medium for exchange of data between PSD Contractors and RS Contractor.	RS Contractor shall ensure that all interface requirements with PSD Contractors are informed to STC Contractor.
~~20~~ 24	Any other requirements from Employer's Requirements - Technical Specification or this interface specification.	STC Contractor shall ensure all the interface requirements pertaining to RS Contractor are shared agreed and implemented mutually.	RS Contractor shall ensure all the interface requirements pertaining to STC Contractor are shared ,agreed and implemented mutually.
~~21~~ 25	RTR-DMS Real Time Remote Diagnostic Monitoring System	STC Contractor shall provide network and power interface for RSC console in OCC, BCC & DCC from the RTR-DMS central server installed in OCC. STC Contractor shall transmit the data of the central RTR-DMS server to DCCs and BCCs located at geographically different locations. The DCCs shall be available in all Designated Depot(s) of the CMRL phase 1 & phase 1 extn	RS Contractor shall install a RTR DMS central server in OCC to store the data of all trains of the system. RS Contractor shall use this data to display in RSC console in OCC, BCC & DCC. Also the same data shall be available in the RS maintenance laptops with Viewing rights and without the control access.

S. No	Item	STC Contractor	RS Contractor
		network.	
26	Transmission of CCTV footages from Train to OCC, BCC, DCC & at SCR(within one station vicinity of the train on either ends)	STC Contractor shall transmit these footages online to OCC, BCC, DCC and at SCR(within one station vicinity of the train on either ends).	RS Contractor shall store the CCTV footages of train within central video recorder (NVR) in each train.
22 27	Detailed Interface document (DID)	~~STC Contractor shall provide the necessary information as requested by RS Contractor.~~ STC Contractor shall prepare DID and shall ensure that it covers Design, Interface Hazard log, Construction, Testing & Commissioning, Test report formats, Maintenance, etc.,	~~RS Contractor shall prepare DID and shall ensure that it covers Design, Interface Hazard log, Construction, Testing & Commissioning, Test report formats, Maintenance, etc.,~~ RS Contractor shall provide the necessary information as requested by STC Contractor
28	Display of RTR-DMS feed in Video wall system at OCC/ BOCC/ DCC	Shall connect the feed and arrange for the display of RTR - DMS information.	Shall extend the RTR - DMS feed in a format compatible with the displays, as specified by the STC Contractor.
29	On-Board Track condition monitoring and warning system:	STC Contractor shall provide network and power interface for RSC console in OCC, BCC & DCC from the RTR-DMS central server installed in OCC. STC Contractor shall transmit the data of the central RTR-DMS server to DCCs and BCCS located at geographically different locations. The DCCs shall be available in all Designated Depot(s) of the CMRL phase 1 & phase 1 extn network.	RS Contractor shall install all necessary system for data acquisition and process the Data. RS contractor shall provide all information's to STC contractor. RS Contractor shall install a RTR DMS central server in OCC to store the data of all trains of the system.
Construction Stage			
23 29 30	Hardware interface	The contractor shall supply the on-board ATC system equipment for all the rakes to the Rolling Stock Contractor, including the cab signalling and supervise the installation of ~~STC S &~~	The Contract provide the space and interfacing hardware in the vehicle and install on-board ATC equipment. install the ATC & train braking and propulsion system for automatic braking, acceleration

S. No	Item	STC Contractor	RS Contractor
		Equipment on the prototype rake. interface hardware between ATC & train braking and propulsion systems for automatic braking, acceleration and deceleration of the car	and deceleration of the car
24 30 31	Cabling	ensure that signalling cables are installed with adequate separation without mixing with other cables.	install the signalling and telecom cables (driver cab wiring and data cables from one end of rake to other end) with proper separation arrangements from other electrical cables.
25 34 32	Installation of PAPIS system	check the interconnection between P.A. System/ PIDS system and the STC S & T equipment.	install the PA system and PIDS system.
26 32 33	Installation of TCMS & Interconnections	check the interconnection between TCMS and ATC & Other signalling equipment.	install the TCMS and inter connect with ATC and Other Signalling equipment.
27 33 34	Power & Earthing	Provide his own equipment to filter the transients, provide regulators etc., to suit the requirements of his equipment. check and confirm that the requirements of earthing arrangement for ATC equipment are fulfilled	Install the power supply equipment with suitable fuses & protection and provide suitable plug points as per STC S & T requirements. Install the earthing arrangement one for ATC equipment
TEST & COMMISSIONING			
28 34 35	Tests at Rolling Stock Factory	a. The contractor shall check and validate the integrated test plan including all the necessary testing documentation. b. conduct the joint testing of all interfaces between Rolling stock equipment and ATC & Telecommunication equipment. c. Record the data in standard forms with joint signatures wherever necessary.	a. The contractor shall submit the integrated test plan covering both proto type and all other trains along with necessary testing documentation. b. attend joint testing of all interfaces between rolling stock and ATC & Telecommunication equipment. c. Record the data in standard forms with joint signatures wherever necessary.

S. No	Item	STC Contractor	RS Contractor
29 35 36	Tests on Test Track in Koyambedu depot	a. conduct the joint testing of train control system, braking system, and its interconnection to the on-board CCTV monitor, operation of train in all modes including UTO, auto door system, auto train stopping and audio visual indications system on the test track b. Record the data in standard forms with joint wherever necessary.	a. Attend and validate the joint testing of train control system, braking system, operation of train in all modes including UTO, auto door system, auto train stopping and audio visual indications system on the test track. b. Record the data in standard forms with joint signatures wherever necessary.
30 36 37	Tests on Main line Track	a. Conduct the joint testing on the main line for train control system, braking system, operation of train in all modes including UTO, auto door system, monitoring of permanent speed restrictions, auto train stopping at stations, opening and closing of platform screen doors at underground stations, audio visual indications system, operation of Tetra Radio system, radio system and their interconnection with train PA system/ on – board CCTV system as well as ~~TIMS~~ TCMS system b. Record the data in standard forms with joint signatures wherever necessary	a. Attend the joint testing on the main line for all the functions involving RS/ ~~S&T~~ STC interface, including train control system, braking system, operation of train in all modes including UTO, auto door system, monitoring of permanent speed restrictions, auto train stopping at stations, opening and closing of Platform screen doors at underground stations, audio visual indications system, operation of Tetra Radio system and its interconnection with train PA system as well as ~~TIMS~~ TCMS system b. Record the data in standard forms with joint signatures wherever necessary.

2.13.3 Interface description brief

- Installation of ATC in the Train at the rolling stock factory.
- Provision of Power supply and Earthing arrangements to ATC and Telecommunication equipment by rolling stock.

- c. Interfacing between Train information management system(TCMS) and ATC & Telecommunication equipment
- d. Physical Testing, verification of wiring between rolling stock and STC equipment.
- e. The joint functional testing between on-board ATC equipment and Rolling stock system on the test track.
- f. Rolling stock contractor shall be the in charge of Interface Management Plan (IMP)

3 TELECOMMUNICATION RADIO CONTRACT (TETRA):

3.1 General

- 3.1.1 This section describes the interface requirements between Rolling Stock (RS) Contract and Telecommunication TETRA (TETRA) Contractor.
- 3.1.2 The existing TETRA has been Designed M/s Motorola and Commissioned by M/s Siemens Aktiengesellschaft, Germany & Siemens India Consortium.
- 3.1.3 The Contractors shall ensure that all the requirements of the Metro Railway General Rules 2020 are duly met by incorporating appropriate alarms, remote commands and other features.
- 3.1.4 The Contractors as above shall ensure that all requirements of the Specification pertaining to interfaces are properly satisfied.
- 3.1.5 All Interface Meetings, unless specifically approved by CMRL shall be held at CMRL site and they shall be given sufficient notice to attend the meeting.
- 3.1.6 Each Contractor shall be responsible for interface identification, establishment, construction and testing works either in the capacity as the Lead Contractor or Participating Contractor.
- 3.1.7 RS Contractor shall provide equipment, software, functionalities etc. of the RS part of the Train to meet the requirement of Interface. TETRA Contractor shall provide on board TETRA equipment, software, functionalities etc., to meet the requirements of TETRA part of the interface. The requirements specified herein are by no means exhaustive and it remains the responsibility of the Contractors to develop and execute an interface plan during execution of the work to ensure that:
 - a) All interface issues between the different contracts are satisfactorily resolved
 - b) Supply, installation and testing of equipment and software are fully co-ordinated
 - c) All equipment supplied in the contract are fully compatible with each other
 - d) **UTO mode of operation, Non UTO modes of operation and all other degraded mode of operation shall be achieved with all its inherent features in the mainline and in all Designated Depot(s) of the CMRL Phase 1 & Phase 1 Extn. network**
 - e) All the system tolerances at the interface shall meet the requirements of the respective specifications relating to the interface points
 - f) Interface Contractors shall mutually respect each other's project timelines with respect to the interface requirements.
 - g) Interface Contractors shall finalize their respective interface equipment only after clear agreement on interface requirements with the other designated Contractors.
 - h) Interface Contractors shall ensure that in any case, no equipment of their system shall be put into production or installation without meeting the interface requirements spelt out in this Appendix or in the Technical Specification of respective contracts.
 - i) Test procedures, troubleshooting manuals and any other documentation shall be updated with technical details from of each Contractor and shall be submitted to CMRL
- 3.1.8 **UTO mode of operation and other Non-UTO modes shall be achieved by all designated Contractors right after the commissioning of train by the Rolling Stock Contractor.**
- 3.1.9 **All the trains of the CMRL phase 1 & phase 1 network shall be capable of being operated within specifically the sections of Corridor 1 & 2 and also interoperable between Corridor 1 & 2 and its extensions., The trains shall be capable of operating in Bi-directional way during passenger**

services & during commissioning in all these corridors, in the related depots and other related lines. All the systems and Interface contractors shall design their equipment for the same.

3.2 Interface Management

- 1 3.2.1 **RS Contractor shall be the Lead Contractor.** The Lead Contractor will be responsible to initiate, plan, coordinate and produce jointly with the Participating Contractors all the required interfaces and interface design documents and interface progress reports for submission to CMRL for acceptance. The Lead Contractor will also prepare and issue all interface meeting of minutes after incorporating TETRA Contractors comments within 3 days of the meeting and provide bi-weekly interface progress reports to all the participating Contractors for information. Later, forwarding of issued minutes of meeting and bi-weekly interface progress reports to concerned Contractors shall be lead Contractor's responsibility.
- 3.2.2 TETRA Contractor will be the participating Contractor. The Participating Contractors shall collaborate fully with the Lead Contractor in the development and finalization of the interface design, joint production of the interface documents and interface progress reports.
- 3.2.3 All the participating Contractors shall ensure that copy of the Interface design documents submitted to CMRL.
- 3.2.4 The costs for all interface design and testing works shall be deemed to be included in the Contract sum of respective contracts regardless of the actual extent of effort required or expended by the Contractor.
- 3.2.5 The Contractors shall be fully responsible for the management and control of his subcontractors in relation to all interfacing activities carried out under the Contract.
- 1 3.2.6 The interface design shall be for 6 car rake configuration.
DMC+TC+MC + MC+TC+DMC (67% Traction power)
- 1 3.2.7 The Telecommunications TETRA Contractor shall provide necessary support and modifications in their system as part of the contract, to resolve all pending or interface related issues arising during the operation of the trains which are under the scope of the contract till completion of RS Contractor's defect notification period. The cost of these support and modifications shall be part of the actual cost of the Telecommunications TETRA contract. RS Contractor shall provide necessary support and modifications in their system as part of the contract, to resolve all pending or interface related issues arising during the operation of trains which are under the scope of the contract till completion of Telecommunications TETRA Contractor's defect liability period/defect notification period for the respective corridors and inter-corridors of the CMRL Phase 1 & Phase 1 Extn. The cost of these support and modifications shall be part of the actual cost of the RS contract.
- 1 3.2.8 Both RS and TETRA Contractors shall ensure that complete and detailed logs of the signals exchanged between Train borne TETRA system & TCMS shall be retrievable locally and on demand for diagnostics from the OCC, BCC and DCC control panels.
- 1 3.2.9 Where-ever requirements of OCC are mentioned in this chapter, the same shall mean to be implemented for both Operations Control Centre (OCC) and Backup Control Centre (BCC) for the respective corridor.
- 1 3.2.10 STC Contractor shall prepare a comprehensive Operating Modes and Principle Document(OMPD). RS, PSD and, Telecommunication TETRA Contractors will provide required inputs to the STC Contractor in preparation of the document. The traction Contractors and Tunnel Ventilation Contractors will also assist STC Contractor in preparation of the documents. CMRL will provide necessary inputs such as standard operating procedure. The document shall establish the principles related to system and interface design under normal, degraded and emergency modes of operation. For each operating principle, the document shall describe the scenario, action to be taken by operator and system in a structured process flow chart. The additional requirement generated while preparing OMPD document shall be treated as the requirement within the contract without any cost implication.

- 1 3.2.11 TETRA Contractor and the RS Contractor shall prepare a joint compliance matrix for this interface specification which includes the relevant clauses of the Metro Railway General Rules 2020, especially in ATO / UTO operation related and submit to CMRL for review.

3.3 **Not-used Train Operating Modes**

General System Description

- 1 3.3.1 The train-borne Automatic Train Control (ATC) system will consist of Unattended Train Operation (UTO), Driverless train operation (DTO), Automatic Train Operation (ATO) system and Automatic Train Protection (ATP), RM, ROS, Cut out.
- 3.3.2 Rolling Stock will be fitted with all ATP, ATO, UTO system. The UTO system will conform up-to Grade of Automation 4 (GoA4) as defined in IEC 62290-1.
- 3.3.3 During Un-attended Train Operation modes, all the audio visual alarms of RS, STC, TETRA equipment inside the Operator's desk shall be kept in mute.

3.4 **Identification**

- 1 3.4.1 RS and TETRA Contractors shall exchange information identifying the effective mode, the active or non-active status of each cab, location information, line and corridor details, direction of travel etc. The inputs shall be categorised as vital and non-vital. The levels and form of these inputs shall be coordinated between the two Contractors.
- 1 3.4.2 RS Contractor shall provide necessary inputs to the TETRA Contractor identifying the required mode and status of active cab etc. The levels and form of these inputs shall be coordinated between the two Contractors.

3.5 **Interface Requirements**

- 3.5.1 The TETRA Contractor shall provide the RS Contractor with a list of equipment to be supplied by the TETRA Contractor and installed by the RS Contractor on the Rolling Stock. The list of equipment shall include, but not be limited to the following:
- a) Train-borne TETRA equipment
 - b) Various types of antennas
 - c) Control panel, Headset, Speakers etc
- 3.5.2 The TETRA equipment shall consist of separate compact modular sub-rack for each function, readily replaceable and mounted in the Communication compartment provided in the train.
- 3.5.3 The TETRA Contractor shall submit drawings showing the recommended placement of their train borne TETRA equipment in the train. This is in addition to specifying the locations where the exterior equipment has to be mounted for optimal performance.
- 1 3.5.4 The RS Contractor shall ensure that TETRA compartments shall be compatible with the car interior design and decor. The complete assemblies shall be capable of being mounted in suitable positions. The assemblies shall be secured from passenger interference but shall be easily accessible for inspection and maintenance when required. The TETRA driving console equipment shall be mounted in the appropriate position in driver console considering the overall ergonomics for the Train Operator / Roving attendant.
- 1 3.5.5 The interface shall be designed between the TETRA Contractor and the RS Contractors in a manner that the Hardware design of the on-board TETRA system (including the Antennas, control display units) shall be maintained the same to the extent possible, with the existing Rolling stock operated in CMRL Phase 1 & Phase 1 Extn.
- 1 3.5.6 There shall be 4-separate radio systems for communication between Train and wayside. The system will broadly cater to Train Radio (TETRA), CBTC Radio, CCTV Radio and passenger Wi-Fi radio. The radio system (TETRA) for Train Radio traffic shall be provided by the Telecommunication Contractor primarily for voice communication and for limited system alarms and controls. CBTC radio is for train control functionalities as well as for certain remote-control

facilities of the train with ATS. CCTV traffic is for video streams, alarms and status to ATS as well as for RTR-DMS. The design of the respective wireless networks, its antennas, its relative positions, other wireless network parameters etc shall take the influence of other radios into consideration.

- 3.5.7 Interfacing wiring for each module provided by TETRA Contractor including the interfacing wiring between their equipment shall terminate in a quick disconnect robust plug connector suitable for railway applications, with direct cable connection as far as possible. All cable connectors shall be identified within the cubicle using robust cable markers with distinctive colours for identification of e.g. safety function cables.
- 3.5.8 The TETRA and RS Contractors shall develop and produce detailed descriptions of interfaces, as follows (Not exhaustive):
- a) TETRA equipment environment requirements.
 - b) TETRA equipment internal temperature.
 - c) Vibration and shock.
 - d) Humidity.
 - e) Ventilation requirements.
 - f) All equipment dimensions, mounting arrangements and necessary clearances.
 - g) Cable size / type / routing and specifications.
 - h) Electro-magnetic interference protection.
 - i) In addition to the above, the TETRA Contractor shall provide the following information (Not exhaustive)
 - j) Weights and dimensions
 - k) Quantity
 - l) Equipment layout and clearances relative to the rack enclosure, including envelopes for operation, installation and removal.
 - m) Models of all train-borne equipment with fixing holes and cable connectors together with installation details and layout details
 - n) Fixing details
 - o) Smoke and toxicity level release information.
 - p) Enclosure performance, IP rating
- 3.5.9 The TETRA and RS Contractors are required to develop in more detail the electrical interfaces, not limited to, as follows:
- a) Type and Number of Interface Points - includes all data required by both parties,
 - b) Power Supply Interface - The power supply wiring between the Train power supply and the TETRA termination board shall be supplied and connected by RS Contractor. The TETRA Contractor will specify the power requirements. There shall be no relays or contacts between the negative return connection and the battery terminals.
 - c) Train Power Supply Isolation – The TETRA Contractor shall co-ordinate with the RS Contractor to ensure that all electronics can withstand the voltage spikes at the input of the TETRA equipment, as specified in EN50155.
 - d) Transient Suppression – The TETRA Contractor shall interface with the RS Contractor for the required details where TETRA Contractor can produce the design of the TETRA's relay coils spike suppression circuit to eliminate the possible interference due to disconnection of power from the TETRA system.
 - e) Earthing Requirements - The earthing shall be designed to minimise the noise voltage generated and to avoid creating earth loops susceptible to magnetic field and differences in potential. The TETRA Contractor shall specify the earth impedance required for the earthing point.
 - f) Train Lines – The TETRA Contractor shall liaise with the RS Contractor on the required number

of Train lines to fulfil the functional requirements of TETRA. They will be verified and validated jointly during Testing & Commissioning phase. A provision of redundancy (100% redundant with path diversity) and adequate spares shall be provided for train lines post DLP (at least 10%). The RS Contractor shall ensure that the connectors used in train line shall be of proven type with very high reliability and availability so that no momentary or permanent disconnection occurs when the train travels in high speed or in sharp curves.

- g) Train-borne Communication Protocol – The TETRA Contractor shall comply with train-borne communication protocol to be proposed by the RS Contractor.
- h) The sophomoric current of one 6 car train at full rated power, at all degraded modes of traction operation at various speeds up to maximum speed shall not exceed 5 amperes. Psophometric current of train shall be measured according to the requirements of EN 50121-3-1 and ITU-T O.41.

3.5.10 The TETRA and RS Contractors shall coordinate with each other to ensure all Works are carried out seamlessly. The following split (Not limited to) of installation works are envisaged between the TETRA and RS Contractors:

a) TETRA Contractor Responsibilities:

- i Supply of Train-borne TETRA equipment supplied with anti-vibration pads, if applicable which shall be installed by RS Contractor
- ii Shall supply cables, mating connectors and plug couplers between TETRA equipment (excluding cab to cab).
- iii Shall supply termination board/connector in Tetra Equipment for interfacing Contractor to terminate their connections.
- iv Provide equipment such as antennas, Train operator control panel, Radio control head, Handset Speaker etc related to the TETRA system.
- v Mounting details and dimensions of the exterior equipment.

b) Rolling Stock Responsibilities:

- i Provide all supports, brackets braces, mounting holes, etc. to ensure proper mounting and to allow adequate maintenance access to the train-borne TETRA equipment.
- ii Provide adequate supports and stress relieving provisions for the cabling of TETRA equipment after these are mounted to ensure that cables are not fouling, chaffing or unduly stressed with other equipment.
- iii Good ventilation facilities (e.g., ventilation louvers/ openings) in compartments shall be provided to allow air into the train-borne TETRA equipment and to prevent condensation.
- iv Shall install each of Train exterior TETRA equipment.
- v Mounting brackets for junction box housing, if applicable.
- vi Suitable support or clamping arrangement for the flexible conduit to ensure that the connectors or cables shall not work loose or break due to the movement of flexible conduit even during the most adverse operation of the Trains. Such support / clamping arrangement shall ensure non-chaffing with other equipment or create undue stress on cables or connectors.
- vii Mounting plates and brackets for the exterior equipment
- viii Shall supply all cables from the Termination Board/Connector to RS/STC equipment.
- ix Specification of the cables from the junction box to the termination board shall be proposed by RS Contractor in consultation with TETRA Contractor.

3.5.11 It shall also be noted that changes in the interface specifications such as key alarms, remote commands, interface signals and GUI specifications etc., are to be expected throughout the project execution stage and shall extend even after commencement of ATO / UTO operation based on operational and passenger requirements. TETRA Contractor and RS Contractor system design shall be capable of accommodating these changes without major modification in the systems. Necessary spare interface points, communication band widths etc shall be incorporated

into the design from the beginning of the design phase itself to accommodate these future requirements.

- 3.5.12 All installation of train-borne TETRA equipment shall be ruggedized and be able to withstand train and track vibrations in accordance with IEC 61373 standard and EN 13749 for bogie mounted equipment, if applicable. Once complete, TETRA Contractor will jointly verify with the RS Contractor of the completed installation.
- 3.5.13 As a minimum, all electronic equipment to be mounted on Rolling Stock, including those provided by TETRA Contractors shall comply with IEC 60571, for design, manufacture and testing, and shall use components purchased against an internationally recognised quality assurance and reliability certification procedure.
- 3.5.14 The screened cables used for the train-borne TETRA equipment shall be properly terminated so that no return loops are formed to cause an electrically noisy environment within the train-borne TETRA equipment cubicle wiring.
- 3.5.15 TETRA Contractor shall certify the procedure of fixation of relevant connections, cables to on-board TETRA equipment after their assembling in first train at RS Contractor's premises. This procedure shall be agreed between TETRA Contractor and RS Contractor and the same shall be followed for all the subsequent trains of the manufacturing. TETRA Contractor shall conduct random inspections in RS Contractor's manufacturing unit, if required, to ensure proper procedure is followed in all trains. Any change to the agreed procedure based on the subsequent supplier recommendations, or failure observed in previous trains, modification in the design, mounting arrangements shall be incorporated in complete fleet of trains.
- 3.5.16 Any re-installation, replacement of cables, connectors, equipment, antennas or modifications in mounting arrangements etc because of failures, damages, replacement because of quality issues, during the installation, T&C as well as DLP period, shall be taken up by the respective Contractors, who was responsible for the supply or for the installation as per the original work. These replacements are included in the scope of this interface.
- 3.5.17 The TETRA Contractor and RS Contractor shall liaise with each other regarding the electrical requirements on the TCMS interface. The RS Contractor shall advise the TETRA Contractor on the protocol of communication with the TCMS and the response time.
- 3.5.18 The data to be transmitted from the train borne TETRA equipment to the TCMS and from the TCMS to the train borne TETRA equipment shall be determined mutually by both the RS and TETRA Contractor and submitted to CMRL for review and approval.
- 3.5.19 Both TETRA & RS Contractors to ensure that all input and output signals exchanged between Rolling Stock equipment and on-board TETRA equipment shall be recorded in TCMS and shall be available for retrieval on demand for analysis / record. All signals (import/export between TETRA & STC) shall generally be routed through TCMS.
- 3.5.20 The list of critical alarms, equipment status events to be carried by TETRA to the ATS system shall be decided by RS, TETRA and STC Contractors and approved by CMRL. The implementation of alarms, events shall be ensured by all the Contractors in ATS system. The packet size should have margin to accommodate additional requirement for future.
- 3.5.21 TETRA Contractor shall furnish RS Contractor with the interface required between the TETRA radio system and the on-train public address system to allow on-board passenger live announcements to be made from the OCC. The interface design shall allow the OCC to make live announcements by selecting one or more audio zones available in the train (saloon, exterior etc)
- 3.5.22 The interface shall provide the necessary means to enable OCC to initiate triggering of pre-recorded messages in the on-train public address system. The interface should support dispatching of play list (Multiple messages and announcement schedules) to on-board PA from OCC. The interface design shall allow the OCC to make pre-defined announcements by selecting one or more audio zones available in the train (saloon, exterior etc).
- 3.5.23 There shall be a provision of roving attendant to make the passenger announcement through his/her mobile handset (TETRA) inside a particular train through TETRA radio network using radio identification number. The interface between train TETRA radio and onboard (PA/PIS) system

shall be jointly done by RS & TETRA Contractor.

3.5.24 The priority of various concurrent messages, different audio zones in the on-train public address system shall be submitted by RS Contractor for CMRL review.

1

3.5.25 TETRA. Contractor shall furnish RS Contractor with the interface required between the TETRA radio system and the on-train public address system/other suitable system of RS to allow on-board passenger emergency Intercom (PEI) to be made to the OCC. The identifier of the PEI device (which call point in which car of the train), shall be communicated by the RS system to the on-board TETRA system. The call shall be full duplex in nature.

1

3.5.26 TETRA. Contractor shall furnish RS Contractor with the interface required between the TETRA radio system and the on-train public address system/other suitable system of RS to allow on-board passenger emergency Intercom (PEI) call point mic of RS to be used for silent listening of saloon voice through TETRA by OCC. The identifier of the PEI device (which call point in which car of the train) shall be communicated by the on-board TETRA system to the RS system for selecting the mic of that call point to be used for this feature. There shall not be any indication on the PEI call point or any other location on the train, visible for passengers, denoting the silent listening mode activation.

1

3.5.27 Various states on the on-board TETRA equipment (e.g.: Shutting ON, Active, silent mode, standby mode, shutting down) shall complement various modes of Operation like UTO, DTO, ATO, ATP, RM, in addition to the other standby modes like sleep, remote wakeup etc.

3.5.28 The complete on-train public address system, and interface hardware, including the transmission link, and a TETRA panel shall be furnished by RS Contractor. Levels and protocols shall be agreed between the two Contractors.

1

3.5.29 TETRA Contractor shall furnish RS Contractor with the interface required between the TETRA radio system and the TCMS/Event recorder for recording the initiation, termination, and success or failure of emergency calls initiated by the train operator and/or OCC or DCC on the radio. The hardware interface shall be furnished and installed by RS Contractor. Levels and protocols shall be agreed between the two Contractors.

1

3.5.30 TETRA Contractor shall furnish RS Contractor with the interface required between the TETRA radio system and the Rolling stock system/ TCMS to execute certain critical remote commands to train from OCC (ATS system). This facility will be utilised by the ATS when the signalling radio transmission network is not available because of any reason for a particular train. Adequate reliability and availability shall be build into this functionality by suitable measures (e.g.: message duplicated telegrams, acknowledgements, message counters, time stamps etc). Emergency door release is one such remote command under this interface. The detail list of critical remote commands from ATS to Rolling stock through TETRA shall be finalised by RS, Signalling and TETRA Contractors in the detail interface design phase in consultation with CMRL.

3.6 Integrated Testing and Commissioning:

1

3.6.1 RS, STC, Telecom TETRA and PSD Contractors shall jointly setup an integrated test bed at CMRL premise to arrange for the integration testing of various subsystems, as a minimum but not limited to ATS, ATO, on-board CCTV management system by signalling Contractor, On-board passenger information system, on-board driver display units, TCMS, On-board NVR, RTR-DMS by RS Contractors, station passenger information systems etc of the Telecom Contractors. The test bed shall have provision for testing the actual software over the actual hardware. Necessary train running mimicking simulator shall be provided by the SIG Contractor to simulate a train running. RS Contractors shall provide necessary simulators to simulate various failure and operational scenarios in the TCMS pertaining to the Interface data.

3.6.2 This integrated test bed shall be designed in a manner that it mimics the real-world test scenario.

3.6.3 This test bed can share the hardware from the hardware test bed, if envisaged in respective contracts. The tests for vital interface tests and the tests pertaining to the driving parameters of the train or ATO are excluded from this test bed scope.

1

3.6.4 This test bed shall be used for the initial preliminary type tests of the interface, regression tests,

software tests after modifications, preliminary interface tests pertaining to stage integration etc. This test bed shall not completely replace the original testing using the train.

- 3.6.5 RS, STC, Telecom -TETRA & PSD Contractors shall perform Integration Testing which shall include but not limited to traction and braking control, precision stopping, turn back, jog function, door operation, PSD, train wake up and PA/PIS functioning test, remote command & control for Rolling Stock monitoring & troubleshooting from OCC to train and safety related test etc. All Contractors shall jointly produce a protocol document for Integrated Testing and Commissioning.

1

~~RS, STC, Telecom -TETRA & PSD Contractors jointly produce a protocol document for Integrated Testing and Commissioning.~~

- 3.6.6 Integrated Testing of each train shall comply with the accepted international standards agreed between the Contractors and agreed with the CMRL.
- 3.6.7 Integration Testing specific to each train shall be done at the Rolling Stock factory, depot and main line of CMRL to ensure satisfactory performance of all train control, STC, telecom - TETRA and PSD interfaces.
- 3.6.8 TETRA and RS Contractors shall jointly sign off the interface design being proposed, the details of design interface requirements expected from each other, interface details of manufacture of prototype etc., which are required for clear understanding of CMRL.
- 3.6.9 For each stage of RS - TETRA interface testing, Contractors shall jointly sign off test reports which need to be approved by CMRL.
- 3.6.10 RS Contractor shall complete the train's static & dynamic testing, reports to be approved by CMRL RS and further RS Contractor shall hand over the train to TETRA Contractor to conduct the TETRA portion of tests in train. TETRA Contractor after completion of all Interface testing shall hand-over the train back to RS Contractor.
- 3.6.11 Integration Tests subsequently shall be signed-off jointly by the Rolling Stock, Signalling & Train Control, Telecom-TETRA and PSD Contractors.

- 3.6.12 For UTO and other non-UTO modes of operation, the Integrated Testing between the Rolling Stock, Signalling & Train Control, Telecommunications and PSD Contractors shall include tests on mainline to confirm below minimum features:

1

- a) realization of demanded acceleration rate, deceleration rate, Jerk in all UTO and non-UTO modes of operation
- b) train stopping accuracy in stations, wet rail conditions/adhesion levels
- c) synchronization with PSDs,
- d) automatic train operation with all the train controls from OCC/DCC,
- e) Train RTR-DMS data transmission to OCC server and display of fault information at OCC and Depot controller console
- f) Verification of alarms & other vital information transmission from train to OCC & vice versa
- g) Passenger to OCC communication and vice versa
- h) Train radio verification
- i) Automatic route related passenger announcements in train
- j) Pre-recorded and manual announcement from OCC
- k) Streaming of CCTV videos of train in OCC & DCC
- l) Any other tests necessitated by the technical specification of the interfacing Contractors.

RS Contractor shall highlight any other required interface testing in the test plan

1

- 3.6.13 All the above requirements shall be tested in all the sections of Corridor 1 and corridor 2 and their extensions

1

- 3.6.14 Based on operational requirement, rakes may have to be operated in GoA2 mode with driver / in GoA3 mode with attendant / in GoA4 (UTO). However, the rakes are planned with operations in GoA2 (ATO) during the initial passenger service and subsequently in GoA4 (UTO). Contractor shall develop and submit the detailed scheme for tests (in addition to the tests mentioned in Appendix C required to be done for the safe and reliable operation in UTO & ATO mode. Contractor shall successfully conduct these tests. CMRL shall witness these tests.

- 3.6.15 These above tests mentioned shall be completed before the start of the Rolling Stock Burn-in trials for each train individually.

1

3.7 Factory Installation and Testing

- 3.7.1 All the special equipment and applicable cables, connectors associated with the train borne TETRA system, shall be designed and supplied by TETRA Contractors, as applicable, to RS Contractor factory. Each Contractor shall be aware of the locations of manufacturing plants, which could concurrently be manufacturing cars.
- 3.7.2 TETRA Contractor shall be responsible for providing all data and training of RS Contractor staff in all aspects of TETRA installation and verification wherever applicable. Necessary training material shall be provided to CMRL and RS Contractor for this purpose. The first set of TETRA equipment shall be installed by RS Contractor, under the supervision of TETRA Contractor representatives, including the wiring for the interface with Rolling Stock.
- 3.7.3 TETRA Contractor while handing over the TETRA equipment to RS Contractor for train fitment in manufacturing facility, shall provide the equipment fitness certificates and quality assurance certificates for all the equipment being handed over to RS Contractor.
- 3.7.4 RS Contractor shall be responsible for installing wiring and equipment and TETRA Contractor shall conduct the confirmation testing on each car at the factory itself.
- 3.7.5 Testing of each car shall comply with the accepted international standards agreed between the Contractors and CMRL. Initial integration tests (static) shall be done at Rolling Stock factory and carried out by the test personnel of respective Contractors jointly. Further main line integration tests (static and dynamic) will be required to be carried out to ensure all **STC train control functions and TETRA functions between OCC and Train which will be required to be done jointly by RS, Signalling and TETRA contractors at site in Chennai**. The test reports subsequently shall be issued jointly by RS, STC & TETRA Contractors. The procedure will pertain to the respective areas of the Contractor's responsibility and shall be decided during the interface.
- 3.7.6 RS Contractor shall provide facilities for comprehensive static and interface tests between Rolling Stock, Signalling and TETRA systems at his premises. Signalling and TETRA Contractors shall be responsible for the provision of special test equipment and instrumentation.
- 3.7.7 Should the need arise for modifications in the configurations of respective equipment or systems as a result of Integration Test or otherwise, the scope of work and division of responsibility shall be jointly agreed amongst the Contractors and detailed procedure shall be developed. RS Contractor shall provide the requisite manpower to monitor and/or implement the modifications on Rolling Stock for work involving scope as identified in above clause.

1

3.8 EMC / EMI Interface

- 3.8.1 Regarding electromagnetic interference, TETRA Contractor shall provide a list of working frequencies and other sensitive requirements to the STC Contractor and RS Contractor, to enable RS Contractor to avoid such frequency bands in design, and to provide devices to isolate the source of emission wherever required. STC Contractor will have first right of use for radio frequency 2.4GHz/~~5-8~~ 5 GHz for CBTC application.
- 3.8.2 RS& TETRA Contractors shall ensure that the emission and immunity level of their respective equipment meet the requirements of EN50121-3-1 & EN50121-3-2.
- 3.8.3 The cable layout of the TETRA system in the cable ducts provided by RS Contractor shall be jointly agreed. The separation between signalling cables and power cables of 25kV, 415 V 3φ AC, 230 V AC 1φ, 110 V DC and further other DC voltages rating shall be in accordance with accepted international practice and jointly agreed.
- 3.8.4 The cable ducts shall be earthed at notionally at every 2 m and also at the ends and shall be in accordance with accepted international practices.
- 3.8.5 The psophometric current of one 6 car train at full rated power, at all degraded modes of traction

1

operation at various speeds up to maximum speed shall not exceed 5 amperes. Psophometric current of train shall be measured according to the requirements of EN 50121-3-1 and ITU-T O.41.

3.9 INTERFACE- Division of Responsibility

- 3.9.1 RS Contractor shall coordinate with TETRA Contractors in order to achieve the functional and operational requirements of the system. The roles and activities of the Contractors shall broadly include minimum but not limited to those mentioned in table below. Apart from the below table, RS and TETRA Contractors shall also adhere to all the requirements of Appendix C and their referred sub-clauses of Section VI A ERTS-RS mentioned in this Appendix C.

S. No	Item	TETRA Contractor	RS Contractor
1	On board radio equipment, Antennae for train radio including special cables etc.	To supply the equipment, related cables (excluding trainlines and interface cables) to the RS Contractor Works as per manufacturing schedule of RS Contractor.	To provide space in the vehicle design for fixing and installation at the manufacturer's facility, by RS Contractor, under the supervision of the TETRA Contractor.
2	Train lines and Ethernet connection	Furnish the requirement to review the Cable Principle Scheme (CPS). To verify the installation at RS Contractors manufacturing premises	To provide redundant train lines and Ethernet Connection as per TETRA Contractors requirement. To provide CPS to TETRA Contractor.
3	Power supply and earthing for on board train radio equipment.	Furnish required voltage values and earthing requirements to RS Contractor for respective scope. To review the earthing scheme, prepared by RS Contractor.	To provide the required voltages and earthing To provide earthing scheme to TETRA Contractor.
4	Climatic requirements for on board Train Radio equipment.	TETRA Contractor to specify at an early date, the total heat load wattage, and maximum permitted temperature	RS Contractor to provide Air Conditioning to maintain a nominal temperature of 25°C. Suitable ventilation shall be provided by the Contractor for the backside area of the console. RS Contractor to provide conditioning air from the saloon to all relevant telecom installations to maintain a nominal temperature of 25°C. Conditioned air ventilation shall be provided by the Contractor for the console.
5	EMI / EMC interface	TETRA Contractor shall advise EMI/EMC plan and test reports for radio equipment to RS Contractor at early date.	RS Contractor shall ensure the compliance of the requirements of TETRA Contractors for on board radio equipment.

S. No	Item	TETRA Contractor	RS Contractor
6	Functional interfaces for Live PA, Pre-recorded PA, Roving attendant announcement, PEC, Silent listening, Alarms, Event recording etc	Necessary hardware and software interface as in above,	Necessary hardware and software interface as in above,
7	Detailed Interface document (DID)	TETRA Contractor shall provide the necessary information as requested by RS Contractor.	RS Contractor shall prepare DID and shall ensure that it covers Design, Interface Hazard log, Construction, Testing & Commissioning, Test report formats, Maintenance, etc.,

4 PLATFORM SCREEN DOORS (PSD):

4.1 General

- 4.1.1 This section describes the interface requirements between Rolling Stock (RS) Contract and Platform Screen Doors (PSD) Contractors.
- 4.1.2 The existing PSDs in Phase-1 and Phase-1 extn. Has been designed and built by M/s Faiveley Systems and ~~has been Designed by M/s~~ Singapore Technologies Electronics and Commissioned by M/s Siemens Aktiengesellschaft, Germany & Siemens India Consortium. Full Height Platform screen doors (PSD) are installed on all platforms of underground stations and Half height Platform Screen Doors (PSD) will be installed in Elevated Stations. The Contractor shall interface accordingly with all the PSD and all the RS Contractors of Phase 1 & Phase 1 Extn.
- 4.1.3 The Contractors shall ensure that all the requirements of the Metro Railway General Rules 2020 are duly met by incorporating appropriate alarms, remote commands and other features.
- 4.1.4 The Contractors as above shall ensure that all requirements of the Specification pertaining to interfaces are properly satisfied.
- 4.1.5 All Interface Meetings, unless specifically approved by CMRL shall be held at CMRL site and they shall be given sufficient notice to attend the meeting.
- 4.1.6 Each Contractor shall be responsible for interface identification, establishment, construction and testing works either in the capacity as the Lead Contractor or Participating Contractor.
- 4.1.7 The requirements specified herein are by no means exhaustive and it remains the responsibility of the Contractors to develop and execute an interface plan during execution of the work to ensure that:
- All interface issues between the different contracts are satisfactorily resolved
 - Supply, installation and testing of equipment and software are fully co-ordinated
 - All equipment supplied in the contract are fully compatible with each other
 - All the system tolerances at the interface shall meet the requirements of the respective specifications relating to the interface points
 - UTO mode of operation, Non UTO modes of operation and all other degraded mode of operation shall be achieved with all its inherent features in the mainline and in all Designated Depot(s) of the CMRL Phase 1 & Phase 1 Extn. Network.
 - Interface Contractors shall mutually respect each other's project timelines with respect to the interface requirements.
 - Interface Contractors shall finalize their respective interface equipment only after clear agreement on interface requirements with the other designated Contractors.

h) Interface Contractors shall ensure that in any case, no equipment of their system shall be put into production or installation without meeting the interface requirements spelt out in this Appendix or in the Technical Specification of respective contracts.

i) Test procedures, troubleshooting manuals and any other documentation shall be updated with technical details from of each Contractor and shall be submitted to CMRL

4.1.8 UTO mode of operation and other Non-UTO modes shall be achieved by all designated Contractors right after the commissioning of train by the Rolling Stock Contractor

4.1.9 All the trains of the CMRL phase 1 & phase 1 network shall be capable of being operated within specifically the sections of Corridor 1 & 2 and also interoperable between Corridor 1 & 2 and its extensions., The trains shall be capable of operating in Bi-directional way during passenger services & during commissioning in all these corridors, in the related depots and other related lines. All the systems and Interface contractors shall design their equipment for the same.

4.2 Interface Management

4.2.1 RS Contractor shall be the Lead Contractor. The Lead Contractor will be responsible to initiate, plan, coordinate and produce jointly with the Participating Contractors all the required interfaces and interface design documents and interface progress reports for submission to CMRL for acceptance. The Lead Contractor will also prepare and issue all interface meeting of minutes after incorporating PSD Contractors comments within 3 days of the meeting and provide bi-weekly interface progress reports to all the participating Contractors for information. Later, forwarding of issued minutes of meeting and bi-weekly interface progress reports to concerned Contractors shall be lead Contractor's responsibility.

4.2.2 The PSD Contractor will be the participating Contractor. The Participating Contractors shall collaborate fully with the Lead Contractor in the development and finalization of the interface design, joint production of the interface documents and interface progress reports.

4.2.3 All the participating Contractors shall ensure that copy of the Interface design documents submitted to CMRL.

4.2.4 The costs for all interface design and testing works shall be deemed to be included in the Contract sum of respective contracts regardless of the actual extent of effort required or expended by the Contractor.

4.2.5 The Contractors shall be fully responsible for the management and control of his sub-contractors in relation to all interfacing activities carried out under the Contract.

4.2.6 The interface design currently shall be functional for 6 car configuration train.

DMC+TC+MC + MC+TC+DMC (67% Traction power)

4.2.7 The PSD Contractor shall provide necessary support and modifications in their system, to resolve all pending or new interface related issues arising during the operation of the trains till completion of RS Contractor defect Notification period. RS Contractor shall provide necessary support and modifications in their system, to resolve all pending or new interface related issues arising during the operation of trains till completion of PSD Contractor's defect liability / Notification period for the respective corridors of the CMRL Phase 1 & Phase 1 Extn.

4.2.8 Both RS and PSD Contractors shall ensure that complete and detailed logs of the signals exchanged regarding this interface shall be retrievable on demand for diagnostics from the OCC, BCC and DCC control panels.

4.2.9 Where-ever requirements of OCC are mentioned in this chapter, the same shall mean to be implemented for both Operations Control Centre (OCC) and Backup Control Centre (BCC) for the respective corridor.

4.2.10 STC Contractor shall prepare a comprehensive Operating Modes and Principle Document (OMPD). RS, PSD and TETRA, Telecommunication Contractors will provide required inputs to the STC Contractor in preparation of the document. The traction Contractors and Tunnel Ventilation Contractors will also assist STC Contractor in preparation of the documents. CMRL will provide necessary inputs such as standard operating procedure. The document shall

establish the principles related to system and interface design under normal, degraded and emergency modes of operation. For each operating principle, the document shall describe the scenario, action to be taken by operator and system in a structured process flow chart. The additional requirement generated while preparing OMPD document shall be treated as the requirement within the contract without any cost implication.

- 4.2.11 Each respective PSD Contractor and the RS Contractor shall prepare a joint compliance matrix for this interface specification which includes the relevant clauses of the Metro Railway General Rules 2020, especially in ATO / UTO operation related and submit to CMRL for review.

4.3 ~~Not used~~ Train Operating Modes

General System Description

- 4.3.1 The train-borne Automatic Train Control (ATC) system will consist of Unattended Train Operation (UTO), Driverless train operation (DTO), Automatic Train Operation (ATO) system and Automatic Train Protection (ATP), RM, ROS, Cut out.

- 4.3.2 Rolling Stock will be fitted with all ATP, ATO, UTO system. The UTO system will conform up-to Grade of Automation 4 (GoA4) as defined in IEC 62290-1.

- 4.3.3 During Un-attended Train Operation modes, all the audio visual alarms of RS, STC, TETRA equipment inside the Operator's desk shall be kept in mute.

4.4 ~~Requirement of standardisation of certain aspects of existing Phase 1 Rolling Stock related to PSD interface.~~ Requirement of standardisation of certain aspects of rolling stock related to PSD interface to enable operability of ARE05 trains with existing installed PSD

- 4.4.1 The exterior layout of the Rolling Stocks shall be the same for the following characteristics

- Rake's inter-door distances of any two corresponding doors of all Rolling Stocks shall be the same. (centre to centre distance)
- The width of the doors (1400 mm or the value mentioned in RS contract)
- The location of Emergency Egress Device (EED), Emergency Ingress Device, Crew switch and parking brake release lever

- 4.4.2 The width of the Rolling Stock car (at the passenger floor level) in static condition, in the passenger door area, shall be same for all the ~~three types of~~ Rolling stocks of Phase 1 & Phase 1 Extn.

- 4.4.3 The door numbering strategy of all the ~~three types of~~ Rolling stock of Phase 1 & Phase 1 Extn. shall be maintained the same for all PSD related communication telegrams with Signalling.

- 4.4.4 The Operator Keys related to RS doors (that for opening the RS door from inside or outside mechanically and that for isolation of the train door) shall be the same for all the ~~three types of~~ Rolling stocks of Phase 1 & Phase 1 Extn.

4.5 Interface Requirements

- 4.5.1 RS Contractor shall provide KE and door drawings (door position, width & pitch) of train to PSD Contractor for placement of Platform Screen Doors and shall share the location of Emergency Egress Device (EED) / Emergency Ingress Device, Crew switch and parking brake release lever with the PSD Contractor and also share their operating mechanism. The access for this equipment with respect to the PSD shall be analysed and agreed upon by both the Contractors in view of the stopping accuracy band of ± 300 mm.

- 4.5.2 The RS Contractor shall share the details of the Operator key / keys of the Rolling Stock for door opening, from outside and inside and for manual door isolation. The details shall include the profile of the key, available manufacturers, License / approval for the manufacturing or procurement of the particular keys etc. The details shall be adequate and shall authorise the PSD Contractors to manufacture or procure the key in a rightful legal manner for usage in CMRL PSD system. PSD

Contractor shall procure/manufacture the key and use in PSD system, so that Operators can use the same set of key for similar functionalities in RS door and PSD door. Necessary approval shall be taken from CMRL before the procuring/ manufacturing.

4.5.3 Signalling system shall be the medium between RS system & PSD system for electronic command / status signals. Both RS & PSD Contractors shall provide necessary signals to the STC Contractor for proper functioning.

1 4.5.4 RS and PSD Contractors shall prepare the numbering scheme of the RS doors and PSD doors respectively for the door specific information communication through Signalling system. The numbering shall be independent of the car identifier number/alphabet and shall be in a manner that irrespective of the direction of travel, the number which points to a particular door does not change.

1 4.5.5 The train passenger door matching with the corresponding Platform screen doors shall be designed for 6 car train from the initial design stage itself. Adequate precaution shall be taken to identify the numbering the doors in sequence to match the PSD doors when the platform active cab change is done.

4.5.6 RS and PSD Contractors shall exchange the defective / Isolated train door and PSD door information, through signalling system so that if a particular train door is defective/isolated, the corresponding PSD shall not open and vice versa. The function shall include both Audio and visual in their respective panels to facilitate passengers.

4.5.7 RS and PSD Contractors shall exchange the obstruction detected train door and PSD door information, through signalling system so that if a particular train door is having obstruction detection, the corresponding PSD shall open and vice versa.

4.5.8 Door synchronization:

1 The doors of the PSD and the RS shall synchronize, in the very similar manner, while opening and closing, irrespective of the combination of suppliers of PSD or RS. All the PSD suppliers and the Rolling stock suppliers shall arrive at the synchronization parameters (transmission timing, processing time, delays etc) to ensure the same. The synchronization timings shall be validated in the CMRL test track to ensure similar behaviour for any combination of RS and PSD Contractors. The timing diagram from STC Contractor shall also be considered for the calculation.

1 4.5.9 The design of the passenger door control system shall ensure that the train passenger doors open before the PSDs open and PSD doors close before closure of train passenger doors. The operation of the “Door Close” pushbutton/ door close command from UTO/ATO shall broadcast an audible warning in each saloon, signifying that both the PSD doors and passenger doors shall subsequently close.

4.5.10 After the pre-set time, adjustable between 0 and 5 seconds, following the finish of the audible warning, the control system shall synchronously “Close and Latch” all the passenger doors and PSD on the corresponding side. The design of the passenger door control system shall ensure that the PSD doors close before the train passenger doors close.

4.6 Integrated Testing and Commissioning:

1 4.6.1 RS, STC, Telecom TETRA and PSD Contractors shall jointly setup an integrated test bed at CMRL premise to arrange for the integration testing of various subsystems, as a minimum but not limited to ATS, ATO, on-board CCTV management system by signalling Contractor, On-board passenger information system, on-board driver display units, TCMS, On-board NVR, RTR-DMS by RS Contractors, station passenger information systems etc of the Telecom Contractors, SCADA of PSD systems. The test bed shall have provision for testing the actual software over the actual hardware. Necessary train running mimicking simulator shall be provided by the SIG Contractor to simulate a train running. RS Contractors shall provide necessary simulators to simulate various failure and operational scenarios in the TCMS pertaining to the Interface data.

~~RS, STC & PSD Contractors shall jointly perform Integrated Testing and tests shall include but not limited to traction and braking control, precision stopping, door operation, PSD, PA/PIS functioning test. All Contractors shall jointly produce a protocol document for Integrated Testing~~

~~and Commissioning.~~

- 1 4.6.2 This integrated test bed shall be designed in a manner that it mimics the real-world test scenario.
- 1 4.6.3 This test bed can share the hardware from the hardware test bed, if envisaged in respective contracts. The tests for vital interface tests and the tests pertaining to the driving parameters of the train or ATO are excluded from this test bed scope.
- 1 4.6.4 This test bed shall be used for the initial preliminary type tests of the interface, regression tests, software tests after modifications, preliminary interface tests pertaining to stage integration etc. This test bed shall not completely replace the original testing using the train.
- 1 4.6.5 RS, STC, Telecom -TETRA & PSD Contractors shall jointly perform Integrated Testing and tests shall include but not limited to traction and braking control, precision stopping, turn back, jog function, door operation, PSD, train wake up and PA/PIS functioning test, remote command & control for Rolling Stock monitoring & troubleshooting from OCC to train and safety related test etc. All Contractors shall jointly produce a protocol document for Integrated Testing and Commissioning.
- 4.6.6 Integrated testing of each train shall comply with the accepted international standards agreed between the Contractors and agreed with the CMRL.
- 1 4.6.7 Integrated Testing specific to each train shall be done at the Rolling Stock factory, depot and main line of CMRL to ensure satisfactory performance of all train control, STC, Telecom-TETRA and PSD interfaces.
- 1 4.6.8 Integrated Tests subsequently shall be signed-off jointly by the Rolling Stock, Signalling & Train Control, Telecom-TETRA and PSD Contractors.
- 4.6.9 For UTO and other non-UTO modes of operation, the Integration Testing between the Rolling Stock, Signalling & Train Control, Telecommunications and PSD Contractors shall include tests on mainline to confirm below minimum features:
- 1
- a) realization of demanded acceleration rate, deceleration rate, Jerk in all UTO and non-UTO modes of operation,
 - b) train stopping accuracy in stations, wet rail conditions/adhesion levels,
 - c) synchronization with PSDs,
 - d) automatic train operation with all the train controls from OCC/DCC,
 - e) Train RTR-DMS data transmission to OCC server and display of fault information at OCC and Depot controller console
 - f) Verification of alarms and other vital information transmission from train to OCC and vice versa
 - g) Passenger to OCC communication and vice versa
 - h) Train radio verification
 - i) Automatic route related passenger announcements in train
 - j) Pre-recorded and manual announcement from OCC
 - k) Streaming of CCTV videos of train in OCC & DCC.
 - l) Any other tests necessitated by the technical specification of the interfacing Contractors. RS Contractor shall highlight any other required interface testing in the test plan.
- 1 4.6.10 All the above requirements shall be tested in all the sections of Corridor 1 and corridor 2 and their extensions if any.
- 4.6.11 Based on operational requirement, rakes may have to be operated in GoA2 mode with driver / in GoA3 mode with attendant / in GoA4 (UTO). However, the rakes are planned with operations in GoA2 (ATO) during the initial passenger service and subsequently in GoA4 (UTO). Contractor shall develop and submit the detailed scheme for tests (in addition to the tests mentioned in Appendix C required to be done for the safe and reliable operation in UTO & ATO mode. Contractor shall successfully conduct these tests. CMRL shall witness these tests.
- 1 4.6.12 These above tests mentioned shall be completed before the start of the Rolling Stock Burn-in trials for each train individually.

4.7 INTERFACE- Division of Responsibility

- 4.7.1 RS Contractor shall coordinate with PSD Contractors in order to achieve the functional and operational requirements of the system. The roles and activities of the Contractors shall broadly include minimum but not limited to those mentioned in table below. Apart from the below table, RS and PSD Contractors shall also adhere to all the requirements of Appendix C and their referred sub-clauses of Section VI A ERTS-RS mentioned in this Appendix C.

S.No.	Item	PSD Contractors	RS Contractor
1	Kinematic envelope, height of train floor (in unloaded and fully loaded condition) and car width of RS SOD document shall be complied.	PSD Contractors shall design the PSD taking this into account.	RS Contractor shall furnish the KE details at platforms and the car width details to the PSD Contractor.
1	2 The PSD façade layout	~~PSD Contractors shall design the PSD taking this into account.~~ In Phase 1 UG stations, the PSD façade for 6 car is already in place for all 44 platforms.	RS Contractor shall provide the general arrangement drawing of RS exterior which indicates, the door widths, inter door distances, train door widths, its pitch, location of Emergency Egress Device (EED) / Emergency ingress device, crew switch, and parking brake release lever. Note: Since the door width and pitch is already fixed, those details may have been shared with the PSD Contractors in advance if those Contracts are awarded in advance of ARE04a.
1	3 The Operator Key details related to doors.	~~PSD Contractors shall use the key profile provided by the RS Contractor in PSD for similar functions comparing to RS doors.~~ The existing profile shall be used for the PSD	~~RS Contractor shall provide the Lock & key details, Lock & key licences, authorization for the PSD Contractor to procure / manufacture the key and lock with same profile for PSD~~ RS to standardise as per existing keys.
4	The PSD and RS Door numbering scheme	RS and PSD Contractors shall agree on the door numbering scheme of PSD and RS. All the door inhibition/obstruction telegrams through Signalling system shall follow this scheme.	RS and PSD Contractor shall agree on the door numbering scheme of PSD and RS. All the door inhibition/obstruction telegrams through Signalling system shall follow this scheme.
5	Door synchronization	RS and PSD Contractors shall assess the processing time, transmission time,	RS and PSD Contractor shall assess the processing time, transmission time, polling cycle

S.No.	Item	PSD Contractors	RS Contractor
		polling cycle etc and estimate the system delay in the door operation actuation (duly taking input from STC Contractor) and synchronize the doors	etc and estimate the system delay in the door operation actuation (duly taking input from STC Contractor) and synchronize the doors
6	Joint test protocols for testing of the interface	Shall support RS Contractor for the preparation of test documents.	Shall prepare the tests incorporating PSD Contractor inputs
7	Any other requirements from Employer - Technical Specification. (for RS PSD & STC, as many interfaces are through signalling system)	RS Contractor shall ensure all the interface requirements pertaining to PSD Contractor are shared and agreed mutually.	PSD Contractor shall ensure all the interface requirements pertaining to RS Contractor are shared and agreed mutually.
8	Detailed Interface document (DID)	PSD Contractors shall provide the necessary information as requested by RS Contractor.	RS Contractor shall prepare DID and shall ensure that it covers Design, Interface Hazard log, Construction, Testing & Commissioning, Test report formats, Maintenance, etc.,
9	Stopping Accuracy	PSD Contractors shall open the door according to the train stopping accuracy. PSD Contractor shall ensure that when doors are opened, it shall be minimum of 1400mm.	RS Contractor shall ensure that the train stops within $\pm 300\text{mm}$ of station stopping point. This information shall be share to PSD Contractor.

5 RAILWAY ELECTRIFICATION, POWER SUPPLY CONTRACTORS

5.1 General

- 5.1.1 This section describes the interface requirements between Rolling Stock (RS) Contract and 25KV overhead catenary, traction power, and SCADA Contractor.
- 5.1.2 Overhead Catenary System (OCS) shall be Flexible and Rigid type system.
- 5.1.3 ~~OCS system will be awarded as a separate contract for Phase 1 corridors.~~ OCS system will be awarded as a separate contract for the related work in Phase 1 capacity enhancement. There is possibility of having multiple Contractors for OCS. RS Contractor shall interface accordingly with more than one designated Contractor.
- 5.1.4 The Contractors shall ensure that all the requirements of the Metro Railway General Rules are duly met by incorporating appropriate alarms, remote commands and other features.
- 5.1.5 The Contractors as above shall ensure that all requirements of the Specification pertaining to interfaces are properly satisfied.
- 5.1.6 All Interface Meetings, unless specifically approved by CMRL shall be held at site and they shall be given sufficient notice to attend the meeting.
- 5.1.7 Each Contractor shall be responsible for interface identification, establishment, construction and testing works either in the capacity as the Lead Contractor or Participating Contractor.

5.2 Interface Management

- 5.2.1 RS Contractor shall be the Lead Contractor. The Lead Contractor will be responsible to initiate, plan, coordinate and produce jointly with the Participating Contractors all the required interfaces and interface design documents and interface progress reports for submission to CMRL for acceptance. The Lead Contractor will also prepare and issue all interface meeting minutes after incorporating Railway Electrification, Power Supply (OCS) Contractors' comments within 3 days of the meeting and provide bi weekly interface progress reports to all the participating Contractors for information. Later, forwarding of issued minutes of meeting and bi weekly interface progress reports to respective Engineers shall be responsibility of concerned Contractors.
- 5.2.2 OCS Contractor will be participating Contractors. The Participating Contractors shall collaborate fully with the Lead Contractor in the development and finalization of the interface design, joint production of the interface documents and interface progress reports.
- 5.2.3 All the participating Contractors shall ensure that copy of the Interface design documents submitted to CMRL of the OCS Contractor shall also be submitted to the concerned team (will be intimated by CMRL) to participate in the Interface Meetings.
- 5.2.4 The costs for all interface design and testing works shall be deemed to be included in the Contract sum regardless of the actual extent of effort required or expended by the Contractor.
- 5.2.5 The Contractors shall be fully responsible for the management and control of his Subcontractors in relation to all interfacing activities carried out under the Contract.
- 5.2.6 OCS Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of the trains till completion of RS Contractor's defect liability period. RS Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of trains till completion of OCS Contractor defect liability period.

5.3 Integrated Testing and Commissioning:

- 5.3.1 RS & OCS Contractors shall perform Integrated Testing for both Mainline and Designated Depot(s).
- 5.3.2 Both Contractors shall jointly produce a protocol document for Integrated Testing and Commissioning which shall be submitted for CMRL review and approval.

5.4 INTERFACE- Division of Responsibility

- 5.4.1 RS Contractor shall provide KE, Energy consumption and power requirements, Pantograph details, etc., and any other details required by OCS Contractors. These shall include but not limited to the following,
- 5.4.2 Interface between Rolling stock and OCS Contractors shall be for **all the corridors of Phase 1 & Phase 1 Extn. Network. i.e., Corridor 1 and Corridor 2, all the three corridors of CMRL Phase 1 i.e., Corridor 3, Corridor 4, Corridor 5;** their future extensions and for their inter-corridor operations.
- 5.4.3 Trains of CMRL Phase 1 & Phase 1 Extn. Network Project shall be operated in ATO / UTO mode. Based on operational requirement, rakes may have to be operated in GoA2 mode with driver / in GoA3 mode with attendant / in GoA4 (UTO). However, the rakes are planned with operations in GoA2 (ATO) during the initial passenger service and subsequently in GoA4 (UTO). ~~from the initial stage of revenue operation.~~ The interface system requirements of RS Contractor shall consider the interface systems with train operation in both ~~ATO and all Non-ATO~~ UTO and Non-UTO modes of operation.

S.No.	Item	RS Contractor	OCS Contractors
1	Supply of basic data, i.e Train configuration, Kinematic Envelope,	Shall coordinate with the OCS Contractors and provide all the relevant	Shall coordinate with RS Contractor and collect all the relevant data and information

S.No.	Item	RS Contractor	OCS Contractors
	speed-current characteristic, Tractive effort-speed curves, Auxiliary power, acceleration, braking, regeneration, Current & voltage Harmonics, Traction Motor Specification, Power factor correction, Pantograph design details, etc.	data and information of proposed Rolling Stock to the OCS Contractors.	required for carry out simulation studies and designing the Traction Power supply and distribution system.
2	Min., max., level of Traction power parameter (V, I, Hz) of FOCS and ROCS.	RS Contractor shall ensure performance of Rolling Stock for designed for both Rigid and Flexible OCS as per IS / IEC / RDSO standard	OCS Contractor shall provide the value of max., min. permissible level of Voltage, Current, Frequency of Power supply system as specified in IS / IEC / RDSO standard
3	Size, shape and types of conductor wire	to incorporate into the design of the Pantograph	shall provide information to RS Contractor Pantograph profile shall be similar to Phase-1 existing Rolling stock in order to avoid change in existing Mainline and Depot OCS
4	Contact wire tension	To incorporate into the design of the Pantograph	shall provide information to RS Contractor Pantograph profile shall be similar to Phase-1 existing Rolling stock in order to avoid change in existing Mainline and Depot OCS
5	Arrangement of the Overhead line system and sectioning, height, stagger, etc. for the entire Corridor 3, 4 & 5 of Phase 1 & Phase 1 Extn. Network.	To incorporate into the design of the Pantograph	shall provide information to RS Contractor Pantograph profile shall be similar to Phase-1 existing Rolling stock in order to avoid change in existing Mainline and Depot OCS
6	Detailed drawings of Pantograph and Pantograph head	Shall provide information to the OCS Contractors	To incorporate into the design of the OCS System To verify the dynamic behaviour of pantograph and OCS. (Pantograph profile shall be similar to Phase-1 existing Rolling stock in order to avoid change in existing Mainline and Depot OCS)

S.No.	Item	RS Contractor	OCS Contractors
1	7	Material of Pantograph contact strip	Shall provide information to the OCS Contractors To incorporate into the design of the OCS System shall be similar to Phase-1 existing Rolling stock in order to avoid change in existing Mainline and Depot OCS
1	8	Detailed masses, springing and damping of Pantograph.	Shall provide information to the OCS Contractors To incorporate into the design of the OCS System To verify the dynamic behaviour of pantograph and OCS. (shall be similar to Phase-1 existing Rolling stock in order to avoid change in existing Mainline and Depot OCS)
1	9	Pantograph sway calculations	Shall provide information to the OCS Contractors To incorporate into the design of the OCS System To verify the dynamic behaviour of pantograph and OCS. (shall be similar to Phase-1 existing Rolling stock in order to avoid change in existing Mainline and Depot OCS)
1	10	Details of current, voltage Harmonic contents generated by Rolling Stock power supply during various modes of operation.	Shall provide information to the OCS Contractors To incorporate into the design of the OCS System To study, simulate and verify the forecasted Electrical load demand, Power quality, shall be catered with existing Receiving Substations
1	11	Maximum Traction return current	Shall provide information to the OCS Contractors To incorporate into the design of the OCS System To study, simulate and verify the touch and step potential in the OCS zone.
	12	Harmonic limitations of Power supply.	To incorporate into the design of the Pantograph and other HV Systems Conduct EMC / EMI tests, Harmonics THD, TDD test on mainline as per IEEE 519 to confirm the limits as per specification. Shall provide information to RS Contractor and assist in conducting the tests. shall monitor the harmonics on the traction power supply and regeneration mode.
1	13	Neutral section	Shall check and confirm suitability Shall provide information about existing location,

S.No.	Item	RS Contractor	OCS Contractors
		RS Contractor shall interface with STC Contractor for Operation of Train's VCB's in Neutral section by using commands from On-board ATP as primary method. This function shall be a vital output from On-board ATP. However, RS Contractor shall provide a back-up software logic in train for operation of VCBs during all modes of train operation while passing in Neutral section region.	arrangement, etc., to RS Contractor.
14	Warning boards and visual indication at Neutral Section	shall confirm the suitability	shall supply and install warning boards and indications
15	Testing & commissioning	Shall conduct test for monitoring, recording and analysing pantograph current collection performance.	Shall coordinate with RS Contractor.
		Shall conduct test to measure, record and analyse power quality.	Shall jointly check electrical loads, harmonic levels, proper contact between pantograph and OCS.
		shall jointly witness the test	shall conduct testing for proper contact of pantograph and OCS with CMV (Tower wagon)
16	Any other requirements from Employer's Requirements - Technical Specification	RS Contractor shall ensure all the interface requirements pertaining to OCS Contractor are shared and agreed mutually.	OCS Contractor shall ensure all the interface requirements pertaining to RS Contractor are shared and agreed mutually.
1	17	Inter-distance details between two pantographs	~~Shall provide to the info OCS Contractors for design of Neutral section length.~~ Shall design according to the existing Neutral sections ~~Shall incorporate in the design of Neutral section length.~~ Shall provide the details of existing Neutral sections
1	18	Train Energy consumption details in elevated, at-grade and tunnel sections of CMRL Phase 1 & Phase 1 Extn. considering the Air	Shall provide details to the OCS Contractors to design the sub-system capacities. Shall incorporate the RS details in line with the operational plan of trains in the design of sub-system capacity.

S.No.	Item	RS Contractor	OCS Contractors
	resistance formulae for train design.		
1	19 Arrangement of the Overhead line system and sectioning, height, stagger, etc. for the depots of CMRL phase 1	To incorporate into the design of the Pantograph	shall provide information to RS Contractor.
1	20 19 OCS Interlocking details required for operation of Trains in depot during ATO and Non-ATO UTO and Non-UTO modes of operation. This shall include details for all lines of the Designated Depot(s).	Details to be collected from the OCS Contractors	Details shall be submitted to RS Contractor.
1	24 20 Any other requirements from Employer's Requirements - Technical Specification	RS Contractor shall ensure all the interface requirements pertaining to OCS Contractor are shared and agreed mutually.	OCS Contractor shall ensure all the interface requirements pertaining to RS Contractor are shared and agreed mutually.
1	22 21 Detailed Interface document (DID)	RS Contractor shall prepare DID and shall ensure that it covers Design, Interface Hazard log, Construction, Testing & Commissioning, Test report formats, Maintenance, etc.,	OCS Contractor shall provide the necessary information as requested by RS Contractor.
1	23 22 Gradient of OHE	RS Contractor requires details of gradient of OHE to obtain smooth current collection	OCS Contractor shall agree to give the details of gradient of OHE

6 TRACK CONTRACTORS

6.1 General

- 6.1.1 This section describes the interface requirements between Rolling Stock (RS) Contract and the Track Works (TRW) Contractors.
- 6.1.2 The term "Track Works (TRW) Contractors" is collectively referring to multiple Track Works Contractors; ~~each being responsible for different sections related works~~ of the Phase 1 & Phase 1 Extn. Network alignment. ~~It is also includes a material supply only Contract that will be awarded for the JICA Corridor.~~ There is possibility of having Detailed Design Consultants (DDC) for Track Works. RS Contractor shall interface accordingly with more than one designated Contractor.
- 6.1.3 The Contractors shall ensure that all the requirements of the Metro Railway General Rules are duly met by incorporating appropriate alarms, remote commands and other features.
- 6.1.4 The Contractors as above shall ensure that all requirements of the Specification pertaining to interfaces are properly satisfied.

- 6.1.5 All Interface Meetings, unless specifically approved by CMRL shall be held at site and they shall be given sufficient notice to attend the meeting.
- 6.1.6 Each Contractor shall be responsible for interface identification, establishment, construction and testing works either in the capacity as the Lead Contractor or Participating Contractor.

6.2 Interface Management

- 6.2.1 RS Contractor shall be the Lead Contractor. The Lead Contractor will be responsible to initiate, plan, coordinate and produce jointly with the Participating Contractors all the required interfaces and interface design documents and interface progress reports for submission to CMRL for acceptance. The Lead Contractor will also prepare and issue all interface meeting minutes after incorporating ~~Comm~~ TRW Contractors comments within 3 days of the meeting and provide bi weekly interface progress reports to all the participating Contractors for information. Later, forwarding of issued minutes of meeting and bi weekly interface progress reports to respective Engineers shall be responsibility of concerned Contractors.
- 6.2.2 TRW Contractors will be participating Contractors. The Participating Contractors shall collaborate fully with the Lead Contractor in the development and finalization of the interface design, joint production of the interface documents and interface progress reports.
- 6.2.3 All the participating Contractors shall ensure that copy of the Interface design documents submitted to CMRL of the TRW Contractor(s) shall also be submitted to the concerned team (will be intimated by CMRL) to participate in the Interface Meetings.
- 6.2.4 The costs for all interface design and testing works shall be deemed to be included in the Contract sum regardless of the actual extent of effort required or expended by the Contractor.
- 6.2.5 The Contractors shall be fully responsible for the management and control of his Subcontractors in relation to all interfacing activities carried out under the Contract.
- 6.2.6 TRW Contractors shall provide necessary support to resolve all pending or new interface related issues arising during the operation of the trains till completion of TRW Contractors defect liability period. RS Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of trains till completion of RS Contractor defect liability period.

6.3 Integrated Testing and Commissioning:

- 6.3.1 RS & TRW Contractors shall perform Integrated Testing.
- 6.3.2 Both Contractors shall jointly produce a protocol document for Integrated Testing and Commissioning which shall be submitted for CMRL review and approval.

6.4 INTERFACE- Division of Responsibility

- 6.4.1 Interface between Rolling Stock and Track Works Contractors (TRW) shall be for all ~~three~~ corridors of the CMRL ~~Phase II Network. (i.e., Corridor 3, Corridor 4, Corridor 5)~~ Phase-I & Phase-I Extn. Network (i.e. Corridor 1, Corridor 2) as well as their future extensions and their inter-corridor operations. The TRW Contractors shall interface for the Corridor / Section under their contractual jurisdiction.
- 6.4.2 ~~Trains of the CMRL Phase II Project shall be operated in ATO mode from the initial stage of revenue operation.~~ Based on operational requirement, rakes may have to be operated in GoA2 mode with driver / in GoA3 mode with attendant / in GoA4 (UTO). However, the rakes are planned with operations in GoA2 (ATO) during the initial passenger service and subsequently in GoA4 (UTO). The interface system requirements of RS Contractor shall consider the interface systems with train operation in both ~~ATO and all Non-ATO~~ UTO and Non-UTO modes of operation.
- 6.4.3 RS Contractor shall provide all necessary details as required by Track Works Contractors (TRW) and vice-versa. These shall include, but not limited to the following:

S.No.	Item	RS Contractor	TRW Contractors
1	Kinematic Envelope and SG envelope	RS Contractor shall provide the details of KE and SG to track Contractor for various design speeds such as 25kmph, 45kmph, 55 kmph and 80 kmph	The TRW Contractors shall use this information in their design for ensuring clearances
2	Track Alignment	Shall use the information for his design requirements and train running simulation	TRW Contractors shall provide the detail of track geometry, curves, gradients and other requirement information required for RS design
3	Rail wheel interaction	The wheel profile and Wheel back-to back spacing shall be compatible with the rail profiles and track gauge.	Track gauge is 1435mm ~~and rail profile is UIC 60, E1 profile,~~ Rail Section on main line is 60 E1 Profile 1080 HH Grade ~~HH~~ and 60 kg Rail on main line. Main Line – Ballast less track. Rail Section on Depot is 60 E1 Grade 880 Rail and 60 kg. Depot – ~~Ballasted &~~ Ballast less track. TRW Contractors shall provide any additional details of the gauge / rail profile to RS Contractors.
4	Check rail geometry	The wheel flange back-side and wheel back-to back spacing shall be compatible with the check rail geometry. RS Contractor shall carryout simulation to determine the check rail clearance at the particular speed	The lateral and vertical position and tolerance of the check rail shall be compatible with the wheel set geometry and the TRW Contractors shall provide the Check rail clearance as recommended by RS Contractor by simulation
5	Contact Geometry:	~~Switch and crossing geometry shall be compatible with the wheel set geometry in both mainline and in all Designated Depot(s)~~ The wheel set geometry shall be compatible with the switch & crossing geometry in both mainline and in all Designated Depot(s)	~~The wheel set geometry shall be compatible with the switch & crossing geometry in both mainline and in all Designated Depot(s)~~ Switch and crossing geometry shall be compatible with the wheel set geometry in both mainline and in all Designated Depot(s)
6	Materials: The Wheel material shall be optimised to	RS shall take rail hardness provided by TRW into consideration to	TRW Contractors shall provide the details of rail hardness ~~and rail~~

S.No.	Item	RS Contractor	TRW Contractors
	give the minimum whole-life cost.	ensure rail wheel compatibility and to provide optimum service life.	~~characteristics throughout the entire alignment of corridors 3,4 and 5~~ to the RS Contractor. As per IRS T12- 2009: Steel hardness for mainline shall be in the range of 340-390BHN (Brinell hardness Number) for 1080 rails Rail Section on main line is 60 E1 1080 Grade HH Rail on main line. Main Line – Ballast less track. Rail Section on Depot is 60 E1 Grade 880 Rail. Depot – Ballasted & Ballast less track.
7	The Buffer stops used in all Designated Depot(s) shall be compatible with the train's front & rear end automatic couplers & anti climbers.	RS Contractor shall share the details of couplers including anti-climbers as required by the TRW Contractors.	TRW Contractors shall interface with RS for design of Buffer stop & Wheel stoppers
8	Not Used	n/a	n/a
9	Vehicle Dynamics Simulation Studies	RS Contractor shall conduct vehicle dynamics simulation studies on new and worn wheel and rail profiles.	Track Contractors shall provide all the relevant design data of track to RS Contractor, required for vehicle dynamics simulation studies.
10	Separation of Natural Frequencies between Train and Track systems.	Natural frequencies of the track and its support system shall be different from the natural frequencies of the train and its systems to avoid the possibility of resonance. Natural frequencies of the bogie are significantly below the lowest natural frequency of the track system.	Natural frequencies of the track and its support system shall be different from the natural frequencies of the train to avoid the possibility of resonance. Natural frequencies of the bogie are significantly below the lowest natural frequency of the track system.
1	11 Wayside Equipment: Hot Axle Box detection system	~~The RS Contractor shall provide detailed drawings of way side equipment to be installed in the track slab/track plinth to the TRW Contractors if any provision is required within the track slab.~~	~~TRW Contractors shall accommodate the required design requirements in the track slab/track plinth to facilitate for the installation by the RS~~ TRW Contractors shall accommodate the wayside equipment in slab/ plinth track to

S.No.	Item	RS Contractor	TRW Contractors
		The RS Contractor shall provide the wayside equipment (required if any) without infringing to SOD. Detailed drawing of the wayside equipment's shall be shared with TRW contractor for their confirmation.	facilitate for the installation by the RS
12	Any other requirements from Employer's Requirements - Technical Specification	The RS Contractor shall ensure all the interface requirements pertaining to the TRW Contractors are shared and mutually agreed.	TRW Contractors shall ensure all the interface requirements pertaining to the RS Contractor are shared and mutually agreed.
13	RS Bogie details	RS Contractor shall provide design axle load, bogie spacing, wheel spacing, weight calculation and distribution to the respective TRW Contractors	TRW Contractors shall use this data for track design
14	RS Anti-Climbers details	RS shall provide the details of Rolling Stock Anti-climbers for the design of buffer stops by TRW Contractors	TRW Contractors shall use this data for the design of buffer stops for various speeds
15	Track plinth drawings	RS use this information for the design of Emergency egress doors.	TRW Contractors shall provide the typical Track plinth/slab drawings of elevated and tunnel to RS
16	Detailed Interface document (DID)	The RS Contractor shall prepare the DID and shall ensure it covers Design, Interface Hazard log, Construction, Testing & Commissioning, Test report formats, Maintenance, etc.,	TRW Contractors shall provide the necessary information as requested by the RS Contractor.
17	Structure Gauge Test	The RS Contractor will participate in and support the Structure Gauge Test for the complete network as required.	A Structure Gauge will be prepared by the TRW Contractors and shall be run throughout each section on completion of Track Works. Coverage shall include the complete network.
18	Attainable Speed	Based on the track geometry details provided by TRW Contractors, the RS Contractor shall carry	TRW Contractors based on attainable speed as per simulation study shall modify the value of actual cant and provide the same

S.No.	Item	RS Contractor	TRW Contractors
		out simulation studies to determine the max attainable speed along the alignment. (the simulation study shall consider both a stopping at stations running pattern as well as a skipping through stations pattern)	during construction stage. Value of maximum speed on curves according to revised actual cant also to be revised.
19	Oscillation Trials	The RS Contractor shall share the report / results of oscillation trials to the TRW Contractor	TRW Contractors shall associate during integrated testing and commissioning and carry out all necessary rectification of track anomalies based on oscillation trial reports.
20	On-Board Track condition monitoring and warning system:	RS contractor shall incorporate the details and design the conditional monitoring system accordingly.	The TRW Contractors shall provide all the necessary information's related to Track mentioned in the ERTS.

7 DETAILED DESIGN CONSULTANTS - VIADUCT

7.1 General

- 7.1.1 This section describes the interface requirements between Rolling Stock (RS) Contract and Detailed Design Consultants - Viaduct (VD) Contractors.
- 7.1.2 ~~Viaduct system will be awarded as a separate contract for Phase 1 corridors.~~ There is possibility of having multiple contracts for Viaduct Contractor. RS Contractor shall interface accordingly with more than one designated Contractor.
- 7.1.3 The Contractors shall ensure that all the requirements of the Metro Railway General Rules are duly met by incorporating appropriate alarms, remote commands and other features.
- 7.1.4 The Contractors as above shall ensure that all requirements of the Specification pertaining to interfaces are properly satisfied.
- 7.1.5 All Interface Meetings, unless specifically approved by CMRL shall be held at site and they shall be given sufficient notice to attend the meeting.
- 7.1.6 Each Contractor shall be responsible for interface identification, establishment, construction and testing works either in the capacity as the Lead Contractor or Participating Contractor.

7.2 Interface Management

- 7.2.1 VD Contractor shall be the Lead Contractor. The Lead Contractor will be responsible to initiate, plan, coordinate and produce jointly with the Participating Contractors all the required interfaces and interface design documents and interface progress reports for submission to CMRL for acceptance. The Lead Contractor will also prepare and issue all interface meeting minutes after incorporating RS Contractors comments within 3 days of the meeting and provide bi weekly interface progress reports to all the participating Contractors for information. Later, forwarding of issued minutes of meeting and bi weekly interface progress reports to respective Engineers shall be responsibility of concerned Contractors.
- 7.2.2 RS Contractor will be participating Contractors. The Participating Contractors shall collaborate

fully with the Lead Contractor in the development and finalization of the interface design, joint production of the interface documents and interface progress reports.

- 7.2.3 All the participating Contractors shall ensure that copy of the Interface design documents submitted to CMRL of the RS Contractor shall also be submitted to the concerned team (will be intimated by CMRL) to participate in the Interface Meetings.
- 7.2.4 The costs for all interface design and testing works shall be deemed to be included in the Contract sum regardless of the actual extent of effort required or expended by the Contractor.
- 7.2.5 The Contractors shall be fully responsible for the management and control of his Subcontractors in relation to all interfacing activities carried out under the Contract.
- 7.2.6 VD Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of the trains till completion of RS Contractor defect liability period. RS Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of trains till completion of VD Contractor defect liability period.

7.3 Integrated Testing and Commissioning:

- 7.3.1 RS & VD Contractors shall perform Integrated Testing.
- 7.3.2 Both Contractors shall jointly produce a common protocol document for Integrated Testing and Commissioning which shall be submitted for CMRL review and approval.

7.4 INTERFACE- Division of Responsibility

- 7.4.1 RS Contractor shall provide necessary details as required by VD Contractor and vice-versa. These shall include but not limited to the following,
- 7.4.2 Interface between Rolling stock and Viaduct Contractors shall be for all the ~~three~~ corridors of ~~CMRL Phase 1 i.e., Corridor 3, Corridor 4, Corridor 5, CMRL Phase 1 & Phase 1 Extn i.e., Corridor 1, Corridor 2,~~ their future extensions and for their inter-corridor operations.
- 7.4.3 ~~Trains of CMRL Phase 1 Project shall be operated in ATO mode from the initial stage of revenue operation.~~ Based on operational requirement, rakes may have to be operated in GoA2 mode with driver / in GoA3 mode with attendant / in GoA4 (UTO). However, the rakes are planned with operations in GoA2 (ATO) during the initial passenger service and subsequently in GoA4 (UTO). The interface system requirements of RS Contractor shall consider the interface systems with train operation in both ~~ATO and all Non-ATO~~ UTO and all Non-UTO modes of operation.

S.No.	Item	RS Contractor	VD Contractors
1	Kinematic Envelope & SOD	Shall design the Rolling Stock within the space proof given by Viaduct Contractor. Shall provide the details of kinematic and structural gauges to Viaduct Contractors.	Shall provide the space proof details to RS Contractor. Shall obtain details of kinematic and structural gauges from RS Contractor.
2	Test run	Required to conduct test run with one train at low speed and at highest operational speed	Shall participate in test run and perform modifications, if required
3	Integrated test	Required to conduct integrated test with all systems in ~~ATO~~ UTO and all non-UTO mode of operation	Shall co-ordinate with RS Contractor to complete testing and commissioning work. Shall commission the section free of obstacles, construction debris and dust.

S.No.	Item	RS Contractor	VD Contractors
4	Any other requirements from Employer's Representative – Technical Specification	RS Contractor shall ensure all the interface requirements pertaining to VD Contractor are shared and agreed mutually.	VD Contractor shall ensure all the interface requirements pertaining to RS Contractor are shared and agreed mutually.
5	Detailed Interface document (DID)	RS Contractor shall prepare DID and shall ensure that it covers Design, Interface Hazard log, Construction, Testing & Commissioning, Test report formats, Maintenance, etc.,	VD Contractor shall provide the necessary information as requested by RS Contractor.

8 DETAILED DESIGN CONSULTANTS - TUNNEL

8.1 General

8.1.1 This section describes the interface requirements between Rolling Stock (RS) Contract and Detailed Design Consultants – Tunnel (TU) Contractors.

1 8.1.2 ~~Underground Tunnel contract will be awarded as a separate contract for Phase 1 corridors.~~ There is possibility of having multiple contracts for Tunnel Contractor. RS Contractor shall interface accordingly with more than one designated Contractor.

8.1.3 The Contractors shall ensure that all the requirements of the Metro Railway General Rules are duly met by incorporating appropriate alarms, remote commands and other features.

8.1.4 The Contractors as above shall ensure that all requirements of the Specification pertaining to interfaces are properly satisfied.

8.1.5 All Interface Meetings, unless specifically approved by CMRL shall be held at site and they shall be given sufficient notice to attend the meeting.

8.1.6 Each Contractor shall be responsible for interface identification, establishment, construction and testing works either in the capacity as the Lead Contractor or Participating Contractor.

8.2 Interface Management

8.2.1 TU Contractors shall be the Lead Contractor. The Lead Contractor will be responsible to initiate, plan, coordinate and produce jointly with the Participating Contractors all the required interfaces and interface design documents and interface progress reports for submission to CMRL for acceptance. The Lead Contractor will also prepare and issue all interface meeting minutes after incorporating RS Contractors comments within 3 days of the meeting and provide bi weekly interface progress reports to all the participating Contractors for information. Later, forwarding of issued minutes of meeting and bi weekly interface progress reports to respective Engineers shall be responsibility of concerned Contractors.

8.2.2 RS Contractor will be participating Contractors. The Participating Contractors shall collaborate fully with the Lead Contractor in the development and finalization of the interface design, joint production of the interface documents and interface progress reports.

8.2.3 All the participating Contractors shall ensure that copy of the Interface design documents submitted to CMRL of the RS Contractor shall also be submitted to the concerned team (will be intimated by CMRL) to participate in the Interface Meetings.

8.2.4 The costs for all interface design and testing works shall be deemed to be included in the Contract sum regardless of the actual extent of effort required or expended by the Contractor.

8.2.5 The Contractors shall be fully responsible for the management and control of his sub-contractors

in relation to all interfacing activities carried out under the Contract.

- 8.2.6 TU Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of the trains till completion of RS Contractor defect liability period. RS Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of trains till completion of TU Contractor defect liability period.

8.3 Integrated Testing and Commissioning:

- 8.3.1 RS & TU Contractors shall perform Integrated Testing.
- 8.3.2 Both Contractors shall jointly produce a protocol document for Integrated Testing and Commissioning which shall be submitted for CMRL review and approval.

8.4 INTERFACE- Division of Responsibility

- 8.4.1 RS Contractor shall provide necessary details as required by TU Contractor and vice-versa. These shall include but not limited to the following,
- 1 8.4.2 Interface between Rolling stock and TU Contractors shall be for all the ~~three~~ corridors of CMRL Phase 1 & Phase 1 Extn. i.e., Corridor 1, Corridor 2, i.e., ~~Corridor 3, Corridor 4, Corridor 5~~, their future extensions and for their inter-corridor operations.
- 1 8.4.3 Trains of CMRL Phase 1 & Phase 1 Extn. Project shall be operated in ATO mode from the initial stage of revenue operation. The interface system requirements of RS Contractor shall consider the interface systems with train operation in both ~~ATO and all Non-ATO~~ UTO and all Non-UTO modes of operation.

S.No.	Item	RS Contractor	TU Contractors
1	Kinematic Envelope & SOD	Shall design the Rolling Stock within the space proof given by Viaduct Contractor. Shall provide the details of kinematic and structural gauges	Shall provide the space proof details to RS Contractor Shall obtained details of kinematic and structural gauges from RS Contractor
2	Test run	Required to conduct test run with one train at low speed and at highest operational speed	Shall participate in test run and perform modifications, if required
3	Integrated test	Required to conduct integrated test with all systems	Shall co-ordinate with RS Contractor to complete testing and commissioning work. Shall commission the section free of obstacles, construction debris and dust.
4	Any other requirements from Employer's Requirements - Technical Specification	RS Contractor shall ensure all the interface requirements pertaining to UG Contractor are shared and agreed mutually.	UG Contractor shall ensure all the interface requirements pertaining to RS Contractor are shared and agreed mutually.
5	Detailed Interface document (DID)	RS Contractor shall provide the necessary information as requested by RS Contractor.	TU Contractor shall prepare DID and shall ensure that it covers Design, Interface Hazard log, Construction, Testing & Commissioning, Test report formats,

S.No.	Item	RS Contractor	TU Contractors
			Maintenance, etc.,

9 DETAILED DESIGN CONSULTANTS - UNDERGROUND

9.1 General

- 9.1.1 This section describes the interface requirements between Rolling Stock (RS) Contract and Detailed Design Consultants - Underground (STN) Contractor.
- 9.1.2 ~~Underground Station will be awarded as a separate contract for Phase 1 corridors. There are 19 Underground stations in Phase I and 2 Underground stations in Phase I Extension of CMRL and~~ There is possibility of having multiple contracts for Underground Station (STN) Contractor. RS Contractor shall interface accordingly with more than one designated Contractor.
- 9.1.3 The Contractors shall ensure that all the requirements of the Metro Railway General Rules are duly met by incorporating appropriate alarms, remote commands and other features.
- 9.1.4 The Contractors as above shall ensure that all requirements of the Specification pertaining to interfaces are properly satisfied.
- 9.1.5 All Interface Meetings, unless specifically approved by CMRL shall be held at site and they shall be given sufficient notice to attend the meeting.
- 9.1.6 Each Contractor shall be responsible for interface identification, establishment, construction and testing works either in the capacity as the Lead Contractor or Participating Contractor.

9.2 Interface Management

- 9.2.1 STN Contractor shall be the Lead Contractor. The Lead Contractor will be responsible to initiate, plan, coordinate and produce jointly with the Participating Contractors all the required interfaces and interface design documents and interface progress reports for submission to CMRL for acceptance. The Lead Contractor will also prepare and issue all interface meeting minutes after incorporating RS Contractors comments within 3 days of the meeting and provide bi weekly interface progress reports to all the participating Contractors for information. Later, forwarding of issued minutes of meeting and bi weekly interface progress reports to respective Engineers shall be responsibility of concerned Contractors.
- 9.2.2 RS Contractor will be participating Contractors. The Participating Contractors shall collaborate fully with the Lead Contractor in the development and finalization of the interface design, joint production of the interface documents and interface progress reports.
- 9.2.3 All the participating Contractors shall ensure that copy of the Interface design documents submitted to CMRL of the RS Contractor shall also be submitted to the concerned team (will be intimated by CMRL) to participate in the Interface Meetings.
- 9.2.4 The costs for all interface design and testing works shall be deemed to be included in the Contract sum regardless of the actual extent of effort required or expended by the Contractor.
- 9.2.5 The Contractors shall be fully responsible for the management and control of his Subcontractors in relation to all interfacing activities carried out under the Contract.
- 9.2.6 STN Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of the trains till completion of RS Contractor defect liability period. RS Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of trains till completion of STN Contractor defect liability period.

9.3 Integrated Testing and Commissioning:

- 9.3.1 RS & STN Contractors shall perform Integrated Testing.
- 9.3.2 Both Contractors shall jointly produce a protocol document for Integrated Testing and

Commissioning which shall be submitted for CMRL review and approval.

9.4 INTERFACE- Division of Responsibility

- 9.4.1 RS Contractor shall provide necessary details as required by STN Contractor and vice-versa. These shall include but not limited to the following,
- 9.4.2 Interface between Rolling stock and STN Contractors shall be for all the ~~three~~ corridors of CMRL Phase 1 & Phase 1 Extn. i.e., Corridor 1, Corridor 2, ~~i.e., Corridor 3, Corridor 4, Corridor 5~~, their future extensions and for their inter-corridor operations.
- 9.4.3 ~~Trains of CMRL Phase 1 Project shall be operated in ATO mode from the initial stage of revenue operation.~~ Based on operational requirement, rakes may have to be operated in GoA2 mode with driver / in GoA3 mode with attendant / in GoA4 (UTO). However, the rakes are planned with operations in GoA2 (ATO) during the initial passenger service and subsequently in GoA4 (UTO). The interface system requirements of RS Contractor shall consider the interface systems with train operation in both ATO and all Non-ATO modes of operation.

1

S.No.	Item	RS Contractor	STN Contractors
1	Station Design	Shall give requires details of Rolling stock including Length of train cars, height and location of doors for station design	Shall be incorporated in station design.
2	KE & SOD	Shall give the details of kinematic And structural gauges.	Requires details of kinematic and structural gauges from RS Contractor.
3	Integrated Physical Verification	Shall co-ordinate and confirm with station Contractor	Shall jointly check and confirm the curves, dimensional clearances, gradients, chainages, levels and emergency escape provision
4	Noise and Vibration testing. Noise and Vibration levels at station levels	Shall co-ordinate and confirm with Station Contractor Shall follow the Noise and Vibration Guidelines of RDSO referred in Appendix D.4 and Section VI A ERTS-RS Chapter 2.	Shall jointly check and confirm the maximum noise / echo level with respect to various operating speeds of Rolling Stock. Shall follow the Noise and Vibration Guidelines of RDSO referred in Appendix D.4.
5	Integrated test	Require to conduct integrated test with all systems	shall coordinate with RS Contractor to complete testing and commissioning work
6	Any other requirements from Employer's Requirements – Technical Specification	RS Contractor shall ensure all the interface requirements pertaining to STN Contractors are shared and agreed mutually.	STN Contractor shall ensure all the interface requirements pertaining to RS Contractor are shared and agreed mutually.
7	Detailed Interface	RS Contractor shall provide the necessary information as	STN Contractor shall prepare DID and shall

S.No.	Item	RS Contractor	STN Contractors
	document (DID)	requested by RS Contractor.	ensure that it covers Design, Interface Hazard log, Construction, Testing & Commissioning, Test report formats, Maintenance, etc.,

10 DETAILED DESIGN CONSULTANTS - DEPOT

10.1 General

- 10.1.1 This section describes the interface requirements between Rolling Stock (RS) Contract and Detailed Design Consultants – Depot (DDC) Contractors.
- 10.1.2 DDC system will be awarded as a separate contract for Phase 1 & Phase 1 Extn. corridors for various Designated Depot(s). There is possibility of having multiple contracts awarded to different DDC Contractors. In such case the RS Contractor shall interface accordingly with more than one Designated Contractor.
- 10.1.3 The Contractors shall ensure that all the requirements of the Metro Railway General Rules are duly met by incorporating appropriate alarms, remote commands and other features.
- 10.1.4 The Contractors as above shall ensure that all requirements of the Specification pertaining to interfaces are properly satisfied.
- 10.1.5 All Interface Meetings, unless specifically approved by CMRL shall be held at site and they shall be given sufficient notice to attend the meeting.
- 10.1.6 Each Contractor shall be responsible for interface identification, establishment, construction and testing works either in the capacity as the Lead Contractor or Participating Contractor.

10.2 Interface Management

- 10.2.1 Detailed Design Consultants - Depot shall be the Lead Contractor. The Lead Contractor will be responsible to initiate, plan, coordinate and produce jointly with the Participating Contractors all the required interfaces and interface design documents and interface progress reports for submission to CMRL for acceptance. The Lead Contractor will also prepare and issue all interface meeting minutes after incorporating RS Contractors comments within 3 days of the meeting and provide biweekly interface progress reports to all the participating Contractors for information. Later, forwarding of issued minutes of meeting and biweekly interface progress reports to respective Engineers shall be responsibility of concerned Contractors.
- 10.2.2 DDC Contractor will be participating Contractors. The Participating Contractors shall collaborate fully with the Lead Contractor in the development and finalization of the interface design, joint production of the interface documents and interface progress reports.
- 10.2.3 All the participating Contractors shall ensure that copy of the Interface design documents submitted to CMRL of the DDC Contractor shall also be submitted to the concerned team (will be intimated by CMRL) to participate in the Interface Meetings.
- 10.2.4 The costs for all interface design and testing works shall be deemed to be included in the Contract sum regardless of the actual extent of effort required or expended by the Contractor.
- 10.2.5 The Contractors shall be fully responsible for the management and control of his sub-contractors in relation to all interfacing activities carried out under the Contract.
- 10.2.6 RS Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of the trains till completion of DDC Contractor defect liability period. DDC Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of trains till completion of RS Contractor defect liability

period.

10.3 Integrated Testing and Commissioning:

10.3.1 RS & DDC Contractors shall perform Integrated Testing.

10.3.2 Both Contractors shall jointly produce a protocol document for Integrated Testing and Commissioning which shall be submitted for CMRL review and approval.

10.4 INTERFACE- Division of Responsibility

10.4.1 RS Contractor shall provide necessary details as required by DDC Contractor and vice-versa. These shall include but not limited to the following,

S.No.	Item	RS Contractor	DDC Contractors
1	T&C of trains	Review the planning by CMRL and DDC and define the minimum facilities required for train delivery, testing & commissioning of trains in depot.	Design: Based on CMRL design and review of RS Contractor, DDC shall design the infrastructure facilities for train delivery, testing & commissioning of trains in nominated Designated Depot(s). Construct: Shall construct the facilities for delivery, commissioning and testing of trains in nominated Designated Depot(s) to meet the commissioning schedule of Rolling Stocks
2	Maintenance	Shall furnish the maintenance schedules and equipment requirement for complete cars, assemblies and sub-assemblies systems and sub systems	Design: DDC shall design the Depot maintenance facilities including all depot buildings, to suit Rolling Stock requirement Construct: Shall construct the facilities (except certain maintenance equipment's) needed to meet the maintenance need as advised by RS Contractor.
3	Plants and Machinery	Supply all special tools / test panels suitable for the maintenance of Rolling Stock as part of the Spares List of ARE-02 contract.	Design: CMRL shall design and develop specification for supply and Commissioning of General-purpose plant and machinery, tools and instruments at Depot. Construct: Incorporate structural provision and electrical & mechanical provisions for all Machinery and Plant.
4	Store's	Shall furnish the special requirements for storage and the quantities for storage	Design: DDC shall design the store Facilities for assemblies, sub-assemblies, various spares as defined in ARE-02 contract and

S.No.	Item	RS Contractor	DDC Contractors
			other Interface Contractors' spares, etc. at Depot. Construct: Shall construct the store facilities
5	Shore supply sockets and connecting cables to train in Designated Depot(s)	RS Contractor shall define the requirements as per Section VI A ERTS-RS Chapter 9.4.7, 9.4.8.	DDC Contractor shall provide, install and test the hardware components as requested by RS Contractor
6	Any other requirements from Employer's Requirements - Technical Specification	RS Contractor shall ensure all the interface requirements pertaining to DDC Contractors are shared and agreed mutually.	DDC Contractor shall ensure all the interface requirements pertaining to RS Contractor are shared and agreed mutually.
7	Detailed Interface document (DID)	RS Contractor shall prepare DID and shall ensure that it covers Design, Interface Hazard log, Construction, Testing & Commissioning, Test report formats, Maintenance, etc.,	DDC Contractor shall provide the necessary information as requested by RS Contractor.

11 NOT USED DEPOT MACHINERY AND PLANT (DM&P) CONTRACTOR

11.1 General

- 1** 11.1.1 This section describes the interface requirements between Rolling Stock (RS) Contract and the Depot Machinery & Plant (DM&P) Contractors for each of the Designated Depot(s).
- 11.1.2 Depot M&P systems are available in each of the Designated Depot(s). It is therefore multiple designated Contractors with whom the RS Contractor must manage interfaces for Depot M&P Assets. However, Rolling Stock contractor is responsible for Depot Machinery & Plant procured under this contract including for its interfacing.
- 11.1.3 The Contractors shall ensure that all the requirements of the Metro Railway General Rules are duly met by incorporating appropriate alarms, remote commands and other features
- 11.1.4 The Contractors as above shall ensure that all requirements of the Specification pertaining to interfaces are properly satisfied.
- 11.1.5 All Interface Meetings, unless specifically approved by CMRL shall be held at site and they shall be given sufficient notice to attend the meeting.
- 11.1.6 Each Contractor shall be responsible for interface identification, establishment, construction and testing works either in the capacity as the Lead Contractor or Participating Contractor.

11.2 Interface Management

- 11.2.1 DM&P Contractor shall be the Lead Contractor. The Lead Contractor will be responsible to initiate, plan, coordinate and produce jointly with the Participating Contractors all the required interfaces and interface design documents and interface progress reports for submission to CMRL for acceptance. The Lead Contractor will also prepare and issue all interface meeting minutes after incorporating RS Contractors comments within 3 days of the meeting and provide

biweekly interface progress reports to all the participating Contractors for information. Later, forwarding of issued minutes of meeting and biweekly interface progress reports to respective Engineers shall be responsibility of concerned Contractors.

11.2.2 RS Contractor will be participating Contractors. The Participating Contractors shall collaborate fully with the Lead Contractor in the development and finalization of the interface design, joint production of the interface documents and interface progress reports.

1 11.2.3 All the participating Contractors shall ensure that copy of the Interface design documents submitted to CMRL of the RS Contractor shall also be submitted to the concerned team (will be intimated by CMRL) to participate in the Interface Meetings.

11.2.4 The costs for all interface design and testing works shall be deemed to be included in the Contract sum regardless of the actual extent of effort required or expended by the Contractor.

11.2.5 The Contractors shall be fully responsible for the management and control of his sub-contractors in relation to all interfacing activities carried out under the Contract.

11.2.6 RS Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of the trains till completion of DDC Contractor defect liability period. DDC Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of trains till completion of RS Contractor defect liability period.

11.3 Integrated Testing and Commissioning:

11.3.1 RS & DM&P Contractors shall perform Integrated Testing.

11.3.2 Both Contractors shall jointly produce a protocol document for Integrated Testing and Commissioning which shall be submitted for CMRL review and approval.

11.4 INTERFACE- Division of Responsibility

11.4.1 RS Contractor shall provide necessary details as required by DM&P Contractor and vice-versa. These shall include but not limited to the following:

Item	DM&P Contractor	RS Contractor
1. Auto Train Wash Plant (ATWP)	a. Shall collect all relevant details i.e train dimensions (Front to Rear end including coupler) etc of RS for the effective design of Wash plant.	a. Shall provide details of RS dimensions as relevant to the design of Wash plant.
	b. Shall collect all relevant information and details of type of detergent and water suitable for RS with a view to avoid any damage to RS surface and design the Wash plant accordingly	b. Shall provide all relevant information and details regarding type of detergent and water suitable for the RS material with other instructions as relevant.
	c. Shall obtain any specific instruction	c. Shall provide specific details e.g infringement objects if any which may hindrance to the washing etc.
	d. Shall conduct joint test with RS Contractor that the wash plant is adapted and compliant to RS requirement.	d. Shall attend and provide necessary support to DM&P Contractor during wash plant testing and commissioning as necessary.

Item	DM&P Contractor	RS Contractor
2. Battery Operated Railroad Shunter (BORRS)	a. Shall collect all relevant details regarding RS characteristics including weight for the effective design of BORRS	a. Shall provide all relevant details regarding RS characteristics including weight, dimensions etc.
	b. Shall collect all relevant information and details of type of coupler of RS and design/provide the BORRS coupler with compatibility accordingly.	b. Shall provide all relevant information and details of type of coupler of RS.
	c. Shall demonstrate the testing and commissioning with coupling / uncoupling, shunting with 6 coupled car, braking with and without shunting load etc as per tender requirement.	c. Shall attend and provide necessary support to DM&P Contractor during BORRS testing and commissioning as necessary.
3. Synchronised Pit Jacks (SPJ)	a. Shall collect all relevant details regarding RS characteristics including weight, dimensions, lifting pad location and dimension, Bogie wheelbase, Bogie centre to centre, wheel profile etc for the effective design of Pit Jacks.	a. Shall provide all relevant details regarding RS characteristics including weight, dimensions, lifting pad location and dimension, Bogie wheel base, Bogie centre to centre, wheel profile etc
	b. Shall manufacture the equipment ensuring no infringement in the vertical plane below the lifting points.	b. Shall coordinate with Jacks Contractor to provide specific details as required.
	c. Shall demonstrate the testing and commissioning with lifting / lowering / holding etc as per tender with RS 6 car configuration.	c. Shall attend and provide necessary support to DM&P Contractor during Jacks testing and commissioning as necessary.
4. Synchronised Mobile Lifting Jacks (SMPJ) and Car Body Stands	a. Shall collect all relevant details regarding RS characteristics including weight, dimensions, lifting pad location and dimension etc for the effective design of Mobile Jacks and Car body stands.	a. Shall provide all relevant details regarding RS characteristics including weight, dimensions, lifting pad location and dimension etc.
	b. Shall manufacture the equipment ensuring no infringement in the vertical plane below the lifting points.	b. Shall coordinate with Jack and car body stand Contractor to provide specific details as required.
	c. Shall demonstrate the testing and commissioning of jacks with lifting / lowering / holding etc as per 6 RS car configuration.	c. Shall attend and provide necessary support to DM&P Contractor during Jack and car body stand testing and commissioning as necessary.
5. Under floor Wheel Lathe (UFWL)	a. Shall collect the required design related data for Bogie, wheel profile and all relevant information	a. Shall provide the required design related data for Bogie, wheel profile and all relevant information to DM&P Contractor.

Item	DM&P Contractor	RS Contractor
	b. Shall take into account RS specification and detailed parameters for designing machine.	b. Shall furnish to DM&P Contractor, all along the design stage, any update, accurate details to enable him to finalise the machine design.
	c. Shall manufacture the equipment ensuring no infringement of bogie component and shunter underframe component which may cause hindrance during rollover, profiling etc.	c. Shall coordinate with DM&P Contractor to provide and confirm specific details as required.
	d. Shall demonstrate the testing and commissioning as per tender requirement.	d. Shall attend and provide necessary support to DM&P Contractor during Wheel lathe testing and commissioning as necessary.
6. Diesel Operated Relief and Rescue vehicle (RRV) with Re-railing and Rescue devices	a. Shall collect all relevant details regarding RS characteristics including weight, dimensions for the effective design of RRV.	a. Shall provide all relevant details regarding RS characteristics including weight, dimensions etc.
	b. Shall collect all relevant information and details of type of coupler of RS and provide the RRV coupler with compatibility accordingly.	b. Shall provide all relevant information and details of type of coupler of RS.
	c. Shall demonstrate the testing and commissioning of RRV coupling and uncoupling test with RS, shunting upto 3/6 coupled car with RRV (pulling and pushing), braking etc.	c. Shall attend and provide necessary support to DM&P Contractor during testing and commissioning as necessary.
	d. Shall demonstrate the testing and commissioning of all Re-railing and Rescue devices with and without RS as decided by Engineer/Employer at agreed site/location.	d. Shall attend and provide necessary support to DM&P Contractor during testing and commissioning as necessary.
7. Bogie Turn Table (BTT)	a. Shall collect all relevant details regarding RS weight, bogie weight, Bogie dimensions, wheel profile etc of all types of Bogies for the effective design of BTTs and manufacture the BTTs accordingly.	a. Shall provide all relevant details regarding RS weight, bogie weight, Bogie dimensions, wheel profile etc
	b. Shall demonstrate the testing and commissioning of BTTs turning with and without bogie, alignment of BTTs after locking, rollover of train etc as decided by Engineer/Employer.	b. Shall attend and provide necessary support to DM&P Contractor during testing and commissioning as necessary.

Item	DM&P Contractor	RS Contractor
8. Bogie Manipulator (BFM)	a. Shall collect all relevant details for all types of bogies weight, Bogie dimensions (with wheel and without wheel) and frame weight and dimensions, etc for all types of bogies for the effective design of machine and manufacture the machine accordingly.	a. Shall provide all relevant details regarding bogie weight, Bogie dimensions (with wheel and without wheel) and frame weight and dimensions, etc.
	b. Shall demonstrate the testing and commissioning of BTTs turning with and without bogie, alignment of BTTs after locking, rollover of train etc as decided by Engineer/ Employer.	b. Shall attend and provide necessary support to DM&P Contractor during testing and commissioning as necessary.
9. Bogie Testing Unit (BTU)	a. Shall collect all relevant details regarding bogie weight, dimensions, wheel profile, height etc of all types of Bogies for the effective design of BTU and manufacture the BTU accordingly.	a. Shall provide all relevant details regarding bogie weight, dimensions, wheel profile, height etc
	b. Shall demonstrate the testing and commissioning of BTU with bogie.	b. Shall attend and provide necessary support to DM&P Contractor during testing and commissioning as necessary.
10. TTCV	a. Shall collect all relevant information and details of type of coupler of RS and provide the TTCV coupler with compatibility accordingly.	a. Shall provide all relevant information and details of type of coupler of RS.
11. Driver Desk Simulator	a. Shall collect all relevant information and details including desk control, other controls etc of RS and design the simulator accordingly.	a. Shall provide all relevant information and details of RS desk control and other details required to design the Simulator.
12. Maintenance Desk Simulator	a. Shall collect all relevant information and details RS and its subsystem to design the simulator accordingly.	a. Shall provide all relevant information and details of RS and its subsystem required to design the Maintenance Simulator.
13. General	a. DM&P Contractor shall ensure all the interface requirements pertaining to RS Contractor are shared and agreed mutually.	a. RS Contractor shall ensure all the interface requirements pertaining to DM&P Contractor are shared and agreed mutually.

Item	DM&P Contractor	RS Contractor
	b. DM&P Contractor shall prepare Detailed Interface document (DID) and shall ensure that it covers Design, Interface Hazard log, Construction, Testing & Commissioning, Test report formats, Maintenance as applicable.	b. RS Contractor shall provide the necessary information and support as requested by DM&P Contractor.

12 TUNNEL VENTILATION SYSTEM

12.1 General

- 12.1.1 This section describes the interface requirements between Rolling Stock (RS) Contract and Tunnel Ventilation System (TVS) Contractors.
- 12.1.2 ~~TVS system will be awarded as a separate contract for Phase 1 corridors.~~ There is possibility of having multiple contracts for TVS Contractor. RS Contractor shall interface accordingly with more than one designated Contractor.
- 12.1.3 The Contractors shall ensure that all the requirements of the Metro Railway General Rules are duly met by incorporating appropriate alarms, remote commands and other features.
- 12.1.4 The Contractors as above shall ensure that all requirements of the Specification pertaining to interfaces are properly satisfied.
- 12.1.5 All Interface Meetings, unless specifically approved by CMRL shall be held at site and they shall be given sufficient notice to attend the meeting.
- 12.1.6 Each Contractor shall be responsible for interface identification, establishment, construction and testing works either in the capacity as the Lead Contractor or Participating Contractor.

12.2 Interface Management

- 12.2.1 TVS Contractor shall be the Lead Contractor. The Lead Contractor will be responsible to initiate, plan, coordinate and produce jointly with the Participating Contractors all the required interfaces and interface design documents and interface progress reports for submission to CMRL for acceptance. The Lead Contractor will also prepare and issue all interface meeting minutes after incorporating RS Contractors comments within 3 days of the meeting and provide bi weekly interface progress reports to all the participating Contractors for information. Later, forwarding of issued minutes of meeting and bi weekly interface progress reports to respective Engineers shall be responsibility of concerned Contractors.
- 12.2.2 RS Contractor will be participating Contractors. The Participating Contractors shall collaborate fully with the Lead Contractor in the development and finalization of the interface design, joint production of the interface documents and interface progress reports.
- 12.2.3 All the participating Contractors shall ensure that copy of the Interface design documents submitted to CMRL of the RS Contractor shall also be submitted to the concerned team (will be intimated by CMRL) to participate in the Interface Meetings.
- 12.2.4 The costs for all interface design and testing works shall be deemed to be included in the Contract sum regardless of the actual extent of effort required or expended by the Contractor.
- 12.2.5 The Contractors shall be fully responsible for the management and control of his sub-contractors in relation to all interfacing activities carried out under the Contract.
- 12.2.6 RS Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of the trains till completion of TVS Contractor defect liability period. TVS Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of trains till completion of RS Contractor defect liability

period.

12.3 Integrated Testing and Commissioning:

12.3.1 RS & TVS Contractors shall perform Integrated Testing.

12.3.2 Both Contractors shall jointly produce a protocol document for Integrated Testing and Commissioning which shall be submitted for CMRL review and approval.

12.4 INTERFACE- Division of Responsibility

12.4.1 RS Contractor shall provide necessary details as required by TVS Contractor and vice-versa. These shall include but not limited to the following,

S.No.	Item	RS Contractor	TVS Contractors
1	Train Configuration	RS Contractor shall provide the details of: - train configuration, - kinematic envelope, - structural gauge - average empty car weight, - train rolling resistance coefficient - skin friction coefficient - drag coefficient of the Rolling Stock, and any other data required by the TVS Contractor to verify the necessary Subway Environmental Simulation / IDA Tunnel and 3-dimensional CFD analyses.	TVS Contractor shall obtain the necessary inputs for Train Physical Data to verify and validate the Subway Environmental Simulation / IDA Tunnel and 3-dimensional CFD analyses.
2	Fire Load	RS Contractor shall provide the details of: - train design heat release rate - fire growth rate and curve - heat of combustion - soot yield - CO yield material composition for the train walls, train floor and the seats	TVS Contractor shall obtain the necessary inputs for the Fire Load parameters to verify and validate the Tunnel Ventilation System design and TVF/OTE fan capacities.
3	Auxiliaries Heat Release	RS Contractor shall provide: - the location and details of braking / traction equipment - sensible and latent heat rejection from auxiliaries - power consumption of auxiliaries - regeneration braking effectiveness - regeneration braking efficiency and any other data required by the TVS Contractor to verify and validate	TVS Contractor shall obtain the necessary inputs for the Auxiliaries Heat Release parameters to verify and validate the required fan flow capacities during normal and congested operations.

S.No.	Item	RS Contractor	TVS Contractors
		the required fan flow capacities during normal and congested operations.	
4	VAC Unit	RS Contractor shall provide: - the location and details of train air conditioning unit - Condenser fan flowrate - fan diameter - nominal and crush-loaded passenger loading capacities - AC unit COP - AC unit off-loading / cut-off temperature and any other data required by the TVS Contractor to verify and validate the required fan flow capacities during normal and congested operations.	TVS Contractor shall obtain the necessary inputs for the Train VAC Unit parameters to verify and validate the required tunnel ventilation fan flow capacities during normal and congested operations.
5	Not used.		
6	Train Performance Data	RS Contractor shall provide: - the train speed and respective tractive effort at those speeds, - acceleration rate - deceleration rate - max operating speed - design operating speed in tunnels and any other data required by the TVS Contractor to verify the necessary Subway Environmental Simulation / IDA Tunnel analyses.	TVS Contractor shall obtain the necessary inputs for Train Performance Data to verify and validate the Subway Environmental Simulation / IDA Tunnel analyses.
7	Detailed Interface document (DID)	RS Contractor shall provide the necessary information as requested by TVS Contractor.	TVS Contractor shall prepare DID and shall ensure that it covers Design, Interface Hazard log, Construction, Testing & Commissioning, Test report formats, Maintenance, etc.,

13 OTHER DESIGNATED CONTRACTOR

13.1 General

- 13.1.1 Besides above there are few other designated Contractors who would need the information regarding the design features and other parameters of the Rolling Stock. Their contracts shall have the provisions to interface directly with the RS Contractor for the exchange of information. The details of these contracts and Contractors shall be made available to RS Contractor during the execution of the Contract.

14 OTHER ROLLING STOCK CONTRACTOR

14.1 General

- 14.1.1 This section describes the interface requirements between the RS Contractor and the other RS Contractors (ARE01).
- 14.1.2 The Contractors shall ensure that all the requirements of the Metro Railway General Rules are duly met by incorporating appropriate alarms, remote commands and other features.
- 14.1.3 The Contractors as above shall ensure that all requirements of the Specification pertaining to interfaces are properly satisfied.
- 14.1.4 All Interface Meetings, unless specifically approved by CMRL shall be held at site and they shall be given sufficient notice to attend the meeting.
- 14.1.5 Each Contractor shall be responsible for interface identification, establishment, construction and testing works either in the capacity as the Lead Contractor or Participating Contractor.
- 1 14.1.6 Besides above there are RS Contractors of other corridors of CMRL phase 1 & Phase 1 Extn. network who would need the compatibility & inter-operability information of the Rolling Stock of this contract. Their contracts shall have the provisions to interface directly with the RS Contractor for this exchange of information. The details of these contracts and Contractors shall be made available to RS Contractor during the execution of the Works.
- 1 14.1.7 Below mentioned minimum features shall be interfaced with other RS Contractors operating in CMRL phase 1 & Phase 1 Extn. network. Any other additional features required during the project execution stages shall also be interfaced by the RS Contractor:
- a) Rake's Front end & rear end couplers
 - b) Rake's Front end & rear end Anti climbers
 - c) Pit Jack's lifting points of each coach
 - d) Wheel profiles
 - e) Any other features which shall be required for operation of two different trains operated in ATO mode.

14.2 Interface Management

- 14.2.1 ARE05 RS Contractor shall be the Lead Contractor. The Lead Contractor will be responsible to initiate, plan, coordinate and produce jointly with the Participating Contractors a list of all the required interfaces, interface design documents and interface progress reports for submission to CMRL for acceptance. The Lead Contractor will also prepare and issue all interface meeting minutes after incorporating ARE01 Contractors comments within 3 days of the meeting and provide bi weekly interface progress reports to all the participating Contractors for information. Later, forwarding of issued minutes of meeting and bi weekly interface progress reports to respective Engineers shall be responsibility of concerned Contractors.
- 14.2.2 The respective ARE01 Contractor will both be participating Contractors. The Participating Contractors shall collaborate fully with the Lead Contractor in the development and finalization of the interface design, joint production of the interface documents and interface progress reports.
- 14.2.3 All the participating Contractors shall ensure that copy of the Interface design documents submitted to CMRL is circulated to the concerned team (will be intimated by CMRL) that will participate in the Interface Meetings.
- 14.2.4 The costs for all interface design and testing works shall be deemed to be included in the Contract sum regardless of the actual extent of effort required or expended by the Contractor.
- 14.2.5 The Contractors shall be fully responsible for the management and control of his Sub-contractors in relation to all interfacing activities carried out under the Contract.

14.3 Integrated Testing and Commissioning:

14.3.1 ARE05 & ARE01 Contractors shall perform an Integrated Testing.

14.3.2 Both Contractors shall jointly produce a protocol document for Integrated Testing and Commissioning which shall be submitted for CMRL review and approval.

14.4 INTERFACE- Division of Responsibility

14.4.1 The ARE05 Contractor shall provide necessary details as required by other RS Contractor and vice-versa. These shall include but not limited to the following,

S.No.	Item	ARE05 Contractor	ARE01 Contractors
1	Train Configuration	a) Rake's Front end & rear end couplers. b) Rake's Front end & rear end Anti climbers . c) Pit Jack's lifting points of each coach. d) Wheel profiles. e) Any other features which shall be required for operation of two different trains operated in- ~~ATO~~ UTO mode.	ARE05 Contractor shall adopt the necessary information as provided by ARE01 Contractor
2	Detailed Interface document (DID)	ARE05 Contractor shall prepare DID and shall ensure that it covers Design, Interface Hazard log, Construction, Testing & Commissioning, Test report formats, Maintenance, etc.,	ARE01 Contractor shall provide the necessary information as requested by RS Contractor.

APPENDIX D – GUIDELINES AND DRAWINGS

Appendix No.	Description
D1	Schedule of Dimensions (SOD) for Standard Gauge 1435mm CMRL Phase 1 Project (R12)
D2	Alignment Data
D2.1	Alignment Data Corridor 1
D2.2	Alignment Data Corridor 2
D2.3	Alignment Data Corridor 1 extension
D2.4	Phase I Metro Network map
D2.5	Alignment Data Koyambedu Depot
D2.6	Alignment Data Wimco Nagar Depot
D3	Procedure for safety Certifications and technical clearance of Metro systems
D4	Guidelines for noise and vibrations for Metro Rail transit system
D5	Metro Railways General Rules
D6	The Railways Opening for Public Carriage of Passengers Rules, 2000
D7	Opening of Metro Railways for Carriage of Passengers Rules, 2013
D8	Koyambedu Depot Layout Drawings
D9	Speed Restriction Data of CMRL Phase 1 and Phase 1 extension network

Link to download the files:

https://cmrlindia-my.sharepoint.com/:f/g/personal/bhavya_s_cmrl_in/lqD_7Qta1bISRazPOb0StliqAVBPjdaQEeq0espE3VaDSL0?e=IxxXe

D1 to D9 files updated in the above link.

Note : The reference documents / drawings included under this section are for general information only and any interpretation of the results shall be construed as opinions only and not as representations as to the actual site conditions. The accuracy or reliability of the documents / drawings included under this section and of any other information supplied, prepared at any time by the Employer or others in connection with the Contract is not warranted.

APPENDIX E : SUPPLY OF SPARES & SPECIAL TOOLS

1.1 GENERAL

- 1.1.1 The Contractor shall supply the following items of spares:
- Unit Exchange Spares
 - Consumable spares for maintenance of all trains during commissioning, service trials and up to completion of Defect Notification Period / Warranty period
 - Mandatory spares
 - Recommended spares
 - Overhauling spares
 - Special tools, Testing and Diagnostic equipment
 - Special Jigs, Fixtures & Gauges required for maintenance, repair and overhaul of various equipment, sub-systems in particular and the complete trains in totality
- 1.1.2 The relevant list of the spares mentioned above shall be submitted in the technical bid after blanking the prices, where applicable. The financial bid shall have the price details.
- 1.1.3 Contractor shall submit technical specifications of the items used in this project. CMRL views if any, shall be suitably incorporated.
- 1.1.4 Contractor shall provide the list of equivalent indigenous consumables and spares with all relevant technical specifications and any other details as required.
- 1.1.5 The Contractor agrees to provide all necessary spares for a period of ten (10) years after the completion of Defect Notification Period (DNP), at the request of CMRL, the prices quoted in the tender documents, subject to the Price Adjustment as per sub-clause 13.8 of PCC.
- 1.1.6 The Contractor shall carry sufficient inventories to ensure an ex- stock supply of consumable spares for the plant and equipment. Other spare parts and components shall be supplied as promptly as possible, but at the most within six (6) months of placing the order.
- 1.1.7 In addition, in the event of termination of the production of spare parts, advance notification will be made to the Employer of the pending termination, with sufficient time to permit the Employer to procure the needed requirement. Following such termination, the Contractor will furnish to the extent possible and at no cost to the Employer the blueprints, drawings and specifications of the spare parts, if requested.

1.2 UNIT EXCHANGE SPARES

- 1.2.1 Contractor shall supply the Unit Exchange Spares as listed in the Appendix GA-1 of Part 1 Section 4 – Bidding forms. The Unit Exchange Spares shall be supplied in the Depot nominated by CMRL. The delivery requirements of different lots are mentioned in the Price Centre G of Part 1 Section 4 – Bidding forms. These shall be delivered as per the milestone dates defined.

1.3 CONSUMABLE SPARES

- 1.3.1 The consumable spares shall include lubricants, oils, greases, sealants, brake pads, filter medias, gaskets, lamps, wearable parts like pantograph strips etc. and any other item, whose declared life is less than 1 year.
- 1.3.2 The consumable spares shall be stored at respective depots of the corridors.
- 1.3.3 The Contractor shall provide a recommended list of consumable spares as noted above for maintenance, repairs and overhaul of trains. Any consumable item if required but not included in the above recommended list by Contractor will be deemed to have been included and shall be supplied as per the provisions of this contract without any extra financial implication to CMRL.

- 1.3.4 Contractor will be required to supply only the requisite quantity of spares, as required irrespective of the quantities indicated by the contractor in the recommended list. CMRL decision in determining any particular item(s) as consumable in line with 1.3.1 above will be final and binding. In case any changes are required in the supply of consumables on account of changes at design stage, the contractor shall have to supply the required consumables within the quoted cost. No increase in per unit quoted cost shall be made due to any change in the list of consumables arising due to change/modification of design.
- 1.3.5 Unpriced list of consumable spares shall be furnished in the Technical Package. List of consumable spares shall contain following information as a minimum:
- a) Names, addresses, telephone numbers and other particulars of OEM
 - b) OEM local representative's details
 - c) Models and part numbers
 - d) Full description of spares including a note whether it is sealed unit or an assembly or sub-assembly which can be broken down into component parts;
 - e) Quantity installed in the system;
 - f) Expected consumption rates;
 - g) Overall dimensions and weight including minimum packing (if any) for shelf space purposes;
 - h) Interchangeability or otherwise with similar parts;
 - i) Normal manufacturing and shipment lead times; and
 - j) Shelf life.
- 1.3.6 It shall be the responsibility of the Contractor to maintain sufficient stock of consumable spares at respective depots of different lines during commissioning, service trials and up to completion of Defect Notification/Warranty period. At the end of Defect Notification Period/Warranty period, the Contractor shall restore the total quoted quantity of Consumable spares at the respective depots.
- 1.3.7 The list of consumable spares recommended by system / sub-system / equipment manufacturers shall be furnished by the Contractor as part of design submission for respective systems / subsystems / equipment.

1.4 MANDATORY SPARES

- 1.4.1 The Contractor shall supply the Mandatory Spares as listed in the Appendix GA-2 of Part 1 Section 4 – Bidding forms. The Spares shall be supplied in the Depot nominated by CMRL. The items and quantity required are mentioned in the list in Price Centre G of Part 1 Section 4 – Bidding forms. The price of these spares shall be quoted at actual.
- 1.4.2 No change in quoted cost of any spare will be allowed even when there is change in design of any equipment / sub-system during execution of the contract. However, Contractor shall provide the cost of such additional/modified item for the information of CMRL as 'non-billable'.
- 1.4.3 Contractor will furnish complete details during contract execution (detailed design stage) as noted below for the listed spares;
- a) Names, addresses, telephone numbers and other particulars of manufacturers and their local representatives;
 - b) Models and part numbers
 - c) Full description of spares including a note whether it is sealed unit or an assembly or sub-assembly, which can be broken down into component parts;
 - d) Quantity installed in the system;

- e) Overall dimensions and weight including minimum packing (if any) for shelf space purposes;
- f) Designed and shelf life;
- g) Interchangeability or otherwise with similar parts;
- h) Normal manufacturing and shipment lead times;
- i) Purchase Technical Specification with relevant drawings

1.4.4 The information as above shall also be given for all other components / equipment etc. which may have to be changed / replaced during maintenance as decided by CMRL based on the proposed maintenance practices of the contractor.

1.5 RECOMMENDED SPARES

- 1.5.1 Contractor shall furnish priced list of the recommended spares, not covered under Unit Exchange Spares, consumables and mandatory spares but are expected to be required during 2 years after expiry of Defect Notification period, along with the bid as per details enclosed in Appendix GA-3 of Part 1 Section 4 – Bidding forms. The Spares shall be supplied in the Depot nominated by CMRL.
- 1.5.2 Contractor shall supply all the spares recommended by equipment / sub-system manufacturers within the quoted cost for recommended spares. Contractor shall furnish list of spares recommended by equipment / sub-system manufacturers at design submission stage.

1.6 OVERHAULING SPARES

- 1.6.1 Contractor shall supply the overhauling kits for One trainset. The price of overhauling kits for One trainset shall be included in the Contract. Overhauling kits for all those equipment, systems, sub-systems of trains that will need overhauling during intermediate overhaul of the train will be included in these kits. Contractor shall submit the list of such kits and if possible the details of the items in the kits in technical offer.
- 1.6.2 Contractor shall quote the price of the kits at actual price (not an apportioned price). The value of these spares shall form part of the evaluation.
- 1.6.3 In addition to above, CMRL may procure additional overhauling kits (for IOH) at the quoted price with Price Adjustments as applicable.
- 1.6.4 Any item if required as per OEM's documents but not included in the above recommended list by the Contractor will be deemed to have been included and shall be supplied as per the provisions of this contract without any extra financial implication to CMRL.

1.7 SPECIAL TOOLS, TESTING AND DIAGNOSTIC EQUIPMENT:

- 1.7.1 Contractor shall provide 2 sets of recommended list of Special Tools, Testing & Diagnostic Equipment separately for preventive and breakdown maintenance, overhauling and diagnostics of various equipment provided in the cars. These shall be delivered at maintenance Depots of CMRL. The unpriced list of set of such equipment together with the details and description of such equipment shall be furnished along with the bid in the technical package.
- 1.7.2 Any Special Tools, Testing and Diagnostic Equipment required for preventive and breakdown maintenance, overhauling and diagnostics of various equipment and recommended by OEMs shall be included in the recommended list by Contractor. The Contractor within the quoted cost shall supply any items that are not specifically included by Contractor in the recommended list but is recommended by the OEMs. List of items recommended by the OEMs shall be furnished as part of detailed design submission. This list shall however be suitably augmented based on information supplied by OEM to CMRL.

- 1.7.3 All items of Special Tools, Testing and Diagnostic equipment supplied by the Contractor, shall be accompanied by drawings, manuals and full operating instructions to enable them to be used by suitably skilled (but not necessarily specially trained) personnel in a non-hazardous manner and to achieve the desired result in terms of accuracy and quality. Each set of these equipment will be provided along with individual set of these drawings, manuals and full operating instructions.
- 1.7.4 Contractor shall provide the means and instructions which describe the parameters of each item of Special Tools, Testing and Diagnostic Equipment that are critical to their proper methods of use and which enable the staff using the equipment to achieve the proper performance and operation. Such means and instruction shall include, but not be limited to any routine checking or re-calibration, needs for the tool or test equipment itself. Demonstration of the use of these special tools, testing and diagnostic equipment to the satisfaction of CMRL shall be provided by the contractor.
- 1.7.5 Relevant details of Special Tools, Testing and Diagnostic equipment on the same lines as asked for mandatory spares above shall be furnished by the contractor.
- 1.7.6 CMRL at his sole discretion may decide to increase / decrease the quantity of procurement to any extent.
- 1.7.7 Delivery schedule of all items of Special Tools, Testing and Diagnostic equipment shall be linked with Key Date mentioned in Price Centre G of Part 1 Section 4 – Bidding forms.

1.8 SPECIAL JIGS, FIXTURES AND GAUGES

- 1.8.1 Contractor shall provide 2 sets of recommended list of Special Jigs, Fixtures and Gauges separately for preventive and breakdown maintenance, overhauling and diagnostics of various equipment provided in the cars. These shall be delivered at maintenance Depots of CMRL. The unpriced list of such equipment together with the details and description of such equipment shall be furnished along with the bid in the technical package.
- 1.8.2 Any Special Jigs, Fixtures and Gauges required for preventive and breakdown maintenance, overhauling and diagnostics of various equipment and recommended by OEMs shall be included in the recommended list by the Tenderer. Tenderer shall note that the list enclosed at Annexure PBS of "Price Bid Submission Sheet" is indicative and Tenderer is expected to incorporate any additional items which may be required during maintenance as recommended by OEMs. The Contractor within the quoted cost shall supply any items that are not specifically included by Contractor in the recommended list but is recommended by the OEMs. List of items recommended by the OEMs shall be furnished as part of detailed design submission.
- 1.8.3 All items of Special Jigs, Fixtures and Gauges supplied by the Contractor, shall be accompanied by drawings, manuals and full operating instructions to enable them to be used by suitably skilled (but not necessarily specially trained) personnel in a non-hazardous manner and to achieve the desired result in terms of accuracy and quality. Each set of these equipment will be provided along with individual set of these drawings, manuals and full operating instructions.
- 1.8.4 The Contractor shall provide the means and instructions which describe the parameters of each item of Special Jigs, Fixtures and Gauges that are critical to their proper methods of use and which enable the staff using the equipment to achieve the proper performance and operation. Such means and instruction shall include, but not be limited to any routine checking or re-calibration, needs for the tool or test equipment itself. Demonstration of the use of these special tools, testing and diagnostic equipment to the satisfaction of CMRL shall be provided by the Contractor.
- 1.8.5 Relevant details of Special Jigs, Fixtures and Gauges on the same lines as asked for mandatory spares above shall be furnished by the Contractor.
- 1.8.6 Contractor shall note that supply of different spares, tools, equipment, jigs and fixtures etc. mentioned at different places in Employer's Requirements Technical Specification shall be over and above the spares, special tools, testing and diagnostic equipment, special jigs, fixtures and gauges to be supplied under cost centre 'G'. The cost for such items is deemed to be included in quoted price of the contract and no additional cost shall be payable.

- 1.8.7 Delivery schedule of all items of Special Jigs, Fixtures and Gauges shall be linked with Key Date as mentioned in Price Centre G of Part 1 Section 4 – Bidding forms.

1.9 MANUFACTURE, DELIVERY AND WARRANTY

- 1.9.1 The major spare parts ordered under the Contract shall be manufactured, works tested and inspected in accordance with the relevant quality system, suitably packed and labelled in accordance with Section 18-15 in Employer's Requirements Technical Specification "Storage, Packing, Crating and Marking" and delivered by the Contractor to the depot as directed by CMRL. All spares shall be subject to inspection by CMRL. In the event that any item is known to be going out of production, then the Contractor shall give advance notice to CMRL.
- 1.9.2 The warranty period of unit exchange, mandatory and overhauling spares, special tools, testing and diagnostic equipment, special jigs, fixtures and gauges, simulator or any other item / equipment delivered shall be:
- (i) either 24 months from the date of acceptance; or
 - (ii) up to expiry of the defect liability period of all trains, including the option trains, whichever is later.

1.10 PURCHASE OF SPARES FROM VENDORS

- 1.10.1 The Contractor shall furnish an undertaking that he has no objection whatsoever to and shall not in any way deter or obstruct CMRL, its licensee or its representative from dealing directly with the Contractor's Vendors for the purchase of the spares during the Contract period. The spares purchased shall be subject to inspection by CMRL.
- 1.10.2 Contractor shall obtain an undertaking from vendors, OEMs etc. at detailed design submission stage that they will deal directly with Employer for supply of spares, equipment and/or sub-systems.
- 1.10.3 COMMISSIONING AND DLP SPARES
- 1.10.4 The Contractor shall submit to CMRL for review a list of minimum spare parts that he intends to make available during the installation, erection, commissioning and defect liability periods.
- 1.10.5 The Contractor shall keep on Site, at his own cost, throughout the installation, erection, commissioning and defect liability periods, stocks of spare parts, as per the list to enable rapid replacement of any item found to be defective or in any way in non-conformance with the Specification.
- 1.10.6 The Contractor shall generally not be entitled to use any of CMRL's spare parts during the installation, erection and commissioning periods or during the Defects Liability Period.
- 1.10.7 Contractor shall not be permitted to remove any working / healthy equipment / components / sub-systems / systems from any of the train available at any of the depot for any reason whatsoever without specific approval in writing from the CMRL Depot Incharge.
- 1.10.8 Spares as per the agreed list shall be supplied at least 3 months before receipt of first/pilot train. Stocks of such spares as available in Contractor stores will be jointly checked with CMRL every 3 months. Certificate by CMRL confirming availability of the spares in contractor stores in Depots as per agreed list will be a pre-requisite for release of interim payments of the Contractor. However, this condition will not be applicable for 6 months before the expected expiry of the DLP period.

1.11 LIST OF SPARES

- 1.11.1 The Contractor shall ensure availability of spare parts for a period of 10 year from the last date of taking over of whole of Works.
- 1.11.2 If during the period of 10 years, the Contractor/OEMs intends to discontinue the manufacture of spare or replacement parts for the Rolling Stock, the Contractor shall immediately give notice to CMRL of such intention. CMRL shall be given the opportunity of ordering at contracted prices such quantities of such spare or replacement parts as CMRL shall reasonably require in relation to the anticipated life of the Rolling Stock.
- 1.11.3 In the event of Contractor failing to supply the spare parts in accordance with this Clause, he shall in respect of each item of spare, furnish free of cost to CMRL, the drawings, specifications, patterns and other information to enable CMRL to make or have made such spare parts. CMRL shall be entitled to retain the aforesaid drawings etc., for such time only as is necessary for the exercise by CMRL of his rights under this clause and the drawings, if the Contractor so requires, shall be returned by CMRL to the Contractor in good order and condition (fair wear and tear excepted).
- 1.11.4 Under such circumstances, the Contractor shall also grant to CMRL, without payment of any royalty or charge, full right and liberty to make or have made spare or replacement parts as aforesaid and for such purposes only to use, make and have made copies of all drawings, patterns, specifications and other information supplied by the Contractor to CMRL pursuant to the Contract.
- 1.11.5 The Contractor will so far as it is reasonably able to bind his sub-contractors to conform with the requirements of this Clause and shall, prior to entry into any sub-contracts, provide CMRL with full details of any sub-contractor who will not so conform in which event CMRL may direct the Contractor to seek an alternative sub-contractor.
- 1.11.6 If the Contractor fails to provide spare or replacement parts as described in this sub-clause and these are available from the Contractor's sub-contractor, CMRL shall have the right to obtain such spare and replacement parts from the sub-contractor or any other supplier and any additional cost incurred by CMRL shall be recoverable from the Contractor.
- 1.11.7 In case the Contractor is unable to supply spares in accordance with Clause above, he shall furnish, free of cost to CMRL, the drawings, specifications, and other technical details, to enable CMRL to manufacture parts, or have them manufactured. Such drawings and technical data shall be provided free of any charge or royalty, on the understanding that CMRL will use such data and drawings, only for the manufacture of parts for his own use.
- 1.11.8 The foregoing shall hold equally good for the Contractor, any or all of his sub-contractors, and vendors.
- 1.11.9 In the event that technological progress results in improved versions of spares and replacement parts, the latest version shall have the same plug compatibility, and spatial needs of its predecessor, to avoid modifications being required, to accept the up-graded version of the part.

APPENDIX G : DOCUMENTATION & DRAWING REQUIREMENTS

1.1 INTRODUCTION

- 1.1.1 The purpose of this document is to define the minimum standards for Documentation and Drawings provided by the Contractor for the purpose of the Works.
- 1.1.2 The format for Documentation (including Drawings and CAD files) has been predefined in order to optimise the exchange of information and maximise the use of CAD capabilities throughout the design process and execution of the Works.
- 1.1.3 The Contractor shall submit electronically all documents and drawings in agreed format to CMRL & GC. The Contractor shall also submit knowledge sharing presentations / drawings / documents to CMRL & GC.
- 1.1.4 Paper and drawing sizes shall be “A” series sheets as specified in BS 3429 or latest International Standards.
- 1.1.5 The documents shall be submitted in the following software unless otherwise stated, for the various electronic submissions required. Any formulae / micros / programmes used therein shall not be hidden / masked and must be visible and transparent without any compromise and shall be validated for the submissions. The following software compatible for use with Intel-Windows based computers shall be used, unless otherwise stated, for the various electronic submissions required:

<u>Document Type</u>	<u>Electronic Document Format</u>
Text Documents	MS office (latest) Professional version
Spread Sheets	
Data Base Files	
Presentation Files	
Programmes Version 2.0a	Primavera for Windows or any latest better tools
AATOCAD Graphics	AATOCAD 2019 (latest)
Photographic	Adobe Photoshop, Ver.4.0 or latest version
Desktop Publishing	Page Maker 6.5,5
CADD Drawings	AATOCAD 2019 (latest)

- 1.1.6 Media for Electronic File Submission: CMRL has established PMIS which will be web-based platform on cloud to monitor and track the progress of the whole project, tailored to match the specific needs of the project (refer Clause 16.17 for more details).
- 1.1.7 Internet File Formats / Standards
- The following guidelines shall be followed when the Contractor uses the Internet browser as the communication media to share information with CMRL.
 - All the data formats or standards must be supported by Microsoft Internet Explorer version 3 or above running on Windows NT and Windows 7 and/or upgraded version.
 - The following lists the file types and the corresponding data formats to be used on the Internet. The Contractor shall comply with them unless prior consent is obtained from CMRL's Requirement for a different Data format:

File Type	Data Format
Photo Image	Joint Photographic Experts Group (JPEG)
Image other than Photo	GIF or JPEG
Computer Aid Design files (CAD)	Computer Graphics Metafile (CGM)
Video	Window video (.avi)
Sound	Wave file (.wav)

- 1.1.8 The following states the standards to be used on Internet when connecting to database(s). The Contractor shall comply with them unless prior consent is obtained from CMRL's Requirement for a different standard:

Function to be Implemented	Standard to be Complied With
Database connectivity	Open Database Connectivity (ODBC)
Publishing hypertext language on World Wide Web	Hypertext Mark-up Language (HTML)

- 1.1.9 All documentation shall be provided in English language only. Any related documentation related to audio visual announcements shall also be submitted in Tamil language.

1.2 GENERAL REQUIREMENTS

1.1.10 General

- a) The Contractor shall adopt the standard format for Document / Drawings which will be shared by CMRL to the successful bidder.

1.1.11 Document & Drawing Numbering System

Project Code	Corridor	Package Code	Project wide	Issue Entity	Discipline	Sub- Discipline	Document Type	Sequential Number	Revision
1	2	3	4	5	6	7	8	9	10

- a) Project code: E.g., P1- CMRL Phase 1
 b) Corridor: E.g., C00- All Corridor
 c) Package code: E.g., ARE05
 d) Project wide: E.g., PRW
 e) Issue Entity: E.g., CMRL
 f) Rolling Stock-Discipline: E.g., RST
 g) Sub-Discipline: E.g., Car Body (CRB), Coupler and Draft Gear (CDG), Emergency Operator's desk (EOD), Passenger Doors (PDO)
 h) Document Type: E.g., Preliminary Design (PLD), Pre-Final Design (PFD), Final Design (FLD)

- i) Sequential Number: Contractor specific can be numbered as per product breakdown for design documents & Sequential Number auto generated for non-design documents in PMIS.
- j) Revision: Alphabetic for rejected and Numerical for NOWC / NONO.

1.1.12 Types of Drawing

- a) 'Manufacturing drawings' are special drawings prepared by the Sub-contractor / Original Equipment Manufacturer or fabricator of various items within the Works to facilitate manufacture or fabrication.
- b) 'As-built drawings' show the Works exactly as constructed or installed. They are usually prepared by amending the working drawings to take into account changes necessitated by site conditions and described in Site drawings. These drawings shall be completed on a regular basis as the works progress and shall not be left until completion of the entire works.

1.3 COMPUTER AIDED DESIGN & DRAUGHTING (CADD) STANDARDS

1.1.13 Introduction

Data input procedures between CMRL and the Contractors must be co-ordinated, and the key parameters used to form CAD data files must be standardised. The production of all CAD data files shall comply with the following requirements. The main objectives of the CAD standards are as follows

- a) To ensure that the CAD data files produced for Project are co-ordinated and referenced in a consistent manner.
- b) To provide the information and procedures necessary for a CAD user from one discipline or external organisation to access (and use as background reference), information from a CAD data file prepared by another discipline or external organisation.
- c) To standardise the information contained within CAD data files, which may be common to more than one discipline such as drawing borders, title boxes, grid lines etc.
- d) To establish procedures for the management of CAD data files.
- e) To ensure all Contractors use 'Model space' and 'Paper space' in the production of their CAD files'.

1.1.14 General

- a) To facilitate co-ordination between Contractors, it is a requirement that all drawings issued by Contractors for co-ordination or record purposes shall be produced using CAD methods. Drawings shall be issued in digital format in addition to the paper copies.
- b) The intent of the issue of digital information is to aid the related design by others. The definitive version of all drawings shall always be the paper or polyester film copies, which have been issued by the Contractor or organisation originating the drawing.
- c) Drawings and drawing packages issued for co-ordination, record purposes or for acceptance shall be accompanied by a complete set of the corresponding CAD data files.
- d) Any Contractor or organisation making use of the CAD data from others shall be responsible for satisfying him that such data is producing an accurate representation of the information on the corresponding paper drawing, which is satisfactory for the purpose for which he is using it. Provided the general principles of this section have been achieved by the originator of the CAD data, Contractors making use of the CAD data from others shall not be entitled to require alterations in the manner in which such CAD data is being presented to them.
- e) In particular, automatic determination of physical dimensions from the data file shall always be verified against the figured dimensions on the paper or polyester drawings. Figured dimensions shall always be taken as correct where discrepancies occur.

1.1.15 Terminology & Associated Standards / Guidelines

Any terminology used within this section that is ambiguous to the user shall be clarified with

CMRL Requirement. British Standard BS1192 is used in principle as a guide for drawing practice, convention, CAD data structure and translation.

1.1.16 Paper Drawings

- a) For the Project “Paper” drawings are considered to be the main vehicle for the receipt and transmittal of design and production information, typically plans, elevations and sections.
- b) The Project wide accepted media for the receipt and transmittal of “Paper” drawings will be paper and polyester film of various standards ISO ‘A’ sizes. The composition of this information shall be derived from a CAD “Model”.
- c) The CAD derived “Paper” drawing composition will reflect a window of information contained within a CAD “Model Space” file together with a selection of information contained within the associated CAD “Paper Space” file.

1.1.17 CAD Data Creation, Content & Presentation

A consistent method of CAD data creation, together with content and presentation is essential. The method of CAD “Model Space and Paper Space” creation is as follows:

a) Model Space Files

Typically, CAD “Model Space” files are required for general arrangement and location plans and will consist of a series of other “Model Space” referenced CAD files covering the total design extents at a defined building level (the number of referenced files should be kept to an absolute minimum). Data contained within a CAD “Model Space” files is drawn at full size (1:1) and located at the correct global position and orientation on the Project Grid / or defined reference points.

Each CAD “Model Space” file will relate to an individual discipline. Drawing border / text, match / section lines or detailed notation shall NOT be included within a CAD “Model Space” file. Dimensions shall be included within a CAD “Model Space” but located on a dedicated layer. Elevations, Long Sections and Cross Sections shall also be presented in CAD “Model Space” as defined above, but do not need to be positioned and orientated on the Project Grid.

b) Paper Space CAD Files

Paper Space” CAD files are utilised to aid the process of plotting “Paper” drawings and are primarily a window of the CAD “Model Space” file. A “Paper Space” CAD file will typically contain drawing borders, text, match or section lines & detailed notation. Once these files are initially set up and positioned, the majority of “Paper Drawing” plots at various approved scales are efficiently and consistently generated by displaying different combinations of element layers and symbology contained within the “Paper Space” file and the referenced “Model Space” files.

The purpose is to ensure that total co-ordination is achieved between the CAD “Model Space” file and the “Paper Drawing” output during the revision cycle of the design and production process. Duplicated data in “Model and Paper Space” files will not be acceptable unless an automatic update link exists between the two data sets. “Paper Space” files are not typically required as part of the CAD Media Receipt from the Contractors, unless specifically requested.

1.1.18 CAD Quality Control Checks

- a) Random CAD Quality Control Audits will be carried out by CMRL on all CAD media received and transmitted.
- b) These checks DO NOT verify the technical content of the CAD data received or transmitted (as this is the responsibility of the originating organisation), however compliance with Project CAD and Draughting Standards shall be checked.
- c) In addition, all the Contractors who transmit and receive CAD data from the Project shall have CAD quality control procedures in place. A typical quality control procedure shall contain CAD data quality checking routines coupled with standards for CAD data transmittal and archiving.

1.1.19 CAD Data Transfer Media and Format

When CAD data is received & transmittal between CMRL and the Contractor, the media shall be

as follows:

- a) Data Exchange Format - AATOCAD as stated above in clause 1.5.
- b) Operating System - Window NT 3.51 / Windows 11 and/or upgraded version.
- c) Data Transfer Media: web based platform.
- d) All media must be labelled on the data shield with (Name of Company, Project Title, Drawing Filenames (for diskettes only), and Diskette No. / Total No. of diskettes or Tape No. / Total No. of Tapes.)
- e) All media shall be submitted with a completed Form (CAD Disk/Tape Sheet).
- f) The Contractor must ensure the supplied media is free from virus.
- g) Sub-directories on tapes or disks are not permitted. If CAD Data is created using UNIX, archive commands must be un rooted.

1.1.20 CAD Media Receipt & Transmittal

- a) CAD Media Transmittal (from the Contractor to CMRL) - this will consist of the following:
 - i. CAD Digital Media [disk(s), CD's or tape (s)] shall typically contain CAD "Model Space" and "Paper Space" files.
 - ii. CAD data sheet.
 - iii. CAD issue / revision sheet.
 - iv. CAD Quality Checklist confirming compliance.
 - v. Plot of each "Model Space" file issued on an A1 drawing sheet (to best fit).
- b) The above CAD media will be collectively known as "CAD Media Transmittal Set". The CAD data file transmittal format required by CMRL from all Contractors shall be in AATOCAD.
- c) All CAD media received from Contractors will be retained by CMRL except for SCSI disk (if used) as an audit trail / archive of a specific Contractor's design evolution.
- d) CAD Media Receipt (from CMRL to the Contractor)
 - i. CAD media should normally be obtained from the respective designated Contractor(s), but should CMRL issue CAD media it will consist of, CAD Digital Media (disk (s) or tape (s)) typically contain only CAD "Model Space" files. CAD data sheet. CAD issue / revision sheet.
 - ii. The above CAD media will be collectively known as the "CAD Media Receipt Set". The CAD data file transmittal format used by CMRL to all Contractors will be in AATOCAD version as stated in clause 1.5.
 - iii. Each CAD transmittal disk / tape will be labelled with proper disk label as approved by CMRL. Any CAD data transmitted without this label is assumed to be provisional information not to have been quality checked and therefore not formally issued.

1.1.21 Revisions

- a) All 'Revisions', 'In Abeyance' and 'Deletions' shall be located on a common layer. This layer can be turned on or off for plotting purposes.
- b) The following example text indicates the current CAD file revision, i.e. 'Revision [A]'. This shall be allocated to a defined layer on all CAD "Model Space" files, in text of a size that will be readable when the CAD "Model Space" file is fitted to the screen, with all levels on.

1.1.22 Block Libraries, Blocks, & Block Names

- a) All Metro Railway Industry symbols produced as CAD Cells shall typically conform to international standards.
- b) All Blocks created shall be Primitive (i.e. NOT Complex) and shall be placed Absolute (i.e. NOT Relative).
- c) The Contractor's specific block libraries shall be transmitted to CMRL together with an associated

block library list containing the filename (max. 6 characters) and block description. The Contractor shall ensure that the library is regularly updated and circulated to all other users, together with the associated library listing.

- d) All Blocks of a common type, symbols or details should initially be created within a CAD “Model Space File” specifically utilised for that purpose. These files will be made available on request by CMRL.
- e) All Blocks created will typically be 2D unless 3D is specifically requested. In both instances they shall have an origin at a logical point located within the extents of each Block’s masked area or volume.

1.1.23 CAD Dimensioning

Automatic CAD Dimensioning will be used at all times. Any dimensional change must involve the necessary revision to the model space file. If the CAD Quality Control Checks find that the revisions have not been correctly carried out, the rejection of the entire CAD submission will result.

1.1.24 CAD Layering

All CAD elements shall be placed on the layers allocated for each different discipline. The layer naming convention to be adopted by the Contractor shall be submitted for acceptance and inclusion within these standards.

1.1.25 Line Thickness and Colour

To assist plotting by other users, the following colour codes will be assigned to the following line thickness / pen sizes.

Colour	Code No.	Line Thickness	Colour	Code No.	Line Thickness
Red	10	0.18	Blue	130	0.7
White	7	0.25	Orange	30	1.0
Yellow	2	0.35	Green	3	1.4
Brown	34	0.5	Grey	253	2.0

1.1.26 CAD Utilisation of 2D & 3D Files

Although the project standard is 2D CAD files, certain disciplines and Contractors may use 3D CAD files for specific applications or where the isolated use of 3D aids the design and visualisation process (i.e., Architecture, Survey and Utilities). In these specific instances 3D CAD data will only be transmitted if all other users can use this data. If this is not the case, 3D to 2D translation shall be processed by the creator prior to issue.

1.1.27 CAD File Numbering

- a) Contractors CAD File Numbering shall be described in 1.2.2 above.
- b) CMRL CAD File numbering unlike most of the Contractors, CMRL will not be required to produce numerous CAD files. This will follow the numbering system as mentioned in 1.2.1(iii)

1.1.28 CAD File Naming Convention - General

CAD “Model Space” files shall be named in accordance with general drawing conventions.

APPENDIX H - DELIVERABLES LIST

1.1 General

1.1.1 The Contractor shall prepare Design Submission Programme and submit to CMRL review. This shall include the anticipated programme of activities for the preparation, submission and review of Design Packages. This shall include, but not be limited to the following:-

- a. Preliminary Design submission
- b. Pre-final Design submission
- c. Final Design Submission
- d. Test procedures
- e. Design Interface Documents (DID)
- f. Integrated Test Procedures
- g. Test Reports
- h. All inspection and quality hold points
- i. As-built drawings and Manufacturing Drawings
- j. Interdependency and inter-relationship with Designated Contractors and their commissioning programme.
- k. various Plans and processes
- l. Any other submissions required for the Issue of NONO / NOWC in relation thereto.
- m. Assigned PMIS document number & its document submission plan.
- n. Respective Design Engineer & email.

1.1.2 Advice of “Notice of No Objection” (NONO) or “No Objection with Comment” (NOWC) by CMRL following submission shall not relieve the Contractor of any of its obligations, liabilities or responsibilities under the contract nor shall it create any obligations or liability on the part of CMRL.

Documents awarded NOWC / NONO will enable the Contractor to proceed on the basis of the Contractor’s documents; provided that in cases where NOWC is initially awarded, the Contractor agrees to continue efforts to fully addresses any comments made by CMRL to the full extent required to receive an award of NONO upon resubmission.

The Contractor shall not reject / fail to implement any such comments, suggestions or recommendations except for cases where to implement the same would result in a breach of contract by the Contractor or except where upon giving to the Employer a full explanation, the reasoning and justification is found to be fully acceptable to CMRL. Award of NONO shall also be subject to obtaining approval from RDSO and other Statutory authorities if it is applicable to the submitted document.

1.1.3 The documents listed under Table 21-2 is tentative. It shall be updated by the Contractor regularly in consultation / recommendations from CMRL.

1.2 TABLE - 1: DELIVERABLES MILESTONE

Sl. No.	Description	Time for Completion
1a	Submission of Compliance matrix for entire works	NTP + 63 days (Updated monthly)
1b	Submission of Design Submission Programme with all activities for entire work	NTP + 70 days (Updated monthly)
1c	Submission of Detailed Master Schedule programme with all activities for entire work	NTP + 70 days (Updated monthly)
2	Preliminary Design (PDR) – obtain No Objection With Comments (NOWC) from CMRL	NTP + 240
3	Pre-Final Design (PFDR) – obtain No Objection With Comments (NOWC) from CMRL	NTP + 450
4	Final Design (FDR) – obtain No Objection With Comments (NOWC) from CMRL	NTP + 550
5	Test Reports – obtain No Objection With Comments (NOWC) from CMRL	NTP + 1190
6	Submission of As built drawings as per the below condition. I. Preliminary Version - 84 days prior to delivery of Prototype Train to Depot. II. Final Version - 14 days prior DLP Completion.	
7	This Key date covers -Submission of Car history book. I. CHB (Manufacturing) - 14 days prior to delivery of each train arrival to Depot. II. CHB (Testing) – within 14 days after completion of testing of each train. III. CHB (DLP) - 14 days prior to completion of DLP completion.	
8	Obtain Notice of No Objection (NONO) from CMRL for the complete list of documents / drawings / reports mentioned in Design Submission Programme	NTP + 1300

1.3 TABLE - 2: DELIVERABLES LIST

Sl.No.	Reference	DESCRIPTION
Chapter 2 : System Requirements		
1	PDR-2-1	EMC-EMI-Control-Plan
2	PDR-2-2	Fire-Control-Plan
3	PDR-2-3	Compliance-Matrix
4	PFDR-2-1	Passenger-Capacity-Calculation
6	PFDR-2-3	Car-Weight-Distribution-Calculation
7	PFDR-2-4	Shock-&-Vibration-Plan
8	PFDR-2-5	Acoustics-Plan
9	PFDR-2-6	Vehicle-Dynamic-Analysis

1

Sl. No.	Reference	DESCRIPTION
10	PFDR-2-7	Estimated Train Harmonic Current
11	PFDR-2-8	Measure Taken on Radiated EMI
12	PFDR-2-9	Measure Taken on Inductive Interference
13	PFDR-2-10	Measure Taken on Conductive Interference
14	PFDR-2-11	Measure Taken on Magnetic Field
15	PFDR-2-12	Shock & Vibration Prediction Report
16	PFDR-2-13	Noise Level Prediction Report
17	PFDR-2-14	EMC-EMI Safety Assessment Report
18	PFDR-2-15	Life cycle cost
19	PFDR-2-16	Traction & Braking Performance
20	PFDR-2-17	Specific Energy Consumption Calculation
21	FDR-2-1	Factory level Test Specification of Car weight distribution
22	FDR-2-2	Test Specification of Climatic Chamber
23	FDR-2-3	Site level Test Specification of Shock & Vibration
24	FDR-2-4	Site level Test Specification of Stability Analysis
25	FDR-2-5	Site level Test Specification of Oscillation test
26	FDR-2-6	Site level Test Specification of Acoustics
27	FDR-2-7	Site level Test Specification of EMC & EMI
28	FDR-2-8	Site level Test Specification of Specific Energy Consumption
29	FDR-2-9	Site level Test Specification of Kinematic Envelope
30	RPT-2-1	Factory level Test Report of Car Weight Distribution
31	RPT-2-2	Test Report of Climatic Chamber
32	RPT-2-3	Site level Test Report of Shock & Vibration
33	RPT-2-4	Site level Test Report of Stability Analysis
34	RPT-2-5	Site level Test Report of Oscillation test
35	RPT-2-6	Site level Test Report of Acoustics
36	RPT-2-7	Site level Test Report of EMC & EMI
37	RPT-2-8	Site level Test Report of Specific Energy Consumption
38	RPT-2-9	Site level Test Report of Kinematic Envelope
Chapter 3 : Car Body Structure		
1	PDR-3-1	Train general arrangement and dimensions
2	PDR-3-2	General description of Carbody Structures
3	PDR-3-3	Carbody Structures FEA calculation plan
4	PDR-3-4	Car Finishes, Aesthetics and Models

1

Sl. No.	Reference	DESCRIPTION
5	PDR-3-5	General description and layout of Saloon & Cab Interiors
6	PDR-3-6	General description and layout of underframe & roof equipment
7	PFDR-3-1	Detailed design & drawings of Carbody Structures
8	PFDR-3-2	Kinematic Envelope Study
9	PFDR-3-2	Carbody Structures FEA calculation
10	PFDR-3-3	Carbody crashworthiness calculation including Collision Scenario Analysis
11	PFDR-3-4	Car End clearance calculation
12	PFDR-3-5	Detailed design & drawings of Saloon & Cab Interiors
13	PFDR-3-6	Final Kinematic Envelope Calculation and Drawings
14	PFDR-3-7	Ergonomic reports & Visibility study report for Cab Driver Desk
15	PFDR-3-9	Ergonomic report for saloon & Cab
16	PFDR-3-10	Design Specification & drawings of Signage and labelling
17	PFDR-3-11	Collision and Energy Absorption Calculation Report of Coupler System including Collision Scenario Analysis and rescue operation
18	PFDR-3-12	Technical Specification and drawings of Gangway
19	PFDR-3-13	Gangway Movement calculation
20	PFDR-3-14	System Description & Technical Specification of Smoke and Heat detection system
21	PFDR-3-15	Technical Specification & drawing of underframe & roof equipment
22	PFDR-3-16	Submission of Car manufacturing drawing for approval before start of manufacturing of cars
23	PFDR-3-17	Technical Specification & drawings of Equipment enclosures
24	PFDR-3-18	Technical Specification & drawings of Exterior accessories & fittings
25	PFDR-3-19	Strength Analysis of Saloon & Cab Interiors fittings
26	PFDR-3-20	Strength Analysis of Exterior fittings
27	PFDR-3-21	Carbody and sub-assemblies Inspection & test procedures and check sheets
28	PFDR-3-22	Technical Specification & drawings of Floor Covering
29	PFDR-3-22	Car fittings Inspection & test procedures and check sheets
30	FDR-3-1	Test Specification and procedure of Gangway
31	FDR-3-2	Test Specification and procedure of Floor
32	FDR-3-3	Test Specification and procedure including replacement procedure of Windscreen
33	FDR-3-4	Test Specification and procedure including replacement procedure of Windows
34	FDR-3-5	Test Specification and procedure of Seats

1

Sl. No.	Reference	DESCRIPTION
35	FDR-3-6	Test Specification and procedure of Saloon & Cab Interior fittings & Exterior fittings
36	FDR-3-7	Test Specification and procedure of Static Gauging
37	FDR-3-8	Test Specification and procedure of Kinematic Gauging
38	FDR-3-9	Test Specification and procedure of Straphangers Endurance
39	FDR-3-10	Test Specification and procedure of Floor Fire barriers
40	FDR-3-11	Test Specification and procedure of side walls and end walls Fire barriers
41	FDR-3-12	Car exterior and interior chemical cleaners submission and cleaning and washing procedure
42	FDR-3-13	Crashworthiness Analysis Approach and Test Plan
43	FDR-3-14	Test Specification and procedure of interior panels
44	RPT-3-1	Test reports of Gangway
45	RPT-3-2	Test reports of Floor
46	RPT-3-3	Test reports of Windscreen
47	RPT-3-4	Test reports of Windows
48	RPT-3-5	Test reports of Seats
49	RPT-3-6	Test reports of Saloon & Cab Interior fittings & Exterior fittings
50	RPT-3-7	Test reports of Static Gauging
51	RPT-3-8	Test reports of Kinematic Gauging
52	RPT-3-9	Test reports of Straphangers Endurance
53	RPT-3-10	Test reports of Floor Fire barriers
54	RPT-3-11	Test Specification and procedure of side walls and end walls Fire barriers
55	RPT-3-12	Test reports of interior panels
Chapter 4 : Coupler & Draft gear		
1	PDR-4-1	Product Description of Couplers
2	PFDR-4-1	Technical Description & Drawings of Couplers
3	PFDR-4-2	Technical Description & Drawings of Draft gear
4	PFDR-4-3	Technical Description & Drawings of Electrical Coupling
5	PFDR-4-4	Technical Description & Drawings of Electrical Jumpers
6	PFDR-4-5	Energy Absorption Calculation of Couplers
7	PFDR-4-6	Coupler Movement Calculation
8	FDR-4-1	Product level Test Specification of Couplers
9	FDR-4-2	Product level Test Specification of Draft gear
10	FDR-4-3	Product level Test Specification of Electrical Coupling

1

Sl. No.	Reference	DESCRIPTION
11	FDR-4-4	Product level Test Specification of Electrical Jumpers
12	FDR-4-5	Product level Test Specification of Energy Absorption of Couplers
13	FDR-4-6	Site level Test Specification of Coupler Movement
14	FDR-4-7	Site level Test Specification of Rescue Operation
15	RPT-4-1	Test Report of Couplers
16	RPT-4-2	Test Report of Draft gear
17	RPT-4-3	Test Report of Electrical Coupling
18	RPT-4-4	Test Report of Electrical Jumpers
19	RPT-4-5	Test Report of Energy Absorption of Couplers
20	RPT-4-6	Site level test Report of Coupler Movement
21	RPT-4-7	Site level test Report of Rescue Operation
Chapter 5 : Emergency Operator's Desk		
1	PDR-5-1	General Description of Emergency Operator's Desk
2	PFDR-5-1	Technical Description & Drawings of Emergency Operator's Desk
3	PFDR-5-2	Technical Description & Drawings of Windscreen
4	PFDR-5-3	Technical Description & Drawings of Wiper
5	PFDR-5-4	Technical Description & Drawings of Master Controller
6	PFDR-5-5	Technical Description & Drawings of Operating & Controlling Panel
7	PFDR-5-6	Technical Description & Drawings of Operator Seat
8	FDR-5-1	Product level Test Specification of Emergency Operator's Desk
9	FDR-5-2	Product level Test Specification of Windscreen
10	FDR-5-3	Product level Test Specification of Wiper
11	FDR-5-4	Product level Test Specification of Master Controller
12	FDR-5-5	Product level Test Specification of Operating & Controlling Panel
13	FDR-5-6	Product level Test Specification of Operator Seat
14	FDR-5-7	Factory level Test Specification of Wiper system
15	FDR-5-8	Factory level Test Specification of Operating & Controlling Panel
16	RPT-5-1	Test Report of Emergency Operator's Desk
17	RPT-5-2	Test Report of Windscreen
18	RPT-5-3	Test Report of Wiper
19	RPT-5-4	Test Report of Master Controller
20	RPT-5-5	Test Report of Operating & Controlling Panel
21	RPT-5-6	Factory level Test Report of Wiper system
22	RPT-5-7	Factory level Test Report of Operating & Controlling Panel

1

Sl. No.	Reference	DESCRIPTION
23	RPT-5-8	Factory level Test Report of Operator Seat
Chapter 6 : Passenger Doors		
1	PDR-6-1	General Description of Door System
2	PFDR-6-1	Technical Description & Drawings of Passenger Saloon Door system
3	PFDR-6-2	Technical Description & Drawings of Detrainment Door
4	PFDR-6-3	Evacuation Plan
5	FDR-6-1	Product level Test Specification of Saloon Door System
6	FDR-6-2	Product level Test Specification of Detrainment Door
7	FDR-6-3	Factory level Test Specification of Saloon Door System
8	FDR-6-4	Factory level Test Specification of Detrainment Door
9	FDR-6-5	Site level Test Specification of Evacuation Plan
10	RPT-6-1	Test Report of Saloon Door System
11	RPT-6-2	Test Report of Detrainment Door
12	RPT-6-3	Factory level Test Report of Saloon Door System
13	RPT-6-4	Factory level Test Report of Detrainment Door
14	RPT-6-5	Site level Test Report of Evacuation Plan
Chapter 7 : Ventilation and Air-conditioning		
1	PDR-7-1	General Description of VAC
2	PFDR-7-1	Technical Description & Drawing of VAC
3	PFDR-7-2	Technical Description & Drawing of Air Ducts
4	PFDR-7-3	Technical Description & Drawing of Air filters
5	PFDR-7-4	Heat Load Calculation
6	FDR-7-1	Product level Test Specification of VAC
7	FDR-7-2	Product level Test Specification of Air Ducts
8	FDR-7-3	Factory level Test Specification of VAC
9	FDR-7-4	Test Specification—Climatic Room Test for Complete Car
10	RPT-7-1	Test Report of VAC
11	RPT-7-2	Test Report of Air Ducts
12	RPT-7-3	Factory level Test Report of VAC
13	RPT-7-4	Test report—Climatic Room Test for Complete Car
Chapter 8 : Lighting		
1	PDR-8-1	Conceptual Design of Lighting System
2	PFDR-8-1	Technical Description & Drawing of Lighting System
3	FDR-8-1	Product level Test Specification of Lighting System

1

Sl. No.	Reference	DESCRIPTION
4	FDR-8-2	Factory level Test Specification of Lighting System
5	RPT-8-1	Test Report of Lighting System
6	RPT-8-2	Factory level Test report of Lighting System
Chapter 9 : Auxiliary Electrical Equipment		
1	PDR-9-1	Conceptual Design of APS
2	PDR-9-2	Conceptual Design of Battery & Battery Charger
3	PFDR-9-1	Technical Description & Drawings of APS
4	PFDR-9-2	Technical Description of APS—Circuit requirements
5	PFDR-9-3	Technical Description & Drawings of Battery
6	PFDR-9-4	Technical Description & Drawings of Battery Charger
7	PFDR-9-5	Technical Description & Drawings of Battery Control Box
8	PFDR-9-6	Technical Description & Drawings of Battery Box
9	PFDR-9-7	Calculation of Emergency Loads
10	PFDR-9-8	Energy Consumption Study & Simulation
11	PFDR-9-9	Train Earthing Concept
12	FDR-9-1	Product level Test Specification of APS
13	FDR-9-2	Product level Test Specification of Battery
14	FDR-9-3	Product level Test Specification of Battery Charger
15	FDR-9-4	Product level Test Specification of Battery Box
16	FDR-9-5	Product level Test Specification of Battery Control Box
17	FDR-9-6	Factory level Test Specification of APS
18	FDR-9-7	Factory level Test Specification of Battery Charging
19	RPT-9-1	Test Report of APS
20	RPT-9-2	Test Report of Battery
21	RPT-9-3	Test Report of Battery Charger
22	RPT-9-4	Test Report of Battery Control Box
23	RPT-9-5	Test Report of Battery Box
24	RPT-9-6	Factory level Test Report of APS
25	RPT-9-7	Factory level Test Report of Battery Charging
Chapter 10 : High Voltage & Propulsion system		
1	PDR-10-1	Conceptual Design of High Voltage Equipment's
2	PDR-10-2	Conceptual Design of Propulsion System
3	PFDR-10-1	Technical Description & Drawings of Pantograph
4	PFDR-10-2	Technical Description & Drawings of Vacuum Circuit Breaker

1

Sl. No.	Reference	DESCRIPTION
5	PFDR-10-3	Technical Description & Drawings of Earth Ground Switch
6	PFDR-10-4	Technical Description & Drawings of Lightning Arrestor
7	PFDR-10-5	Technical Description & Drawings of Current Transformer
8	PFDR-10-6	Technical Description & Drawings of Earth Brush
9	PFDR-10-7	Technical Description & Drawings of Main Transformer
10	PFDR-10-8	Technical Description & Drawings of Cable head
11	PFDR-10-9	Technical Description & Drawings of Propulsion System
12	PFDR-10-10	Technical Description of Propulsion System—Circuit Requirements
13	PFDR-10-11	Technical Description & Drawings of Traction Motor
14	PFDR-10-12	Technical Description & Drawings of Driving Gear
15	PFDR-10-13	Technical Description & Drawings of PWM Generator
16	PFDR-10-14	Train Performance & Characteristics
17	PFDR-10-15	Run Curve Study & Simulation
18	PFDR-10-16	Energy Consumption Study & Simulation
19	PFDR-10-17	Technical Description & Drawings of Neutral Section Detector
20	PFDR-10-18	Technical Description of EMI & EMC—HV & Propulsion System
21	FDR-10-1	Product level Test Specification of Pantograph
22	FDR-10-2	Product level Test Specification of Vacuum Circuit Breaker
23	FDR-10-3	Product level Test Specification of Earth Ground Switch
24	FDR-10-4	Product level Test Specification of Lightning Arrestor
25	FDR-10-5	Product level Test Specification of Current Transformer
26	FDR-10-6	Product level Test Specification of Earth Brush
27	FDR-10-7	Product level Test Specification of Main Transformer
28	FDR-10-8	Product level Test Specification of Cable head
29	FDR-10-9	Product level Test Specification of Propulsion System
30	FDR-10-10	Product level Test Specification of Traction Motor
31	FDR-10-11	Product level Test Specification of Driving Gear
32	FDR-10-12	Product level Test Specification of PWM Generator
33	FDR-10-13	Product level Test Specification of Neutral Section Detector
34	FDR-10-14	Factory level Test Specification of HV Equipment's
35	FDR-10-15	Factory level Test Specification of Propulsion System
36	FDR-10-16	Site level Test Specification of Propulsion System
37	FDR-10-17	Site level Test Specification of Neutral Section Detector
38	FDR-10-18	Site level Test Specification of Thermal Capacity

1

Sl. No.	Reference	DESCRIPTION
39	RPT-10-1	Test Report of Pantograph
40	RPT-10-2	Test Report of VCB
41	RPT-10-3	Test Report of EGS
42	RPT-10-4	Test Report of LA
43	RPT-10-5	Test Report of CT
44	RPT-10-6	Test Report of Earth Brush
45	RPT-10-7	Test Report of Main Transformer
46	RPT-10-8	Test Report of Cable Head
47	RPT-10-9	Test Report of Propulsion system
48	RPT-10-10	Test Report of Traction Motor
49	RPT-10-11	Test Report of Driving Gear
50	RPT-10-12	Test Report of PWM Generator
51	RPT-10-13	Test Report of NSD
52	RPT-10-14	Factory Level Test Report of HV Equipment's
53	RPT-10-15	Factory Level Test Report of Propulsion System
54	RPT-10-16	Site Level Test Report of Propulsion System
55	RPT-10-17	Site Level Test Report of NSD
56	RPT-10-18	Site Level Test Report of Thermal Capacity
Chapter 11 : Bogie Assembly		
1.	PDR-11-1	Conceptual Design of Bogies
2.	PFDR-11-1	Technical Description & drawings of Driving gear
3.	PFDR-11-2	Technical Description & Drawings of Wheel-Flange Lubricator
4.	PFDR-11-3	Technical Description & Drawings of Secondary suspension
5.	PFDR-11-4	Technical Description & Drawings of Primary suspension
6.	PFDR-11-5	Technical Description & Drawings of Derailment Detection and Obstruction Deflection Device
7.	PFDR-11-6	Technical Description & drawings of wayside Hot Axle measuring system
8.	PFDR-11-7	Technical Description & drawings of Wheel & Axle
9.	PFDR-11-8	Technical Description & drawings of Axle box
10	PFDR-11-9	Technical Description & drawings of Dampers
11	PFDR-11-10	Calculation of Un-sprung mass
12	PFDR-11-11	Life cycle calculation of Journal Bearing
13	PFDR-11-12	Wheel Stress calculations
14	PFDR-11-13	Axle strength calculations

1

Sl. No.	Reference	DESCRIPTION
15	PFDR-11-14	Thermal Calculations of Wheel
16	PFDR-11-15	FEA of Bogie Frame
17	PFDR-11-16	FEA of centre pivot
18	PFDR-11-17	FEA of axle box
19	PFDR-11-18	FEA of anti-roll bar
20	PFDR-11-19	FEA of Traction Linkage
21	PFDR-11-20	Design Description and analysis of stresses for Gear pinions, Gear case and transmission assembly
22	FDR-11-1	Vehicle Dynamics Simulation Studies
23	FDR-11-2	Product level Test Specification of Bogie frame
24	FDR-11-3	Product level Test Specification of complete Bogie
25	FDR-11-4	Test Specification of Dynamic running behaviour
26	FDR-11-5	Product level Test Specification of Secondary suspension
27	FDR-11-6	Product level Test Specification of Primary suspension
28	FDR-11-7	Product level Test Specification of Damper
29	FDR-11-8	Product level Test Specification of Wheel
30	FDR-11-9	Product level Test Specification of Axle
31	FDR-11-10	Product level Test Specification of Driving gear system
32	FDR-11-11	Product level Test Specification of Gearbox
33	FDR-11-12	Product level Test Specification of Bogie Movement & rotational resistance
34	FDR-11-13	Product level Test Specification of Wheel Flange Lubricator
35	FDR-11-14	Product level Test Specification of wayside Hot Axle measuring system
36	FDR-11-15	Product level Test Specification of Derailment Detection and Obstruction Deflection Device
37	FDR-11-16	Site level Test Specification of damping factor (wedge test)
38	FDR-11-17	Site level Test Specification of Bogie swing tests
39	FDR-11-18	Site level Test Specification of Derailment Detection and Obstruction Deflection Device
40	FDR-11-19	Site level Test Specification of Sway test
41	FDR-11-20	Site level Test Specification of wheel off loading
42	FDR-11-21	Factory level test specification of Interference between Carbody and Bogie
43	RPT-11-1	Test reports of Bogie Frame
44	RPT-11-2	Test reports of Complete Bogie
45	RPT-11-3	Test reports of Dynamic running behaviour
46	RPT-11-4	Test reports of Secondary suspension

1

Sl. No.	Reference	DESCRIPTION
47	RPT-11-5	Test reports of Primary suspension
48	RPT-11-6	Test reports of Damper
49	RPT-11-7	Test reports of Wheel
50	RPT-11-8	Test reports of Axle
51	RPT-11-9	Test reports of Driving gear system
52	RPT-11-10	Test reports of Gearbox
53	RPT-11-11	Test reports of Bogie movement
54	RPT-11-12	Test reports of Wheel Flange Lubricator
55	RPT-11-13	Test reports of wayside Hot Axle measuring system
56	RPT-11-14	Test reports of bogies rotational resistance (X factor)
57	RPT-11-15	Test reports of damping factor (wedge test)
58	RPT-11-16	Test reports of Bogie swing test
59	RPT-11-17	Test reports of Derailment Detection and Obstruction Deflection Device
60	RPT-11-18	Test reports of Sway test
61	RPT-11-19	Test reports of wheel off loading
62	RPT-11-20	Test reports of Interference between Carbody and Bogie
Chapter 12 : Pneumatic and Brake Equipment		
1	PDR-12-1	Conceptual Design of Pneumatic & Brake Equipment's
2	PFDR-12-1	Technical Description & Drawings of Brake Electronic Control Unit
3	PFDR-12-2	Technical Description & Drawings of Dynamometer
4	PFDR-12-3	Technical Description & Drawings of Reservoir
5	PFDR-12-4	Technical Description & Drawings of Air Compressor
6	PFDR-12-5	Technical Description of Pneumatic Piping & Controls
7	PFDR-12-6	Technical Description & Drawing of Brake Calliper
8	PFDR-12-7	Air consumption calculation with Duty cycle
9	PFDR-12-8	Brake calculation with Parking
10	PFDR-12-9	Technical Description & Drawings of Air Suspension system
11	PFDR-12-10	Technical Description of Protection schemes
12	PFDR-12-11	Wheel Slip / Slide Control & Protection
13	PFDR-12-12	Rescue Operation
14	PFDR-12-13	Thermal Capacity Calculation for Brake Disc
15	FDR-12-1	Product level Test Specification of Brake Electronic Control Unit
16	FDR-12-2	Product level Test Specification of Dynamometer
17	FDR-12-3	Product level Test Specification of Reservoir

1

Sl. No.	Reference	DESCRIPTION
18	FDR-12-4	Product level Test Specification of Air Compressor
19	FDR-12-5	Product level Test Specification of Pneumatic Piping
20	FDR-12-6	Product level Test Specification of Air Suspension
21	FDR-12-7	Product level Test Specification of Brake Calliper
22	FDR-12-8	Site level Test Specification of Protection Schemes
23	FDR-12-9	Site level Test Specification of Rescue Operation
24	FDR-12-10	Factory level Test Specification of Brake System
25	FDR-12-11	Factory level Test Specification of Compressor Duty Cycle
26	FDR-12-12	Site level Test Specification of Brake System
27	RPT-12-1	Test Report of BECU
28	RPT-12-2	Test Report of Dynamometer
29	RPT-12-3	Test Report of Reservoir
30	RPT-12-4	Test Report of Air Compressor
31	RPT-12-5	Test Report of Pneumatic Piping
32	RPT-12-6	Test Report of Air Suspension
33	RPT-12-7	Test Report of Brake Calliper
34	RPT-12-8	Test Report of Protection Schemes
35	RPT-12-9	Test Report of Rescue Operation
Chapter 13 : Communications		
1	PDR-13-1	General Description of PAPIS & CCTV System
2	PFDT-13-1	Technical Description & Drawing of PAPIS System
3	PFDT-13-2	Technical Description & Drawing of CCTV System
4	PFDT-13-3	PAPIS Message List
5	FDR-13-1	Test Specification of PAPIS System
6	FDR-13-2	Test Specification of CCTV System
7	FDR-13-3	Factory level Test Specification of PAPIS & CCVT System
8	FDR-13-4	Site level Test Specification of PAPIS & CCTV System
9	RPT-13-1	Test Report of PAPIS System
10	RPT-13-2	Test Report of CCTV System
11	RPT-13-3	Factory level Test Report of PAPIS & CCTV System
12	RPT-13-4	Site level test Report of PAPIS & CCTV System
Chapter 14 : Train Control Management System		
1	PDR-14-1	General Description of TCMS
2	PDR-14-2	General Description of Event Recorder

1

Sl. No.	Reference	DESCRIPTION
3	PDR-14-3	General Description of TCMS Interface
4	PFDR-14-1	Technical Description of TCMS & Drawing
5	PFDR-14-2	Technical Description of TCMS Architecture
6	PFDR-14-3	Technical Description of Event Recorder & Drawing
7	PFDR-14-4	Interface Description of TCMS – Propulsion system
8	PFDR-14-5	Interface Description of TCMS – APS System
9	PFDR-14-6	Interface Description of TCMS – Brake system
10	PFDR-14-7	Interface Description of TCMS – VAC system
11	PFDR-14-8	Interface Description of TCMS – Door system
12	PFDR-14-9	Interface Description of TCMS – PA & PIS system
13	PFDR-14-10	Interface Description of TCMS – CCTV system
14	PFDR-14-11	Interface Description of TCMS – Event Recorder system
15	PFDR-14-12	Interface Description of TCMS – Signalling system
16	PFDR-14-13	Interface Description of TCMS – Telecommunication system
17	PFDR-14-14	Interface Description of TCMS – PSD system
18	PFDR-14-15	Interface Description of TCMS – AMS system
19	PFDR-14-16	Interface Description of TCMS – Other Rolling Stock supplier
20	PFDR-14-17	Interface Description of TCMS – Fire Detection System
21	PFDR-14-18	Interface Description of TCMS – Obstruction Deflection Device
22	PFDR-14-19	Technical Description of HMI
23	PFDR-14-20	Technical Description of Fault Data Acquisition
24	PFDR-14-21	Technical Description of Control Features
25	PFDR-14-22	Technical Description of Diagnostic Features
26	PFDR-14-23	Technical Description of Troubleshooting Features
27	PFDR-14-24	Technical Description of Maintenance Tool
28	PFDR-14-25	Technical Description of Energy Consumption
29	PFDR-14-26	Technical Description of OCC GUI & RSC
30	FDR-14-1	Product level Test Specification of TCMS
31	FDR-14-2	Product level Test Specification of Event Recorder
32	FDR-14-3	Factory level Test Specification of TCMS
33	FDR-14-4	Factory level Test Specification of Event Recorder
34	FDR-14-5	Site level Test Specification of TCMS
35	FDR-14-6	Site level Test Specification of Event Recorder
36	FDR-14-7	Site level Interface Test Specification of TCMS – Propulsion system

1

Sl. No.	Reference	DESCRIPTION
37	FDR-14-8	Site-level Interface Test Specification of TCMS—APS System
38	FDR-14-9	Site-level Interface Test Specification of TCMS—Brake system
39	FDR-14-10	Site-level Interface Test Specification of TCMS—VAC system
40	FDR-14-11	Site-level Interface Test Specification of TCMS—Door system
41	FDR-14-12	Site-level Interface Test Specification of TCMS—PA & PIS system
42	FDR-14-13	Site-level Interface Test Specification of TCMS—CCTV system
43	FDR-14-14	Site-level Interface Test Specification of TCMS—Event Recorder system
44	FDR-14-15	Site-level Interface Test Specification of TCMS—Signalling system
45	FDR-14-16	Site-level Interface Test Specification of TCMS—Telecommunication system
46	FDR-14-17	Site-level Interface Test Specification of TCMS—PSD system
47	FDR-14-18	Site-level Interface Test Specification of TCMS—AMS system
48	FDR-14-19	Site-level Interface Test Specification of TCMS—Other Rolling Stock supplier
49	FDR-14-20	Site-level Interface Test Specification of TCMS—Fire Detection System
50	FDR-14-21	Site-level Interface Test Specification of TCMS—Obstruction Deflection Device
51	RPT-14-1	Test Report of TCMS
52	RPT-14-2	Test Report of Event Recorder
53	RPT-14-3	Factory-level Test Report of TCMS
54	RPT-14-4	Factory-level Test Report of Event Recorder
55	RPT-14-5	Site-level Test Report of TCMS system
56	RPT-14-6	Site-level Test Report of Event Recorder
57	RPT-14-7	Site-level Test Report of TCMS - Propulsion system
58	RPT-14-8	Site-level Test Report of TCMS—APS System
59	RPT-14-9	Site-level Test Report of TCMS—Brake system
60	RPT-14-10	Site-level Test Report of TCMS—VAC system
61	RPT-14-11	Site-level Test Report of TCMS - Door system
62	RPT-14-12	Site-level Test Report of TCMS—PA & PIS system
63	RPT-14-13	Site-level Test Report of TCMS—CCTV system
64	RPT-14-14	Site-level Test Report of TCMS—Event Recorder system
65	RPT-14-15	Site-level Test Report of TCMS—Signalling system
66	RPT-14-16	Site-level Test Report of TCMS—Telecommunication system
67	RPT-14-17	Site-level Test Report of TCMS—PSD system
68	RPT-14-18	Site-level Test Report of TCMS - AMS system

1

Sl. No.	Reference	DESCRIPTION
69	RPT-14-19	Site-level Test Report of TCMS—Other Rolling Stock supplier
70	RPT-14-20	Site-level Test Report of TCMS—Fire Detection System
71	RPT-14-21	Site-level Test Report of TCMS—Obstruction Deflection Device
Chapter 15 : System Support		
1	FDR-15-1	System Maintenance Philosophy
2	FDR-15-2	System Training Philosophy
3	FDR-15-3	System Training Plan
4	FDR-15-4	Operating Rule Book
5	FDR-15-5	Operating Procedure Manual
6	FDR-15-6	System Maintenance Manuals
7	FDR-15-7	Operating Manual & OEM Description
8	FDR-15-8	Operation Manual
Chapter 16 : Management Program		
1	PDR-16-1	Project Management Plan
2	PDR-16-2	Interface Management Plan
3	PDR-16-3	Test & Commissioning Plan
4	PDR-16-4	Delivery Plan
5	PDR-16-5	Health Environment & Safety Plan
6	PDR-16-6	Defect Notification Period Management Plan
7	PDR-16-7	Master Schedule
8	PDR-16-8	Configuration Control Management Plan
9	PDR-16-9	Weight Control Plan
10	PDR-16-10	Vendor Selection / Subcontractor list for Approval
11	FDR-16-1	Car History Book—Manufacturing (for All Trainsets)
12	FDR-16-2	Car History Book—Test & Commissioning (for All Trainsets)
13	FDR-16-3	Car History Book—Defect Notification Period (for All Trainsets)
14	FDR-16-4	Project Management Information System
15	FDR-16-5	As-Built Drawings
16	FDR-16-6	Manufacturing Drawings
17	FDR-16-7	Design Submission Program
18	RPT-16-1	Monthly Progress Report
Chapter 17 : Test Program		
1	PFDR-17-1	Master Test Program
2	FDR-17-1	Test Specification of Car Shell Structural Test

1

Sl. No.	Reference	DESCRIPTION
3	FDR-17-2	Test Specification of Compression Load Test
4	FDR-17-3	Test Specification of End Sill Load Test
5	FDR-17-4	Test Specification of Roof Load Test
6	FDR-17-5	Test Specification of Energy Absorption Test
7	FDR-17-6	Test Specification of Jacking Test
8	FDR-17-7	Test Specification of Fire barrier
9	FDR-17-8	Test Specification of Window Glass
10	FDR-17-9	Test Specification of Water tightness test of Carbody Shell
11	FDR-17-10	Test Specification of Water tightness test of Completed Car
12	FDR-17-11	Test Specification of Car Dimension check
13	FDR-17-12	Test Specification of Wiring Check (Bell Check)
14	FDR-17-13	Operational Performance / Service Trials
15	FDR-17-14	Test Specification of Multi-Consist Of Operation.
16	FDR-17-15	Test Specification of Electrical Control Panel / box
17	FDR-17-16	Test Specification of VCC test
18	FDR-17-17	Test Specification of Di-Electric, Earthing and Return Connection
19	FDR-17-18	Test Specification and procedure of stainless steel/ Aluminium and Structural steel
20	FDR-17-19	Test Specification and procedure of carbody shell watertightness
21	FDR-17-20	Test Specification and procedure of finished car watertightness
22	FDR-17-21	Test Specification and procedure of carbody structural loads test (DM & T-ears) including natural frequency test.
23	FDR-17-22	Test Specification and procedure of car & train level static and dynamic routine tests as per IEC 61133
24	FDR-17-23	Test Specification and procedure of car & train level static and dynamic type tests as per IEC 61133
25	FDR-17-24	Test Specification and procedure of integrated testing and commissioning
Chapter 18 : System Assurance		
1	PDR-18-1	System Safety Analysis – Preliminary
2	PDR-18-2	RAMS Demonstration Plan
3	PDR-18-3	System Assurance Plan
4	PDR-18-4	System Safety Plan
5	PDR-18-5	Preliminary Hazard Analysis
6	PDR-18-6	Inspection Plan
7	PDR-18-7	First Article Inspection

1

Sl. No.	Reference	DESCRIPTION
8	PDR-18-8	Manufacturing Plan
9	PDR-18-9	Site Management Plan
10	PDR-18-10	Road Traffic Management Plan
11	PDR-18-11	Storage Packing Management Plan
12	PDR-18-12	Quality Assurance Plan
13	PFDR-18-1	Hazard Log
14	PFDR-18-2	Failure Modes & Effects Criticality Analysis
15	PFDR-18-3	Sneak Circuit Analysis
16	PFDR-18-4	Operating and Support Hazard Analysis
17	PFDR-18-5	Fault Tree Analysis
18	PFDR-18-6	Hold Point Inspection
19	PFDR-18-7	System Safety Analysis—Pre final
20	PFDR-18-8	Fire Safety Analysis
21	PFDR-18-9	Reliability Program
22	PFDR-18-10	Maintainability Program
23	PFDR-18-11	Availability Program
24	PFDR-18-12	Inspection and test plan of complete car (Contractor and sub-vendors/Contractors)
25	PFDR-18-13	First article inspection FAI procedures and check sheets of complete car (Contractor and sub-vendors/Contractors)
26	FDR-18-1	System Safety Analysis—Final
Chapter 19 : Materials and Workmanship		
1	PFDR-19-1	Technical Specification of Cables
2	PFDR-19-2	Current Estimates of Cables
3	PFDR-19-3	Cable Duct Installation Drawings
4	PFDR-19-4	Wire numbering plan
5	PFDR-19-5	Train Earthing Concept
6	PFDR-19-6	Technical Specification & Drawings of FRP Panels
7	PFDR-19-7	Commercial material specifications
8	PFDR-19-8	List of substitute or single source materials
9	PFDR-19-9	Neoprene foam physical and performance characteristics
10	PFDR-19-10	List and properties of adhesives
11	PFDR-19-11	Elastomer properties and specifications
12	PFDR-19-12	Non-metal material specifications

1

Sl. No.	Reference	DESCRIPTION
13	PFDR-19-13	Metal and non-metal material matrix and test reports/certification
14	PFDR-19-14	List of compatible upholstery cleaning agents
15	PFDR-19-15	Data on paints, primers, and application processes/procedures
16	PFDR-19-16	Paint inspection procedure
17	PFDR-19-17	Powder coating touch-up procedure
18	PFDR-19-18	Combustible material matrix
19	PFDR-19-19	Corrosion Control
20	FDR-19-1	PCB Block Diagrams (For All Subsystems from OEM)
21	FDR-19-2	Microprocessor Block Diagrams (For All Subsystems from OEM)
22	FDR-19-3	Test Specification of special process
23	FDR-19-4	Test Specification of Fiberglass Reinforced Plastic
24	FDR-19-5	NDE procedures
Chapter 20 : Software Management Requirements		
1	PDR-20-1	Software Quality Assurance Plan (For All Subsystems from OEM)
2	PDR-20-2	Software Safety Plan (For All Sub-systems from OEM)
3	PDR-20-3	Software Configuration Management Plan (For All Subsystems from OEM)
4	PFDR-20-1	Software Documentation (For All Subsystems from OEM)
5	PFDR-20-2	Software Development (For All Subsystems from OEM)
6	PFDR-20-3	Software Specifications (For All Subsystems from OEM)
7	FDR-20-1	Software Verification & Validation (For All Subsystems from OEM)
8	FDR-20-2	Software Test Specifications (For All Subsystems from OEM)
9	FDR-20-3	Safety Cases (For All Subsystems from OEM)
10	FDR-20-4	Final Approved Software (For All Subsystems from OEM)
Appendix A : Abbreviations		
		NIL
Appendix B : International Standards		
1	PDR-B-1	All Standards under this section shall be submitted by the Contractor
2	PFDR-B-1	Any other standards used / referred by the contractor shall also be submitted.
Appendix C : Interface		
1	PFDR-C-1	Detailed Interface Document between Rolling Stock & Signalling System
2	PFDR-C-2	Detailed Interface Document between Rolling Stock & Telecommunication TETRA System
3	PFDR-C-3	Detailed Interface Document between Rolling Stock & PSD System (for All Contractor)

1

Sl. No.	Reference	DESCRIPTION
4	PFDR-C-4	Detailed Interface Document between Rolling Stock & Railway Electrification, Power Supply System (for All Contractor)
5	PFDR-C-5	Detailed Interface Document between Rolling Stock & Track works (for All Contractor)
6	PFDR-C-6	Detailed Interface Document between Rolling Stock & Viaduct (for All Contractor)
7	PFDR-C-7	Detailed Interface Document between Rolling Stock & Underground (for All Contractor)
8	PFDR-C-8	Detailed Interface Document between Rolling Stock & Depot (for All Contractor)
9	PFDR-C-9	Detailed Interface Document between Rolling Stock & Depot Equipment (for All Contractor)
10	PFDR-C-10	Detailed Interface Document between Rolling Stock & TVS (for All Contractor)
11	PFDR-C-11	Detailed Interface Document between Rolling Stock & Rolling Stock (ARE03A & ARE04A Contractor)
12	FDR-C-1	Test Specification between Rolling Stock & Signalling System
13	FDR-C-2	Test Specification between Rolling Stock & Telecommunication TETRA System
14	FDR-C-3	Test Specification between Rolling Stock & PSD System (for All Contractor)
15	FDR-C-4	Test Specification between Rolling Stock & Railway Electrification, Power Supply System (for All Contractor)
16	FDR-C-5	Test Specification between Rolling Stock & Track works (for All Contractor)
17	FDR-C-6	Test Specification between Rolling Stock & Viaduct (for All Contractor)
18	FDR-C-7	Test Specification between Rolling Stock & Underground (for All Contractor)
19	FDR-C-8	Test Specification between Rolling Stock & Depot (for All Contractor)
20	FDR-C-9	Test Specification between Rolling Stock & Depot Equipment (for All Contractor)
21	FDR-C-10	Test Specification between Rolling Stock & TVS (for All Contractor)
22	FDR-C-11	Test Specification between Rolling Stock & Rolling Stock (ARE03A & ARE04A Contractor)
23	RPT-C-1	Test Report of Rolling Stock & Signalling System
24	RPT-C-2	Test Report of Rolling Stock & Telecommunication TETRA System
25	RPT-C-3	Test Report of Rolling Stock & PSD System (for All Contractor)
26	RPT-C-4	Test Report of Rolling Stock & Railway Electrification, Power Supply System (for All Contractor)
27	RPT-C-5	Test Report of Rolling Stock & Track works (for All Contractor)
28	RPT-C-6	Test Report of Rolling Stock & Viaduct (for All Contractor)

1

Sl. No.	Reference	DESCRIPTION
29	RPT-C-7	Test Report of Rolling Stock & Underground (for All Contractor)
30	RPT-C-8	Test Report of Rolling Stock & Depot (for All Contractor)
31	RPT-C-9	Test Report of Rolling Stock & Depot Equipment (for All Contractor)
32	RPT-C-10	Test Report of Rolling Stock & TVS (for All Contractor)
33	RPT-C-11	Test Report of Rolling Stock & Rolling Stock (ARE03A & ARE04A Contractor)
34	RPT-C-12	Routine Test Report of Rolling Stock & Signalling System (for Each Trainset)
35	RPT-C-13	Routine Test Report of Rolling Stock & Telecommunication TETRA System (for Each Trainset)
36	RPT-C-14	Routine Test Report of Rolling Stock & Telecommunication TETRA System (for Each Trainset)
Appendix D : Guidelines & Drawings		
		NIL
Appendix E : Not Used		
		NIL
Appendix F : Not Used		
		NIL
Appendix G : Documentation & CAD Drawing Requirements		
4	PDR-G-1	Documentation & CAD Drawing Requirements
Appendix H : Not Used		
		NIL
Appendix I : Train Withdrawal Scenarios For 6-car Trains		
4	PFDR-I-1	Train Withdrawal Scenarios For 6-car Trains

1

1.3 TABLE - 2: DELIVERABLES LIST

Sl. No.	Reference	DESCRIPTION
Chapter 2 : System Requirements		
1	PDR-2-1	EMC EMI Control Plan
2	PDR-2-2	Fire Control Plan
3	PDR-2-3	Compliance Matrix
4	PFDR-2-1	Passenger Capacity Calculation
6	PFDR-2-3	Car Weight Distribution Calculation
7	PFDR-2-4	Shock & Vibration Plan

1

Sl. No.	Reference	DESCRIPTION
8	PFDR-2-5	Acoustics Plan
9	PFDR-2-6	Vehicle Dynamic Analysis
10	PFDR-2-7	Estimated Train Harmonic Current
11	PFDR-2-8	Measure Taken on Radiated EMI
12	PFDR-2-9	Measure Taken on Inductive Interference
13	PFDR-2-10	Measure Taken on Conductive Interference
14	PFDR-2-11	Measure Taken on Magnetic Field
15	PFDR-2-12	Shock & Vibration Prediction Report
16	PFDR-2-13	Noise Level Prediction Report
17	PFDR-2-14	EMC EMI Safety Assessment Report
18	PFDR-2-15	Life cycle cost
19	PFDR-2-16	Traction & Braking Performance
20	PFDR-2-17	Specific Energy Consumption Calculation
21	PFDR-2-18	Fire Safety Certification and Safety Integrity Level (SIL) certification for the fire safety system of the train.
22	FDR-2-1	Factory level Test Specification of Car weight distribution
23	FDR-2-2	Test Specification of Climatic Chamber
24	FDR-2-3	Site level Test Specification of Shock & Vibration
25	FDR-2-4	Site level Test Specification of Stability Analysis
26	FDR-2-5	Site level Test Specification of Oscillation test
27	FDR-2-6	Site level Test Specification of Acoustics
28	FDR-2-7	Site level Test Specification of EMC & EMI
29	FDR-2-8	Site level Test Specification of Specific Energy Consumption
30	FDR-2-9	Site level Test Specification of Kinematic Envelope
31	RPT-2-1	Factory level Test Report of Car Weight Distribution
32	RPT-2-2	Test Report of Climatic Chamber
33	RPT-2-3	Site level Test Report of Shock & Vibration
34	RPT-2-4	Site level Test Report of Stability Analysis
35	RPT-2-5	Site level Test Report of Oscillation test
36	RPT-2-6	Site level Test Report of Acoustics
37	RPT-2-7	Site level Test Report of EMC & EMI
38	RPT-2-8	Site level Test Report of Specific Energy Consumption

1

Sl. No.	Reference	DESCRIPTION
39	RPT-2-9	Site level Test Report of Kinematic Envelope
Chapter 3 : Car Body Structure		
1	PDR-3-1	Train general arrangement and dimensions
2	PDR-3-2	General description of Carbody Structures
3	PDR-3-3	Carbody Structures FEA calculation plan
4	PDR-3-4	Car Finishes, Aesthetics and Models
5	PDR-3-5	General description and layout of Saloon & Cab Interiors
6	PDR-3-6	General description and layout of underframe & roof equipment
7	PFDR-3-1	Detailed design & drawings of Carbody Structures
8	PFDR-3-2	Kinematic Envelope Study
9	PFDR-3-2	Carbody Structures FEA calculation
10	PFDR-3-3	Carbody crashworthiness calculation including Collision Scenario Analysis
11	PFDR-3-4	Car End clearance calculation
12	PFDR-3-5	Detailed design & drawings of Saloon & Cab Interiors
13	PFDR-3-6	Final Kinematic Envelope Calculation and Drawings
14	PFDR-3-7	Ergonomic reports & Visibility study report for Cab Driver Desk
15	PFDR-3-9	Ergonomic report for saloon & Cab
16	PFDR-3-10	Design Specification & drawings of Signage and labelling
17	PFDR-3-11	Collision and Energy Absorption Calculation Report of Coupler System including Collision Scenario Analysis and rescue operation
18	PFDR-3-12	Technical Specification and drawings of Gangway
19	PFDR-3-13	Gangway Movement calculation
20	PFDR-3-14	System Description & Technical Specification of Smoke and Heat detection system
21	PFDR-3-15	Technical Specification & drawing of underframe & roof equipment
22	PFDR-3-16	Submission of Car manufacturing drawing for approval before start of manufacturing of cars
23	PFDR-3-17	Technical Specification & drawings of Equipment enclosures
24	PFDR-3-18	Technical Specification & drawings of Exterior accessories & fittings
25	PFDR-3-19	Strength Analysis of Saloon & Cab Interiors fittings
26	PFDR-3-20	Strength Analysis of Exterior fittings
27	PFDR-3-21	Carbody and sub-assemblies Inspection & test procedures and check sheets

1

Sl. No.	Reference	DESCRIPTION
28	PFDR-3-22	Technical Specification & drawings of Floor Covering
29	PFDR-3-22	Car fittings Inspection & test procedures and check sheets
30	PFDR-3-23	Simulation analysis report demonstrating the behaviour of the coupler under collision conditions at the specified collision speed.
31	FDR-3-1	Test Specification and procedure of Gangway
32	FDR-3-2	Test Specification and procedure of Floor
33	FDR-3-3	Test Specification and procedure including replacement procedure of Windscreen
34	FDR-3-4	Test Specification and procedure including replacement procedure of Windows
35	FDR-3-5	Test Specification and procedure of Seats
36	FDR-3-6	Test Specification and procedure of Saloon & Cab Interior fittings & Exterior fittings
37	FDR-3-7	Test Specification and procedure of Static Gauging
38	FDR-3-8	Test Specification and procedure of Kinematic Gauging
39	FDR-3-9	Test Specification and procedure of Straphangers Endurance
40	FDR-3-10	Test Specification and procedure of Floor Fire barriers
41	FDR-3-11	Test Specification and procedure of side walls and end walls Fire barriers
42	FDR-3-12	Car exterior and interior chemical cleaners submission and cleaning and washing procedure
43	FDR-3-13	Crashworthiness Analysis Approach and Test Plan
44	FDR-3-14	Test Specification and procedure of interior panels
45	RPT-3-1	Test reports of Gangway
46	RPT-3-2	Test reports of Floor
47	RPT-3-3	Test reports of Windscreen
48	RPT-3-4	Test reports of Windows
49	RPT-3-5	Test reports of Seats
50	RPT-3-6	Test reports of Saloon & Cab Interior fittings & Exterior fittings
51	RPT-3-7	Test reports of Static Gauging
52	RPT-3-8	Test reports of Kinematic Gauging
53	RPT-3-9	Test reports of Straphangers Endurance
54	RPT-3-10	Test reports of Floor Fire barriers
55	RPT-3-11	Test Specification and procedure of side walls and end walls Fire barriers

1

Sl. No.	Reference	DESCRIPTION
56	RPT-3-12	Test reports of interior panels
Chapter 4 : Coupler & Draft gear		
1	PDR-4-1	Product Description of Couplers
2	PFDR-4-1	Technical Description & Drawings of Couplers
3	PFDR-4-2	Technical Description & Drawings of Draft gear
4	PFDR-4-3	Technical Description & Drawings of Electrical Coupling
5	PFDR-4-4	Technical Description & Drawings of Electrical Jumpers
6	PFDR-4-5	Energy Absorption Calculation of Couplers
7	PFDR-4-6	Coupler Movement Calculation
8	FDR-4-1	Product level Test Specification of Couplers
9	FDR-4-2	Product level Test Specification of Draft gear
10	FDR-4-3	Product level Test Specification of Electrical Coupling
11	FDR-4-4	Product level Test Specification of Electrical Jumpers
12	FDR-4-5	Product level Test Specification of Energy Absorption of Couplers
13	FDR-4-6	Site level Test Specification of Coupler Movement
14	FDR-4-7	Site level Test Specification of Rescue Operation
15	RPT-4-1	Test Report of Couplers
16	RPT-4-2	Test Report of Draft gear
17	RPT-4-3	Test Report of Electrical Coupling
18	RPT-4-4	Test Report of Electrical Jumpers
19	RPT-4-5	Test Report of Energy Absorption of Couplers
20	RPT-4-6	Site level test Report of Coupler Movement
21	RPT-4-7	Site level test Report of Rescue Operation
Chapter 5 : Operator's Desk		
1	PDR-5-1	General Description of Operator's Desk & Emergency Operator's Desk
2	PFDR-5-1	Technical Description & Drawings of Operator's Desk & Emergency Operator's Desk
3	PFDR-5-2	Technical Description & Drawings of Windscreen
4	PFDR-5-3	Technical Description & Drawings of Wiper
5	PFDR-5-4	Technical Description & Drawings of Master Controller
6	PFDR-5-5	Technical Description & Drawings of Operating & Controlling Panel
7	PFDR-5-6	Technical Description & Drawings of Operator Seat

1

Sl. No.	Reference	DESCRIPTION
8	FDR-5-1	Product level Test Specification of Operator's Desk & Emergency Operator's Desk
9	FDR-5-2	Product level Test Specification of Windscreen
10	FDR-5-3	Product level Test Specification of Wiper
11	FDR-5-4	Product level Test Specification of Master Controller
12	FDR-5-5	Product level Test Specification of Operating & Controlling Panel
13	FDR-5-6	Product level Test Specification of Operator Seat
14	FDR-5-7	Factory level Test Specification of Wiper system
15	FDR-5-8	Factory level Test Specification of Operating & Controlling Panel
16	RPT-5-1	Test Report of Operator's Desk & Emergency Operator's Desk
17	RPT-5-2	Test Report of Windscreen
18	RPT-5-3	Test Report of Wiper
19	RPT-5-4	Test Report of Master Controller
20	RPT-5-5	Test Report of Operating & Controlling Panel
21	RPT-5-6	Factory level Test Report of Wiper system
22	RPT-5-7	Factory level Test Report of Operating & Controlling Panel
23	RPT-5-8	Factory level Test Report of Operator Seat
Chapter 6 : Passenger Doors		
1	PDR-6-1	General Description of Door System
2	PFDR-6-1	Technical Description & Drawings of Passenger Saloon Door system
3	PFDR-6-2	Deleted
4	PFDR-6-3	Evacuation Plan
5	FDR-6-1	Product level Test Specification of Saloon Door System
6	FDR-6-2	Deleted
7	FDR-6-3	Factory level Test Specification of Saloon Door System
8	FDR-6-4	Deleted
9	FDR-6-5	Site level Test Specification of Evacuation Plan
10	RPT-6-1	Test Report of Saloon Door System
11	RPT-6-2	Deleted
12	RPT-6-3	Factory level Test Report of Saloon Door System
13	RPT-6-4	Deleted
14	RPT-6-5	Site level Test Report of Evacuation Plan

1

Sl. No.	Reference	DESCRIPTION
Chapter 7 : Ventilation and Air-conditioning		
1	PDR-7-1	General Description of VAC
2	PFDR-7-1	Technical Description & Drawing of VAC
3	PFDR-7-2	Technical Description & Drawing of Air Ducts
4	PFDR-7-3	Technical Description & Drawing of Air filters
5	PFDR-7-4	Heat Load Calculation
6	FDR-7-1	Product level Test Specification of VAC
7	FDR-7-2	Product level Test Specification of Air Ducts
8	FDR-7-3	Factory level Test Specification of VAC
9	FDR-7-4	Test Specification - Climatic Room Test for Complete Car
10	RPT-7-1	Test Report of VAC
11	RPT-7-2	Test Report of Air Ducts
12	RPT-7-3	Factory level Test Report of VAC
13	RPT-7-4	Test report - Climatic Room Test for Complete Car
Chapter 8 : Lighting		
1	PDR-8-1	Conceptual Design of Lighting System
2	PFDR-8-1	Technical Description & Drawing of Lighting System
3	FDR-8-1	Product level Test Specification of Lighting System
4	FDR-8-2	Factory level Test Specification of Lighting System
5	RPT-8-1	Test Report of Lighting System
6	RPT-8-2	Factory level Test report of Lighting System
Chapter 9 : Auxiliary Electrical Equipment		
1	PDR-9-1	Conceptual Design of APS
2	PDR-9-2	Conceptual Design of Battery & Battery Charger
3	PFDR-9-1	Technical Description & Drawings of APS
4	PFDR-9-2	Technical Description of APS – Circuit requirements
5	PFDR-9-3	Technical Description & Drawings of Battery
6	PFDR-9-4	Technical Description & Drawings of Battery Charger
7	PFDR-9-5	Technical Description & Drawings of Battery Control Box
8	PFDR-9-6	Technical Description & Drawings of Battery Box
9	PFDR-9-7	Calculation of Emergency Loads
10	PFDR-9-8	Energy Consumption Study & Simulation

1

Sl. No.	Reference	DESCRIPTION
11	PFDR-9-9	Train Earthing Concept
12	FDR-9-1	Product level Test Specification of APS
13	FDR-9-2	Product level Test Specification of Battery
14	FDR-9-3	Product level Test Specification of Battery Charger
15	FDR-9-4	Product level Test Specification of Battery Box
16	FDR-9-5	Product level Test Specification of Battery Control Box
17	FDR-9-6	Factory level Test Specification of APS
18	FDR-9-7	Factory level Test Specification of Battery Charging
19	RPT-9-1	Test Report of APS
20	RPT-9-2	Test Report of Battery
21	RPT-9-3	Test Report of Battery Charger
22	RPT-9-4	Test Report of Battery Control Box
23	RPT-9-5	Test Report of Battery Box
24	RPT-9-6	Factory level Test Report of APS
25	RPT-9-7	Factory level Test Report of Battery Charging
Chapter 10 : High Voltage & Propulsion system		
1	PDR-10-1	Conceptual Design of High Voltage Equipment's
2	PDR-10-2	Conceptual Design of Propulsion System
3	PFDR-10-1	Technical Description & Drawings of Pantograph
4	PFDR-10-2	Technical Description & Drawings of Vacuum Circuit Braker
5	PFDR-10-3	Technical Description & Drawings of Earth Ground Switch
6	PFDR-10-4	Technical Description & Drawings of Lightning Arrestor
7	PFDR-10-5	Technical Description & Drawings of Current Transformer
8	PFDR-10-6	Technical Description & Drawings of Earth Brush
9	PFDR-10-7	Technical Description & Drawings of Main Transformer
10	PFDR-10-8	Technical Description & Drawings of Cable head
11	PFDR-10-9	Technical Description & Drawings of Propulsion System
12	PFDR-10-10	Technical Description of Propulsion System – Circuit Requirements
13	PFDR-10-11	Technical Description & Drawings of Traction Motor
14	PFDR-10-12	Technical Description & Drawings of Driving Gear
15	PFDR-10-13	Technical Description & Drawings of PWM Generator
16	PFDR-10-14	Train Performance & Characteristics

1

Sl. No.	Reference	DESCRIPTION
17	PFDR-10-15	Run Curve Study & Simulation
18	PFDR-10-16	Energy Consumption Study & Simulation
19	PFDR-10-17	Technical Description & Drawings of Neutral Section Detector
20	PFDR-10-18	Technical Description of EMI & EMC – HV & Propulsion System
21	FDR-10-1	Product level Test Specification of Pantograph
22	FDR-10-2	Product level Test Specification of Vacuum Circuit Braker
23	FDR-10-3	Product level Test Specification of Earth Ground Switch
24	FDR-10-4	Product level Test Specification of Lightning Arrestor
25	FDR-10-5	Product level Test Specification of Current Transformer
26	FDR-10-6	Product level Test Specification of Earth Brush
27	FDR-10-7	Product level Test Specification of Main Transformer
28	FDR-10-8	Product level Test Specification of Cable head
29	FDR-10-9	Product level Test Specification of Propulsion System
30	FDR-10-10	Product level Test Specification of Traction Motor
31	FDR-10-11	Product level Test Specification of Driving Gear
32	FDR-10-12	Product level Test Specification of PWM Generator
33	FDR-10-13	Product level Test Specification of Neutral Section Detector
34	FDR-10-14	Factory level Test Specification of HV Equipment's
35	FDR-10-15	Factory level Test Specification of Propulsion System
36	FDR-10-16	Site level Test Specification of Propulsion System
37	FDR-10-17	Site level Test Specification of Neutral Section Detector
38	FDR-10-18	Site level Test Specification of Thermal Capacity
39	RPT-10-1	Test Report of Pantograph
40	RPT-10-2	Test Report of VCB
41	RPT-10-3	Test Report of EGS
42	RPT-10-4	Test Report of LA
43	RPT-10-5	Test Report of CT
44	RPT-10-6	Test Report of Earth Brush
45	RPT-10-7	Test Report of Main Transformer
46	RPT-10-8	Test Report of Cable Head
47	RPT-10-9	Test Report of Propulsion system
48	RPT-10-10	Test Report of Traction Motor

1

Sl. No.	Reference	DESCRIPTION
49	RPT-10-11	Test Report of Driving Gear
50	RPT-10-12	Test Report of PWM Generator
51	RPT-10-13	Test Report of NSD
52	RPT-10-14	Factory Level Test Report of HV Equipment's
53	RPT-10-15	Factory Level Test Report of Propulsion System
54	RPT-10-16	Site Level Test Report of Propulsion System
55	RPT-10-17	Site Level Test Report of NSD
56	RPT-10-18	Site Level Test Report of Thermal Capacity
Chapter 11 : Bogie Assembly		
1.	PDR-11-1	Conceptual Design of Bogies
2.	PFDR-11-1	Technical Description & drawings of Driving gear
3.	PFDR-11-2	Technical Description & Drawings of Wheel Flange Lubricator
4.	PFDR-11-3	Technical Description & Drawings of Secondary suspension
5.	PFDR-11-4	Technical Description & Drawings of Primary suspension
6.	PFDR-11-5	Technical Description & Drawings of Derailment Detection and Obstruction Deflection Device
7.	PFDR-11-6	Technical Description & drawings of wayside Hot Axle measuring system
8.	PFDR-11-7	Technical Description & drawings of Wheel & Axle
9.	PFDR-11-8	Technical Description & drawings of Axle box
10.	PFDR-11-9	Technical Description & drawings of Dampers
11.	PFDR-11-10	Calculation of Un-sprung mass
12.	PFDR-11-11	Life cycle calculation of Journal Bearing
13.	PFDR-11-12	Wheel Stress calculations
14.	PFDR-11-13	Axle strength calculations
15.	PFDR-11-14	Thermal Calculations of Wheel
16.	PFDR-11-15	FEA of Bogie Frame
17.	PFDR-11-16	FEA of centre pivot
18.	PFDR-11-17	FEA of axle box
19.	PFDR-11-18	FEA of anti-roll bar
20.	PFDR-11-19	FEA of Traction Linkage
21.	PFDR-11-20	Design Description and analysis of stresses for Gear pinions, Gear case and transmission assembly

1

Sl. No.	Reference	DESCRIPTION
22.	FDR-11-1	Vehicle Dynamics Simulation Studies
23.	FDR-11-2	Product level Test Specification of Bogie frame
24.	FDR-11-3	Product level Test Specification of complete Bogie
25.	FDR-11-4	Test Specification of Dynamic running behaviour
26.	FDR-11-5	Product level Test Specification of Secondary suspension
27.	FDR-11-6	Product level Test Specification of Primary suspension
28.	FDR-11-7	Product level Test Specification of Damper
29.	FDR-11-8	Product level Test Specification of Wheel
30.	FDR-11-9	Product level Test Specification of Axle
31.	FDR-11-10	Product level Test Specification of Driving gear system
32.	FDR-11-11	Product level Test Specification of Gearbox
33.	FDR-11-12	Product level Test Specification of Bogie Movement & rotational resistance
34.	FDR-11-13	Product level Test Specification of Wheel Flange Lubricator
35.	FDR-11-14	Product level Test Specification of wayside Hot Axle measuring system
36.	FDR-11-15	Product level Test Specification of Derailment Detection and Obstruction Deflection Device
37.	FDR-11-16	Site level Test Specification of damping factor (wedge test)
38.	FDR-11-17	Site level Test Specification of Bogie swing tests
39.	FDR-11-18	Site level Test Specification of Derailment Detection and Obstruction Deflection Device
40.	FDR-11-19	Site level Test Specification of Sway test
41.	FDR-11-20	Site level Test Specification of wheel off-loading
42.	FDR-11-21	Factory level test specification of Interference between Carbody and Bogie
43.	RPT-11-1	Test reports of Bogie Frame
44.	RPT-11-2	Test reports of Complete Bogie
45.	RPT-11-3	Test reports of Dynamic running behaviour
46.	RPT-11-4	Test reports of Secondary suspension
47.	RPT-11-5	Test reports of Primary suspension
48.	RPT-11-6	Test reports of Damper
49.	RPT-11-7	Test reports of Wheel
50.	RPT-11-8	Test reports of Axle
51.	RPT-11-9	Test reports of Driving gear system

1

Sl. No.	Reference	DESCRIPTION
52.	RPT-11-10	Test reports of Gearbox
53.	RPT-11-11	Test reports of Bogie movement
54.	RPT-11-12	Test reports of Wheel Flange Lubricator
55.	RPT-11-13	Test reports of wayside Hot Axle measuring system
56.	RPT-11-14	Test reports of bogies rotational resistance (X factor)
57.	RPT-11-15	Test reports of damping factor (wedge test)
58.	RPT-11-16	Test reports of Bogie swing test
59.	RPT-11-17	Test reports of Derailment Detection and Obstruction Deflection Device
60.	RPT-11-18	Test reports of Sway test
61.	RPT-11-19	Test reports of wheel off-loading
62.	RPT-11-20	Test reports of Interference between Carbody and Bogie
Chapter 12 : Pneumatic and Brake Equipment		
1	PDR-12-1	Conceptual Design of Pneumatic & Brake Equipment's
2	PFDR-12-1	Technical Description & Drawings of Brake Electronic Control Unit
3	PFDR-12-2	Technical Description & Drawings of Dynamometer
4	PFDR-12-3	Technical Description & Drawings of Reservoir
5	PFDR-12-4	Technical Description & Drawings of Air Compressor
6	PFDR-12-5	Technical Description of Pneumatic Piping & Controls
7	PFDR-12-6	Technical Description & Drawing of Brake Calliper
8	PFDR-12-7	Air consumption calculation with Duty cycle
9	PFDR-12-8	Brake calculation with Parking
10	PFDR-12-9	Technical Description & Drawings of Air Suspension system
11	PFDR-12-10	Technical Description of Protection schemes
12	PFDR-12-11	Wheel Slip / Slide Control & Protection
13	PFDR-12-12	Rescue Operation
14	PFDR-12-13	Thermal Capacity Calculation for Brake Disc
15	FDR-12-1	Product level Test Specification of Brake Electronic Control Unit
16	FDR-12-2	Product level Test Specification of Dynamometer
17	FDR-12-3	Product level Test Specification of Reservoir
18	FDR-12-4	Product level Test Specification of Air Compressor
19	FDR-12-5	Product level Test Specification of Pneumatic Piping
20	FDR-12-6	Product level Test Specification of Air Suspension

1

Sl. No.	Reference	DESCRIPTION
21	FDR-12-7	Product level Test Specification of Brake Calliper
22	FDR-12-8	Site level Test Specification of Protection Schemes
23	FDR-12-9	Site level Test Specification of Rescue Operation
24	FDR-12-10	Factory level Test Specification of Brake System
25	FDR-12-11	Factory level Test Specification of Compressor Duty Cycle
26	FDR-12-12	Site level Test Specification of Brake System
27	RPT-12-1	Test Report of BECU
28	RPT-12-2	Test Report of Dynamometer
29	RPT-12-3	Test Report of Reservoir
30	RPT-12-4	Test Report of Air Compressor
31	RPT-12-5	Test Report of Pneumatic Piping
32	RPT-12-6	Test Report of Air Suspension
33	RPT-12-7	Test Report of Brake Calliper
34	RPT-12-8	Test Report of Protection Schemes
35	RPT-12-9	Test Report of Rescue Operation
Chapter 13 : Communications		
1	PDR-13-1	General Description of PAPIS & CCTV System
2	PFDT-13-1	Technical Description & Drawing of PAPIS System
3	PFDT-13-2	Technical Description & Drawing of CCTV System
4	PFDT-13-3	PAPIS Message List
5	FDR-13-1	Test Specification of PAPIS System
6	FDR-13-2	Test Specification of CCTV System
7	FDR-13-3	Factory level Test Specification of PAPIS & CCVT System
8	FDR-13-4	Site level Test Specification of PAPIS & CCTV System
9	RPT-13-1	Test Report of PAPIS System
10	RPT-13-2	Test Report of CCTV System
11	RPT-13-3	Factory level Test Report of PAPIS & CCTV System
12	RPT-13-4	Site level test Report of PAPIS & CCTV System
Chapter 14 : Train Control Management System		
1	PDR-14-1	General Description of TCMS
2	PDR-14-2	General Description of Event Recorder
3	PDR-14-3	General Description of TCMS Interface

1

Sl. No.	Reference	DESCRIPTION
4	PFDR-14-1	Technical Description of TCMS & Drawing
5	PFDR-14-2	Technical Description of TCMS Architecture
6	PFDR-14-3	Technical Description of Event Recorder & Drawing
7	PFDR-14-4	Interface Description of TCMS - Propulsion system
8	PFDR-14-5	Interface Description of TCMS - APS System
9	PFDR-14-6	Interface Description of TCMS - Brake system
10	PFDR-14-7	Interface Description of TCMS - VAC system
11	PFDR-14-8	Interface Description of TCMS - Door system
12	PFDR-14-9	Interface Description of TCMS - PA & PIS system
13	PFDR-14-10	Interface Description of TCMS - CCTV system
14	PFDR-14-11	Interface Description of TCMS - Event Recorder system
15	PFDR-14-12	Interface Description of TCMS - Signalling system
16	PFDR-14-13	Interface Description of TCMS - Telecommunication system
17	PFDR-14-14	Interface Description of TCMS - PSD system
18	PFDR-14-15	Interface Description of TCMS - AMS system
19	PFDR-14-16	Interface Description of TCMS - Other Rolling Stock supplier
20	PFDR-14-17	Interface Description of TCMS - Fire Detection System
21	PFDR-14-18	Interface Description of TCMS - Obstruction Deflection Device
22	PFDR-14-19	Technical Description of HMI
23	PFDR-14-20	Technical Description of Fault Data Acquisition
24	PFDR-14-21	Technical Description of Control Features
25	PFDR-14-22	Technical Description of Diagnostic Features
26	PFDR-14-23	Technical Description of Troubleshooting Features
27	PFDR-14-24	Technical Description of Maintenance Tool
28	PFDR-14-25	Technical Description of Energy Consumption
29	PFDR-14-26	Technical Description of OCC GUI & RSC
30	FDR-14-1	Product level Test Specification of TCMS
31	FDR-14-2	Product level Test Specification of Event Recorder
32	FDR-14-3	Factory level Test Specification of TCMS
33	FDR-14-4	Factory level Test Specification of Event Recorder
34	FDR-14-5	Site level Test Specification of TCMS
35	FDR-14-6	Site level Test Specification of Event Recorder

1

Sl. No.	Reference	DESCRIPTION
36	FDR-14-7	Site level Interface Test Specification of TCMS - Propulsion system
37	FDR-14-8	Site level Interface Test Specification of TCMS - APS System
38	FDR-14-9	Site level Interface Test Specification of TCMS - Brake system
39	FDR-14-10	Site level Interface Test Specification of TCMS - VAC system
40	FDR-14-11	Site level Interface Test Specification of TCMS - Door system
41	FDR-14-12	Site level Interface Test Specification of TCMS - PA & PIS system
42	FDR-14-13	Site level Interface Test Specification of TCMS - CCTV system
43	FDR-14-14	Site level Interface Test Specification of TCMS - Event Recorder system
44	FDR-14-15	Site level Interface Test Specification of TCMS - Signalling system
45	FDR-14-16	Site level Interface Test Specification of TCMS - Telecommunication system
46	FDR-14-17	Site level Interface Test Specification of TCMS - PSD system
47	FDR-14-18	Site level Interface Test Specification of TCMS - AMS system
48	FDR-14-19	Site level Interface Test Specification of TCMS - Other Rolling Stock supplier
49	FDR-14-20	Site level Interface Test Specification of TCMS - Fire Detection System
50	FDR-14-21	Site level Interface Test Specification of TCMS - Obstruction Deflection Device
51	RPT-14-1	Test Report of TCMS
52	RPT-14-2	Test Report of Event Recorder
53	RPT-14-3	Factory level Test Report of TCMS
54	RPT-14-4	Factory level Test Report of Event Recorder
55	RPT-14-5	Site level Test Report of TCMS system
56	RPT-14-6	Site level Test Report of Event Recorder
57	RPT-14-7	Site level Test Report of TCMS - Propulsion system
58	RPT-14-8	Site level Test Report of TCMS - APS System
59	RPT-14-9	Site level Test Report of TCMS - Brake system
60	RPT-14-10	Site level Test Report of TCMS - VAC system
61	RPT-14-11	Site level Test Report of TCMS - Door system
62	RPT-14-12	Site level Test Report of TCMS - PA & PIS system
63	RPT-14-13	Site level Test Report of TCMS - CCTV system
64	RPT-14-14	Site level Test Report of TCMS - Event Recorder system
65	RPT-14-15	Site level Test Report of TCMS - Signalling system

1

Sl. No.	Reference	DESCRIPTION
66	RPT-14-16	Site level Test Report of TCMS - Telecommunication system
67	RPT-14-17	Site level Test Report of TCMS - PSD system
68	RPT-14-18	Site level Test Report of TCMS - AMS system
69	RPT-14-19	Site level Test Report of TCMS - Other Rolling Stock supplier
70	RPT-14-20	Site level Test Report of TCMS - Fire Detection System
71	RPT-14-21	Site level Test Report of TCMS - Obstruction Deflection Device
Chapter 15 : System Support		
1	FDR-15-1	System Maintenance Philosophy
2	FDR-15-2	System Training Philosophy
3	FDR-15-3	System Training Plan
4	FDR-15-4	Operating Rule Book
5	FDR-15-5	Operating Procedure Manual
6	FDR-15-6	System Maintenance Manuals
7	FDR-15-7	Operating Manual & OEM Description
8	FDR-15-8	Operation Manual
Chapter 16 : Management Program		
1	PDR-16-1	Project Management Plan
2	PDR-16-2	Interface Management Plan
3	PDR-16-3	Test & Commissioning Plan
4	PDR-16-4	Delivery Plan
5	PDR-16-5	Health Environment & Safety Plan
6	PDR-16-6	Defect Notification Period Management Plan
7	PDR-16-7	Master Schedule
8	PDR-16-8	Configuration Control Management Plan
9	PDR-16-9	Weight Control Plan
10	PDR-16-10	Vendor Selection / Subcontractor list for Approval
11	FDR-16-1	Car History Book – Manufacturing (for All Trainsets)
12	FDR-16-2	Car History Book – Test & Commissioning (for All Trainsets)
13	FDR-16-3	Car History Book – Defect Notification Period (for All Trainsets)
14	FDR-16-4	Project Management Information System
15	FDR-16-5	As Built Drawings
16	FDR-16-6	Manufacturing Drawings

Sl. No.	Reference	DESCRIPTION
17	FDR-16-7	Design Submission Program
18	RPT-16-1	Monthly Progress Report
Chapter 17 : Test Program		
1	PFDR-17-1	Master Test Program
2	FDR-17-1	Test Specification of Car Shell Structural Test
3	FDR-17-2	Test Specification of Compression Load Test
4	FDR-17-3	Test Specification of End Sill Load Test
5	FDR-17-4	Test Specification of Roof Load Test
6	FDR-17-5	Test Specification of Energy Absorption Test
7	FDR-17-6	Test Specification of Jacking Test
8	FDR-17-7	Test Specification of Fire barrier
9	FDR-17-8	Test Specification of Window Glass
10	FDR-17-9	Test Specification of Water tightness test of Carbody Shell
11	FDR-17-10	Test Specification of Water tightness test of Completed Car
12	FDR-17-11	Test Specification of Car Dimension check
13	FDR-17-12	Test Specification of Wiring Check (Bell Check)
14	FDR-17-13	Operational Performance / Service Trials
15	FDR-17-14	Test Specification of Multi Consist Of Operation.
16	FDR-17-15	Test Specification of Electrical Control Panel / box
17	FDR-17-16	Test Specification of VCC test
18	FDR-17-17	Test Specification of Di-Electric, Earthing and Return Connection
19	FDR-17-18	Test Specification and procedure of stainless steel/ Aluminium and Structural steel
20	FDR-17-19	Test Specification and procedure of carbody shell watertightness
21	FDR-17-20	Test Specification and procedure of finished car watertightness
22	FDR-17-21	Test Specification and procedure of carbody structural loads test (DM & T- cars) including natural frequency test.
23	FDR-17-22	Test Specification and procedure of car & train level static and dynamic routine tests as per IEC 61133
24	FDR-17-23	Test Specification and procedure of car & train level static and dynamic type tests as per IEC 61133
25	FDR-17-24	Test Specification and procedure of integrated testing and commissioning
26	FDR-17-26	Train Level Safety Case demonstrating compliance with applicable safety standards

1

Sl. No.	Reference	DESCRIPTION
27	FDR-17-27	Submissions For Statutory Approvals – (Documents listed in the ERTS Clause SI.No. 17.11 submissions for statutory approvals)
Chapter 18 : System Assurance		
1	PDR-18-1	System Safety Analysis – Preliminary
2	PDR-18-2	RAMS Demonstration Plan
3	PDR-18-3	System Assurance Plan
4	PDR-18-4	System Safety Plan
5	PDR-18-5	Preliminary Hazard Analysis
6	PDR-18-6	Inspection Plan
7	PDR-18-7	First Article Inspection
8	PDR-18-8	Manufacturing Plan
9	PDR-18-9	Site Management Plan
10	PDR-18-10	Road Traffic Management Plan
11	PDR-18-11	Storage Packing Management Plan
12	PDR-18-12	Quality Assurance Plan
13	PFDR-18-1	Hazard Log
14	PFDR-18-2	Failure Modes & Effects Criticality Analysis
15	PFDR-18-3	Sneak Circuit Analysis
16	PFDR-18-4	Operating and Support Hazard Analysis
17	PFDR-18-5	Fault-Tree Analysis
18	PFDR-18-6	Hold Point Inspection
19	PFDR-18-7	System Safety Analysis – Pre final
20	PFDR-18-8	Fire Safety Analysis
21	PFDR-18-9	Reliability Program
22	PFDR-18-10	Maintainability Program
23	PFDR-18-11	Availability Program
24	PFDR-18-12	Inspection and test plan of complete car (Contractor and sub-vendors/Contractors)
25	PFDR-18-13	First article inspection FAI procedures and check sheets of complete car (Contractor and sub-vendors/Contractors)
26	FDR-18-1	System Safety Analysis – Final
Chapter 19 : Materials and Workmanship		
1	PFDR-19-1	Technical Specification of Cables

1

Sl. No.	Reference	DESCRIPTION
2	PFDR-19-2	Current Estimates of Cables
3	PFDR-19-3	Cable Duct Installation Drawings
4	PFDR-19-4	Wire numbering plan
5	PFDR-19-5	Train Earthing Concept
6	PFDR-19-6	Technical Specification & Drawings of FRP Panels
7	PFDR-19-7	Commercial material specifications
8	PFDR-19-8	List of substitute or single-source materials
9	PFDR-19-9	Neoprene foam physical and performance characteristics
10	PFDR-19-10	List and properties of adhesives
11	PFDR-19-11	Elastomer properties and specifications
12	PFDR-19-12	Non-metal material specifications
13	PFDR-19-13	Metal and non-metal material matrix and test reports/certification
14	PFDR-19-14	List of compatible upholstery cleaning agents
15	PFDR-19-15	Data on paints, primers, and application processes/procedures
16	PFDR-19-16	Paint inspection procedure
17	PFDR-19-17	Powder coating touch-up procedure
18	PFDR-19-18	Combustible material matrix
19	PFDR-19-19	Corrosion Control
20	FDR-19-1	PCB Block Diagrams (For All Subsystems from OEM)
21	FDR-19-2	Microprocessor Block Diagrams (For All Subsystems from OEM)
22	FDR-19-3	Test Specification of special process
23	FDR-19-4	Test Specification of Fiberglass Reinforced Plastic
24	FDR-19-5	NDE procedures
Chapter 20 : Software Management Requirements		
1	PDR-20-1	Software Quality Assurance Plan (For All Subsystems from OEM)
2	PDR-20-2	Software Safety Plan (For All Sub-systems from OEM)
3	PDR-20-3	Software Configuration Management Plan (For All Subsystems from OEM)
4	PFDR-20-1	Software Documentation (For All Subsystems from OEM)
5	PFDR-20-2	Software Development (For All Subsystems from OEM)
6	PFDR-20-3	Software Specifications (For All Subsystems from OEM)
7	FDR-20-1	Software Verification & Validation (For All Subsystems from OEM)

1

Sl. No.	Reference	DESCRIPTION
8	FDR-20-2	Software Test Specifications (For All Subsystems from OEM)
9	FDR-20-3	Safety Cases (For All Subsystems from OEM)
10	FDR-20-4	Final Approved Software (For All Subsystems from OEM)
11	FDR -20-5	Final Cybersecurity case
Appendix A : Abbreviations		
		NIL
Appendix B : International Standards		
1	PDR-B-1	All Standards under this section shall be submitted by the Contractor
2	PFDR-B-1	Any other standards used / referred by the contractor shall also be submitted.
Appendix C : Interface		
1	PFDR-C-1	Detailed Interface Document between Rolling Stock & Signalling System
2	PFDR-C-2	Detailed Interface Document between Rolling Stock & Telecommunication TETRA System
3	PFDR-C-3	Detailed Interface Document between Rolling Stock & PSD System (for All Contractor)
4	PFDR-C-4	Detailed Interface Document between Rolling Stock & Railway Electrification, Power Supply System (for All Contractor)
5	PFDR-C-5	Detailed Interface Document between Rolling Stock & Track works (for All Contractor)
6	PFDR-C-6	Detailed Interface Document between Rolling Stock & Viaduct (for All Contractor)
7	PFDR-C-7	Detailed Interface Document between Rolling Stock & Underground (for All Contractor)
8	PFDR-C-8	Detailed Interface Document between Rolling Stock & Depot (for All Contractor)
9	PFDR-C-9	Detailed Interface Document between Rolling Stock & Depot Equipment (for All Contractor)
10	PFDR-C-10	Detailed Interface Document between Rolling Stock & TVS (for All Contractor)
11	PFDR-C-11	Detailed Interface Document between Rolling Stock & Rolling Stock (ARE03A & ARE04A Contractor)
12	FDR-C-1	Test Specification between Rolling Stock & Signalling System
13	FDR-C-2	Test Specification between Rolling Stock & Telecommunication TETRA System
14	FDR-C-3	Test Specification between Rolling Stock & PSD System (for All Contractor)

1

Sl. No.	Reference	DESCRIPTION
15	FDR-C-4	Test Specification between Rolling Stock & Railway Electrification, Power Supply System (for All Contractor)
16	FDR-C-5	Test Specification between Rolling Stock & Track works (for All Contractor)
17	FDR-C-6	Test Specification between Rolling Stock & Viaduct (for All Contractor)
18	FDR-C-7	Test Specification between Rolling Stock & Underground (for All Contractor)
19	FDR-C-8	Test Specification between Rolling Stock & Depot (for All Contractor)
20	FDR-C-9	Test Specification between Rolling Stock & Depot Equipment (for All Contractor)
21	FDR-C-10	Test Specification between Rolling Stock & TVS (for All Contractor)
22	FDR-C-11	Test Specification between Rolling Stock & Rolling Stock (ARE03A & ARE04A Contractor)
23	RPT-C-1	Test Report of Rolling Stock & Signalling System
24	RPT-C-2	Test Report of Rolling Stock & Telecommunication TETRA System
25	RPT-C-3	Test Report of Rolling Stock & PSD System (for All Contractor)
26	RPT-C-4	Test Report of Rolling Stock & Railway Electrification, Power Supply System (for All Contractor)
27	RPT-C-5	Test Report of Rolling Stock & Track works (for All Contractor)
28	RPT-C-6	Test Report of Rolling Stock & Viaduct (for All Contractor)
29	RPT-C-7	Test Report of Rolling Stock & Underground (for All Contractor)
30	RPT-C-8	Test Report of Rolling Stock & Depot (for All Contractor)
31	RPT-C-9	Test Report of Rolling Stock & Depot Equipment (for All Contractor)
32	RPT-C-10	Test Report of Rolling Stock & TVS (for All Contractor)
33	RPT-C-11	Test Report of Rolling Stock & Rolling Stock (ARE03A & ARE04A Contractor)
34	RPT-C-12	Routine Test Report of Rolling Stock & Signalling System (for Each Trainset)
35	RPT-C-13	Routine Test Report of Rolling Stock & Telecommunication TETRA System (for Each Trainset)
36	RPT-C-14	Routine Test Report of Rolling Stock & Telecommunication TETRA System (for Each Trainset)
Appendix D : Guidelines & Drawings		
		NIL
Appendix E : Not Used		
		NIL

1

Sl. No.	Reference	DESCRIPTION
Appendix F : Not Used		
		NIL
Appendix G : Documentation & CAD Drawing Requirements		
1	PDR-G-1	Documentation & CAD Drawing Requirements
Appendix H : Not Used		
		NIL
Appendix I : Train Withdrawal Scenarios For 6 car Trains		
1	PFDR-I-1	Train Withdrawal Scenarios For 6 car Trains

APPENDIX – I: TRAIN WITHDRAWAL SCENARIOS FOR 6 CAR TRAIN

In case of occurrence of below mentioned conditions during revenue operations, the specific train shall be withdrawn from service in UTO mode of operation (desired operation mode) or rescued by another train to clear the faulty train from passenger service.

Desired mode of operation during initial stage of passenger service operation shall be ATO & subsequently UTO.

The below mentioned train withdrawal conditions shall be considered for reliability performance calculations as mentioned in Section VI A ERTS (RS) Chapter 18.6.

Contractor shall suggest additional withdrawal conditions required to be added specific to the train design and shall be finalized during the design stage of contract execution.

S. No.	System name	Withdrawal Condition
1	Front windshield	Broken / cracked front window in the cab Breakage due to stone throwing / vandalism shall not be on the Contractor's account.
2	Suspension	Any defect in primary / secondary suspension resulting in passenger safety, comfort or performance.
3	Wheel	If wheel flat is > 40 mm wide or as finalised in design. Any abnormal hammering as reported by the Train Operator / Passengers. Axle bearing seized.
4	Pantograph	Isolation of any one pantograph
5	Transformer	Isolation / fault in any one main transformer.
6	Battery charger	Battery Charger of one unit isolated.
7	Mechanical drive on gear box system	Any defect resulting in high temperature / fault Abnormal Noise from underframe.
8	Gang way	If the side wall of the gangway torn out, then train will be withdrawn.
9	Communication loss with OCC	If any communication loss with OCC, train shall be withdrawn
10	Traction Motors	Isolation of more than 4 traction motors.
11	Traction converters	Isolation of more than Two traction inverter incase of bogie control propulsion system or Isolation of more than One traction inverter incase of car control propulsion system.
12	Main compressor unit	Isolation / fault in any one Main Compressor Unit.
13	Air leakage	Any leakage which necessitate continuous running of compressor. Any leakages which may lead to incorrect brake application. Any leakages from brake valves, pantograph, main circuit breaker.
14	Auxiliary converter inverter	In any Two Auxiliary Converter-Inverter unit is faulty or isolated.

S. No.	System name	Withdrawal Condition
15	Brake system (mechanical)	If isolation of brakes of 4 bogies occurs.
16	Exterior lights and Interior lights	- Failure of any Head / Tail / Marker light in any car. - Failure of more than 50% saloon lights in a Car
17	Operator's Desk	If master controller prevents the train from further movement. Any defect in master controller or any operator's desk controls even if no delays are reported. Any defective cab switches leading to unsafe operation.
18	TCMS & Vehicle circuits	If TCMS DDU display fails. Any failure in TCMS component / equipment / circuit element / software / communication system etc. resulting in loss of intended function. Further cases will be included based on TCMS redundancy and configuration.
19	PA, PIS & CCTV	If automatic announcements fail & OCC operator or Train Operator is not able to make manual announcements. If 50% announcements in saloon are not audible. If more than one PEI (Passenger Emergency Intercom) in any car is defective. Any of the front CCTV not functioning during GoA4 operation One saloon CCTV, including its backup if any, is isolated.
20	Passenger doors	If ≥ 2 (two) doors per train side is isolated. If at-least one door cannot be properly closed / locked. If at-least one door communication with PSD is faulty.
21	~~Detrainment door~~ Deleted	~~If detrainment door cannot be closed if the detrainment door safety circuit prevents moving of the train~~ Deleted
22	VAC (passenger area)	Failure of any one VAC unit in any car leading to increase in inside saloon temperature beyond 28 °C Failure of two VAC's in one car. Noisy Air Conditioner.
23	Ground fault in DC Circuit	Train to be withdrawn in case of single ground fault in any part of the train.
24	A failure or symptom which may endanger safe and/or normal operation of train	Failure in safety interlock or protection circuit such as door loop, brake loop, EB loop. Abnormal noise in underframe. Wheel flat creating abnormal noise. Arcing in pantograph or on the train roof. Failure of emergency equipment. Failure which may disable train's push out duty.

1

S. No.	System name	Withdrawal Condition
		Train which that requires more than 2 instances of reset within 30 minutes. Jerky movement. Failure of battery fuse. Unintended operation or malfunction of any safety device / emergency equipment causing operational exceeding 3 minutes delays. Train fail to start after successful completion of pre-departure checkout.
25	Communication failure with Signalling due to Rolling stock hardware or software failure	Any communication failure with Signalling train component or way side component due to Hardware or software failure occurred in Rolling stock equipment and which shall interrupt UTO / DTO / ATO / ATP train operation shall be considered as Rolling stock failure.
26	Others	Any hardware or software failures of Rolling stock which shall cause delay in train operation at a specific location greater than 5 minutes shall also be considered as a Train Withdrawal condition and shall also be counted in Reliability calculations.
27	Failures in UTO operation	During operation of train in UTO, if it is required to depute a train operator / any attender to pull off the train out of passenger service shall be a withdrawal scenario.
28	Car-body structure	Failure of the structural integrity of any car.
29	Exterior equipment	Failure of exterior equipment (VAC, Underframe equipment) resulting in risk to line side personnel or exceeding kinematic envelope
30	Windows & draught screen	Failure of any One window on train. Window cracked due to defect of window. Draught screen broken.
31	Internal controls	Failure of train door control circuits at either cab. Failure of brake control circuits in either cab.
32	Windscreen Wiper	Rainy weather and defective wiper in any cab.
33	Under frame	Loss of integrity of any major equipment mounting.
34	Bogie	Loss of integrity of bogie structure Anti-roll bar failure
35	Semi-permanent half coupler	Failure of coupler Mechanical failure of coupler Pneumatic connection failure if not isolated through isolating cock.
36	Auto-coupler	Failure of coupler Mechanical failure of coupler Pneumatic connection failure if not isolated through isolating cock.
37	Gear coupling and Reaction Rod	Reduction of propulsion power.

S. No.	System name	Withdrawal Condition
		Failure of the drive gear causes the gear seized or major oil leakage from gear box
38	Saloon Interior	Interior panel including gangway panels fall off Light diffusers damages or broken
39	Fire system	≥ 2 in one car fire detector failure Failure of fire control unit including its backup
40	Further additions	This list shall be further developed during DLP.

Note:

1. In case the Withdrawal Condition arises solely for reasons not attributable to the Contractor, the failure shall not be to Contractor's account and shall not be considered for reliability MDBF calculation.
2. In any case of occurrence of above listed failures in mainline/depot, CMRL may still continue to operate the train in revenue service in view of any operational constraints. These failure scenarios shall also be considered for Reliability performance calculations as mentioned in Section VI A ERTS (RS) Chapter 18.6.



CHENNAI METRO RAIL LIMITED

CHENNAI METRO RAIL PROJECT PHASE – I

BID Tender No. ARE05

PART- 2: SECTION VI B – EMPLOYER’S REQUIREMENTS TECHNICAL SPECIFICATIONS (ERTS) – DEPOT MACHINERY & PLANT (DM&P)

TABLE OF CONTENTS

Chapter / Clause	Description	Page
1	CHAPTER 1 : GENERAL REQUIREMENTS AND SCOPE	1-1 to 1-15
1.1	INTRODUCTION	1-1
1.2	LIST OF DEPOT MACHINERY AND PLANT	1-1
1.3	SUPPLY OF DOCUMENTS AND MANUALS	1-4
1.4	INSTALLATION, INSPECTION, TESTING AND COMMISSIONING	1-5
1.5	NOT USED	1-7
1.6	TRAINING	1-7
1.7	TOOLS	1-8
1.8	NOT USED	1-8
1.9	NOT USED	1-8
1.10	NOT USED	1-8
1.11	STANDARDS (WHERE APPLICABLE)	1-8
1.12	MARKING AND IDENTIFICATION	1-10
1.13	NOT USED	1-10
1.14	ABBREVIATIONS & DEFINITIONS	1-10
1.15	PERSONNEL	1-11
1.16	PROJECT MANAGEMENT INFORMATION SYSTEM (PMIS)	1-12
1.17	DOCUMENTATION AND CAD STANDARDS	1-12
1.18	OTHER	1-12
1.19	SUBCONTRACTOR/MANUFACTURER	1-13
1.20	TECHNICAL SPECIFICATION	1-15
2	CHAPTER 2 : EMPLOYER’S REQUIREMENTS TECHNICAL SPECIFICATIONS (ERTS) – DEPOT MACHINERY & PLANT (DM&P)	2-1 to 2-166
2.1	UNDER FLOOR WHEEL LATHE (UFWL)	2-1

Chapter / Clause	Description	Page
2.2	AUTOMATIC TRAIN WASH PLANT (ATWP)	2-17
2.3	SYNCHRONISED PIT JACKS (SPJ)	2-25
2.4	BOGIE TURN TABLES (BTT)	2-32
2.5	BATTERY OPERATED RAIL-CUM-ROAD SHUNTER (BORRS)	2-34
2.6	SYNCHRONISED MOBILE LIFTING JACKS (SMLJ)	2-40
2.7	CAR BODY STAND	2-44
2.8	RELIEF AND RESCUE VEHICLE (RRV)	2-45
2.9	BOGIE MANIPULATOR	2-56
2.10	BOGIE TESTING UNIT (BTU)	2-58
2.11	ELECTRIC OVERHEAD TRAVELING (EOT) CRANES	2-69
2.12	~~DOUBLE CYLINDER HYDRAULIC WHEEL PRESS DELETED~~	2-79
2.13	~~VERTICAL TURNING LATHE DELETED~~	2-88
2.14	TUNNEL & TRACK CLEANING VEHICLE	2-100
2.15	DRIVER DESK SIMULATOR	2-107
2.16	MAINTENANCE DESK SIMULATOR	2-113
2.17	ULTRASONIC FLAW DETECTOR (UFD)	2-116
2.18	BATTERY-OPERATED PLATFORM TRUCK (BOPT)	2-118
2.19	BATTERY-OPERATED SELF-PROPELLED SCISSOR LIFT	2-120
2.20	HIGH-PRESSURE WASH PUMP	2-124
2.21	HAND PALLET TRUCK	2-127
2.22	BATTERY-OPERATED FORKLIFT TRUCK	2-128
2.23	MOBILE LIFTING TABLES (MLT)	2-131
2.24	KEY MANAGEMENT SYSTEM	2-135
2.25	VERTICAL STORAGE SYSTEM (VSS)	2-137
2.26	MOBILE AIR COMPRESSOR	2-141
2.27	INDUCTION HEATER	2-144
2.28	BATTERY OPERATED CART/BUGGY	2-145
2.29	RS PUSHER	2-147
2.30	HYDRAULIC FLOOR CRANE	2-149
2.31	TRACTION MOTOR DRYING OVEN	2-150
2.32	WHEEL PROFILE MEASUREMENT DEVICE - HAND HELD CONTACT TYPE	2-152
2.33	INDUSTRIAL VIDEOSCOPE	2-154
2.34	TWO POST LIFTING JACK	2-155
2.35	VARIOUS STORAGE ITEMS	2-157
2.36	TOOLS AND OTHER ITEMS	2-162
3	CHAPTER 3: INTERFACE MANAGEMENT	3-1 to 3-11
3.1	INTRODUCTION	3-1
3.2	INTERFACE SPECIFICATION: DEPOT MACHINERY & PLANT (DM&P) CONTRACTOR & ROLLING STOCK (RS) CONTRACTOR	3-2

Chapter / Clause	Description	Page
3.3	INTERFACE SPECIFICATION: DEPOT MACHINERY & PLANT (DM&P) CONTRACTOR AND TRACK WORKS (TW) CONTRACTOR	3-5
3.4	INTERFACE SPECIFICATION: DEPOT MACHINERY & PLANT (DM&P) CONTRACTOR AND DEPOT ELECTRICAL & MECHANICAL CONTRACTOR (E&M / MEP) CONTRACTOR	3-6
3.5	INTERFACE SPECIFICATION: DEPOT MACHINERY & PLANT (DM&P) CONTRACTOR AND SIGNALLING TRAIN CONTROL (STC) CONTRACTOR	3-9
3.6	INTERFACE SPECIFICATION: DEPOT MACHINERY & PLANT (DM&P) CONTRACTOR AND OVERHEAD EQUIPMENT (OHE) CONTRACTOR	3-10
3.7	INTERFACE SPECIFICATION: DEPOT MACHINERY & PLANT (DM&P) CONTRACTOR AND TELECOM & RADIO (RAD) CONTRACTOR	3-10
4	CHAPTER 4: Employer's drawing	4-1

CHAPTER 1

1. GENERAL REQUIREMENTS AND SCOPE

1.1 INTRODUCTION

- 1.1.1 This chapter covers the general requirements and scope for Depot Machinery and Plant and is to be read in conjunction with the Technical Specification in Chapter-2 Part 2 Section VIB as well as employer's drawings and other contract documents.
- 1.1.2 The Koyambedu depot will be utilised to stable, maintain and dispatch new rolling stocks to be procured for CMRL Phase I project for passenger service. Unless otherwise stated, the machinery and plant referred to in this section is to be installed and commissioned at Koyambedu Depot.
- 1.1.3 The Rolling Stock will be of approx. 2.9-metre-wide air-conditioned cars. The trains, maximum of 6-car configuration shall be capable of sustaining a maximum permissible speed of maximum 90 kmph. All Trains in CMRL phase-I & Phase 1 extension network shall be operated in ~~GOA-2 mode (Grade of Automation level 2) / Non-UTO~~ UTO & Non-UTO mode. The Contractor shall design the Machinery and Plant accordingly.
- 1.1.4 The main purpose of Koyambedu depot is to carryout Preventive Maintenance (PM), Corrective Maintenance (CM) and overhaul of rolling stock fleets serving CMRL Phase I network. To improve the efficiency and reduce downtime for maintenance activities, Chennai Metro Rail Limited has decided to procure below given Machinery and Plant. Provisional Civil works required to provide foundations for the respective Depot Machinery and Plant shall be constructed by CMRL's designated civil Contractor. The Depot M&P Contractor shall check and study the climate condition of Chennai to design, manufacture and execute the works for Depot M&P accordingly.

1.2 LIST OF DEPOT MACHINERY AND PLANT:

Table 1-1 : List of Major Machinery and Plant

Machine No.	Major Machinery and Plant	Unit	Qty
DM&P-Q1	Under Floor Wheel Lathe (UFWL)	Nos	1
DM&P-Q2	Automatic Train Wash Plant (ATWP)	Nos	1
DM&P-Q3	Synchronised Pit Jacks (SPJ) for 6 Car Length	Set	1
DM&P-Q4	Bogie Turn Table (BTT)	Nos	4
DM&P-Q5	Battery Operated Rail Cum Road Shunter-for 6 car shunting (BORRS)	Nos	2
DM&P-Q6	Synchronised Mobile Lifting Jacks (SMLJ) for 6 Car Length	Set	1
DM&P-Q7	Car Body Stand (CBS) for 6 Car Length	Set	1
DM&P-Q8	Diesel Operated Relief and Rescue Vehicle (RRV) With Rerailing & Rescue Equipment	Nos	1
DM&P-Q9	Bogie Manipulator (BM)	Nos	1
DM&P-Q10	Bogie Testing Unit (BTU)	Nos	1
DM&P-Q11	EOT Crane 15/5t (Category 1)	Nos	1
DM&P-Q12	EOT Crane 15/5t (Category 2)	Nos	1

1

Machine No.	Major Machinery and Plant	Unit	Qty
DM&P-Q13	EOT Crane 5t for Depot Store	Nos	1
~~DM&P-Q14~~	~~Double Cylinder Hydraulic Wheel Press (DWP) Deleted~~	~~Nos~~	~~1~~
~~DM&P-Q15~~	~~Vertical Turning Lathe (VTL) Deleted~~	~~Nos~~	~~1~~
DM&P-Q16	Track & Tunnel Cleaning Vehicle	Nos	1
DM&P-Q17	Drivers Desk Simulator	Nos	1
DM&P-Q18	Maintenance Desk Simulator	Nos	1

Table 1-2 : List of Other Machinery and Plant

Machine No.	Other Machinery and Plant	Unit	Qty
DM&P-R1	Ultrasonic Flaw Detector (Handheld Device)	Nos	1
DM&P-R2	Battery Operated Platform Truck (2t)	Nos	3
DM&P-R3	Battery Operated Scissor Lift	Nos	4
DM&P-R4	High Pressure Water Jet cleaning machine (Hot & Cold wash)	Nos	2
DM&P-R5	Pallet Truck Manual - 2.5t	Nos	5
DM&P-R6	Battery Operated Forklift Truck(3t)	Nos	2
DM&P-R7	Mobile Lifting Table (MLT) 5t	Nos	1
DM&P-R8	Mobile Lifting Table (MLT) 2t	Nos	1
DM&P-R9	Automatic Key Management System	Nos	1
DM&P-R10	Vertical Storage System	Nos	1
DM&P-R11	Mobile Air Compressor	Nos	2
DM&P-R12	Induction Heater	Nos	1
DM&P-R13	Battery Operated Cart/Buggy (6-Seater)	Nos	2
DM&P-R14	RS Pusher (Battery Operated)	Nos	2
DM&P-R15	Hydraulic Floor Crane 2t	Nos	2
DM&P-R16	Traction Motor Drying Oven	Nos	1
DM&P-R17	Wheel Profile Measurement device - Hand Held Contact Type	Nos	1
DM&P-R18	Industrial Videoscope	Nos	1
DM&P-R19	Two Post Lifting Jack	Nos	1

Table 1-3 : List of Storage Items

Machine No.	Storage Items	Unit	Qty
DM&P-S1	Storage Racks	Nos	40
DM&P-S2	Mechanical Work Bench	Nos	10
DM&P-S3	Storage Bins – Type 1	Nos	50
DM&P-S4	Storage Bins – Type 2	Nos	50

Machine No.	Storage Items	Unit	Qty
DM&P-S5	Storage Bins – Type 3	Nos	50
DM&P-S6	Pallet (Heavy Duty)	Nos	25
DM&P-S7	Storage Cabinet – Almirah type	Nos	25
DM&P-S8	Personnel Lockers	Set	10
DM&P-S9	Flammable Liquid Storage Safety Rack	Nos	5
DM&P-S10	Stand for HVAC Filter Cleaning	Nos	2
DM&P-S11	Industrial Vacuum Cleaner	Nos	1
DM&P-S12	Movable Platform(Upto train Door Level)	Nos	10
DM&P-S13	Manual Mobile Ladder for window glass access	Nos	5

Table 1-4 : List of Tools and other minor items

Machine No.	Tools, Measurement and Other Items	Unit	Qty
DM&P-T1	Weighing Machine (Capacity 1000kg)	Nos	2
DM&P-T2	Piece Counting Weighting Machine	Nos	2
DM&P-T3	Welding Machine Portable	Nos	2
DM&P-T4	Portable Hand Grinder	Nos	2
DM&P-T5	Drilling Machine Portable	Nos	2
DM&P-T6	Pedestal Grinding Machine (2 Disc Type)	Nos	1
DM&P-T7	Pillar Drilling Machine	Nos	1
DM&P-T8	Metal Cutting Machine	Nos	2
DM&P-T9	Dewatering Pump Portable	Nos	3
DM&P-T10	Coupling/Bearing Puller	Nos	2
DM&P-T11	Tool Cabinet Trolley	Nos	5
DM&P-T12	Bench Vise 6"	Nos	5
DM&P-T13	Mechanical hand Tool Kits	Nos	5
DM&P-T14	Ratchet socket set	Nos	3

1.2.1 The scope of Works under this contract is for Design, manufacture, Supply, delivery (at Koyambedu Depot or any designated depot by CMRL), installation, testing and commissioning, training, supply of operation & maintenance manuals, Operation(during testing, trail & DLP period) alongwith the operator, supply of spares parts and consumables for periodic, preventive and corrective maintenance during DLP for all the machines mentioned above at Koyambedu Depot or any designated depot by CMRL.

1.2.2 Special Note:

- i) All Depot Machinery and Plant given in the tender scope, shall be utilized for new (6 car configuration) as well as existing rolling stocks (4 car configuration). The above depot machinery shall be designed, manufactured, and demonstrate its compatibility during testing & commissioning for new as well as existing rolling stocks in CMRL phase -I.
- ii) Besides, CMRL has planned to procure additional RS in future as stated in Detailed Project Report, therefore the Contractor shall ensure to design the respective major M&P in compatibility of future expansion.

- iii) The Contractor shall comply with the Interface Requirements (specified in Chapter 3 of this section VIB) and shall undertake all trials, and acceptance tests required to verify the compatibility with new as well as existing train fleets at no additional cost to CMRL.
- iv) Unless otherwise stated, the clause conditions specified in this document shall apply to all the machines listed in Table 1-1, Table 1-2, Table 1-3 & Table 1-4.

1.3 SUPPLY OF DOCUMENTS

- 1.3.1 The Contractor shall supply to CMRL a list of deliverables for the procurement, design, manufacture, Inspection, testing, installation, training, maintenance, and operation of each machine.
- 1.3.2 The Contractor's list of deliverables shall be submitted to CMRL as per instruction of Engineer / Employer.
- 1.3.3 The Contractor shall submit the following detailed documents for getting notice of no objection from CMRL (but not limited to)
 - a) List of sub-Contractors / suppliers / vendors of all the DM&Ps.
 - b) Compliance matrix
 - c) Master Schedule Programme with all activities for entire Works
 - d) Project Management plan
 - e) Quality & Safety procedures and plans
 - f) Proposed planning and programming of manufacturing and execution of the work relating to the procurement / availability of the equipment and achieving the completion of the work as per technical specifications within the stipulated period of completion.
 - g) Interface Management Plan and Detailed Interface Documents.
 - h) Monthly progress reports
 - i) Detailed Design Submission for respective machine.
 - j) General Arrangement drawing showing mounting arrangement & Foundation Drawing (to interface with depot civil Contractor appropriately).
 - k) Installation, Testing, Commissioning and Training programs
 - l) As-built drawings and Manufacturing drawings
 - m) BIM model and drawings
- 1.3.4 Manuals : The Contractor shall submit the following detailed manuals and documents for getting notice of no objection from CMRL.
 - a) Installation / Erection manual
 - b) Operations manual
 - c) Training manual
 - d) Preventive Maintenance Manual
 - e) Trouble shooting Manual
 - f) Testing & Commissioning manual
 - g) Electrical and pneumatic schemes
 - h) Spare parts catalogue including supplier details
- 1.3.5 The complete M&P maintenance documents management software shall be provided before DLP. This software shall contain all maintenance manuals, operations manual, troubleshooting manuals, design documents, material catalogues with Vendor credentials.

1.4 INSTALLATION, INSPECTION, TESTING & COMMISSIONING

1.4.1 General Requirements

- a) The Contractor shall put in place a full testing program to demonstrate that all the requirements of the Specification are met.
- b) The Contractor shall develop an Integration Testing & Commissioning plan to verify the machines in all modes of operation and with all necessary interfacing requirements. Test programs, methods and results shall be documented and submitted to CMRL.
- c) The Contractor shall include in the Integration Testing & Commissioning plan, methodology of ensuring safety during integration testing and commissioning and service trials.
- d) CMRL may conduct independent safety audits and will therefore require access to all the relevant design and product information. The Contractor shall provide all necessary assistance to CMRL.
- e) All the tests shall be carried out by the Contractor. CMRL shall be invited to attend as a witness. However, this does not absolve the Contractor's responsibility to test to the applicable standard and the Specification. All the costs associated with the CMRL's representative(s) witnessing of tests shall be borne by the CMRL either in India or abroad.
- f) During the execution of works, the Contractor's support shall include, but not be limited to:
 - i) Provision of test equipment.
 - ii) Attendance of competent staff.
 - iii) Provision of test procedures.
 - iv) CMRL may request that repeat tests be carried out to simulate the failure mode of any critical hardware / software component that is deemed to have a significant effect on the safety or reliability of the system.
 - v) The Contractor shall provide any simulation equipment, required for testing or commissioning.
 - vi) The Contractor shall submit a Testing and Commissioning program for the CMRL's review.
 - vii) The Contractor shall provide details of the testing activities as specified in the Specification.
 - viii) All alterations to equipment, systems and designs shall be carried out within the scheduled time prior to installation & commissioning.
 - ix) Access shall be granted to the CMRL to any facility where installation, cutover work, or other tests are in progress.
 - x) CMRL reserves the right to access at any time the records of all pre and post installation inspection and testing of equipment. In the absence of adequate documentation, CMRL shall have the right to request the Contractor to repeat these tests to avoid problems being accumulated at subsequent phases. Testing and commissioning will not be allowed to start until the Post Installation Inspection and Testing phases are completed.

1.4.2 Sequence of Tests

- a) Type Tests is not required to be performed. However previous type test reports of similar Design shall be submitted for information of CMRL.
- b) Factory Acceptance Tests (FAT):
 - i) Factory acceptance test plan shall be submitted for CMRL's review. The plan shall adopt a top-down approach and describe the FAT strategy as regards to methodology, procedures to be followed and records to be submitted. The Contractor shall submit the comprehensive list of specifications to be followed.
 - ii) FAT plan / submission shall include the appropriate testing and inspection items for Notice of No Objection.
 - iii) FAT shall demonstrate that each machine/subsystem meets its functional specification. Prerequisites, if any shall be made available by the Contractor at his own cost. For example, for UFWL FAT, a suitable wheel set should be made available by the

Contractor/manufacturer at his facility for demonstrating the capabilities of the machine at its own cost.

- iv) No equipment or software should be delivered to the Site until the Contractor has demonstrated to the satisfaction of the CMRL that the equipment or software conforms to the Specification by carrying out the FAT.
- v) The Site for the FAT of equipment shall be notified to the CMRL 60 days prior to commencement of the FAT. CMRL shall have the right to witness or waive-off the FAT.
- vi) Cost related to travel and stay of CMRL representatives during FAT at manufacturer site as per FAT Program will be borne by CMRL.
- vii) In case of failure of FAT, the Contractor shall be responsible for arranging Re-FAT and all the cost incurred associated with travel, accommodation, food visas and permits for CMRL and Engineer.

1.4.3 Pre-installations tests and inspection

- a) Prior to installation, the Contractor shall ensure that equipment delivered to Site has not been damaged in transit. Inspection and testing shall be conducted by the Contractor to determine that the equipment has not been damaged or the performance impaired in any manner subsequent to shipment.
- b) Test procedures shall be carefully planned to ensure that the work can be completed within the time available. If the time available is restricted, this planning shall include a contingency plan to be implemented if testing proceeds slower than anticipated or defects are identified, which cannot be corrected.
- c) The Contractor shall submit to CMRL a site preparation plan before installation.
- d) The Contractor shall prepare the site in all respects required for installation.

1.4.4 Post Installation Tests

- a) Site tests shall be carried out in order to verify that the installations are correct and that, when the system as a whole is connected together, they function safely as an integrated system.
- b) All tests shall be documented, and tests results recorded. Test certificates with completed test records, which demonstrate equipment and components meet the performance requirements of the specification, shall be submitted for information.
- c) Post Installation tests shall be carried out by the Contractor before Functional Tests to demonstrate that the installation has been carried out correctly.
- d) The Contractor shall submit a Post Installation Inspection and Testing Plan prior to the commencement of the post installation inspection and testing.
- e) Inspection shall verify that equipment has been installed to the procedures and designs that have received no objection from the CMRL, and equipment is correctly located and labelled.
- f) Inspection shall verify that any false feed, temporary wiring, and redundant items have been removed and that equipment is correctly protected against interference, damage and deterioration.
- g) The Contractor shall maintain inspection records to demonstrate that each item of equipment has been inspected and found to be satisfactory and attach to this record a detailed list of any discrepancies found and remedial work carried out. Inspection records shall be kept for all installed equipment and a detailed list attached of any discrepancies.
- h) As the discrepancies are rectified, the record sheets shall be amended to record the corrections.

1.4.5 System Acceptance Tests (SAT)

- a) System Acceptance Tests shall comprise comprehensive testing of the completely assembled installation to ensure that every item has been installed, adjusted, and to demonstrate that all machines operate correctly in accordance with the Specification, perform in accordance with the Specification and the local configuration and are available for integration testing & commissioning.
- b) Prior to System Acceptance Testing, the Contractor shall submit a System Acceptance Plan to

- the CMRL for Notice of No Objection. The plan shall adopt a top-down approach and describe the System Acceptance strategies and processes.
- c) System Acceptance Plan shall identify a comprehensive list of specifications, standards, method statements, procedures, drawings and records to be submitted to CMRL for Notice of No Objection. The Plan shall also include a programme which identifies the dates for system acceptance submission and tests.
 - d) Any tests carried out which are deemed as System Acceptance Tests shall be identified. If these tests have been carried out earlier or form the part of earlier carried tests, the same need not be repeated unless desired by the CMRL. However, these tests should be identified and included in the System Acceptance Test Plan.
 - e) These tests shall be conducted in the presence of the CMRL who may decline for witness.
 - f) Any defects which become apparent in the course of these tests shall be made good and modifications as approved shall be implemented and recorded. All affected equipment shall be retested and certified before the system is accepted.
 - g) Prerequisites for SAT;
 - i) All documentation for the Safety Report shall be submitted to the CMRL for a Notice.
 - ii) All SAT shall be completed, and test records submitted to CMRL for a Notice.
 - iii) Facilities for the maintenance of the System shall be in place.
 - iv) SAT Plan shall be submitted to the CMRL for a Notice of at least 60 days before the commencement of the SAT.
 - h) System Acceptance Test Requirements
 - i) It shall be the Contractor 's responsibility to conduct all tests and record data and restore the machines to full operational use following the SAT.
 - ii) During the SAT, all interfaces with external systems other than those pertaining to the designated Contractor shall be tested.

1.4.6 Integration Testing and Commissioning

- a) On completion of testing and commissioning of the Contractor 's own system to the satisfaction of the CMRL the Contractor shall carry out all tests necessary to integrate the particular machine with all other systems of CMRL such as new as well as existing Rolling Stock, Track, Communication / signalling and train control, Overhead Equipment, Civil, etc. and demonstrate correct operation of all internal and external interfaces as applicable.
- b) Integration Testing & commissioning plan containing the schedule of integration tests in coordination with the interface Contractors and test procedures shall be submitted to the CMRL for a Notice of No Objection. The tests shall be carried out in coordination with the interface Contractor.
- c) The Contractor shall be required to lead in certain Integration Testing and Commissioning where such tests are required to prove the performance of system provided by the Contractor.
- d) All the defects and shortfalls in the Contractor 's system discovered in the course of Integration Testing and Commissioning shall be made good and retested / performed to the satisfaction of the CMRL before the issue of Taking Over Certificate by CMRL.
- e) Testing and commissioning shall be managed without perturbation and/or interruption of operation and maintenance.
- f) CMRL may require additional tests if needed.

1.5 NOT USED

1.6 TRAINING

- 1.6.1 The Contractor has to prepare a comprehensive training plan for all the machines and submit to CMRL for notice of no objection.

- 1.6.2 The Contractor shall provide training that enables operators and maintainers to work with the machines in the most efficient and safe manner.
- 1.6.3 The Contractor shall provide comprehensive training and documentation to the CMRL's staff including Machine Operators & Machine Maintainers.
- 1.6.4 The Contractor shall adapt the content of its standard training courses to the CMRL's infrastructure and also to the trainees' skills background.
- 1.6.5 The Contractor shall:
- a) provide classroom training to trainees at the CMRL's depot premises.
 - b) provide competent training instructors, training manuals, all necessary aids and materials as required for training.
 - c) provide handouts for each trainee during the training.
- 1.6.6 The Contractor shall provide training for at least 6 CMRL nominated staff for each machine at Koyambedu depot. Period of training should be adequate (but not less than 6 working days for each major machinery and minimum 3 working days for each other machinery and plant other than major machinery and plant) and shall cover all aspects to make nominated staff of CMRL to carry out operation, schedule attention, troubleshooting and repairs to these machines as and when required. A competency certificate shall be issued to each trainee after completion of training on the respective machine. Training should be imparted in English. Cost of training should be included in the cost of equipment.

1.7 TOOLS:

- 1.7.1 The Contractor shall provide one (1) individual Industrial Grade Laptop (windows OS professional with latest MS office package) with each machine quantity (ATWP, UFWL, SPJ, BORRS, BTU, DWP, VTL & VSS) for software loading / failure logs downloading etc :
- Such laptops, shall comply with (but not be limited to) the following minimum specification: -
- a) Core i7 processor or latest
 - b) RAM 32GB
 - c) SSD Storage Unit 1TB and above
 - d) Screen 14 Inch
 - e) Enhanced Battery Life
- The Contractor shall submit details of the laptop specification / configuration to CMRL for approval during design stage. All Laptops shall be handed over to CMRL prior to DLP.
- 1.7.2 3 sets of keys for each applicable machine.
- 1.7.3 Any other tools such as special keys, measuring and monitoring tools etc which are required for rectifying the machine failures, shall be supplied for each machine. Contractor shall furnish details of such above special tools.

1.8 NOT USED

1.9 NOT USED

1.10 NOT USED

1.11 STANDARDS (WHERE APPLICABLE):

- 1.11.1 Work related to the design, manufacturing, and execution etc of the equipment shall comply with the relevant European / International Standards, Codes of Practice or equivalent Indian codes & standards (subject to CMRL approval) and latest Statutory Requirements of India (subject to CMRL approval), as given in Table below (but not limited to) The respective standards for few machines are indicated vide given respective machine specification too.

Table 1-5: Standards

Standard	Description
BS EN ISO 4413:2010	Hydraulic fluid power. General rules and safety requirements for systems
IS 8623/1977	Factory built assembly switch gear and control gear
IS 4460/1967	Specifications for gears
IS 3028	Sound Level
ISO 1217	Displacement compressors - Acceptance tests-09/1996.
ISO 1711	Assembly tools for screws and nuts – Technical Specification - Hand operated wrenches and sockets
BS 5378	Safety colours and safety signs
BS EN 287	Approval testing of welders for fusion welding
BSEN 288	Specification and approval of welding procedures for metallic materials
BS 5304	Code of practice for safety of machinery
BS 5395	Stairs, ladders and walkways
BS 5950	Structural use of steelwork in building
BSEN 60073	Specification for coding of indicating devices and actuators by colours and supplementary means
EN 60204	Electrical equipment
BSEN 60529	Specification for degrees of protection provided by enclosures (IP code)
EN 954-1	Safety for Control System
IS 325	Electric Motor
ISO 9001-3:1991	Guideline for the Application of ISO9001 to the Development, Supply and Maintenance of Software

1.11.2 Where no standard is identifiable, the Contractor shall make a proposal, based on the best international Industrial practice, which shall be subject to review and approval by CMRL. The Contractor shall submit a consolidated list of all the standards that he intends to use for the design, manufacturing and testing and other phases of the Contract, for review and approval by CMRL. All drawings and design calculations submitted with the Bid, or in accordance with the requirements of the Contract, shall use SI units.

1.11.3 Surface Treatment:

- Surface treatment of the Equipment shall be suitable for the working environment under the climatic conditions of Chennai.
- External surfaces shall be subjected to brushing, degreasing and sand / shot / grit blasting. Thereafter a coat of anti-corrosion paint shall be applied. The thickness of this coat after drying shall not be less than 60 microns (as applicable).
- Hollow parts shall be treated prior to assembly.

1.11.4 Painting:

- External and related parts shall be, after the surface treatment, given two coats of polyurethane lacquer with a dry unit thickness of at least 60 microns. The second coat shall be applied over the first coat when it is approximately half dry.

- b) The Contractor shall touch up at site any paint as may be necessary.
- c) Paint color scheme shall be submitted to CMRL for his notice of No Objection and shall be finalized during the design phase separately for each machine.
- d) All rubbing parts or those to remain polished shall be covered with a coating designed to protect them from oxidation until such time as the machine enters the service.
- e) If any of above aspect under Finish and Painting vary for any machine, the same shall be finalized during design stage.

1.12 Marking and Identification:

- 1.12.1 A plate indicating Name of manufacturer, Important technical particulars, Year of Manufacture & Serial Number shall be fixed on each Machine at suitable location.
- 1.12.2 Logo of CMRL shall be affixed at suitable location(s) on each Machine.
- 1.12.3 The Contractor shall submit the proposed scheme of identification to the CMRL for his Notice of No Objection
- 1.12.4 The Contractor shall arrange its own lifting / handling facilities for unloading, shifting, execution or any other handling activity / work before & during installation and commissioning of Machinery and Plants at depot site.
- 1.12.5 The Contractor shall supply and deliver the machine till Koyambedu depot site in good condition. Suitable safe unloading arrangement shall be made by Contractor. Safety and security of each machine and its associated assembly, parts, spares etc shall be well taken care by the Contractor.

1.13 NOT USED

1.14 ABBREVIATIONS & DEFINITIONS:

- 1.14.1 Various abbreviations used in this tender are set out in alphabetical order in the below table where applicable (but not limited to):

Table 1-6: Abbreviations & Definitions

Abbreviation	Description
AC	Alternating Current
AMS	Asset Management System
ATP	Automatic Train Protection
BIM	Building Information Modelling
BS	British Standard
CAD	Computer Aided Design and Drafting
CD	Compact Disc
CNC	Computer Numerical Control
DC	Depot Contractor
DDC	Detail Design Consultants
DM&P	Depot Machinery & Plant
E&M	Electrical & Mechanical
EMC	Electro Magnetic Compatibility
EMI	Electro Magnetic Interference

Abbreviation	Description
ES	European Standard
FAT	Factory Acceptance Test
GA	General Arrangement
GC	General Consultants
IMP	Interface Management Plan
IP	Ingress Protection
IT	Information Technology
LAN	Local Area Network
LED	Light-Emitting Diode
NoNO	Notice of No Objection
OCC	Operational Control Center
OCS	Overhead Catenary System
OEM	Original Equipment Manufacturer
OHE	Over Head Equipment
OHS&E	Operational Health, Safety & Environment
O&M	Operation and Maintenance
PM	Project Manager
QA	Quality Assurance
RS	Rolling Stock
SAT	Site Acceptance Test
SI	International System (of Measurement)
STC	Signalling and Train Control
Telecom	Telecommunication
TRW	Track Works Contractor

1.15 PERSONNEL

- 1.15.1 The Contractor shall submit their Complete Staffing proposal for all the following Key Staffs duly in compliance with the conditions / criteria specified below, within 7 days from the Date of Commencement, for Notice of No Objection (NONO) from CMRL. At any time during the course of the Works, if the Contractor wants to replace any of the Key staffs, the Contractor shall propose replacement candidate with equal or better qualification / experience criteria and shall obtain NONO from CMRL at least 30 days before such replacement.

Position	Total Work Experience (Minimum number of years)	Experience in Similar Works * (Minimum number of years)
Interface Manager	10	5
Service Manager	10	5

Note: The above project resources shall be exclusive to this project.

** Only time served in a role / designation which has direct involvement in similar responsibilities, duties and industrial sector will be counted as experience in similar Works*

1.15.2 Interface Manager:

Shall be responsibility to coordinate for all the activities pertaining to interface requirement including interface with other designated system Contractor for designing, manufacturing and execution of each respective machinery and plant successfully. The Interface Manager (must be minimum engineering graduate in Electrical / Electronics / Mechanical) will be responsible satisfactory coordinate and resolution of all interface issues. Interface manager shall be available at depot project site within 28 days of the commencement of project works until the completion of defect notification period of last machinery and plant.

1.15.3 Service Manager:

Shall be responsible for Installation, Testing & Commissioning, Training, DNP period services for each respective machinery and plant successfully. The Service Manager (must be minimum engineering graduate in Electrical / Electronics / Mechanical) will be responsible for satisfactory resolution of all execution related issues. Service manager shall be available at depot project site prior to arrival of machinery and plant at site until the completion of DLP/DNP period of last machinery and plant.

1.16 PROJECT MANAGEMENT INFORMATION SYSTEM (PMIS)

1.16.1 The Contractor shall refer clause 16.17 of Part 2 Section VIA for details.

1.17 DOCUMENTATION AND CAD STANDARDS

1.17.1 The Contractor shall refer Appendix G of Part 2 Section VIA for details and shall follow as applicable.

1.18 OTHER

1.18.1 All types of consumables (oil, greases, inserts, detergents, chemicals, hardware, software, components etc) and fasteners required for operation and maintenance for each machine shall be deemed included and maintained by the Contractor during the Test/Trails, operation & till completion of DLP period.

1.18.2 Unless otherwise stated in Chapter 2 ERTS DM&P Section VIB, the noise level of the respective machine during its operation shall not exceed 75 dBA when measured at a distance of one meter from the machine. In case the noise level exceeds 75dBA, additional arrangement i.e acoustic/sound proofing or similar shall be provided by the Contractor to maintain the noise level below 75dBA.

1.18.3 Internet connection for all M&Ps (where applicable) shall be in scope of Contractor for the purpose of remote diagnosis etc.

1.18.4 All data, failure records, history etc. shall be transferable to CMRL server.

1.18.5 Safety : All the M&Ps drive parts, nip points and other exposed parts etc shall be provided with safety guards.

1.18.6 Considering Koyambedu depot is situated at flood prone area, therefor the Contractor shall deign the machine vital components (PLC, sensor, electrical & control panel etc) at minimum height of 1m from floor level.

1.19 Subcontractors / Manufacturers

Subcontractors / Manufacturers for the following major M&Ps of supply or services must meet the following minimum criteria, herein listed for that item:

Item No.	Description of Item	Minimum Criteria to be met
1	Under Floor Wheel Lathe (UFWL)	The Sub-contractor/ Manufacturer should have executed at least two similar Works of Design, manufacture, Supply, Installation, Testing and Commissioning of Under Floor Wheel Lathe (UFWL) to any Metro Rail Projects / LRT / High Speed Rail Network / Railways system in India or Abroad or both during the last 10 years of ending date of bid submission.
2	Automatic Train Wash Plant (ATWP)	The Sub-contractor/ Manufacturer should have executed at least two similar Works of Design, manufacture, Supply, Installation, Testing and Commissioning of Automatic Train Wash Plant (ATWP) to any Metro Rail Projects / LRT / High Speed Rail Network / Railways system in India or Abroad or both during the last 10 years of ending date of bid submission.
3	Synchronized Pit Jacks (6 Car Length)	The Sub-contractor/ Manufacturer should have executed at least two similar Works of Design, manufacture, Supply, Installation, Testing and Commissioning of Synchronized Pit Jacks for 6 Car Length (minimum 42 ton each car lifting/lowering) to any Metro Rail Projects / LRT / High Speed Rail Network / Railways system in India or Abroad or both during the last 10 years of ending date of bid submission.
4	Bogie Turn Tables (BTT)	The Sub-contractor/ Manufacturer should have executed at least three similar Works of Design, manufacture, Supply, Installation, Testing and Commissioning of Bogie Turn Tables (BTT) to any Metro Rail Projects / LRT / High Speed Rail Network / Railways system in India or Abroad or both during the last 10 years of ending date of bid submission.
5	Battery Operated Rail Cum Road Shunter- For 6 Car Shunting	The Sub-contractor/ Manufacturer should have executed at least three similar Works of Design, manufacture, Supply, Installation, Testing and Commissioning of Battery Operated Rail Cum Road Shunter (Capacity minimum 35KN tractive efforts) to any Metro Rail Projects / LRT / High Speed Rail Network / Railways system in India or Abroad or both during the last 10 years of ending date of bid submission.
6	Synchronized Mobile Lifting Jacks (6 Car Length)	The Sub-contractor/ Manufacturer should have executed at least three similar Works of Design, manufacture, Supply, Installation, Testing and Commissioning of Synchronized Mobile Lifting Jacks (6 Car Length) to any Metro Rail Projects / LRT / High Speed Rail Network / Railways system in India or Abroad or both during the last 10 years of ending date of bid submission.
7	Car Body Stand (6 Car Length)	The Sub-contractor/ Manufacturer should have executed at least 12 nos similar Car Body Stand including Design, manufacture, Supply, Installation, Testing and Commissioning to any Metro Rail Projects / LRT / High Speed Rail Network / Railways system in India or Abroad or both during the last 10 years of ending date of bid submission.
8	Diesel Operated Relief and Rescue Vehicle with Rerailing & Rescue	The Sub-contractor/ Manufacturer should have executed at least two similar Works of Design, manufacture, Supply, Installation, Testing and Commissioning of Diesel Operated Relief and Rescue Vehicle with Rerailing & Rescue Equipment (RRV) to any Metro Rail Projects / LRT / High Speed Rail Network / Railways system in India or Abroad or both during the last 10 years of ending date of bid submission.

Item No.	Description of Item	Minimum Criteria to be met
	Equipment (RRV)	
9	Bogie Manipulator (BFM)	The Sub-contractor/ Manufacturer should have executed at least two similar Works of Design, manufacture, Supply, Installation, Testing and Commissioning of Bogie Manipulator (BFM) to any Metro Rail Projects / LRT / High Speed Rail Network / Railways system in India or Abroad or both during the last 10 years of ending date of bid submission.
10	Bogie Testing Unit (BTU)	The Sub-contractor/ Manufacturer should have executed at least two similar Works of Design, manufacture, Supply, Installation, Testing and Commissioning of Bogie Testing Unit (BTU) to any Metro Rail Projects / LRT / High Speed Rail Network / Railways system in India or Abroad or both during the last 10 years of ending date of bid submission.
11	Electric Overhead Travelling Crane (EOT)	The Sub-contractor/ Manufacturer should have executed at least three similar Works of Design, manufacture, Supply, Installation, Testing and Commissioning of EOT Crane Double Girder of minimum 15t capacity to any Metro Rail Projects / LRT / High Speed Rail Network / Railways system /infrastructure/Industrial project in India or Abroad or both during the last 10 years of ending date of bid submission.
12	~~Double Cylinder Hydraulic Wheel Press (DWP)~~	~~The Sub-contractor/ Manufacturer should have executed at least two similar Works of Design, manufacture, Supply, Installation, Testing and Commissioning of Double Cylinder Hydraulic Wheel Press (DWP) to any Metro Rail Projects / LRT / High Speed Rail Network / Railways system/Rolling Stock manufacturer in India or Abroad or both during the last 10 years of ending date of bid submission.~~ Deleted.
13	~~Vertical Turning Lathe (VTL)~~	~~The Sub-contractor/ Manufacturer should have executed at least two similar Works of Design, manufacture, Supply, Installation, Testing and Commissioning of Vertical Turning Lathe (VTL) to any Metro Rail Projects / LRT / High Speed Rail Network / Railways system/ Rolling Stock manufacturer in India or Abroad or both during the last 10 years of ending date of bid submission.~~ Deleted.
14	~~Tack Track &~~ Tunnel Cleaning Vehicle	The Sub-contractor/ Manufacturer should have executed at least two Works of Design, manufacture, Supply, Installation, Testing and Commissioning of Rail Cum Road Bogie operated (8 wheeler) vehicles to any Metro Rail Projects / LRT / High Speed Rail Network / Railways system/ other infrastructure project in India or Abroad or both during the last 10 years of ending date of bid submission.
15	Drivers Desk Simulator	The Sub-contractor/ Manufacturer should have executed at least two similar Works of Design, manufacture, Supply, Installation, Testing and Commissioning of Drivers Desk Simulators to any Metro Rail Projects / LRT / High Speed Rail Network / Railways system/ Rolling Stock manufacturer in India or Abroad or both during the last 10 years of ending date of bid submission.
16	Maintenance Desk Simulator	The Sub-contractor/ Manufacturer should have executed at least two similar Works of Design, manufacture, Supply, Installation, Testing and Commissioning of Maintenance Desk Simulators to any Metro Rail Projects / LRT / High Speed Rail Network / Railways system/ Rolling Stock manufacturer in India or Abroad or both during the last 10 years of ending date of bid submission.

- In case, if the Contractor do not manufacture or otherwise produce the proposed M&P, the Contractor shall provide the manufacturer's authorization.
- The Contractor shall submit minimum TWO numbers Subcontractor/Manufacturer name/make for each M&P in compliance to the above clause 1.19 requirement within 28 days from LOA issuance.

1.20 TECHNICAL SPECIFICATION

1.20.1 The technical specification and details for each machine is given in CHAPTER 2.

CHAPTER 2

2. EMPLOYER'S REQUIREMENTS TECHNICAL SPECIFICATIONS (ERTS) – DEPOT MACHINERY & PLANT (DM&P)

2.1 UNDER FLOOR WHEEL LATHE (UFWL)

2.1.1 Purpose of the machine:

- 2.1.1.1 The Under Floor Wheel lathe (CNC) is required for simultaneous profiling of new or worn-out wheels of metro cars in situ condition. Wheel sets of multiple types (4 car & 6 car) Rolling stock at CMRL Phase-I Koyambedu depot shall be turned on this machine. It shall be equipped with dual CNC tool post for turning any wheel profile along with pre and post measurement system.

2.1.2 Technical Particulars- Fully Automatic CNC Under Floor Wheel Lathe

- 2.1.2.1 The Contractor shall undertake to comply with the requirements of "Design, Manufacture, Supply, Installation, Testing & Commissioning of One (1) number of Fully Automatic CNC Under Floor Wheel Lathe along with Chip Crusher and Conveyor and other accessories to make the machine fully functional and operational.
- 2.1.2.2 Automatic Operation: Automatic means that machine shall have the following minimum features but not limited to, while working in fully automatic mode-
- Automatic job setting.
 - Pre-measurement of the wheel profile and wheel diameter.
 - Complete profile turning operation of the wheel and optimisation of metal removal by comparison with the stored profile to obtain specified surface finish and accuracy. Options to take partial cut and resultant profile with partial cut shall be determined by the system.
 - Post measurement of the wheel profile and wheel diameter.
 - Display of tread diameters of both wheels of an axle before and after turning.
 - All the function shall be carried out by the machine automatically without any interference of operator.
 - Programming of a new profile should be possible.
 - Not Used
 - Placement of car bogie on the Wheel Lathe after interlocking of Shunter with Wheel Lathe.
- 2.1.2.3 The machine shall be equipped with provision of independent mode specific to wheel profile and diameter Measurement only as an additional feature.
- ##### 2.1.3 Detailed Scope of Works
- 2.1.3.1 Design, Manufacture, Supply, Installation, Testing & Commissioning of fully automatic CNC Under Floor Wheel Lathe at Koyambedu Depot of CMRL phase-I. The supply shall include all equipment and accessories required to make the machine fully functional when connected to a power source. The Wheel Lathe shall comply with the configurations of Rolling Stock and Track profile.
- 2.1.3.2 Electrical cables for connecting Power point to Control cabinet of machine shall be supplied by the Contractor as per the requirement.
- 2.1.3.3 Wheel lathe shall be equipped with all hardware and software (attachments, programmes etc) required for machining / turning of all types of rolling stocks alongwith its installation testing commissioning etc.
- 2.1.3.4 Not Used.
- 2.1.3.5 Not Used.
- 2.1.3.6 One (1) Laser Printer compatible with PC provided with the CNC Wheel Lathe shall be supplied

for report printing.

- 2.1.3.7 One calibration wheel set, with its axle and discs painted in yellow colour, shall be supplied by the Contractor along with the Wheel Lathe. The calibration wheel set shall be used for calibration as per recommended frequency mentioned by the manufacturer of the Wheel Lathe. A suitable cover to protect the calibration wheel set from all atmospheric adverse effects shall be supplied.
- 2.1.3.8 Necessary co-ordination shall be made and action taken for interlocking of the Battery Shunters (2 nos) with the Wheel Lathe operation.
- 2.1.3.9 The Wheel Lathe shed shall be constructed by the Depot Civil Contractor. The Contractor shall plan the foundation designing in the shed constructed by Depot Civil Contractor.
- 2.1.3.10 Back-up of the machine software (CNC programming) for re-profiling, along with a standby hard disc with complete machine standard software shall be provided along with the Wheel Lathe.
- 2.1.3.11 UFWL scope of work shall also include following :
 - a) Instrument (Digital) to check Surface Finish(Ra) – 1no
 - b) Wheel Profile Measuring device – Hand Held (Contact less)
 - c) Stationary Air Compressor of suitable capacity for UFWL operation and maintenance.

The Contractor shall supply above items alongwith UFWL. Price of above items shall be deemed included in the UFWL price including DLP services.

2.1.4 Design Requirements of Wheel Lathe:

- 2.1.4.1 The Equipment shall be of proven design. Major structural elements of the Wheel Lathe, e.g., column, cross rail, tool slide etc. that are subjected to cutting loads, must be cast structural or of welded steel construction, duly stress relieved and shall be designed for atleast 30-year design life of heavy-duty workshop use and shall be available without any limitation in day-to-day wheel re-profiling of the rolling stock without any vibrations during operation.
- 2.1.4.2 Equipment that requires electricity supply shall be compatible with the supply voltage of 415V, 50Hz, $\pm 10\%$, surge protection, low voltage protection to be included whenever necessary, 3-phase neutral. Any regulation or protection required shall be in the scope and the responsibility of the Contractor.
- 2.1.4.3 Equipment shall incorporate means of adjustment in order to allow for building movement and concrete beam deflections.
- 2.1.4.4 The Wheel Lathe shall be of robust construction capable of withstanding severe duty during its design life.
- 2.1.4.5 The Wheel Lathe shall be built in rigid dual column construction with both columns connected by rigid cross rail.
- 2.1.4.6 In case the bidders prefer to offer any other better construction method, it will have to be a proven technology which will have to demonstrate with documents and test report to the satisfaction of the technical offer.
- 2.1.4.7 The Contractor shall certify that the steel structure and metal component used in the plant / machine will last for 30 years without any corrosion duly supported by quality test certificate during the design of the machine.
- 2.1.4.8 The Wheel Lathe shall be equipped with four driving rollers, each capable of individual vertical movement to effectively take care of irregularities of un-machined wheel set.
- 2.1.4.9 The Wheel Lathe shall be equipped with axle box support jack and hold down device both capable of operating through CNC pendant. Similarly, box type hardened and ground guide ways matching with slide ways shall be used for tools slides to ensure durable and vibration free operation.
- 2.1.4.10 The Wheel Lathe shall have the provision of manual override in re-profiling to generate the intermittent profile.
- 2.1.4.11 The fully automatic CNC under floor Wheel Lathe shall be capable to perform, even without the

integration of the shunting electric Shunter.

- 2.1.4.12 The Wheel Lathe shall have remote diagnostic feature to enable remote interaction with manufacturer / supplier end for rectification of faults. The Contractor shall provide all the Software and Hardware for remote diagnostic and provide hands on training to CMRL's staff to enable the same. The Contractor shall be responsible for provision of communication set-up to enable the supplier and the CMRL to interact remotely with the Wheel Lathe computer for rectification of faults. The Internet connection shall be in scope of equipment Contractor.
- 2.1.4.13 The Wheel Lathe shall be designed such a way so that no chips arising from wheel profiling work shall fall out of the machine area and it should get accumulate in the Chip Crusher chamber.
- 2.1.4.14 The use of Wheel Lathe may not be restricted to Cars of Metro trains only and may be used for turning / re-profiling wheels of other rail vehicles also like existing Catenary Maintenance Vehicle, Diesel Loco etc. with gross load not more than 64 tons for which detailed parameters shall be obtained during design stage.
- 2.1.4.15 CAD drawings of wheel profiles of the different wheels shall be supplied during the design phase to the Contractor.
- 2.1.4.16 The Wheel Lathe shall be capable of re-profiling in situ & also in isolation, simultaneously at both wheels of an uncoupled wheel set, old work hardened and new wheels of all types of rolling stocks without the need of removing any components such as wheel sets, bogie brake gear, axle box covers etc.
- 2.1.4.17 The Wheel Lathe shall be so designed to ensure an effective and efficient work sequence. Single operator placed between the columns of the machine shall be able to control all the operation of the machine from the single centralized CNC operator pendant and shall have full and clear view of both the cutting points of both sides of rollers.
- 2.1.4.18 Each work phase shall be reliable, durable and safe in operations.
- 2.1.4.19 The noise level of the machine during its operation shall not exceed 75 dBA when measured at a distance of one meter from the machine.
- 2.1.4.20 The machine shall be capable of Independent handling the input voltage fluctuation and harmonics without any additional equipment like Isolation transformer, Voltage stabiliser, active harmonic filter. Refer clause 2.1.4.2 for supply voltage details.
- 2.1.4.21 The connected load of the unit shall be less than or equal to 90KW.
- 2.1.4.22 Considering Koyambedu depot is situated at flood prone area, therefor the Contractor shall design the machine vital components (PLC, sensor, electrical & control panel etc) at minimum height of 1m from floor level.

2.1.5 Operating requirements

- 2.1.5.1 The Wheel Lathe's Computerised Numeric Control (CNC) system shall have the capability to store different wheel profiles.
- 2.1.5.2 Not Used.
- 2.1.5.3 The Wheel Lathe shall be capable of machining the inside faces of the wheels in continuation of the profile turning of the wheel tread. In addition, it shall also be capable of re-profiling wheel sets removed from the rolling stock by means of suitable holding down devices.
- 2.1.5.4 It should be possible to control cut manually so as to achieve some intermediate profile. MMI (Man-Machine Interface) / HMI (Human Machine Interface) should enable to determine the profile with cuts of different depths.
- 2.1.5.5 The Wheel Lathe shall be able to calculate the required depth of cut after the measuring the wheels parameter of a given axle.
- 2.1.5.6 The Wheel Lathe shall have the intermittent profiles of variable flange thicknesses of different profiles with proper operational manuals for different profile cutting.
- 2.1.5.7 Different vehicles of different weights / axle load (within maximum specified) may have to be re-

profiled. The Wheel Lathe should either automatically set different relevant parameters or the Contractor shall furnish detailed procedure for such adjustments and impart training to CMRL's staff to do such adjustments.

2.1.6 Wheel Lathe Machining Capacity

2.1.6.1 The Wheel Lathe shall have the capacity to re-profile the four (4) wheel sets of a car in less than four (4) hours, excluding the time for setting up, from a fully worn profile to a completely new profile, considering removal of maximum of 8 mm (in 2 rough cuts) material radially (diameter reduction up to 16 mm) from the wheels. The total time of a single complete cycle required for a wheel set with normal worn wheels in one cut and heavy worn wheels in 2 (two) cuts shall be optimized for efficient operation. Details of calculation of cycle time in order to complete the same within the target time shall be described and same shall be demonstrated by the Contractor at his premises as part of the FAT and at site during the commissioning. The wheel set for demonstration of the machining capabilities shall be arranged by the Contractor.

2.1.6.2 Not Used.

2.1.6.3 The Wheel Lathe should be designed for

i. Cutting Speed (infinitely variable)	-	10 to 120 m/min
ii. Feed (infinitely variable)	-	0.1 to 5.0 mm/rev
iii. Depth of cut(single)	-	Not less than 4mm (radially)

2.1.6.4 Wheel Lathe Measurement Capacity

After wheel machining, the difference between the profile obtained and the theoretical profile should not exceed $\pm 0.1\text{mm}$ on the wheel tread and the active side of the flange. After machining of a wheel, comparison will be made with the calibration wheel supplied alongwith the machine and the deviation permitted shall be of $\pm 0.1\text{mm}$ maximum for all dimensional parameters.

2.1.6.5 Wheel Profile Measurement Capability

The facility shall be available for pre-loading the reference profiles, comparing the measured data with reference profiles, displaying the comparison, and recording the results.

2.1.7 Machine control

2.1.7.1 Operation of the Wheel Lathe and related equipment shall be by computerised numerical control (CNC).

2.1.7.2 All functions of the Wheel Lathe shall be controlled from a single centralised ergonomically designed control panel through both soft keys and push buttons. The control panel / operator pendant shall allow a full and clear view of the cutting points and the drive rollers to the operator. The control panel shall be pendant type and shall not be floor mounted. The CNC controller shall be of the latest series from M/s Siemens or equivalent. Details of CNC controller shall be described in offer.

2.1.7.3 Main functions of the CNC software shall be-

- i. Interface with the operator.
- ii. Command of Wheel Lathe and accessories.
- iii. Control on the safety device.
- iv. Data storage for profile and history of profiled wheel sets.
- v. Profiling cycle.
- vi. Auto diagnosis of Wheel Lathe and accessories.
- vii. Printing and exporting of profile reports.
- viii. Data exchange with wheel sets management database.

2.1.8 Principle of the Wheel Lathe operation cycle

- 2.1.8.1 The rolling stock vehicle shall be driven inside and moved out of the Wheel Lathe building by means of a remote-controlled Battery-Operated Shunter. On Operator's command through remote controller from the pit, the Shunter shall position the wheel set for re-profiling on the Wheel Lathe running on their tread on retractable rails within the tolerance of ± 25 cm. The operator pendant shall allow a full and clear view of both the cutting points and both side drive roller to the operator.
- 2.1.8.2 The pair of mobile rails with automatic translation shall ensure the continuity of the rail track over the Wheel Lathe for positioning of the wheel sets. Thereafter the load of wheel sets shall be taken over on to a pair of friction rollers. Hydraulic jacks shall be interlocked with the retraction of mobile rails.
- 2.1.8.3 Profiled friction rollers shall then drive the train wheels on the Wheel Lathe. The rollers shall be equipped with anti-slip system. The wheel sets shall be kept in position laterally by a pair of lateral guide rollers and shall be vertically retractable.
- 2.1.8.4 The axle box supports shall be commanded by the CNC and shall be integrated in the operation cycle of the Wheel lathe. These shall be in locked position during the machining processes to keep the axle boxes steady, even in case of power failure.
- 2.1.8.5 Axle box hold down device shall allow increasing the pressure between the driving rollers and the wheel sets to increase the torque during the reprofiling. The CNC shall calculate the hold down force required according to the wheel set load.
- 2.1.8.6 Before the actual profiling cycle, the operator shall perform a pre-measurement of all wheel sets. After calculation of wheel set dimensions and of acceptable tolerances, the Wheel Lathe shall propose an economical depth of cut for re-profiling wheel sets to the operator.
- 2.1.8.7 The Wheel Lathe shall be operated for profiling via a CNC control panel so that the operator shall have continuous access to all its functions for the safety and efficiency. During re-profiling, the driving roller arms shall be made independent by CNC to compensate the wheel tread wear and defects, e.g. wheels with heavy wear, normal wear and others like profiling flat tread, brake, only flange, tread with or without the flange.
- 2.1.8.8 Measuring shall be done after completion of machining. The whole parameters defining the wheel set geometry shall be measured. The new dimensions of the profiled wheels shall be displayed on the CNC control panel.
- 2.1.8.9 The CNC shall compute and deliver a complete profiling report, which shall be printed by an industrial printer.
- 2.1.8.10 All the data concerning to re-profiling cycle shall be stored in the hard drive of the PC of CNC and thus shall be protected against any electrical shut down.
- 2.1.8.11 The profiling report stored in the PC hard drive shall be able to be exported to an industrial laptop via USB port or better. The dedicated software for the data downloading shall be provided by the supplier alongwith the Industrial Laptop.

2.1.9 Description of measurement cycles

- 2.1.9.1 Wheel profile measurements, including measurement of wheel diameter, shall be undertaken as follows:-
- 2.1.9.2 Each tool post of Wheel Lathe shall be equipped with suitable contact type electronic measuring device (retractable type) of proven design. Contact type scanning of wheel profile of worn wheel from the flange top to outer edge shall be determined for optimum cutting depth and electronic measurement of wheel set's circumference shall be determined by the CNC system in order to determine the actual diameter.
- 2.1.9.3 The Wheel Lathe shall be able to measure the parameters like flange height, flange thickness, wheel back-to-back distance, tread diameter, root wear, flange wear, tread wear, QR (the distance, in millimetres, measured parallel to the axis of the axle, between points on the wheel flange 10 mm above the tread datum position and 2 mm below the tip of the flange) etc.

2.1.10 Description of machining cycle

2.1.10.1 Wheel machining: Following should be achieved-

- i. The Wheel lathe first measures the profile of wheel set to be machined. Rail wheel contact causes different types of wear on the wheel tread and on the active sides of the flanges. Certain limits are prescribed for the allowed variation from one wheelset to another in a bogie and from one bogie to another and from one car of train to another. The Contractor shall interface with Rolling Stock Contractor for these limits.
- ii. The Wheel Lathe shall measure the actual profile of worn wheels and CNC control system determines the new optimum wheel set diameter by means of measured data. This nominal machining diameter is indicated at the operator control console, and it can be accepted and rejected by operator. The machine shall compare the measured actual profile with the nominal machining diameter and determine the optimum cutting depth and automatically perform preliminarily and finished cuttings. The alteration by operator shall be allowed. The profile shall be user programmable. Machine shall be capable of machining newly manufactured un-mounted wheel sets using centres and hold down device.
- iii. During wheel machining, tool damaging or sudden cycle stopping actuated by the machine station shall take place with retraction of tool. This provision shall make it possible to replace tools, etc. Automatic tool retraction and backup power to HMI in case of power failure shall be provided by the Contractor. The scheme employed for this shall be explained during design stage and shall be a machine design feature.

2.1.11 Screen page

2.1.11.1 The CNC display shall be operator friendly, and the screen page shall display the pre- and post-machining values to the operator simultaneously.

2.1.11.2 Following Display Principle may be adopted (OP - given by the operator & NC - given by the numeric control system)

Train No	: OP
Vehicle No	: OP
Wheel No	: OP
Type of vehicle	: OP
Date and time	: NC, operator correction possible
Axle position	: OP
Faults	: NC
Remainder of wheel diameter	: NC
Wheel position (left or right)	: OP / NC
Wheel diameter	: NC
Height, thickness, QR dimensions	: NC of flanges, wheel wrap
Wheel profile	: NC

2.1.11.3 Depending on the accepted tolerances for the wheels of a given vehicle, it is possible that the wheels already machined would be out of tolerance, thus requiring re-machining. To avoid this, the Wheel Lathe will have capability to measure four wheels of a same bogie in a car and decide the optimum turning requirement.

2.1.11.4 The software shall store the new measurements of the wheelset already machined and replace the previous measurements with post machining. Historical records of re-profiling of wheel set should be stored.

2.1.12 Machine Configuration (Mechanical part)

2.1.12.1 The machining technique should normally restore the worn wheel profile to true profile conditions. However, it should be possible to restrict the cuts depth without achieving the true profile. The profile obtained shall not depend on the wheel wear status and shall be in accordance with the specified tolerances to be given by the Rolling Stock Contractor.

2.1.12.2 The additional mechanical installation shall make it possible to simultaneously re-profile two wheels of a given axle, dress the inner sides of the wheels.

2.1.12.3 For all these machining works, no dismantling will be required on wheel, axle box and the wheel drive system.

2.1.13 Setting up the Axle:

2.1.13.1 The operational sequence shall be fully described in the offer, considering the full safety of the system, which should be as per the following-

2.1.13.2 The Rolling Stock shall be hauled inside the Wheel Lathe shed by means of a Battery-operated Shunter interlocked with Wheel Lathe. The operator commanding remotely from the Wheel Lathe pit at the machine control panel shall be able to position the wheel set for re profiling within a tolerance of +25 mm and to achieve necessary interface with the supplier of Battery-operated Shunter shall be done.

2.1.13.3 The wheels positioned for re-profiling shall run on their wheel tread on mobile retractable rails (hydraulically actuated and operation interlocked with the vehicle movement from the machine control panel).

2.1.13.4 The axle boxes shall be supported by lifting with hydraulic actuated jack.

2.1.13.5 The wheel set shall be positioned and centred by synchronised lifting of the driving rollers.

2.1.13.6 The mobile rails shall be retracted to home position.

2.1.13.7 The hold down arms shall hold the axle boxes in position by applying force from top.

2.1.13.8 The wheel sets shall be kept in position laterally by a pair of lateral guide roller or suitable arrangement.

2.1.14 Axle centring - During centre-less profile turning.

2.1.14.1 Axle centring during centre-less re-profiling shall be achieved by means of the drive rollers and lateral guide rollers locating the axle in the vertical and horizontal planes. Only one train wheel setting-up operation shall be required for a particular type of vehicle.

2.1.14.2 Concentricity of the profile shall be provided by the vertical movements of the drive rollers mounted on the slide blocks by suitable arrangement, which shall be described in detail along with the offer.

2.1.14.3 Irregularities in the wheel treads may be flats, thermal cracks, splits or out-of round areas. All these faults should be corrected in a single machining pass with minimum tool wear / damage.

2.1.14.4 During machining, the axis of the axle shall not move, in any case whatsoever, in the track direction. The Contractor shall give full details on the method used to impede any longitudinal movement.

2.1.15 Axle centring - Between-centre turning

2.1.15.1 The Wheel Lathe shall be designed for mounting of bare axles between rotating centres. The rotating centre shall be easy to remove and shall be replaceable with hold down arm from their support and shall be fitted with handling rings. The revolving centres (weight <25 kgs) shall be fitted by replacing the hold down device. Centre points shall be machined to 60 or 90 degrees.

2.1.15.2 The supports of the rotating centres shall be located in the axis of the lathe. Centres shall be adjustable upwards and side wards to enable machining of wheel set of different types of axles.

2.1.15.3 The supports and the rotating centres shall be designed to handle the vertical turning reactions and the loads from the drive rollers applied to the wheels.

2.1.16 Axial support of the axle - Centre-less profile turning

2.1.16.1 A side-securing device for axles shall be designed and proposed by the Contractor for facing turning. In particular, this device should:

- i. Lift the wheel set from retractable rails.
- ii. Maintain the axle in the axis of the lathe during turning,
- iii. Enable movement of the axle to position it in the axis of the lathe,
- iv. Centre the axles, no matter what might be the spacing between the inner sides, wheels.
- v. Transfer of torque from drive roller onto the wheel set during machining.

2.1.16.2 The loads applied to the inner sides of the wheels shall not cause deformation of the wheel.

2.1.16.3 This device shall be designed to leave operators with very good visibility and to make it possible monitor tools during wheel machining.

2.1.16.4 Axial support of the axle - Between-centre turning.

2.1.16.5 The axle shall be held sideways by rotating centres for between-centre turning.

2.1.17 Axle drive

2.1.17.1 The Wheel Lathe shall rotate the wheels by means of a pair of rollers on the wheel tread. It shall be equipped with four driving rollers. AC Servomotor with variable speed drive shall be used for roller drive. Details shall be furnished during the design stage. This shall be integrated with the CNC system.

2.1.17.2 Drive to the wheels shall be from a set of two drive rollers on either side. The design shall be equipped preferably with common drive for each side paired Rollers or Single drive for all 4 rollers. Drive rollers shall be of suitably heat-treated alloy steel. Distance between the drive rollers shall be designed to accommodate all wheel sets.

2.1.17.3 Considering the maximum torque required for wheel re-profiling, especially at hard points on the wheel tread at the tool, it is necessary that all provisions be taken so that the drive roller-wheel adherence remains effective in all configurations.

2.1.17.4 The axle drive shall be monitored to avoid any slippage during turning. Any slippage conditions shall warn the operator by displaying an error message, stop the feed or retract the tools depending on the extent of the slippage.

2.1.18 Tooling

2.1.18.1 The Wheel Lathe shall be capable of turning wheel profiles with throw away type carbide inserts with built in Chip Crusher. The chips that are yielded from the machining process shall not exceed an average 300 mm in length before entering the Chip Crusher. The total number and type of inserts required for each tool holder shall be indicated. The tools and tool holders shall preferably be available in India. Sandvik / Widia or better make tooling shall be accepted.

2.1.18.2 The profiling tool saddle shall be of standard reversible tools, designed to provide short broken chips. The saddles horizontal & vertical motions shall be obtained with ball screws controlled by AC motor and transducer. In case of power failure CNC shall command the retraction of the tool holder.

2.1.18.3 Tool-holders shall be easy to remove and their positioning on the toolholder carriages shall be very precise to provide accurate machining of wheels.

2.1.18.4 Interchanging tool-holders shall not require readjustment of the Wheel Lathe

2.1.18.5 Cutting tools shall be mounted vertically between the drive rollers.

2.1.18.6 Special care shall be taken in the design and construction of the tool holder carriages to facilitate any disassembly required for maintenance purposes or for replacement of components, e.g., ball screw, screw block, etc.

2.1.19 Wheel Measurement Devices

2.1.19.1 The Wheel Lathe shall be fitted with suitable retractable type of wheel measurement devices of proven design to make the wheel measurements. The devices shall be so designed to be protected from dust and chips. The Contractor shall indicate the selected types of protection systems. The Wheel Measurement Devices should be able to measure-

- i. Wheel Diameter: The Contractor shall spell out detailed methodology in the offer.
- ii. Wheel Profile: Measurement facility shall be provided for measuring wheel profile before and after the machining. The facility shall be capable of pre-loading of reference profiles, comparing the measured data with reference profiles, displaying the comparison, and recording the results. Standard Test piece shall be used for calibration.

2.1.19.2 A spare wheel set shall be used for the calibration of the Wheel Lathe numeric controls. The Wheel Lathe shall be capable to recalibrate the 2-axis using calibration wheel set. The wheel set shall be pre-calibrated and certified from a certified test house. A suitable stand along with a cover shall be provided for keeping the wheel set when not in use. Calibration schedule, procedure and tools requirement shall be supplied.

2.1.20 Result editing

2.1.20.1 After the machining or measurement operations have been performed on a vehicle (from 1 to 4 axles), the pre- and post-machining measurement results shall be printed on an A-4 size sheet of paper in table form of parameters, like flange height, flange thickness, wheel back-to-back distance, tread diameter, root wear, flange wear, tread wear etc of newly profiled wheel. An Industrial Laser printer compatible to CNC Wheel Lathe shall be supplied for the same.

2.1.20.2 The profiling reports that are stored in the Wheel Lathe hard drive shall be possible to be exported to an Industrial laptop / microcomputer via interface software with hardware like USB port or better.

2.1.21 Machine Performance Requirements

2.1.21.1 Not Used.

2.1.21.2 Maximum tolerances are as follows-

- i. Difference between the diameters of the wheels of a given axle : 0.2 mm
- ii. Difference between the diameters of the wheels of a given bogie : 0.3 mm
- iii. Out of round : 0.2 mm
- iv. Surface finish : 25 μ m (Ra)

2.1.21.3 Suitable templates shall be provided to check each profile after machining.

2.1.22 Chip Disposal System

2.1.22.1 Chip Crusher

- i. An integrated Chip Crusher of proven design shall be provided to crush the chips produced from turning the wheels to small chips with an average length of 300 mm.
- ii. The Chip Crusher shall be capable of handling a volume of chips produced under any machining condition.
- iii. The Chip Crusher shall be a box type steel casing with number of high-grade special steel blades running at slow speed. It shall be mounted under the Wheel Lathe. The construction of a linking duct between this hopper and the crusher shall form part of the supply.
- iv. The structure of the crusher shall have strength for long lasting operation without denting and deformation. The plate thickness shall not be less than 3 mm.
- v. The crusher shall incorporate with safety measures to handle the blocking situation of chips at the crusher or the Chip Conveyor.
- vi. The electrical switchboard and other accessories, which require to be attended by an operator, shall be located at safe places for protection of human injuries.

- vii. An electrical overload load trip shall be provided to save the crusher against accidental overload due to some foreign material. Detailed design of Chip Crusher shall be described during the design stage.

2.1.22.2 Chip Conveyor

- i. A Chip Conveyor shall be provided in the Wheel Lathe shed for chip removal. The chips shall be conveyed and discharged to a skip located inside the Wheel Lathe shed. It needs to be designed as per the site availability.
- ii. Wheeled chip Metal trollies (10 nos) with unloading by tilting mechanism shall be provided.
- iii. An electrical Contactor shall be provided in order to slave its operation to that of the lathe machining cycle. Nonetheless, manual control shall be allowed, subject to approval by CMRL.
- iv. The flow capacity of chip conveyer shall not be less than 20 Kg/hr or weight of chip cutting per hour.

2.1.23 Rails

2.1.23.1 A track rail running from one side of the pit Wheel Lathe shed to the other end except on the pit shall be provided by the Interfacing Track Contractor and used to enter and exit trains.

2.1.23.2 All sliding rails and fixed rails, which are an integral part of the Wheel Lathe, shall be supplied and laid by the Contractor.

2.1.23.3 Not Used.

2.1.24 Holding Down devices

2.1.24.1 Holding down devices shall be applied to the external axle box cases at locations designed for this purpose in order to make re-profiling of un-mounted wheel sets as well as mounted wheel sets and the lightest vehicle wheels possible.

2.1.24.2 All types of adaptation tooling / claws shall be designed and made available for various types of axle boxes on multiple Metro cars, locomotives, wagons, and any other rail vehicles as applicable. The required data for design shall be obtained from Interface Contractors. The travel distances of hold down device shall make it possible to apply the loads on the various types of axles involved.

2.1.24.3 The complete assembly of the Wheel Lathe shall be clear of the Kinematic profile of the train car. This will need an interface with the Rolling Stock Contractor.

2.1.25 Hydraulic Installation (Hydraulic Unit)

2.1.25.1 The Hydraulic power unit shall be inbuilt and integrated into the Wheel Lathe.

2.1.25.2 The unit shall be fitted with temperature and level control systems. Filters shall be compatible with distribution and regulation apparatus and pumps (filtering less than 12 microns). A pan shall be provided to recover fluid in the event of leakage.

2.1.25.3 The hydraulic system shall be equipped with protection devices for Overheating, Overpressure, Low oil level, Surge protection (if required)

2.1.25.4 Preferably, hydraulic pumps shall operate during controlled movements. Accumulators shall compensate for component movement during machining and any possible leaks. Other solutions may be suggested.

2.1.25.5 Commissioning of the hydraulic installation shall be the responsibility of the Contractor who, consequently, shall provide the hydraulic fluid recommended by the manufacturer of the hydraulic unit, including filling, draining after operation of the number of hours scheduled by the manufacturer of the hydraulic unit and further maintaining the same as per scope.

2.1.25.6 The Contractor shall perform all operations recommended by the manufacturer, e.g., replacement of filters, cleaning of the hydraulic unit tank, etc.

2.1.25.7 The complete hydraulic power pack shall be from proven suppliers.

2.1.25.8 Filter clogging alarms shall be provided to warn the operator.

2.1.25.9 Hydraulic unit tank filling shall be via a port protected with a filter (12 microns).

2.1.25.10 The oil shall be readily available in India.

2.1.26 Chilling unit shall not be used for Hydraulic drive system or any other drive.

2.1.27 Hydraulic gear

2.1.27.1 Hydraulic gear shall be homogeneous throughout the entire installation.

2.1.27.2 Not Used.

2.1.27.3 Piping shall be integrated within the Wheel Lathe enclosure. It should be concealed and suitably protected.

2.1.27.4 Each hydraulic circuit shall be fitted with an easy to access test plug.

2.1.27.5 All supplies, assembly of pipes and connection components concerning the hydraulic installation are the responsibility of the Contractor.

2.1.27.6 All supplies shall be physically identified (riveted labels or numbers stamped on components). The same identification shall be indicated on electrical and hydraulic diagrams and in supply nomenclatures.

2.1.28 Jacks

2.1.28.1 All hydraulic and pneumatic jack pistons shall be protected from dust and chips. Scrappers shall stop foreign particles from entering into the jack barrels. Jacks shall be easy to access for maintenance operations.

2.1.28.2 Jack links by rigid piping or hoses shall be of easy access for all maintenance operations.

2.1.29 Pressure sensors

2.1.29.1 Pressure sensors shall be installed on any hydraulic circuit requiring permanent monitoring for good Wheel Lathe operation.

2.1.30 Lubrication

2.1.30.1 The Wheel Lathe shall be provided with an automatic lubrication system for lubrication of sliding / rolling surfaces. The system shall be complete including filters, level indicator etc.

2.1.30.2 The Wheel Lathe guide ways shall be lubricated for life and shall require no wet lubrication from the system.

2.1.30.3 Arrangement shall be provided to indicate failure of the lubricating system and displaying the adequate information on control panel for the operator and protecting the Wheel Lathe. If it endangers the safety of Wheel Lathe, the operation shall stop.

2.1.30.4 The lubrication system shall be explained during the design stage with a lubrication diagram. Following should also be mentioned:

- i. Periodicity of cleaning / replacement of filters
- ii. Periodicity of replenishing lubricating oil in the sump
- iii. Any other necessary information

2.1.31 Numeric control

2.1.31.1 The numeric control shall be of reputed make and built to satisfy the technical specifications. The workstation screen is proposed to be 15" LCD/LED or better. The Contractor shall give the standard scheme available with their design of Wheel Lathe.

2.1.31.2 Each tool-holder carriage shall be independent during the turning operations.

2.1.31.3 The numeric control shall be designed for maximum reliability and easy maintenance.

2.1.31.4 The control shall be protected from the effects of overheating by operator alarm and by power cut off or better safety.

2.1.31.5 To facilitate numeric control use and maintenance, the following types of diagnostics and test

circuitry shall be provided-

- i. System integrity diagnostics (verification of the software, Wheel Lathe adjustment data, tool corrections, part program, etc.) at equipment power-up.
- ii. Hardware diagnostics (cards fitted, normal operation of critical cards, power supply current and voltage).
- iii. Not Used.
- iv. Test circuits (display of machine position and tracking error, display of memory contents, etc).
- v. Access to the various BUSES for connection of an analyser.

2.1.31.6 Emergency thresholds and limits shall be provided to avoid unwanted feeding the tool in the Wheel Lathe and in the wheel to be re-profiled.

2.1.31.7 The numeric control shall be designed in such a manner that the modification of the profile of a wheel, the replacement of a profile, the modification of a cycle or basic data concerning the definition of profile, can be carried out. Program for modifications should be available.

2.1.31.8 In guided operator mode-

- i. Connectors for the addition of a data input keyboard, an Ethernet connector output (or better) and a laser printer shall also be provided. The software shall be designed to enable the hardware.
- ii. The operator machine dialogue shall be by means of a keyboard and display control touch in operator panel / pendant.
- iii. Operation running cycles and sequences shall be displayed in real time and in plain English language on screen pages. A screen page per operation (setting up of an axle, measurement, machining etc.) shall be provided.
- iv. Interrupts in the sequence shall be reported. Manual sequences shall be guided by means of operator messages.
- v. Parameter input shall be by means of masks intended to guide the operator.

2.1.32 **Roller drive motor**

2.1.32.1 The Wheel Lathe shall be equipped with four driving rollers.

2.1.32.2 The adherence of the wheels drive rollers is provided by the weight of the vehicle and additionally by the axle box holding down devices as required.

2.1.32.3 The circumferential speed of the drive rollers (cutting speed of the tooling) is proposed to be adjustable from 10 to 120 m/min for wheel machining. Contractor shall propose speeds as per their design to meet the specified output.

2.1.32.4 AC servomotor of proven design with variable speed drive shall be used for roller drive. This will be integrated with CNC system.

2.1.32.5 Axis motors and axis coders shall be designed to suit the required machining precision.

2.1.33 **Not Used**

2.1.34 **Control panels**

2.1.34.1 Panels shall be provided for control and monitoring of the Wheel Lathe and shall be sized to take environmental conditions into account. The panel shall be dust and water splash tight and the ambient temperature outside may go up to 50 deg C. The IP level for the control panel shall be at least IP54.

2.1.34.2 All panels shall be designed to accommodate ambient temperature and humidity conditions, by having heating cum air conditioning systems of reputed international makes only.

2.1.34.3 The design shall suitably consider all aspects, which shall be discussed and tested during design

stages. In addition, the panels shall have the following-

- i. It shall have an earthing terminal.
- ii. It shall comply with the regulations in force.
- iii. The front panel shall be fitted with three indicating lights in three different colours (Red, Yellow, Blue) for the three incoming phases of power supply, lit when power on.
- iv. All the control panels should include special button for testing mode.
- v. A three-pole isolating switch pad lockable in the open position will supply power to the installation.
- vi. Doors will have removable keys and compartments for storage of electrical diagrams.
- vii. Material for cabinet shall be metallic anticorrosion and painted / powder coated in colour to be decided with CMRL.
- viii. Wire marking shall be engraved type. Alternative systems may be proposed if better.
- ix. The Contractor shall provide galvanic insulation between the different components. The electronic blocks and boards must be quickly replaceable without requiring dismantling of any other neither component nor removal of a cable or set of cables.
- x. The sub-assemblies performing the same function shall be strictly identical and interchangeable.
- xi. The functions shall be distributed on boards connected to the cabling by connectors, this distribution shall be designed so as to limit the troubleshooting time (each function clearly delimited per board).

2.1.35 **Electrical Cabinet:**

2.1.35.1 The cabinet shall comprise of-

- i. A main three-pole isolating switch which can be padlocked in the open position, fitted each with high rupturing capacity (HRC) fuses and single-phasing preventer in a Fuse Switch Unit.
- ii. A main circuit breaker.
- iii. An isolating switch for each component.
- iv. The contactors and relays used for operation of the installation.
- v. Magnetic / thermal protection specific to each movement.
- vi. A programmable logic controller (type and brand to be specified), A light shall be interlocked with cabinet door opening.
- vii. The dimensions of the cabinet shall be designed for future expansion by about 20%.
- viii. All the electrical equipment specifications are to be submitted for approval, before assembling.

2.1.36 **Electrical switchboards**

2.1.36.1 All control and regulation electronic and electrical devices, etc. shall be mounted in dust-proof switchboards of at least IP-54 protected and shall include an earthing terminal. Switchboards shall be designed so that inspection, repair and maintenance shall be easy after doors have been opened.

2.1.36.2 Switchboards shall be in accordance with the regulations in force and on the front fitted with power on indicators.

2.1.36.3 A general three-pole isolating switch, latch-able in open position, supplies the installation.

2.1.36.4 The inside of the switchboards shall be illuminated by means of LED tubes controlled by door opening. Doors shall be locked with removable keys. Locations shall be provided for storage of

electrical diagrams. All glands to the panel shall be of double compression type.

2.1.36.5 An industrial type power socket with MCB shall be installed separately from the power source.

2.1.37 **Switchboard equipment**

2.1.37.1 Electronic cards or blocks must be designed for quick and easy replacement without requiring disassembly of other apparatus or gear, or the movement of a cable or bundle of cables.

2.1.37.2 Sub-assemblies performing the same function must be fully interchangeable and perfectly identical.

2.1.37.3 Machine electronics must be designed to facilitate repair and troubleshooting.

2.1.37.4 The equipment shall normally be able to operate at the ambient temperature of the workshop.

2.1.37.5 In particular, with regard to the technical cards-

- i. Functions shall be distributed on cards connected to cabling with connectors.
- ii. Distribution shall be studied to limit the troubleshooting and repair time (functions effectively limited per card).
- iii. During card replacement, adjustments must be limited to those which are strictly necessary.
- iv. Technologies used by the various Subcontractors must be homogeneous (same card format, same connectors, etc).
- v. All the Card Cabinets shall be labelled using stamped identification.

2.1.38 **Machine wiring**

2.1.38.1 All outside cables shall be protected from any damage, which could be caused by chips, oil and grease. Protection sheaths shall be mounted on the Wheel Lathe so as not to hinder or retain machining chips. Connections made on protection sheaths and components controlled or junction boxes shall be of a mechanical type and removable, e.g., with screws and nuts.

2.1.38.2 The maximum amount of machine wiring shall be laid inside the machine frame.

2.1.38.3 Machine, panel and electrical switchboard wiring shall be laid inside the machine frame.

2.1.38.4 Limit switches shall be installed in areas where chips do not reach. Protection systems shall be installed in all areas where there are hazards.

2.1.38.5 All wires and cables shall be terminated using relevant lugs with ferrules for cable. Wire identification.

2.1.38.6 All cables, apparatus, gear and terminal strips shall be identified with relation to each connection. The same identification system shall be marked on the hydraulic and electrical diagrams.

2.1.38.7 Cabling and connection of the installation are the responsibility of the Contractor.

2.1.38.8 Machine Earthing: The Wheel Lathe equipment shall be earthed as per relevant IS standards and shall have loop earthing.

2.1.39 **Data processing Equipment:**

2.1.39.1 The data processing equipment of the Wheel Lathe shall have the following minimum configuration-

- i. The Wheel Lathe CNC shall be PC based and shall offer all PC interface like LAN / WAN / wifi connectivity and shall have ample storage capacity to store wheel profiling data. It shall be compatible with IBM standard software or better, suitable for remote diagnostics.
- ii. 102-key Keyboard, 15" LED, Windows OS, latest version. Industrial grade Printer, or equivalent.
- iii. Provision of Uninterrupted Power Supply (UPS) for PC system and Printer with 1 hour back up time.

2.1.39.2 The Contractor will provide the programming consoles, application software, which should be

compatible with and seen on windows platform and should be upwardly compatible. It shall be possible by CMRL to modify specific parameter through application software.

2.1.40 **Maintenance and upkeep conditions**

2.1.40.1 All component parts of the Wheel Lathe must be appropriately protected to stop ingestion of metal dust and chips. All covers, slide caps, hoods and neighbouring boxes of tool holders shall be made sufficiently hermetic to stop metal dust from entering into these areas. All covers, and hoods shall be easy to remove.

2.1.40.2 The Wheel Lathe and its accessories (hydraulic unit, electrical switchboards, numeric control system cabinets, etc.) shall be designed to facilitate maintenance operations.

2.1.40.3 All anomalies shall be reported to the operator by means of messages on the numeric control system screen.

2.1.40.4 A centralised and automatic lubrication device, with pressure and flow control for each lubrication point and display of faults on the numeric control system screen, shall lubricate the maximum number of moving components. Non-centralised lubrication points shall be located so that they do not call for the removal of any components to obtain access.

2.1.41 **Interlocking with Battery Operated Shunter**

2.1.41.1 The Wheel Lathe shall have the provision of wireless interlocking with both Battery Operated Shunter for the movement of the Rolling Stock during the reprofiling of wheel sets. The Wheel Lathe supplier shall co-ordinate with the Shunter supplier during the detailed interface.

2.1.42 **Dust / Fume exhaust system**

2.1.42.1 The dust and fumes emitted during the machining of wheels are needed to be extracted and disposed through exhaust system. The design of the exhaust system shall be Environment friendly and shall be submitted for approval to CMRL.

2.1.43 **Protection and Safety (Machine Safety)**

2.1.43.1 Machine safety

- i. The sliding rails shall be locked in the extended and retracted positions.
- ii. A device shall be provided to impede any accidents during sliding rail operation if an obstacle is encountered.
- iii. The following conditions must be satisfied for vehicle hauling-
- iv. Continuity of the track provided by the sliding rails.
- v. Mobile parts of the machine, viz. roller-holder sliding block, tool-holder sliding block, read head, etc., in retracted position.
- vi. Safety devices shall be provided to impede any damage to the machine and serious personnel injury in the event of false manoeuvres.
- vii. Interlocking of Battery Shunter with lathe machine shall ensure that-
- viii. The shunting will not take place when the lathe is working on Rolling Stock.
- ix. When the shunting is being done using the Shunter, the Wheel Lathe shall not work, and its rails shall be in closed position.

2.1.43.2 Personnel safety : In relation to operator's protection, the machine shall meet the following conditions-

- i. The machining area and workstation shall be appropriately illuminated.
- ii. Protection against movement of vehicle when retracting rails are not locked.
- iii. Automatic tool retraction device to withdraw the tool in the event of sudden power failure.
- iv. Arrangement to ensure adequate support to the vehicle in the event of sudden power failure or failure of the hydraulic system. In these eventualities, the vehicles shall continue to be

securely supported.

v. Protection against faulty sequence of operation shall be provided.

2.1.43.3 Emergency Stop pushbuttons (key lockable) shall be installed on following locations-

- i. On the control panel
- ii. At the workplace
- iii. At the chip disposal system

2.1.43.4 Protection against chips, the machine shall have the system of Swarf- Protection Guards against the direct influence of chip from the cutting area.

2.1.43.5 Proper Work Ergonomics should be provided. Operators stand should be located in a way for allowing optimum use of area of pit type foundation.

2.1.43.6 Fire Protection should be provided on the basic body of the machine. The design parameter of electrical installation shall be in safe range to protect from fire.

2.1.43.7 Mechanical Protection to be provided against dangerous state of break in track continuity over the machine (displaced retractable rails of the machine).

2.1.43.8 The Contractor shall provide details of the complete scheme being proposed.

2.1.44 **Interface** : Interface specification under Chapter- 3 Part-2 section VI-B shall be referred for the interface with other system Interfacing Contractors for Wheel Lathe. Also Wheel Lathe Contractor shall support EOT crane contractor to implement interlock between Wheel Lathe and EOT Crane.

2.1.45 **Standards:**

2.1.45.1 Work related to the design and manufacturing of the proposed machine shall comply with relevant international standard or equivalent Indian standards, Codes of Practice, and the latest statutory requirements of India as applicable.

Note : The Contractor shall submit technical evidence for the compliance against UFWL TS clause no: 2.1.4.20, 2.1.6.1, 2.1.6.3, 2.1.6.4, 2.1.6.5, 2.1.8.3, 2.1.17.2, 2.1.21.2, 2.1.25.1, 2.1.26, & 2.1.27.3 during the design stage.

2.2 AUTOMATIC TRAIN WASH PLANT (ATWP)

2.2.1 Purpose of the machine:

The main purpose of ATWP is to wash and rinse the complete exterior of 4 & 6 car configurations of rolling stock including washing of front and rear cabs periodically in ~~Non~~ UTO/GOA2 UTO and Non-UTO modes of train operations in CMRL Phase-I and Phase-I extension network at Koyambedu depot.

2.2.2 Basic Components of Automatic Train Wash Plant

The installation shall consist minimum (but not limited) of :

2.2.2.1 Pre-wetting station:

- i. It is to refresh the body of the coach and to eliminate light-adhering dust and to moisten the surfaces to be cleaned prior to application of the detergent solution.
- ii. This shall be carried out by manifolds fitted with spray nozzles aimed all over with adjustable flow rate. Two vertical manifolds assembled on single pole shall be designed for both sides.
- iii. The positioning and flow rate of all spray nozzles shall be adjusted during commissioning and trial for efficient working.
- iv. The pre-wetting process shall adopt recycled / reclaimed water, which shall be supplied from the water recycle module.
- v. All the Structure, Frames and Fasteners shall be SS304 or equivalent. All the pipeline, fittings and accessories shall be SS304 or equivalent.

2.2.2.2 Detergent wash station:

- i. Detergent station shall consist of a set of minimums of one sets of vertical brushes (one in each side- total 2 nos) with Stainless Steel spray poles, suited to cleaning the lateral surfaces of the train. Each brush shall include an arrangement to spray water and apply detergent solution evenly on the car surface. The brushing pressure shall be wear-adjusted.
- ii. Contact pressure between brushes and train is automatically controlled and contact pressure shall be maintained constant.
- iii. Brush rotation with direct drive via gearbox and electric motor (Preferably in top mounted). The drive mechanism including the electric motor shall be positioned accordingly so that no water comes in direct contact during wash cycle.
- iv. Mobile swing arms shall be supported with sealed bearings at upper and lower ends.
- v. The start of cycle shall be triggered by sensors.
- vi. The Contractor shall propose the type of detergent to be used for detergent washing in interface with the Rolling Stock Contractor for CMRL review and approval. Supply and maintaining of recommended chemicals / detergent as approved for cleaning of trains shall be in scope of Contractor.
- vii. The detergent solution proposed shall not exceed a permissible pH value as finalised during design stage, so as to eliminate risks of detrimental chemical reactions on the car body. Wash plant Contractor shall ensure this during interface with Rolling Stock Contractor.
- viii. All the Structure, Frames and Fasteners shall be SS304 or equivalent. All the pipeline, fittings and accessories shall be SS304 or equivalent.
- ix. Chain, Sprocket and Other Accessories shall be SS304 or equivalent. Safety guards and protection covers shall be SS304 or equivalent.

2.2.2.3 Water Brush Station :

- i. Two pairs of vertical brushes, two on each side (total 4 nos), shall be provided for water brushing on the car body surfaces. Each brush shall be integrated with a spray pole with simultaneous operation. The water brushing process shall be divided into two

stages. The first stage shall adopt recycled water while the second stage shall use soft water preferably. These brushes shall have motors driving the brushes. The Brush Rotor shall be controlled pneumatically/ electrically to ensure that the brush follows the contour of the train profile.

- ii. The two stages of water brush station shall be separated with appropriate distance such that the water sprayed at each stage can be individually collected by separate drain.
- iii. Type of water to be sprayed and used in various washing stations will be finalized during the detailed design stage of automatic train wash plant. The Contractor shall furnish the details during design stage for approval of Employer.
- iv. Contact pressure between brushes and train is automatically controlled and contact pressure shall be maintained constant.
- v. Brush rotation with direct drive via gearbox and electric motor (Preferably in top mounted).. The drive mechanism including the electric motor shall be positioned accordingly so that no water comes in direct contact during wash cycle.
- vi. Mobile swing arms shall be supported with sealed bearings at upper and lower ends.
- vii. The start of cycle shall be triggered by sensors.
- viii. All the Structure, Frames and Fasteners shall be SS304 or equivalent. All the pipeline, fittings and accessories shall be SS304 or equivalent.
- ix. Chain, Sprocket and Other Accessories shall be SS304 or equivalent. Safety guards and protection covers shall be SS304 or equivalent.

2.2.2.4 Front and rear wash station:

- i. It involves the cleaning of the front and rear of rake including detergent application etc.
- ii. A mobile guided wash system with atleast 2 sets of brushes shall be fitted. It shall wash the complete width and height of cab.
- iii. Brush rotation with direct drive via gearbox and electric motor (Preferably in top mounted). The drive mechanism including the electric motor shall be positioned accordingly so that no water comes in direct contact during wash cycle.
- iv. Contact pressure between brushes and train is automatically controlled and contact pressure shall be maintained constant.
- v. The design shall also include safety provisions for working under live OHE.
- vi. It shall be possible to isolate Front & Rear wash in the wash cycle.
- vii. All the Structure, Frames and Fasteners shall be SS304 or equivalent. All the pipeline, fittings and accessories shall be SS304 or equivalent.
- viii. Chain, Sprocket and Other Accessories shall be SS304 or equivalent. Safety guards and protection covers shall be SS304 or equivalent.

2.2.2.5 Post-wash station

- i. First rinsing: The fresh / soft water shall be sprayed onto the surface of the trains via spray nozzles aimed all over with adjustable flowrate.
- ii. Second rinsing: RO water shall be sprayed onto the surface of the trains via spray nozzles aimed all over with adjustable flow-rate. This process shall eliminate scaling and water

stains from the coach body. Filtration of water shall be done with Reverse Osmosis(RO) system for the second rinse of the train.

2.2.2.6 Drying station :

- i. Pressurized air blowers shall be positioned on both sides of the train to completely eliminating water droplets after the second rinsing. The operation of the blower shall start automatically after sensing the approach of train.
- ii. Material for the blower shall be SS304 or equivalent.
- iii. Noise level shall be less than 75dBA at one meter from blower while both side blowers in operation. In case the noise level exceeds 75dBA, additional arrangement i.e acoustic/sound proofing or similar shall be provided by the Contractor to maintain the noise level below 75dBA.

2.2.2.7 Water treatment and recycling system

- i. The water recycle module shall be provided to minimize the water consumption of the train washing plant and ensure that recycled water does not contain sediments, free oil viz. grease etc., residue detergent and odour.
- ii. The unit shall be designed to treat wastewater coming from train washing. The aim is to recycle part of treated water and discharge the excess. The use of fresh water should be limited.
- iii. All water from the stations of pre-wetting, detergent spraying and first-stage water brushing shall be collected in a sump to discharge to the effluent treatment plant.
- iv. Sufficient care shall be taken to prevent rusting of all fittings in the plant design itself.
 - a) Water softening system: This system shall be used to reduce the hardness of recycled water. This system shall filter the used water to a standard that eliminates the possibility of spray nozzles getting clogged.
 - b) all stations water consumption shall be monitored from HMI by installing Flow meter in the designated pipeline.

2.2.3 Operational Requirement:

2.2.3.1 The plant shall be operable in the following modes:

- i. Automatic mode – the complete washing cycle can be performed without manual intervention in Non-UTO modes of train operations.(Lateral wash without front & Rear Wash and Full wash including front & Rear Wash with dual & single cycle)
- ii. Manual mode – in this mode, each station can be separately operated.

2.2.3.2 The normal operating mode of the equipment shall be automatic. In this mode, start- up and stop functions of the equipment shall be controlled by the arrival / departure of the train in at the designated point with various sequences taking place automatically.

2.2.3.3 The washing plant shall be automatically activated by the presence of the train passing through at a speed of 3 KMPH or less than that.

2.2.3.4 Provision shall be made to switch over to manual mode of operation in which the various sequences shall be regulated by individual controls. The design shall provide for by-passing any one or more stages of washing if warranted.

2.2.3.5 The plant and its accessories shall have necessary provisions for interlocking of entry and exit controls with the spray nozzles manifold so that the plant may not operate in the event of failure of the entry and exit controls.

2.2.3.6 The plant shall not start when a train travels through it in the opposite direction.

2.2.3.7 The plant shall shut down in case of faulty sequence of operation.

2.2.3.8 Over speed sensing device shall be provided to protect the coaches and the plant against

damages. If the train speed exceeds the operating speed of (3 Km/h), then the wash plant shall be completely shut down.

2.2.3.9 Pumps shall automatically shut down in the event of lack of water or detergent solution.

2.2.3.10 The plant shall automatically shut down after a pre-set time in the event of a train stopping inside the plant.

2.2.3.11 The brushes shall automatically retract to their gauges in the event of any malfunction or activation of emergency stop buttons.

2.2.3.12 The plant and its accessories shall have necessary provisions for graphical indication of the washing cycle.

2.2.4 General design requirements

2.2.4.1 The equipment shall be capable of automatically washing the exterior including front and rear of standard gauge (1435 mm) self-propelled metro trains of 6 car rakes as it passes through the washing line in ~~Non-UTO~~ all modes (UTO & Non-UTO) of train operations.

2.2.4.2 Cleaning shall be thorough to get rid the coach exterior of all dust, dirt, grime and other deposits accumulated in service. The coach exterior includes the ends, sides, gangway connection and curved portion of roof visible from sides.

2.2.4.3 The equipment shall be located in the Koymbedu depot at grade level.

2.2.4.4 The equipment shall be designed to handle at least 30 trains per day and to be operated round-the-clock and round-the-year.

2.2.4.5 The train is powered by 25 kV AC overhead electrical equipment running along the full length of the washing line. The overhead line above the track shall remain live during the entire washing cycle.

2.2.4.6 No staff shall be required to man the installation except for replenishing the stock of cleaning media.

2.2.4.7 The direction and flow of water from the washing plant as well as adequate protection from wash splash shall be adjusted to ensure that no water from the plant comes in contact with the pantograph of the metro cars or overhead electrical equipment (traction) at any point of time.

2.2.4.8 A control room of area approximately (8m X 13m) shall accommodate sub-systems of the installation.

2.2.4.9 The Plant shall be of proven design and design life shall be 30-years without rusting & corrosion in fixation base frame and structural components. The design life for mechanism, driving components, spray poles, brushes (except bristles) and others parts of the Plant shall be at least 15 years. No major structural repairs and major component replacement shall normally be required during the respective design life. The material & parts to be used for the same shall be specified in detail design stage for CMRL review and approval.

2.2.4.10 The Plant shall be designed for heavy-duty workshop use and shall be available through out the year without any limitation in day to day washing process.

2.2.4.11 Equipment that requires an electricity supply shall be compatible with the power system of 360-440V, 3 phase 4/5 wire, frequency 47.5 to 51.5 Hz & surge protection, low voltage protection to be included whenever necessary.

2.2.4.12 Equipment shall incorporate a means of adjustment in order to allow for foundation differential settlement of maximum 25mm.

2.2.4.13 The equipment shall be designed and/or selected to allow operation without over stressing, damaging or interfering in any way whatsoever with other equipment in the Depot.

2.2.4.14 Components of equipment of similar construction or similar application shall be mutually interchangeable. The Contractor shall, to the extent that he is responsible for the design or component selections of equipment items recognize and implement all safety requirements and ensure that the design and performance of the equipment are compatible with the suitable

international safety standards.

- 2.2.4.15 Equipment shall be "fail-safe" and "overload protected". The equipment shall incorporate all necessary safety devices to protect the equipment, operators, and all other people in the vicinity of the equipment. No failure of the equipment shall cause or give rise to any damage or catastrophe of any nature whatsoever.
- 2.2.4.16 Equipment design shall take into consideration fire protection, elimination of dust and dirt by means of suitable traps or the like, minimum maintenance requirements and ease of access for cleaning, routine maintenance and general disassembly.
- 2.2.4.17 Guards shall be fitted to all exposed moving parts of the equipment where the environment and working processes of the system dictate that there is a foreseeable risk of injury or causing ill health to personnel from sources such as moving parts, electricity, coolant, noise and vibration, dust and fumes, etc.
- 2.2.4.18 Moving parts of the equipment shall be efficiently lubricated to ensure quiet operation as well as durable and reliable service life. Lubrication points shall be clearly identified for easy replenishment with minimum removal of other equipment components. Oil and lubricants used should preferably be available in India or equivalent Indian makes should be advised.
- 2.2.4.19 It shall be the responsibility of the Contractor to recommend equivalent indigenous detergent / cleaning agent after establishing their chemical equivalence & without compromising the quality of washes and effect on the car body.
- 2.2.4.20 The environment within which the equipment is to operate shall be taken into consideration in the equipment design. The Contractor is advised to carefully examine the air pollutants and deposits generally encountered in Chennai's ambience. The Contractor shall collect the sample of water from the work site before taken into consideration in the equipment design.
- 2.2.4.21 Based on the experience gained during test, trials and use of machine or any problem arises during operation of the machine which warrants re-check of the design / manufacture / quality of the equipment, the Contractor shall be responsible for all modification as required and these shall be done without any extra cost to the CMRL.
- 2.2.4.22 Any modification required to be done for satisfactory cleaning / rinsing / water streak removal shall be mutually decided & carried out by the Contractor free of cost to the satisfaction of CMRL. Therefore, the Contractor shall carefully consider local ambient condition like pollution, dust & quality of water in their design stage.
- 2.2.4.23 Cable: Fire Retardant Low Smoke armoured cable with suitable size and accessories

2.2.5 Design of Accessories

- 2.2.5.1 Brush drive: The brush drive motor and gearbox shall be mounted on the top of the brush frames. No belt drives shall be used in the driving assembly.
- 2.2.5.2 Compressor: Suitable capacity compressor, if required, for the wash plant operation shall be supplied and installed by the wash plant Contractor.
- 2.2.5.3 In order to limit water splashes, so as to reduce water spillage and wastage, splash guard shall be erected around each washing station. The life of the splash guard shall be same as that of other structural members of the plant. The Contractor shall mention the material composition and its life during the design stage. Detailed design of the splash guard shall be furnished during the detailed design stage of the Automatic train wash plant.
- 2.2.5.4 The Contractor shall carry out all necessary work, complete with tanks (except civil work as specified), pumps, pipes, valves, filters, meters and accessories as required in each station.
- 2.2.5.5 The Contractor has to provide a water consumption meter of reputed make at inlet line for Wash Plant.

2.2.6 Design Responsibility

- 2.2.6.1 The Contractor shall be responsible for the design of the Permanent Works, which shall include:
- The development of the design shall be carried out in conjunction with the information

contained in the Drawings and shall be in accordance with the Specification set out in the Contract.

- ii. The Contractor being responsible for the development and completion of the design of any other items of the Works as stated in the Contract, including, without limitation, the updating and amendment of the Drawings from time to time.
- iii. The Contractor shall determine and verify as appropriate the materials, site measurements and installation criteria before adopting in the design of the equipment.
- iv. The information that extracted from the Drawings and adopted by the Contractor in his design shall become the Contractor's design for which neither CMRL nor the CMRL's Representative shall be responsible.
- v. The Contractor shall solely be responsible for design, quality of fabrication works, its installation and shall issue quality certificate for the same. The Contractor shall seek design approval of steel & fabrication, other item proposed to be used, from CMRL
- vi. All fasteners shall be of stainless steel. All structures including the frame shall be of stainless steel of suitable grade as per ASTM-AISI standard or equivalent. All Pipe shall be used inside plant room shall be HDPE pipe. All pipe goes out from Plant room to designated station shall be Stainless steel SS304.
- vii. The Contractor shall solely be responsible for installation, commissioning & testing of the plant and shall depute his representatives during installation, commissioning & testing.
- viii. Stress analysis of sensitive structures shall be carried out from a reputed test house & report shall be submitted.
- ix. Material for the detergent tank and RO water storage tanks shall be of SS-316 grade or equivalent. All other tanks in the plant room shall be of HDPE material.
- x. The Contractor shall submit detailed process flow of the complete system and additional measures taken for improving design to suit specified ambient conditions.

2.2.7 Safety & interlocks

- 2.2.7.1 The plant and its accessories shall ensure safety of the equipment, operator and other personnel at all times and special precautions shall be incorporated against electrocution by live overhead equipment.
- 2.2.7.2 Adequate safe clearances shall be maintained from the overhead equipment by the plant during working and non-working modes. All the electrical equipment including structures shall be earthed as per the latest standard of the Indian electricity rule IS 3043.
- 2.2.7.3 Suitable provisions shall be made for protection against choked nozzles, excessive pressure / low pressure, low water levels, over speeding of trains, voltage fluctuations, malfunctioning of train sensing system, prolonged detention to the train on the washing line and any unusual occurrence.
- 2.2.7.4 The fault diagnostics of the equipment shall be clearly displayed to the operator by suitable audio-visual indications at the designated location.
- 2.2.7.5 The entire layout and erection shall be ergonomically designed and executed. The washing area and important operating parameters shall be clearly visible and accessible to the operator from the designated position.
- 2.2.7.6 During power failure and emergency shut down the equipment shall stop in the "Safe mode" with indication alarm and shall resume operations on restoration of power supply with operator intervention.
- 2.2.7.7 Each elementary function shall also be controlled by manual push buttons in a sequentially interlocked system.
- 2.2.7.8 All the operational overrides shall be facilitated with proper interlock system
- 2.2.7.9 Safety guards shall be provided for all the Moving parts in the ATWP.

2.2.8 Control Console

- 2.2.8.1 The wash plant shall be designed with Control console placed in the Control room.
- 2.2.8.2 The Control consoles shall have all the functionalities to operate the wash plant in all the modes, but at any time only one shall be in active state. Necessary interlock shall be designed for this.
- 2.2.8.3 The console and necessary cables shall be provided and installed by Wash plant Contractor.
- 2.2.8.4 The control of the Plant shall be fitted with PLC to safeguard and sequence all automatic processes and movements. The changes required in -sequencing or timing of various operations shall be implementable through control panel. HMI touch screen Control of related and conflicting operation functions shall be interlocked to enable logical operation of wash cycle. The screen shall be selectable from menu and shall also provide diagnostic /faults messages. The control shall have the provision to revert to a default setting of the plant, if any wrong setting done by an operator.
- 2.2.8.5 Complete graphical indication of completion of washing cycle shall be available at control console of Wash Plant.
- 2.2.8.6 The Contractor shall furnish complete details of flow chart sequencing ladder diagram etc. developed for plant operation.
- 2.2.8.7 The consoles shall be provided with HMI (Human Machine Interface) touch screen display / pushbuttons switches for various operations as well as indicating, lamps / meters for monitoring the operations in progress.
- 2.2.8.8 The terminal block assembly shall have 20% spare terminal for future usage.
- 2.2.8.9 An appropriate IP Rating protection shall be provided for all the control panels, electrical box and pneumatic distribution box and control system.
- 2.2.8.10 Emergency stop button shall be provided at both control consoles.
- 2.2.8.11 Operation and failure Logs: Number of wash cycles and all wash plant failures shall be logged by the wash plant. Monitoring of details i.e. status/ health, operating hours of the plant shall be monitored at control panel/console with fault record storage facility for at least 30 faults.
- 2.2.8.12 Cable: Fire Retardant Low Smoke armored cable with suitable size and accessories
- 2.2.8.13 The control console shall record all types of fault logs & washing history and shall be transferable to external computer/laptop in the format of MS excel & pdf.

2.2.9 Cameras in Wash Plant:

- 2.2.9.1 At least 4 number of cameras with storage devices (atleast 240 hours for each camera) shall be installed in wash plant to monitor the washing progress remotely.
- 2.2.9.2 The camera resists both water and dust ingress in tough environments.
- 2.2.9.3 The fixing location shall be mutually agreed. The live feed shall be available in local control Room always. The Contractor shall provide 10 inch LED monitor to see the feed of camera.
- 2.2.9.4 The same control consoles in both the rooms can be used to view the live footage or separate displays can also be installed.

2.2.10 Plant Area

- 2.2.10.1 The following space is provided for installation of wash plant and its accessories in the Koyambedu depot.
 - i. Space of 8 m x 50 m (approximately) along the track for wash pad.
 - ii. Approximately 8 m X 13 m covered control room close to the wash area for installation of compressors, water recycling units, RO units, local control consoles, etc.,
 - iii. It is the responsibility of the Contractor to design the system which can be accommodated in the space mentioned above.

2.2.11 Signage

2.2.11.1 All necessary signages shall be installed by the Contractor. The scheme of signage shall be submitted for approval of CMRL during the design phase.

2.2.12 Interface:

- i. CMRL civil Contractor will construct four water storage tanks at the ground level near to the control room area. However, any other water tanks, shall be designed, and installed by the wash plant Contractor.
- ii. Sump, pumps and pipes shall also be provided by the Wash Plant Contractor to draw / pump water from/to above mentioned water tanks.
- iii. Interface specification under Chapter- 3 Part-2 section VI-B shall be referred for the interface with other system Interfacing Contractors for Automatic Train wash plant.

2.2.13 Drawings:

2.2.13.1 List of Drawing and details provided in Chapter 4 – Employer's drawing.

2.2.14 Standards:

2.2.14.1 Work related to the design and manufacturing of the Wash Plant shall comply with relevant international standard or equivalent Indian standards, Codes of Practice and the latest statutory requirements of India including (but not limited to) as mentioned vide General requirement and scope Chapter 1 Part-2 Section VI-B.

2.3 SYNCHRONISED PIT JACKS (SPJ)

2.3.1 Purpose of the machine:

The main purpose of Synchronised Pit Jacks (also referred as Under Floor Lifting System) is to lift, lower and support of rolling stock in single and/or group mode to enable inspection of underframe and bogie, maintenance of bogie, dismantling / replacement of bogie etc works at Chennai Metro Rail Limited Phase -I, Koyambedu depot.

2.3.2 Basic parameters for the design of Synchronized Pit Jacks (but not limited to):

Track Parameters:

S. No	Parameter	Dimensions
1	Track Line	Straight
2	Track gauge	1435 mm (Standard)

Bogie Hoist (Cantilever System)

S.No	Parameter	Dimensions
1	Capacity per Bogie hoist	22 t (44t per coach) per pit
2	Effective lift	Maximum 1800 mm
3	Lifting speed	Minimum 400 mm/min

Body Stand

S. No	Parameter	Dimensions
1	Capacity per body Stand	11 t single / 22 t per pair per pit
2	Effective lift	Maximum 2700 mm
3	Lifting speed	800 mm/min

Other Parameters:

S. No	Parameter	Dimensions
1	Auxiliary track capacity with bogie hoists raised	110 kN/axle
2	Gap between platform rails and shop rail	≤ 5 mm
3	Equipment noise level	75 dB(A) max. at 1 meter

Synchronisation Control:

S. No	Parameter	Dimensions
1	Bogie hoist level tolerance within individual bogie	± 3 mm
2	Bogie hoist level tolerance within adjacent bogies	± 5 mm

S. No	Parameter	Dimensions
3	Bogie hoist level tolerance within two cars	±10 mm
4	Body stand level tolerance within a pair	± 3 mm
5	Body stand level tolerance within adjacent pairs	± 5 mm
6	Body stand level tolerance within two cars	±10 mm

The Pit jacks shall allow clearance underneath raised railcar for transport of dismantled bogie. Minimum clearance shall be:

- 3000mm wide X 1100mm high for bogie passage *

**The above values indicative only & will be confirmed during design stage.*

**The Pit Jacks Contractor shall interface with the Rolling Stock Contractor for required drawings and parameters of the train, lifting pad, bogie details etc before design and construction of machine.*

2.3.3 General Description of Scope of Works

- 2.3.3.1 Design, Manufacture, Supply, Installation, Testing, Commissioning & Training, for One (01) set of Synchronised Pit Jacks for 6 car lifting rolling stock in single and/or group mode at Koyambedu Metro Depot of CMRL Phase-I. System shall comprise of a total of 12 Bogie Hoists/Lifter and 24 Body Supports along with a Master Control Console etc.
- 2.3.3.2 The supply shall include all equipment and accessories required to make the Pit Jacks fully functional when connected to a power source. The Pit Jacks shall comply with the configurations of Rolling Stock and Track profile.
- 2.3.3.3 Not Used.
- 2.3.3.4 Preventive schedule and unscheduled Maintenance
- 2.3.3.5 Electrical cables for connecting Power source to Master Control Console shall be supplied by the Contractor as per the requirement.
- 2.3.3.6 The Pit Jack Contractor shall interface with Depot Civil Contractor to provide the pit & foundation design for construction by the Civil Contractor.
- 2.3.3.7 Any special material required for grouting / foundation or inter connection (excluding pipe conduits for cables laying & sump drain connection on workshop floor, which shall be the scope of civil Contractor) shall be supplied by Pit Jacks Contractor along with the instructions to use.
- 2.3.3.8 Ladders shall be provided at suitable location in every pit along the length of long pit to get access inside every Pit.
- 2.3.3.9 Adequate lighting needs to be provided by the Pit jacks Contractor in every pit. Conduit / cable Tray inside the Pits shall be provided by the Contractor as per the requirements.

2.3.4 Design Requirement of Mechanical Parts

2.3.4.1 Jack structure

- a) The structural design of the equipment shall withstand the weights, and other forces from movement of rolling stock.
- b) The structure of the equipment shall be fabricated by welding of steel connections.
- c) The equipment to be installed at the pits shall adopt an approved corrosion prevention coating system to cope up with the possibility of water logging for long hours.

2.3.5 Bogie Hoist

- 2.3.5.1 The Pit Jacks system for each metro train car shall consist of two bogie hoists for lifting and

lowering the metro train and four body supports supporting a metro train.

- 2.3.5.2 Each bogie hoist / lifter shall be raised or lowered by Single or 4 lifting columns of proven design. Each Lifting column shall consist of a spindle-lifting element, a lifting beam, guiding box, one automatic following gap cover and associated electrical equipment.
- 2.3.5.3 Not Used.
- 2.3.5.4 Each bogie hoist shall have a bogie-lifting platform sized for bogies. Each pair of bogie hoists, i.e. for 2 bogies shall be capable of lifting a metro train car of maximum 44t . The lifting platform shall be of cantilever type that provides a clear passage for transport of bogie underneath the raised metro train cars.
- 2.3.5.5 Suitable Lighting (LED) shall be provided by the Contractor on the face of each cantilever lifting head for the adequate illumination of complete under frame of the metro train cars. Adequate lighting arrangement shall also be made inside every pit by the Pit Jack Contractor for smooth maintenance of equipment.

2.3.6 Body Stand:

Each body stand shall have a supporting pad for supporting metro train car body at its jacking pads. Each pair of body stand shall consist of two lifting spindle elements, which may be operated together or individually. The arrangement shall provide a clear passage for transport of bogie underneath the raised metro train cars. Two pairs of body stand shall be capable of supporting a 44t metro train car. The exact locations of jacking pads on the Metro train car shall be determined by interfacing with the Rolling Stock Contractor during design phase by the Pit Jacks Contractor.

2.3.7 Other Assembly:

- 2.3.7.1 The Equipment shall be installed inside in suitably sized pits. No part of the Equipment shall project out of the Chequered plate covering the pits.
- 2.3.7.2 Electrical motors, gear box and other peripheral equipment inside the pit shall be installed at adequate height from the base level of pit to avoid damage to equipment assemblies in case of water logging inside the pits. No system assembly mounted on pit floor(inside) shall be acceptable other than sump pump.
- 2.3.7.3 All basic elements of Synchronized Pit Jacks shall be fully interchangeable.

2.3.8 Spindle Lifting Element and Protection:

- 2.3.8.1 The spindle shall be a robust, vertical, self-locking screw shaft driving a spindle load-lifting nut, which shall be manufactured from cast bronze only. A safety nut shall follow the lifting nut of cast bronze. The load screw shall be of class 3A as per IS 2004/78 having threads in accordance with IS 4696 or equivalent international / European / British standard. Screw must be irreversible under 1.5 times of nominal load.
- 2.3.8.2 The static structural calculation of lifting elements shall be made to verify that the stresses permissible according to European Standards EN 1493 or equivalent for the chosen material are not exceeded under a static factor of 1.5 times and a dynamic factor of 1.15 times of the nominal load.
- 2.3.8.3 The spindles shall be fitted with flexible bellows for protection. The bellows shall be grease, acid, water and steam resistant. The fastening of the bellows shall be designed to facilitate quick disassembly for inspection and maintenance of the spindles.

2.3.9 Auxiliary Rail

- 2.3.9.1 Auxiliary rails / split rails shall be provided to allow for clearance of dismantled / repaired bogies beneath the lifting platforms while the bogie lifting platforms are raised. The rails on & above all Pits shall be in the scope of supply of the Pit Jacks Contractor and shall not be welded to the shop floor rails. Any material required for holding the Auxiliary Rails / Split Rails (i.e pre-cast bridges, steel supports / structure etc.) shall be in the scope of the Pit Jacks Contractor.
- 2.3.9.2 The auxiliary rails shall allow the train to pass over the lifting system without the load being

applied to the bogie hoists.

2.3.10 Pit Jacks cover Plates

2.3.10.1 While the Jacks are at the lowered positions, the shop area, where the pit Jacks are located, shall provide a safe and clear passage for metro trains of weight maximum 44 tons and workshop vehicles.

2.3.10.2 The pit areas shall be covered with hot dip galvanized solid Steel Chequered plates with minimum thickness of 10mm set flush with floor level, which should support workshop road vehicles of max weight 16 tons with axle load of max 8 tons. The maximum deflection of chequered plates shall not exceed 1/750 of the cover spans.

2.3.10.3 The surface of these cover plates shall be non-skid.

2.3.11 Automatic Lubrication System

An automatic centralised lubrication system shall be provided in each pit to assure proper lubrication of equipment components. All moving parts shall be effectively lubricated by either oil or grease.

2.3.12 Operational Requirement of Synchronized Pit Jacks:

2.3.12.1 The Lifting System shall be electrically linked together to allow various combinations of synchronized lifting/lowering operation, viz. System shall be designed and capable of single car lifting, lowering, and supporting, and any combination from 2 to 6 metro train lifting. Any mode (Single and group mode) shall be controlled/selected through central / main control console supplied by Pit jack Contractor.

2.3.12.2 The lifting operations of individual bogie hoists and body stands, which are categorized as local control, shall be commanded at a local control pendant of the corresponding pit.

2.3.13 Hoisting Mechanism

2.3.13.1 Each Lifting spindle element shall be of screw type (absolute self-locking) through an angle of inclination related to the exterior diameter of the screw and driven by geared electric brake motor.

2.3.13.2 Magnetic brakes shall be used to precisely control the stopping of the lifting elements but shall not be used for locking. Automatic brakes shall be applied in the event of power failure.

2.3.13.3 The synchronization of lifting spindle motors shall be monitored and controlled by proven advance control system.

2.3.13.4 System design must comply that, in case of failure of any one motor during hoisting operation, suitable mechanism shall be in-built to safely lower the rail car to floor level, for clearing the track.

2.3.14 Electrical Equipment

2.3.14.1 Electrical equipment of the Bogie hoist and Body stands. The Bogie hoists and body stands are equipped with the following electrical equipment / components :

- a) Squirrel-cage brake motors
- b) Electrical wear detection switches (wear monitoring of spindle nuts)
- c) Electrical nut release detection to prevent free running of nut because of obstacles blockage the lifting beams.
- d) Proximity switch for synchronization or any proven latest method
- e) Limit switches for the lower and upper limit incl. the successive emergency limit switches and an automatic stop, i. e. during lowering all hoists shall stop at a clearance of approx. 150 mm between floor and lower edge of beams. A further lowering is only possible by operating the override button.
- f) A complete terminal box incl. all connecting cables between the terminal board and the lifting elements.

2.3.14.2 Sump Pumps

Automatic sump pump with a water alarm system shall be supplied and installed in each pit floor by pit jack Contractor. In case of water flooding in the pit, the sump pump shall start automatically to remove / drain out the water thru the flexible pipes.

2.3.15 Control Requirement

2.3.15.1 Master Control Console (MCC)

The master control console shall be provided at the central area of the Pit Jacks for mode selection and group controls and respective lifting / lowering operation. The console shall only be accessible by a unique key, which shall be latched into the console during operation. A lockable waterproof cover on operating panel shall be provided for the safety of HMI and other controls when system is not in use. The MCC shall be equipped with minimum:

- a) Main switch, lockable
- b) Control key for maintenance mode
- c) Contactors
- d) Transformer
- e) Circuit breakers
- f) Proven control system- programmable
- g) Electrical synchronization control
- h) Key-switch OFF / ON
- i) Push buttons for lifting / lowering
- j) Override push button "150 mm"
- k) Emergency stop button
- l) Warning signal of sound and flashing
- m) All necessary indicator lamps for the function of the system incl. lamp test HMI display in English language for:
- n) Selecting the groups of car units
- o) Trouble diagnosis with different failures (self-diagnostic function)
- p) Current status (Main messages)
- q) Status of limit switches
- r) Control system overview
- s) Service mode
- t) Reporting archive
- u) Operating hours
- v) Hinged protection cover for the display.

2.3.15.2 Local Control Console (LCC) : A local control console shall be provided at each pit, which accommodates one bogie hoist, and one pair of body stands controls. The LCC shall be linked by suitable long cables and easily retrieved from the pits by opening hinged steel covers, which shall be set flush with the shop floor. The LCC shall be equipped with:

- a) Push buttons for lifting / lowering.
- b) Selection and indication of operation / selection of Car Hoist and Body Stand.
- c) Override button "150 mm"
- d) Emergency stop button.

- 2.3.15.3 The master control console shall be interlocked with operator / acknowledgement / Interlock Pendant and shall be provided for operators to monitor and confirm the movement of the other side of the track, opposite to the MCC. Each operator pendent should be in between the two pits.
- 2.3.15.4 Operation of the bogie hoists shall be interlocked with operation of the body stands ensuring the safety and not permitting incorrect / unsafe operation.
- 2.3.15.5 To identify train car on pit jacks, suitable sensor / detecting device shall be provided to sense the bogie wheel lifting points to confirm that the wheels are correctly located over the bogie lifting platforms. Upon this verification, the device shall permit the lifting operation to proceed. Without sensing the wheel, the lifting operation shall not be permitted by any control.
- 2.3.15.6 The bogie hoist shall not be operable unless the body stands of the same pit are either fully lowered.
- 2.3.15.7 The selected body stands shall be raised in pairs and stopped once contacts with jacking pads of the metro train are detected by sensors at the pads of the body stands.
- 2.3.15.8 The controls, interlock functions and monitoring of the Jacks shall be executed by control system, which allows simplicity in wiring and expandability in future control alterations.
- 2.3.15.9 All push buttons for motion control shall be of non-latch and spring- return type.
- 2.3.15.10 The Control Console shall be of robust enclosures with proven steel material construction, duly treated & colour painted (epoxy paint or powder coated) for longer life and suitably braced to form a rigid structure. Adequate electrical insulation and proper ventilation shall be suitably designed. Exterior corners and edges shall be rounded to give a smooth overall appearance. Interior edges shall be smooth.
- 2.3.15.11 All pushbuttons shall be electrically interlocked to prevent inadvertent operation of opposing motions. All movements shall be clearly indicated on the control pushbuttons by means of labels in English / Signs.
- 2.3.15.12 A fault display panel shall be provided at the master control console. When a fault occurs, a buzzer on the panel shall sound and a lamp shall flash indicating the location and the nature of the fault. By pressing an acknowledge button, the buzzer shall become silent and the flashing lamp shall become steady. After the fault is rectified, the display shall revert to the normal state by pressing a reset button.
- 2.3.16 Protection and Safety provision:**
- 2.3.16.1 System shall be capable of taking the full train load (as per group selection) in case of power failure and any other such abnormal occurrence.
- 2.3.16.2 Wheel stops / roll off guards shall be provided at the bogie Lifting platforms which shall be fully activated and locked to prevent the metro train car from rolling off the platforms whenever the metro train car is raised / lowered from the shop floor. Any other proven design to prevent the rolling off train car while lifting and lowering shall be proposed. While lowering, once the bogie hoist has reached bottom most position, the locking shall be released to enable free movement of train car on track.
- 2.3.16.3 Approaching signals shall be provided and activated when Jacks has reached a clearance of 150 mm or less from the top of rail. The Signals shall include an automatic stop of lowering and audible intermittent alarm for approx. 10 seconds. Further lowering shall only be possible by pressing an override / suitable control function.
- 2.3.16.4 Motion limit switches shall be provided in spindle units to prevent over-lifting and over-lowering of any lifting element. The upward and downward level limits shall be predetermined and adjustable.
- 2.3.16.5 Lifting nut limit switches shall be provided to prevent the up-lifting operation of the system once any of the lifting nuts has worn to a predetermined limit. The fault shall be indicated on the fault display panel. The advance safety feature of automatic cut off (electrical) on wear in lifting / load nut and in safety nut shall be offered.

- 2.3.16.6 A set of traffic signals shall be provided and installed on the wall on the entry side of workshop repair Bay. The signal shall include one red light and one green light and give directions to operators for safe entry of Metro train with the lifting hoists at lowered position.
- 2.3.16.7 Main control panels shall be fitted with door mounted electrical isolation switches for the safety of maintenance personnel.
- 2.3.16.8 Emergency stop buttons of mushroom type shall be provided on all control stations including local control pendants.
- 2.3.16.9 Pit Jacks shall be provided with alarm system in case of water flooding in underground sump with subsequent operation of the float operated sump pump along with drain piping connected to the Depot Drain provided by civil Contractor. This system should be installed in every independent Pit of the System. Flexible drainpipe as per the requirements shall be provided by the pit jack Contractor.
- 2.3.16.10 In case of fault in control system, the operation of lifting or lowering of all the system shall be cut off simultaneously both for bogie hoist and body support.

2.3.17 Maintenance provision:

- 2.3.17.1 The equipment installation shall adopt an open pit design (covered with solid steel chequered plate) to allow adequate space for maintenance of equipment components through ladders.
- 2.3.17.2 All components including motors, gearboxes and shafts etc shall be easily accessible. The handling arrangement to access all assemblies inside pits for maintenance to be provided by Contractor and same shall be described in the offer.
- 2.3.17.3 The equipment shall be of modular design, with components manufactured into sub-assemblies to facilitate easy assembly and removal for maintenance purposes.

2.3.18 Checks and Tests:

All the test procedures / protocols as per EN 1493 standards shall be submitted for CMRL approval.

2.3.19 Drawings:

List of Drawing and details provided in Chapter 4, Part 2, Section VIB – Employer's drawing.

2.3.20 Interface:

Interface Specification under Chapter- 3 Section VIB Part-2 shall be referred for the interface with other system Interfacing Contractors for Synchronised Pit Jacks.

2.3.21 Standard:

Work related to the design of the equipment shall comply with EN 1493(Lifting plants) or International equivalent standard. If the Contractor proposes different standard, then he has to submit necessary documents to prove equivalence. Acceptance of the different standard as equivalent vests with the CMRL.

2.4 Bogie Turn Table (BTT)

2.4.1 Purpose of the machine:

The Bogie Turn Tables are required for rotating and transferring the Bogie from one track to another track line in the workshop for overhaul / repair, washing and assembling to train etc. The Turn table shall be designed and capable for rotating all types of bogies of multiple rolling stock at Koyambedu depot. The Bogie Turn tables also referred here as Turn Tables.

2.4.2 Operating Requirement :

- 2.4.2.1 The bogie turntables shall be designed for transport of bogie from one track to another track in the Workshop Shop area by rotating on the Turn Tables.
- 2.4.2.2 The design of each turntable shall have the roll over capacity of 25 t with maximum axle load of 11 t.
- 2.4.2.3 The turntables shall allow bogies with a maximum weight of 10t for turning and rollover.
- 2.4.2.4 The turntables shall be designed for manual turning by one person with an operating lever. The turning shall be endless in both clockwise and counter clockwise directions.
- 2.4.2.5 The turntables shall be integrated with manual-operated lock bars for securing the turntables in place during bogies being rolled on or off the turntables.

2.4.3 Design requirement of Mechanical parts

2.4.3.1 Turntable Construction :

- i. The turntables shall be constructed of circular platform decks with minimum 3500 mm in diameter. The decks shall sit on center pivot at the centers and castors on the peripheries for turning.
- ii. Two pairs of rails shall be mounted and positioned in perpendicular to each other across diameter on the deck of each turntable to accommodate bogies. Auxiliary rails (Crane Duty) of square / rectangular Steel bars of suitable grade shall be fitted on the Turn Table.
- iii. During over-ride of rail cross the wheel profile should not get any shock load from rail gaps.
- i. The track gauge shall be 1435mm for Standard Gauge as specified.

2.4.3.2 Platform Deck :

- i. The turntable and supporting frame shall be constructed of welded structural steel box section, wide flange beam, standard 'I' beam or reinforced beam fabricated from structural shapes.
- ii. The turntable shall be covered with hot dip galvanized Steel chequered plates and flush with the rail top level to allow normal traffic. The plates shall be stiffened and shall be of minimum 10mm thickness with maximum deflection not exceeding 1/1000 of the span. The plates shall be removable preferably and secured with flush bolts.
- iv. The Turntable platform shall be designed to sustain the rollover load of Workshop vehicle (forklift truck, scissor lift etc).

2.4.3.3 Centre Pivot

Centre pivot shall be provided and equipped with a self-aligning spherical roller thrust bearing (or any other advanced) to facilitate smooth turning operation. Centre pivots shall be designed to take up any horizontal loads.

2.4.3.4 Caster Wheels

Eight Castors wheels shall be provided along the periphery to facilitate turning operation. The castor wheels shall be manufactured from high quality steel for reliability during the service life and equipped with anti-friction bearings for quiet operation.

2.4.3.5 Running / Guiding Surface

Running surface for castors shall be designed with considerations of surface wearing and load bearing without deformation. Surface replacement, if necessary, shall be made possible.

2.4.3.6 Lock Bar / device

- i. The mechanical locking device shall be provided and located at each 90-degree segment of rotation. The tracks on turntable shall be aligned with adjacent embedded tracks in workshop when bogie turntables are in their locked position at any 90-degree of rotation. Lock bars shall be accessible with the bogies on the turntables for locking and unlocking operations.
- ii. Lock bars shall be flush with the shop floor level for both locked and unlocked positions. The Locking bars shall not be easily removable from the turntables.

2.4.3.7 Tolerance

The gap between the turntable deck periphery and the pit ring shall be within 5 to 10 mm. The track rails on turntable decks shall be aligned with the rails embedded on the shop floor. The rails shall be positioned within tolerances of ± 2.5 mm for track alignment, ± 2 mm for rail top and ± 1.5 mm for track gauge.

2.4.3.8 Pit Ring

The edges of the turntable pits shall be protected with pit rings of steel angle section. The curb angles shall be notched on the field side of the rails in addition to the gauge side to accommodate worn wheels, which may strike the curb angle.

2.4.3.9 Operating Lever

One operating lever shall be provided to each turntable for manual turning operation. An inbuilt provision shall be provided for storage of the lever within the Turn table.

2.4.3.10 Wheel Stopper

Two (2) nos. Wheel stoppers portable / removable type shall be provided (with each Turn Table) against any movement of bogie during turning operation.

2.4.4 Maintenance Provision

2.4.4.1 Maintenance access shall be provided for inspection and lubrication of center pivot and casters.

2.4.4.2 Lubrication shall be made by pressure grease fittings to all bearing of pivoting shaft and all castors. The greasing point shall be accessible to routine maintenance.

2.4.4.3 The turntables shall be constructed to allow the entire assembly, except supporting structures, be conveniently removed from the pit as a single unit. The turntables shall be equipped with lifting eyes, which shall be removable or flush with the decks.

2.4.5 Drawings :

2.4.5.1 List of Drawing and details provided in Chapter 4 Part 2 section VIB– Employer's drawing.

2.4.6 Interface:

2.4.6.1 The In addition, the Contractor shall refer Interface matrix / specification Chapter- 3 Section VIB Part 2 for the interface with other system Interfacing Contractors for Bogie Turn Tables.

2.4.6.2 Work related to the design and manufacturing of the BTTs shall comply with relevant international standard or equivalent Indian standards, Codes of Practice and the latest statutory requirements of India including as mentioned in General requirement and scope Chapter 1 Section VIB Part-2 but not limited to.

2.5 BATTERY OPERATED RAIL-CUM-ROAD SHUNTER (BORRS)

2.5.1 Purpose of the machine

The Battery-Operated Rail cum Road Shunter (BORRS) will be required for hauling / pushing / positioning of 6 car rake on Under floor wheel lathe track, workshops and in the depot track network in dry and wet conditions for multiple types of Rolling Stock in CMRL phase-I project at Koymbedu depot.

2.5.2 Basic Parameters / features for the design of Battery-operated Rail cum Road Shunter (but not limited to)

S. No	Parameter	Details
Track Parameters		
1	Track Gauge	1435 mm (standard gauge)
2	Track Gradient*	4%
3	Minimum curve radius*	100 m
BORRS Parameters		
1	Shunter type	Battery powered (Rail cum Road)
2	Tractive effort**	50 kN minimum
3	Height of Shunter (on rail)	3000mm max
4	Coupler	Front and Rear (compatible to all type of Rolling stock)
5	Operational control	Cabin and Radio remote

* The above track data is indicative. The Contractor shall verify the track gradient, curve etc before to design & manufacture the shunters accordingly.**The minimum tractive efforts generated by the vehicle while shunting 6 car trains shall not be less than 50kN.

2.5.3 General Description of Scope of Works

- 2.5.3.1 The scope of the Works shall include the following (but not limited to):
- 2.5.3.2 Design, Manufacture, Supply, Spares, Installation, Testing, Commissioning & Training of two (02) numbers of Battery-operated Shunter. The scope of supply shall include all equipment and accessories required to make the shunter fully functional.
- 2.5.3.3 Preventive Schedule and unscheduled Maintenance
- 2.5.3.4 The Battery Charger, in-built with the Shunter shall be a part of the supply.
- 2.5.3.5 Charging cable of suitable length matching with the depot electrical outlet shall be supplied along with Shunters.
- 2.5.3.6 Coordination with the Wheel Lathe Contractor for Interlocking of the 2 Shunters with Wheel Lathe operation. All connectivity between Remote to Shunter, Remote to Wheel lathe shall be wireless.
- 2.5.3.7 The Contractor shall design and demonstrate the testing and commissioning (coupling & uncoupling, shunting, braking etc) with multiple types of rolling stock of 6 car configuration.

- 2.5.3.8 The Shunter Contractor shall coordinate with other respective interfacing Contractors to get the final relevant design data before designing and manufacturing the Shunter.

2.5.4 Design Requirement

- 2.5.4.1 The Shunter shall be of Rail-cum-Road type and shall be remote controlled through a portable radio control unit as well as through an onboard control panel system provided in the driver cabin.
- 2.5.4.2 The remote control shall be capable to be operated atleast upto 250meters.
- 1 2.5.4.3 The Shunter shall be capable of generating a continuous draw bar pull of minimum ~~35-KN~~ 50 KN while pulling / pushing upto 6-car train load of maximum weight 264t on depot track with a minimum curve radius of 100 metres in dry and wet condition. Shunter shall be driven by electric motor controlled through VVVF drives or latest technology.
- 2.5.4.4 The Shunter shall be capable for pulling / pushing / positioning the 6-car metro train car on any repair Workshops / IBL etc lines and including in the depot track network premises in dry and wet conditions.
- 2.5.4.5 The Shunter shall be provided with rubber / vulcollan tyre wheels with rail guidance wheels and suitable for on rail or off rail travel with a rated shunting capacity. It should preferably have separate individual drive for running on tracks and separate drive for travelling on road.
- 2.5.4.6 It should be compatible with design parameters of all type rolling stock and Track at Koyambedu Depot of CMRL Phase I. Indicative design parameters of Rolling Stock and Track are mentioned vide this tender document.
- 2.5.4.7 No part of the Shunter should infringe the kinematic envelope as given in Schedule of Dimensions in Part 2 of the tender documents.
- 2.5.4.8 The Shunter shall be designed with cabin and shall have sufficient inside height for the operator to enter and work comfortably. It shall be well illuminated with lockable doors, safety glass and wind screen wipers. The cabin itself shall have several grips for the operator to hold on.
- 2.5.4.9 Also, compact cabin fan to be provided with steady airflow for the comfort working of operator and to enable optimum air circulation.
- 2.5.4.10 The Operator seat shall be cushioned, comfortable for operation and preferably adjustable and with backrest angle adjustable. The controls shall be ergonomically designed and allow operation of the Shunter in both direction of travel.
- 2.5.4.11 The height of the Shunter (with cabin) shall not be more than 3000 mm above top of rail while in rail mode. The width of the Shunter shall be as less as feasible and, in any case, less than 2800 mm.
- 2.5.4.12 The Shunter should be compatible for movement on road and off-track at any point in one easy and quick manoeuvre. The in-railing procedure shall allow the Operator to operate and monitor the in-railing process from driver's seat.
- 2.5.4.13 The Shunter shall be designed to cross any switches on tracks of the route it uses.
- 2.5.4.14 The rail wheel size shall be such that operation of Shunter, under all conditions, shall not result in any rail damage, corrugation, or any such effect.
- 2.5.4.15 Suitable hooking / lifting provisions shall be provided for balanced lifting of the Shunter.
- 2.5.4.16 LED headlights shall be provided on both the sides of the Shunter.
- 2.5.4.17 Horn for road and rail mode of suitable capacity shall be provided.
- 2.5.4.18 The Shunter and its accessories (hydraulic unit, electrical switchboards, control system cabinets, etc) shall be designed to facilitate ease in maintenance and operations.

2.5.5 Operational Requirement of BORRS:

- 1 2.5.5.1 ~~Shunter shall be designed to pull / push load of 6-car train (weighing approx. 264 t) with in depot track network, at grade, turnouts & crossings and with curve of 100 m in dry and wet condition.~~

1

Shunter shall be designed to pull / push load of 6-car train (weighing approx. 264 t) with-in depot track network, at grade, turnouts & crossings and with curve of 100 m in dry and wet condition.

Compliance with the above requirements, including the maximum trailing load (towing load) achievable under the specified operating conditions, shall be demonstrated by the Contractor through detailed design calculations and verified by site performance testing during commissioning.

The shunter shall also be capable of self propel (in tare load condition) and operating on a minimum gradient of 4% and shall safely negotiate a minimum horizontal curve radius of 100 metres on depot / mainline under both dry and wet rail conditions. Design calculation, Load vs Gradient chart shall be submitted by the contractor as a part of design submission.

Compliance with the above requirements to pull / push of maximum load (as per the design calculation load vs gradient chart) at Koyambedu Depot ramp in dry and wet conditions shall be demonstrated by the Contractor.

2.5.5.2 The travel speeds of the Shunter shall be infinitely variable running on road and track as under:

- 0 to 5 Km/hr running on roads and on tracks under unloaded conditions.
- 0 to 3 Km/hr running on track with a minimum curve radius of 100 m towing 6-car train (264 t).

2.5.5.3 The braking distances of the Shunter with and without load shall not exceed 4 meters on a track with 6 coupled railcars after the application of brake from a speed of 3 Km/hr. Braking system shall be hydraulically or electromagnetically actuated & controlled by a foot pedal including brake control on the remote-control unit.

2.5.5.4 Emergency stop buttons shall be provided in all four corners of the Shunter and remote unit as well.

2.5.5.5 Shunter under unloaded condition (on ground) shall be capable of climbing 10% gradient.

2.5.5.6 Shunter under unloaded condition (on track) shall be capable of climbing 4% gradient.

2.5.5.7 The Shunter shall have sufficient brake accumulator capacity or similar arrangement for additional braking support to avoid damages in case of failure of brake system while moving with load.

2.5.5.8 The shunting vehicle shall have high degree of manoeuvrability by means of hydraulic system, preferably with a conventional steering wheel, giving a minimum turning radius of not more than 4500 mm.

2.5.6 Mechanical Part

2.5.6.1 Coupler:

- i. A suitable coupler adapter (detachable type) , compatible with all type Metro Car coupler, shall be provided at both ends of the Shunter for coupling the Metro Train cars. It shall be designed for pulling, pushing or braking rated loads at all track lines.
- ii. Coupler height shall be adjustable by hydraulically / electrically from driver desk and through remote control after the shunter has stopped.
- iii. Battery shunter Contractor shall interface with rolling stock Contractor for designing the coupler meeting all type rolling stock coupling requirements.
- iv. The Coupling shall be done automatically & Uncoupling shall be perform automatically from driver cabin & manual lever in the coupler.
- v. The Coupler shall be designed as compact as possible especially in length.
- vi. One number Semi permanent bar detachable type shall be provided with each shunter.

2.5.6.2 Driver Cabin

- i. Driver seat shall be provided inside the Shunter cabin, preferably always facing the direction of

movement with easy manoeuvrability. The driver's controls shall match with orientation of driver seat. The driver seat shall be cushioned and adjustable.

- ii. Push button and switches used should be of IP 65 protection.
- iii. The control panel shall be ergonomically designed and allow operation of the Shunter in both directions of travel without need to twist or turn.

2.5.7 Control Requirement

- 2.5.7.1 Control switch key shall be provided to enable authorized access by Operator to enable shunter operation.
- 2.5.7.2 In onboard control, the operator shall be inside the Shunter and shall be only authorized to operate the Shunter with the given controls mounted on dashboard inside cabin.
- 2.5.7.3 The controls of the Shunters shall be interlocked with Underfloor Wheel Lathe operations. It shall prohibit operation of the Shunter when the Wheel Lathe is in operation and vice versa, while train coupled with Shunter. However, BORRS design allows authorise operator to bypass the same if required.
- 2.5.7.4 In order to avoid the possibility of giving simultaneous commands, i.e., from the cabin control panel and from the radio remote control, the Contractor shall provide an interlock system arrangement inside the cabin control, preferably key switch.
- 2.5.7.5 A portable radio remote control unit shall be provided for each Shunter to tow and position the railcars of 6-car train set for Under-floor Wheel Lathe operation and within depot rail network.
- 2.5.7.6 A spare battery (for remote unit) with compatible compact charger shall be provided.
- 2.5.7.7 The Remote-Control unit shall include at least the following functions (but not limited to) Forward operation, Reverse operation, Emergency stop, Braking, Horn, Coupler height control, Indications for low (remote) battery, etc.,
- 2.5.7.8 The cabin control console shall be mounted on cabin dashboard and shall handle all Shunter functions (but not limited to) On / Off, Forward operation, Reverse operation, Emergency stop, Coupler height controls, All Indicators and Lights, Horn, Battery status, Other relevant controls, etc.,
- 2.5.7.9 The Shunter shall have the facility equipped with cameras to monitor the In-railing and rail wheel position while operation as well as rear and front coupling. A suitable display shall be provided in cabin to monitor the above. The recording feature shall be available with 72 hrs backup for each camera.

2.5.8 Electrical parts / panels

- 2.5.8.1 The electrical components control panel of the Shunter shall have IP 65 protection level.
- 2.5.8.2 All panels shall be designed to accommodate ambient temperature and humidity conditions.
- 2.5.8.3 All control and regulation electronic and electrical devices, etc. shall be mounted in dust-proof switchboards and shall include an earthing terminal. Switchboards shall be designed so that inspection, repair and maintenance shall be easy.
- 2.5.8.4 All monitoring measures shall be provided at the cabin dashboard for full operation of the Vehicle and shall have the following Indications at driver desk (but not limited to), A speedometer, Load Current meter, Emergency switch, Indication for parking brake, Indication for battery condition, Indication for mode of operation (rail / road), Indication for Remote / Manual Operation, Other standard indications as recommended by the Contractor.

2.5.9 Indicators and Marking

- 2.5.9.1 Auto directional light / indicator shall be provided to identify direction while shunter moves on Rail.
- 2.5.9.2 The vehicle shall have the provision of automatic flashlight / beacon arrangement.
- 2.5.9.3 Working lights shall be provided at both side for illuminating the coupling area.

2.5.9.4 All cables, apparatus, gear and terminal strips shall be identified with relation to each connection. The same identification system shall be marked on the hydraulic and electrical diagrams.

2.5.10 Battery and Battery Charger

2.5.10.1 The battery bank shall require least maintenance and shall be suitably placed in the body of the Shunter to facilitate the maintenance with ease.

2.5.10.2 The traction System shall incorporate transmission via electric motor.

2.5.10.3 The Shunter shall have a battery capacity for at least 20 (twenty) kms travelling without load and for at least (nine) 9 kms travelling with load of 6-car train on single charging. Battery shall have lifetime for upto 1500 charging cycles and shall be recorded by Shunter. Details of Battery capacity, voltage, type etc shall be submitted in the offer. Contractor shall provide details for similar type of Battery availability in India.

2.5.10.4 An on-board charger shall be provided on the Shunter to charge the batteries using the power available in the Depot. The charger shall be compatible with the input power supply available in the Depot.

2.5.10.5 It shall be possible to recharge fully the batteries not more than 8 hours with on-board / in-built charger.

2.5.11 Rail / Road Wheel and Brake

2.5.11.1 The proposed life of rail wheels of the Shunter shall not be less than 20 years. In case of rubber wheels, the proposed life shall not be less than 10 years after Operational Acceptance.

2.5.11.2 A parking brake system shall be included in the brake system. The parking brake system should be able to retain stable the Shunter coupled with the 6-car train with 100 m radius in dry and wet condition.

2.5.11.3 Brake Foot pedal to be provided in the cabin in case of emergency braking required.

2.5.12 Protection and Safety provision:

2.5.12.1 Safety devices shall be incorporated to provide protection to the operator and the Shunter against all possible operational and Equipment failures.

2.5.12.2 The Shunter shall be fitted with emergency stop devices to enable actual or impending danger to be averted.

2.5.12.3 The followings minimum protection and provision shall be included with Shunter as mentioned below:

- Protection for low battery voltage alarm.
- Protection against low oil level in hydraulic system.
- Protection against over current of drive motor.
- Provision of auto parking brake.
- Provision of dead man switch.
- No traction with parking brakes on.
- No traction when shunter on charging mode.

2.5.13 Interface:

Interface specification under Chapter 3 Section VIB Part-2 shall be referred for the interface with other system Interfacing Contractors for BORRS.

2.5.14 Standards:

Work related to the design and manufacturing of the BORRS shall comply with relevant International standard or equivalent Indian standards, Codes of Practice and the latest statutory requirements of India including (but not limited to) among as mentioned vide General

requirement and scope Chapter 1 Section VIB Part-2.

2.6 SYNCHRONISED MOBILE LIFTING JACKS (SMLJ)

2.6.1 Purpose of the machine

The main purpose of this Synchronized Mobile Lifting Jacks is for lifting the complete 6 car Rolling stock for replacing the bogies or to do under frame repair works. Delivery and installation of this machine shall be either at Koyambedu Depot workshop line or Wimco Nagar Depot Workshop line (Deck level). Delivery location will be informed by CMRL at the time of delivery.

2.6.2 Basic Parameters for the design of Synchronized Mobile Lifting Jacks:

Parameter	Dimensions
Required quantity of LiftingJacks	24 nos.
Lifting capacity per Jack	12 t (Minimum)
Lifting capacity per set	12 t X 24 = 288 t
Lowest position of cantilever(claw) above T.O.R	500 mm
Highest position of cantilever(claw) above T.O.R	2100 mm
Vertical stroke	1600 mm
Cantilever	Fixed (Min 600mm length with capacity of 12t)
Lifting / lowering speed	Minimum 300 mm/min
Operating voltage	400V±10% / 50Hz±5%/ 3 phases
Control voltage	230V±10%/ 50Hz±5%/ 24V DC
Protection of electrical equipment	IP 55
Insulation class	F
Synchronization tolerance	±5mm
Noise level	Max 75 dB(A) in a distance of 1m

Notes:

- The Jacks shall be design for lifting / lowering of multiple types of Rolling stocks. Contractor shall demonstrate the compatibility with these multiple types of rolling stock. Also, Contractor shall interface with the multiple Rolling Stock supplier for the exact size of the contact head of the cantilever / claw and other specific requirement before design and manufacturing the jacks.
- The roof access platform height from rail / finish floor level shall be verified by the Jacks Contractor to avoid infringement before design and manufacturing the Jacks.

2.6.3 Design Requirements for Mechanical parts:

2.6.3.1 Drive Column

The guide column shall be made of welded steel profiles. The column assembly shall consist of

side fabrications with guide profiles for lifting the Rolling stock, an upper crosshead, and a front base plate. Furthermore, the column shall be equipped with lifting eyes and fork pockets for transport by crane or forklift truck.

2.6.3.2 Drive Mechanism

- i. The self-locking trapezoidal threaded steel spindle shall be suspended from an axial-self-aligning roller bearing in the upper crosshead.
- ii. The lower end of the spindle shall not be secured for allowing slight movement of the claw without jamming on the spindle.
- iii. A rapid changing of the spindle nut without dismounting the jack and without additional hoists shall be possible.
- iv. The spindle shall be driven via a reduction geared brake motor mounted to the crosshead. The motor shall be preferably horizontal to the floor.
- v. The gear torque support shall be provided with rubber bumpers. All bearings of the gear and motor shall be roller bearings.

2.6.3.3 Spindle Nut / Safety Nut

- i. The spindle nut shall be made of cast bronze, shall have free movement and have a convex head that locates into a concave machined recess in the crosshead of the lifting carriage.
- ii. The electric spindle nut free-running safety device shall avoid any casual detaching of the nut from the lifting carriage crosshead during lowering.
- iii. The safety nut shall run behind the spindle nut without load. If the thread of the spindle nut is tearing due to extreme wear, the safety nut assumes the function of the spindle nut and the load shall be lowered. In this case, the electric restarting safety device shall stops/blocks the lifting operation of the whole set.
- iv. The Safety nut shall be made of cast iron.

2.6.3.4 Spindle Protection

The spindle shall be protected above and below the claw assembly against the ingress of dust via a flexible covering / bellows.

2.6.3.5 Lifting Carriage and cantilever with claw

- i. Lifting carriage: Lifting carriage as a weldment shall be guided in the column by means of wheel flange rollers. These rollers shall be made of high-quality material. The unloaded cantilever shall be fixed type.
- ii. Cantilever with claw: The claw shall provide suitable means to prevent relative sliding of coach on the lifting pad. A load indicator switch shall be installed and shall be activated when the claw comes into contact with the car body.
- iii. Interlock: There shall be an interlock provision between the claw and the carriage movement. If load indicator switches are not activated, then the carriage shall not lift the car / coach body.

2.6.3.6 Travelling Device

- i. Each jack shall be equipped with a travelling gear mounted to the base for moving the jack and positioning.
- ii. The travelling gear shall consist of three wheels, two fixed on one side and one double wheel with a steerable hydraulic unit on the other side.
- iii. A handle shall be mounted above the steerable hydraulic unit to assist moving the jack. Lowering and rising of the jack shall be carried out via a three-position lever mounted on the handle.
- iv. The hydraulic unit shall have a clearance of 15 mm under the Lifting Jack for easy

movement on the workshop floor.

2.6.3.7 Lubrication

Lubrication nipples shall be provided at each jack for lubricating the lifting spindle and moving parts.

2.6.4 Design Requirements for Electrical parts:

2.6.4.1 The motor shall be squirrel cage motor with a protection of IP 55 and ISO class F or latest. There shall be a disc brake which shall always be closed and shall be opened by a control signal from the main control system. The brake shall have a hand lever to release it in case of an emergency.

2.6.4.2 Limit switches each for the upper and lower end position shall be located within the gear limit switch.

2.6.4.3 Limit switch for wear monitoring of spindle nut shall be available.

2.6.4.4 Limit switch for monitoring freewheeling (nut release) shall be available.

2.6.4.5 Limit switch for monitoring the position of the travelling device to prevent lifting and lowering when the jacks are on its wheels shall be provided.

2.6.5 Design Requirements for Local Control box:

Local Control box shall be designed with the following minimum buttons, controls (but not limited to):

2.6.5.1 Emergency stop button.

2.6.5.2 Push button without self-locking for the individual operation of the lifting jack "LIFTING / LOWERING".

2.6.5.3 Appropriate length of cable shall be provided for connecting jacks and Local control boxes. All the control and power cables shall be embedded in the pipes.

2.6.5.4 Indicators as applicable

2.6.5.5 A handheld control shall be designed according to EN 1493.

2.6.6 Design Requirements for Master Control Console (MCC):

2.6.6.1 One completely wired preferably movable control console shall be designed for 6 cars operation and shall have a minimum IP 55 protection. The operation of the jacks in a group of four, eight, twelve, sixteen, twenty & twenty four shall be controlled at the control console. A suitable rating and length of power cable shall be supplied with Jacks.

2.6.6.2 The console shall be constructed with sheet steel construction.

2.6.6.3 The console shall ensure safety from the following:

- i. Asymmetry control against phase failure
- ii. Supply overload protection

2.6.6.4 The complete Master Control Console including programmable control unit (PLC) and touch panel shall have a failsafe mechanism.

2.6.6.5 Master Control Console shall ensure synchronization of Jacks with a tolerance ± 5 mm

2.6.6.6 Touch panel of the main console shall have the minimum following features (but not limited to):

- i. Selecting the groups of car units (one to six)
- ii. Trouble diagnosis with different failures (self-diagnostic function)
- iii. Current status (Main messages)
- iv. Status of limit switches
- v. PLC overview
- vi. Service mode

- vii. Reporting archive
- viii. Operating hours
- ix. Hinged protection covers for the display etc

2.6.7 Connecting cables and sockets:

The connecting cable (control desk to jacks) with sufficient length for the main and local control console box shall be provided. These cables shall be provided with the necessary plugs and couplings. Necessary sockets also shall be provided for the operation of the Lifting Jacks.

2.6.8 Synchronization

The complete system (24 jacks) including the synchronization control shall be operated through a failsafe programmable controller (PLC). The maximum Synchronization tolerance is ± 5 mm. Synchronization control shall monitor the lifting run of each jack and compensates automatically possibly arisen differences in height (e.g. unequal distribution of load).

2.6.9 Safety Provisions:

- 2.6.9.1 Visible and audible signals shall be provided to personnel in vicinity during lifting and lowering operation. The audible signal shall be adjustable in volume.
- 2.6.9.2 Each jack and control console shall be fitted with an emergency stop button, one of which when activated shall cut off the power to all jacks.
- 2.6.9.3 The Safe Working Load (SWL) of each jack shall be clearly marked in English prominently on the jack.
- 2.6.9.4 Lifting jacks system design shall be equipped with advance safety features as per relevant standard.

2.6.10 Interface:

- 2.6.10.1 Interface requirement under Chapter-3 Section VI B Part-2 shall be referred for the interface with other system Interfacing Contractors for Lifting Jacks but not limited to.

2.6.11 Standards:

The Design, manufacturing, testing and commissioning of Lifting jacks shall be done as per EN 1493

2.7 CAR BODY STAND

2.7.1 Purpose of the machine

The main purpose of Car Body stand is to keep the lifted car bodies on it for bogie replacement or to perform major under frame repair works.

2.7.2 Basic Parameters for the design of Car body stand:

Parameter	Requirements
Capacity Per car Body Stands	12 t (24 nos)
Max. Support Height	2000 mm above from the floor level
Min. Support Height	1500 mm above from the floor level
Height adjustable pitch	100 mm
Height adjusting mechanism	Mechanical with locking arrangement

Note: The above dimensions are indicative

2.7.3 Design Requirements:

- 2.7.3.1 The equipment shall be designed for heavy duty workshop use and shall be available for throughout the year without any limitation.
- 2.7.3.2 The equipment shall be designed so as to allow operation without overstressing, damaging in any way whatsoever with the other requirement in the shed and its working. Components of the equipment of similar construction or similar application shall be mutually interchangeable.
- 2.7.3.3 The basic structure shall be of welded steel construction and shall be fabricated using suitable section as per IS 2062 of 1999 or latest equivalent.
- 2.7.3.4 The welding shall be carried out as per BS696 of 1960 or latest equivalent.
- 2.7.3.5 The equipment shall be provided with strong, rigid, and adjustable base plates of suitable size and thickness as per IS2062 of 1999 or latest equivalent.
- 2.7.3.6 The design structure shall be Ergonomic in design to facilitate quick and easy movement of car body stands within workshop premises.
- 2.7.3.7 The stands shall easily be moved by means of handles which are welded on the side of the guide pipe and by tilting over the two lower rollers.
- 2.7.3.8 The car body stand shall have a variable height adjustment mechanism. A split- pin bolt shall be used to lock the car body stand at a required height. This split- bin bolt shall be fixed to the car Body stand using a chain.

2.7.4 Regulations:

The Car body stands shall be manufactured in compliance with EN / ISO / DIN / Indian standards and regulations for prevention of accidents as applicable.

2.8 RELIEF AND RESCUE VEHICLE (RRV)

2.8.1 Purpose of the machine:

The Relief and Rescue is required to carry the re-railing, rescue device & personnel to attend the derailment of train and any other related accident on mainline as well as in depot of CMRL phase-I. The Relief and Rescue shall be driven on Road as well as on the track. Its design shall be equipped with compatible coupler for shunting up to 4/6 cars of multiple types of rolling stock in the depot when required.

2.8.2 Scope of Works:

The scope of the Works, includes the following but not limited to:

- 2.8.2.1 Design, Manufacture, Supply, Testing Training & commissioning of RRV with Re-railing and Rescue equipment. The vehicle shall be fully compatible with suitable storage racks to carry all the Re-railing & Rescue equipment as include in this contract to the required location on the CMRL phase-I alignment by rail or by road.
- 2.8.2.2 The Rescue and Re-railing Equipment compartment shall be so designed that it will be easy to retrieve the different items while working in Tunnel / Mainline / Depot etc.
- 2.8.2.3 Training of CMRL O&M staff in operations and maintenance.
- 2.8.2.4 The Contractor shall get the Registration of Rail-cum-Road Vehicle with Regional Transport Office in the name of CMRL. Also Speed Certification of Rail-cum-Road Vehicle from statutory authority / RDSO is in scope of Contractor. Necessary support shall be provided by CMRL.
- 2.8.2.5 The Contractor shall get the vehicle registered in the name of CMRL in the applicable RTO (Regional Transport Office) of Tamil Nadu.
- 2.8.2.6 The Contractor shall be responsible for all recurring and non-recurring costs required to keep the RRV eligible to travel on public roads throughout the entire duration of the Project Periods. This shall include but not be limited to vehicle fitness, permit, Insurance, pollution certificate and any taxes payable.
- 2.8.2.7 Provision for the installation of a Mobile Radio Device shall be provided in driver's cab. The Telecom & Radio Contractor shall supply the Radio Device and will coordinate with RRV Contractor for installation, testing and commissioning.
- 2.8.2.8 The Vehicle shall be designed and manufactured in India.

Note: Indicative data for Track parameters shall be referred from Schedule of Dimensions (SOD), Part-2.

2.8.3 Design requirements of Relief and Rescue Vehicle:

It shall be powered by diesel engine. The rail-to-road and vice-versa changeover functions shall be easy and effortless. The Contractor shall be responsible for the design of the vehicle and any other equipment considered essential for satisfactory operation of vehicle, which shall include but not be limited to the following:

2.8.3.1 Engine:

- i. Minimum 4-cylinder diesel engine for high efficiency,
- ii. Minimum 170 kW capacity,
- iii. EURO VI/ Bharat Stage VI standard or latest equivalent.
- iv. Electronic accelerator, hand throttle and governed max speed.
- v. Noise dampening arrangement as per EU regulation 70/157/EU including 90/20/EU or equivalent.

2.8.3.2 Transmission:

- i. Synchromesh reversing transmission equipped with gear box invertor or fully

synchronized automatic transmission.

- ii. Right Hand Steering wheel to suit left hand driving practice in India.
- iii. Forward and Reverse gear arrangement.

2.8.3.3 Brake shall consist minimum (but not limited to):

- i. Dual brake system,
- ii. Anti-lock brake system,
- iii. Parking brake,

2.8.3.4 Chassis:

- i. Fuel tank lockable of light material having adequate capacity for movement of vehicle for at least 150 kms of running on rail or road whichever is higher.
- ii. Front & Rear towing jaw with pin,
- iii. Anti- slip steps with handle for wind shield cleaning,
- iv. Front integral support for fitting front mounting,
- v. Air-intake pipe.

2.8.3.5 Electrical System:

- i. Low Maintenance Batteries, capacity as per requirements,
- ii. Centrally located electric box, protected within cab.

2.8.3.6 Driver's Cab & Personnel Compartment:

- i. Cab / Personnel compartment for accommodating 6 persons including the vehicle driver.
- ii. Separate access door for personnel compartment on both sides with safety lock. The access door shall be designed suitable to meet the requirements of its functioning inside tunnel / mainline.
- iii. Large storage compartment under dashboard,
- iv. Storage area behind driver's seat / rear cab wall,
- v. Provision of speedometer-recorder,
- vi. Driver's seat height tilt, backrest tilt and longitudinal adjustable,
- vii. Large rear window,
- viii. Air Conditioning of driver's cab and personnel compartment for prevailing ambient temperature up to 45 °C,
- ix. Interior lighting with reading light for driver and accompanying staff,
- x. Effective windshield with wind-shield wipers, 3-setting with intermittent setting and windshield washer,
- xi. Seats with integrated safety belts,
- xii. Sun visors

2.8.3.7 Instruments:

- i. Vehicle shall have electric controls located in centre console,
- ii. Adjustable dashboard illumination,
- iii. Multi-combination lever,
- iv. Functions of the Levers on left and right Side of Steering Column shall consist of hand throttle, cruise control, speed limiter, exhaust brake, headlight beams, blinker, windshield wash / wipers, and horn.

- v. Large instrument panel LCD displays, and gauge shall indicate the minimum following configurations but will not be limited to:
 - gauges for Speedometer kmph, RPM,
 - brake reservoir pressure,
 - coolant temperature,
 - fuel level, hydraulic oil temperature,
 - differential locks, brake pad wear,
 - coolant level,
 - steering fluid level,
 - air filter maintenance,
 - engine oil level,
 - windshield wiper fluid level,
 - transmission gear,
 - service hour counter,
 - Km and trip Km counter, clock, etc.
- vi. Vehicle shall have facility of GPS based location monitoring system, which shall enable location monitoring of the RRV from Depot Control Centre / Operation Control Centre.

2.8.3.8 Vehicle shall be fitted with Lights:

- i. Dual Lighting System (Road- Rail): The vehicle shall have 2 ways of lighting system with automatic change over when the vehicle changes from road to rail and vice-versa. When driving on rail, the vehicle uses specific light for rail driving and when on road it shall use the obligatory lights for road driving.
- ii. Headlights,
- iii. Headlight range adjustment,
- iv. Additional side indicators,
- v. Clearance lamps,
- vi. Blinkers,
- vii. Rear lights,
- viii. Fog lights,
- ix. Rear reflector reversing light,
- x. Emergency Light on the cabin of truck.

2.8.3.9 Speed (vehicle loaded with all rescue and re-railing equipment):

- i. Maximum Running speed on roads ≥ 80 kmph,
- ii. Maximum Running speed on rails ≥ 30 kmph

2.8.3.10 Vehicle shall be equipped with minimum following Accessories & Tools:

- i. Suitable no of cameras in the rear of vehicle and monitor screen in the driver's cab for reverse direction movement,
- ii. Rear mounting brackets,
- iii. Spare Wheel,
- iv. Battery main switch at battery box,
- v. Fine dust and pollen filter,

- vi. Single circuit hydraulic system,
- vii. First aid box,
- viii. Wide angle rear mirror,
- ix. Fire extinguisher, ABC Type, 5 kg - 2 Nos. with bracket,
- x. Air filling hose with manometer,
- xi. Hydraulic jack -suitable capacity,
- xii. Warning triangle,
- xiii. Signal lamp,
- xiv. Search light 2 No.
- xv. 2 nos. of tri-colour torch,
- xvi. On-board tools, wheel chokes.

2.8.3.11 Rail Guidance System:

- i. Rail guiding axles shall be fitted in front of the front vehicle axle and in rear of the rear vehicle axle,
- ii. Rail guiding axles shall take up part of the vehicle weight, which leads to a high safety on rails,
- iii. Full floating rail axle for running on road,
- iv. Telescopic cylinders at front & rear rail guiding axle,
- v. Rail guiding wheel with UIC profile, minimum wheel diameter 400 mm,
- vi. Rail guiding axle to be raised and lowered by suitable and effective hydraulic pressure,
- vii. Separate hydraulic control of front and rear guide axle with pressure compensation and damping from inside the cabin,
- viii. Automatic pressure adjustment for rail guidance system,
- ix. LCD Panel in driver's cab with audio-visual warning in case of pressure decrease.
- x. Provision of cameras and monitor inside the cabin for ease in checking of proper positioning of front and rear rail wheels to help the driver in changeover from road to rail operation,
- xi. Locking of steering wheel in rail mode,
- xii. Locking of rail axles against lowering during road operation,
- xiii. The hydraulic system shall be provided with constantly pressurized control valves for maximum safety against derailment in every driving situation.

2.8.3.12 Hydraulic hand pump:

Hydraulic hand pump of suitable capacity shall be provided for emergency operation of rail guidance system in case of failure of vehicle hydraulic system.

2.8.3.13 Earthing:

Earthing connection shall be from the mounting parts to the vehicle frame. It shall be connected to flexible Cu-cable with one ball pin at the front side and one at the rear side of the vehicle.

2.8.3.14 Lighting system:

- i. Vehicle lighting shall be suitable for movement on rail as well as on road for both running directions,
- ii. Automatic changeover of lighting for forward and reverse,
- iii. Automatic changeover of lighting when changing between rail and road and vice versa,

2.8.3.15 Super Structure:

- i. The complete vehicle with its cabin and compartment for Re-railing and Rescue Equipment shall be designed to conform to the Kinematic Envelope of SOD of CMRL phase-I.
- ii. The Vehicle along with compartment for staff and all equipment dimensions shall be finalised at design stage provided all its functions are satisfactorily complied with and that the dimensions are within the SOD of the Project.

2.8.3.16 Bodywork construction:

- i. Bodywork construction shall be of suitable material which shall provide adequate strength and protected from the corrosion.
- ii. The Contractor shall justify the selection of material and construction in the design stage.

2.8.3.17 Compartment for Re-railing and Rescue Equipment and Tools

Compartment for Re-railing and Rescue Equipment and tools is to be located directly behind the personnel compartment. This compartment has the following requirements.

- i. Compartments made of section profile, to be hinged down by means of toggle levers (with anti-skid cover inside made of light metal chequered plate).
- ii. Sliding shutters or rolling shutters shall be provided on both sides, viz. on left hand and right-hand side for convenience in working inside tunnel / mainline.
- iii. Buffers with adequate strength at the rear.
- iv. Rollers immersed in the body sub frame serving as guide for the re-railing bridge.
- v. Adequate illumination of the compartment.
- vi. Two telescopic spotlights mounted at suitable location on the vehicle.

2.8.3.18 Coupling System:

- i. A suitable coupler adopter / head to match Rolling stock couplers of multiple types shall be provided on each side of the RRV for coupling rail cars from both ends. RRV Contractor to interface with rolling stock Contractor for the coupler type / details.
- ii. Height of coupler shall be manually adjustable if required to match with automatic coupler height of rolling stock for proper coupling.
- iii. RRV shall also have cranked tow bar with flange at both ends.
- iv. The Coupling shall be done automatically & Uncoupling shall be perform automatically from driver cabin & manual lever in the coupler.

2.8.4 Technical Requirements of Re-railing and Rescue Equipment:

2.8.4.1 Re-railing Equipment:

- i. The following Re-railing equipment shall be capable of quickly lifting, displacing, tilting and slewing into position the de-railed rolling stock of CMRL Phase-I.
- ii. The equipment shall be suitable for use in tunnel, mainline as well as on viaducts and inside depot premise.
- iii. The equipment shall be suitable for operation under dusty smoke-filled atmosphere at accident site.
- iv. The quantities of each item are listed in Appendix 1.

2.8.4.1.1 Power Pack for Jacks:

- i. Hydraulic Pumping Set shall be powered by Portable 4-stroke Petrol engine complying with BS VI or equivalent smoke emission norms. The engine shall develop capacity of min 4.2 HP and combined discharge of at least 2.5 lpm. All hydraulic piston pumps shall be capable of generating minimum 490 bar pressure. Bypass pressure and maximum

pressure valve shall be provided. Bypass valve should switch to idle position when jacks are not in operation.

- ii. Oil tank shall have a capacity of minimum 40 litres and provided with an oil filter with optical clogging indicator, a filling filter with integral venting filter, oil sight glasses and oil drain screw with magnet insert.
- iii. The weight of pumping set including oil filled shall be less than 105 kg.
- iv. Power pack shall have carrying handles to facilitate ease of storage and transportation, even in rough areas.

2.8.4.1.2 Control Console or Control Table:

- i. Control Console or Control Table shall be complete with all necessary valves, controls and safety features including dead man switch. Control Console should have minimum four control valves for simultaneous / independent operation of lifting and lowering of four jacks. Necessary pressure gauges for pressure monitoring and safety valves shall be provided. Control Table should have colour coded hose outlet for connecting colour coded hoses to make connections to jacks. Control table should have a sturdy portable frame and the weight shall be less than 70 kg.
- ii. Control Console shall be provided with separate oil flows for simultaneous or independent lifting operation and a provision of inbuilt pressure gauge for individual control valves. It should have selector valve having position for lifting and traversing for a safe re-railing process.
- iii. A suitable filter capable of working under operating pressure shall be used to prevent the dust and sand from the pump unit to get into the hydraulic system during lifting / lowering operation.
- iv. Separate oil flows of same quantity through each control valve shall facilitate simultaneous or independent lifting / lowering operation of jacks with ease, while eliminating chance of load falling from the jack and thus preventing accidents while re-railing due to unbalanced loads on jacks. Separate oil flows for each control valve shall also facilitate functioning of remaining jacks in case one or more jack fails.

2.8.4.1.3 High-Pressure hoses with QC Coupling:

- i. High pressure hoses, approx. 10 m long (bound in pairs) with quick connection couplings shall be provided with oil retaining valves to prevent the leakage of oil when uncoupled with protective caps to prevent soiling.
- ii. Hoses shall be colour coded for ease of connection. They should be capable of withstanding the working pressure provided by the hydraulic pump. Low-pressure hoses shall be capable to handle return oil.
- iii. The hoses shall be capable of coupling and uncoupling even under pressure without oil loss.

2.8.4.1.4 Telescopic Jack with Base Plate:

- i. Telescopic jacks of following capacity and specification shall be supplied:
 - a) Capacity 60/30 Tons, close height max. 465 mm, stroke min. 500 mm
 - b) Capacity 60/30 Tons, close height max. 250 mm, min stroke 185 mm
- ii. The telescopic jacks shall have hydraulically releasable non-return valve for safe holding of the load even in the event of hose ruptures. The jacks shall also have over pressure valves.
- iii. The telescopic jacks shall have carrying handles, colour coded connections, working pressure of minimum 300 kg/cm² and weight less than 35 kg.
- iv. Jacks with integrated Base Plates or separate Base Plate are acceptable to ensure optimum stability during the operation of lifting / traversing. In case separate Base Plates

are proposed, price of Jacks shall be inclusive of Base Plates.

2.8.4.1.5 Displacement Jacks or Auto Traversing Jack:

- i. Displacement Jacks shall be of minimum 12/6 T capacity (12 T for pushing, 6 T for pulling), closed height max. 575 mm, stroke min. 350 mm with steel counter support. The working pressure shall be minimum 300 kg/cm². The displacing jack shall have integral oil retaining valves, colour coded connections and the weight shall be less than 25 kg.
- ii. Alternatively, Auto Traversing Jack of adequate capacity can be provided. The Traversing Jack shall have single point control from the Control Table.

2.8.4.1.6 Re-Railing Bridges and Bridge Coupling:

- i. Re-Railing Bridges shall have the carrying capacity of 60±5 Tons for the following dimensions:
- ii. 3.30 m length,
- iii. 2.20 m length,
- iv. 1.10 m length.
- v. The Re-railing bridges shall be fitted out with carrying handles and mounting points for bridge couplings.
- vi. The maximum weight for the longest bridge shall be less than 180 kg.
- vii. Bridge couplings shall be suitable for joining together two Re-Railing Bridges and shall be compatible to the loading capacity and height of Re-Railing Bridges.

2.8.4.1.7 Roller Carriages:

- i. Roller carriages shall have a capacity of 60 ± 5 T with removable top plate. The height shall be less than 110 mm (without plate) and 140 mm (with plate). The weight shall be less than 60 kg (without plate) and 85 kg (with plate). The width shall be compatible and suitable to operate with Re-railing Bridge.
- ii. The Roller Carriages shall have carrying handles. It shall be equipped with low friction rollers and guiding pin to ensure a linear movement.
- iii. Roller carriages shall be equipped with Counter supports, stopping device with carrying handle and one distance bar having an adjustable length to couple two roller carriages.

2.8.4.1.8 Tilting Jack:

- i. Tilting jack shall have 20 T capacity for pulling and have a height of 575 ± 25 mm, working pressure shall be minimum 300 kg/cm², stroke minimum 400 mm with hooked wheel stop. Tilting jack shall be complete with accessories and suitable for quick re-railing of single wheel or car.
- ii. The tilting jacks shall have carrying handles, colour coded connections and the weight shall be less than 25 kg.

2.8.4.1.9 Accessories:

- i. Lifting cable ladder complete: The lifting cable ladder shall be complete with accessories. The carrying capacity is 40 ± 5 T with factor of safety not less than 3. The length shall be at least 3m.
- ii. Holding Rope: The holding rope shall be complete with accessories. The carrying capacity is 40 ± 5 T with factor of safety not less than 3m.
- iii. D-Shackles: D Shackles shall be complete with accessories and capacity is 40 ± 5 T with factor of safety not less than 3m.

2.8.4.1.10 Single Piston Claw Jack (Step Jack):

- i. Single Piston Claw jack shall have a minimum capacity of 35 T, working pressure shall be minimum 300 kg/cm², height with claw minimum 1150 mm and accessories including

following:

i. Head Piece to Single piston claw jack	2 Nos.
ii. Round Head Piece to Single piston claw jack	2 Nos.
iii. Rocker bearing support (Swivel Radius Plate) to Single piston claw jack.	2 Nos.

- ii. The single piston step jack shall be provided with carrying handles, colour coded connections and the weight shall be less than 70 kg.

2.8.4.1.11 Axle Pusher:

Axle pusher unit shall be used for movement of wheel resting on the rail by a flange or for lateral displacement of the lifted vehicle consisting of two arms with hooks and with a crossbeam of light metal alloy.

2.8.4.1.12 Auxiliary Trolley 25 T Capacity:

- i. Auxiliary Trolley shall be suitable for insertion below wheels of bogie of Rolling Stock to carry it to depot for wheel re-profiling as and when need arises due to wheel skidding or any other reason. Its construction shall be such that there is no infringement for its placement beneath bogie and wheel and during its movement while carrying skidded wheel.
- ii. Auxiliary trolley shall consist of side sections with rollers and carrying handle, connecting tubes suitable for a 1435 mm track gauge, rated carrying capacity of 16 T and maximum capacity of 25 T. It shall have its maximum towing speed as 25 km per hour. The maximum weight of any individual part of the Equipment in dis-assembled state shall not be more than 70 kgs for ease in carrying manually. If however, the equipment is supplied in fully assembled state which cannot be dis-assembled the total weight of the equipment shall not be more than 150 kgs."

2.8.4.1.13 Hauling Device:

- i. Hauling Device, capacity min. 22 T shall be complete with accessories including following:
 - a) Pulling jack: 1 No.
 - b) Fastening Rope: 1 No.
 - c) Pulling Rope: 1 No.
 - d) Retaining Rope: 1 No.
 - e) Rail Block: 2 Nos.
 - f) Wedges: 4 Nos.
- ii. The diameter of ropes shall be between 25 mm to 32 mm.

2.8.4.1.14 Plates and Boards:

- i. The following plates and boards, suitable to take the load while the jacks are used to lift load, are to be supplied:
- ii. Steel plates with two handles each, size 800 x 300 x 30 mm – 2 Nos
- iii. Steel plate with handles, size 500 x 250 x 20 mm – 1 No
- iv. Hard wood boards, size 700 x 350 x 60.mm – 14 Nos
- v. Hard wood boards size 700 x 350 x 80 mm – 9 Nos
- vi. Hard wood boards, size 300 x 120 x 50 mm – 4 Nos
- vii. Hard wood blocks, size 300 x 120 x 30 mm – 6 Nos

2.8.4.2 Rescue equipment:

The quantities of each rescue item are given in Appendix 1.

2.8.4.2.1 Rescue Devices:

- i. Rescue devices shall comprise the following items:
 - a. Hydraulically Operated Cutter with maximum Cutting Force being at least 600 kN and adequate for cutting 5 mm thick Steel Sheet SS 301LN- HT. The weight of the cutter shall not be more than 15 kgs.
 - b. Hydraulically Operated Spreader with maximum Spreading Force being at least 300 kN and adequate for spreading 5 mm thick Steel Sheet SS 301LN- HT. The weight of the spreader shall not be more than 20 kgs.
- ii. The Contractor shall arrange the samples of above material, viz. SS 301LN-HT 5 mm thick, for FAT at OEM's works and for acceptance tests at Depot site.
- iii. Hydraulically operated cutter and spreader shall be complete with a pair of 10 m long high-pressure hoses. In addition, the following accessories need to be supplied:
 - a. two pairs of replacement blades for cutter,
 - b. two pulling chains, two pairs of spare tips and two pairs of peeling tips for spreader.

2.8.4.2.2 Power Pack for Hydraulic Cutter and Spreader:

- i. The hydraulically operated cutter and spreader shall be operated with a power pack of 4-stroke petrol engine for their independent simultaneous use for a minimum of 2 hrs continuously.
- ii. The capacity of power pack shall be at least 2.1 kW.
- iii. The weight of power pack of 4-stroke petrol engine shall not be more than 30 Kg including full filled tank with fuel.
- iv. Engine of the Power pack shall comply with the Euro VI / Bharat Stage VI smoke emission norms.

2.8.4.2.3 Airbags:

Airbags of following capacity shall be supplied:

- i. Lifting capacity : 300 ± 10% kN,
- ii. Lifting height : 350 ± 10% mm

2.8.4.2.4 Compressor:

- i. Pneumatic air compressor shall have displacement of at least 230 lpm with in-built air receiver capacity of at least 10 litres at minimum 10 bar pressure for inflating air bags. Compressor shall be provided for connecting and operating 2 airbags at a time and reinforced air hoses at-least 10 m long for connection between air compressor and the air - bags.
- ii. Engine of the Compressor shall be with capacity of at least 2.1 kW and complying with smoke emission norms of Euro VI / Bharat Stage VI shall be supplied.
- iii. Two set of hoses shall be supplied in different colour.

2.8.4.2.5 Portable Inflatable Lights:

Portable inflatable lights shall be suitable for illumination of about 10,000 m², using 400 W HPMH or any other superior lamp mounted at height of about 4.5 m from ground with its independent diesel / petrol operated light weight power pack (Generator) for electricity and air.

2.8.5 Details of Quantities for Re-Railing & Rescue Equipment:

The quantities of different items of Re-railing & Rescue equipment as required to be supplied under the Contract are given in Appendix 1.

Appendix 1 Quantities of Items to be supplied.

S. No.	Description of Item	Unit	Qty.
1	Power Pack for Jacks	Nos.	2
2	Control console or Control Table	No.	1
3	High pressure hoses with Quick connection coupling	Pairs	7
4	Telescopic Jack with base plate, 60/30T capacity, maximum closed height 465 mm, minimum stroke 500 mm	Nos.	4
5	Telescopic Jack with base plate, 60/30T capacity, maximum closed height 250 mm, minimum stroke 185 mm	Nos.	2
6	Displacing / Auto Traversing Jacks	Nos.	2
7	Re-railing bridge 3.30 m long,	No.	1
8	Re-railing bridge 2.20 m long,	No.	1
9	Re-railing bridge 1.10 m long,	No.	1
10	Bridge coupling	Nos.	2
11	Roller Carriages with distance bar	Nos.	4
12	Tilting jack 20 T Capacity	Nos	2
13	Accessories		
a)	Lifting cable ladder	Nos.	2
b)	Holding rope	Nos.	2
c)	D-Shackles	Nos.	2
14	Single piston Claw jack with claw, 35T, with accessories	Set	2
15	Axle pusher	Nos.	2
16	Auxiliary Truck 25 T capacity	No.	1
17	Hauling device 25T capacity	Set	1
18	Plates & Boards	Set	
19	Rescue device consisting of cutter and spreader		
i	Hydraulically operated Cutter, with high pressure hoses, pulling chains, etc.	No.	1
ii	Hydraulically operated Spreader with high pressure hoses, pulling chains, etc.	No.	1

S. No.	Description of Item	Unit	Qty.
iii	Power Pack for hydraulically operated Rescue devices	No.	1
20	Airbags	Nos.	2
21	Compressor, 230 lpm at 10 bars	No.	1
22	Portable inflatable emergency light	No.	2

2.8.6 Standards:

Work related to the design and manufacturing of the RRV shall comply with relevant international standard or equivalent Indian standards.

2.9 BOGIE MANIPULATOR (BM)

2.9.1 Purpose of the machine:

The main purpose of Bogie Manipulator for the lifting and rotation of all types of bogie & bogie frame of multiple rolling stock in order to give improved access for assembly, inspection and maintenance etc activities.

2.9.2 Basic parameters for the design of each Bogie Manipulator (but not limited to):

Parameter	Dimensions*
Capacity per Jack	Min 5t
Capacity per set	Min 10t
Lowest position of turning axis above floor	600mm
Highest position of turning axis above floor	1800-2200mm
Effective lift	1400mm
Synchronisation of both jacks	± 5 mm
Lifting and lowering speed	approx. 400 mm/min

Note : The above dimensions are indicative. The Contractor shall interface with Rolling stock Contractor for required drawings and parameters of the bogie and frame parameters etc before design and construction of machine.

2.9.3 Design Requirement

2.9.3.1 Main features

- The Bogie manipulator shall consist of two Jacks, each jack shall be of minimum 5t capacity.
- Design shall preferably with one Jack fixed to the floor and the other movable via a rail system to provide adjustment for different bogie frame types. Rails supply and installation etc is in scope of manipulator Contractor.
- Jacks shall be sturdy, stable and robust in construction and of compact size.
- Both jacks should have independent servo operated drive system for synchronization of lifting & lowering movement.
- The lifting, lowering & turning of jobs with this machine should be smooth & easy to control at various heights and positions.
- These jacks together shall be used for lift and rotating the Bogie assembly / frame.
- The lifting jacks support the weight of the bogie being rotated via the two fixturing frames with clamps. The fixturing frame and clamps shall be suitably designed to accommodate all types of bogie / frames.
- Lifting / lowering of frame shall be amenable to control and setting to various heights depending upon the required position for bogie rotation.

2.9.3.2 Rotating / Turning

- One of the two jacks shall be provided with electrically operated Turning Device to rotate the job through 360 degrees.
- The turning drive should be through precision cut gear / gear box (to ensure low maintenance and longer life) with flanged brake motor, facilitating stoppage of rotation at desired locations

/ angles.

- iii. Suitable mechanism to be provided to prevent rotation, at lower most position to avoid fixture hitting any other part.

2.9.3.3 Spindle Lifting Element and Protection:

- i. The spindle shall be a robust, vertical, self-locking screw shaft driving a spindle load-lifting nut, which shall be manufactured from cast bronze only. A safety nut shall follow the lifting nut of cast iron.
- ii. The spindles shall be fitted with flexible bellows for protection. The bellows shall be grease, acid, water and steam resistant. The fastening of the bellows shall be designed to facilitate quick disassembly for inspection and maintenance of the spindles.

2.9.3.4 Lubrication

Lubrication nipples shall be provided at each jack and other assemblies for lubricating the lifting spindle and moving parts.

2.9.3.5 Control Requirement

- i. One of lifting jack is fitted with a control console (in an IP54 enclosure) with a handheld pendant type control unit attached by means of a minimum 10m cable.
- ii. The following minimum controls shall be equipped with main console (but not limited to):
 - Main switch, lockable
 - 1 key switch OFF / ON
 - Key operated switch with green indicator lamp “on”
 - Indicator lamp (red) “failure”
 - Emergency stop push button
 - All necessary indicator lamps for the function of the system as applicable
- iii. The hand-held control shall be equipped with following minimum controls:
 - Push buttons for lifting / lowering.
 - Push buttons for turning (clock / anti clock)
 - Emergency stop push button

2.9.4 Protection and Safety provision:

2.9.4.1 The System shall be capable of taking the full bogie load in case of power failure and any other such abnormal occurrence.

2.9.4.2 Limit switches are provided for the upper and lower end position of the lifting carriage / bracket. The upper limit switch is backed up by a secondary limit switch to operate in the event of failure of the primary limit switch.

2.9.4.3 Each jack is fitted with a spindle safety nut to ensure the load is not dropped in the event of failure of the primary spindle nut.

2.9.4.4 Emergency stop buttons of mushroom type shall be provided on control station including local control pendant.

2.9.5 Interface

The Contractor shall refer Interface matrix / specification Chapter- 3 Section VIB Part 2 for the interface with other system Interfacing Contractors for Bogie manipulator.

2.9.6 Standard:

The lifting jacks are designed in compliance with the presently valid European and international regulations for prevention of accidents.

2.10 BOGIE TESTING UNIT (BTU)

2.10.1 Purpose of the machine:

The Bogie Testing Unit (BTU) shall be used to carry out the height adjustment of trailer bogies and motor bogies, to check distribution of loads, measurement of all the critical parameters and air suspension test etc of bogies supplied by multiple Rolling Stock Contractor) at Koyambedu depot of CMRL phase-I project. The details of bogies shall be obtained by the Contractor during detailed design stage from multiple rolling stock Contractor. The Bogie Testing Unit (BTU) shall also read / referred as Bogie Test Stand (BTS).

2.10.2 Scope of Works (but not limited to)

- 2.10.2.1 Design, Manufacture, Supply, Installation, Testing & Commissioning of Bogie Testing Unit (BTU) at Koyambedu Depot of CMRL phase-I. The supply shall include all equipment and accessories required to make the machine fully functional when connected to a power source.
- 2.10.2.2 Electrical cables for connecting Power point to Control cabinet of machine shall be supplied by the Contractor as per the requirement.
- 2.10.2.3 Mechanical structure
- 2.10.2.4 Hydraulic power unit with cylinders
- 2.10.2.5 Air leakage test unit.
- 2.10.2.6 Load cells
- 2.10.2.7 Suitable adapters
- 2.10.2.8 Standard piece for calibration
- 2.10.2.9 Control and display mechanism with accessories.
- 2.10.2.10 All external and internal wiring and piping
- 2.10.2.11 Air Compressor (soundproof including all accessories) of suitable capacity for Air Leakage test
- 2.10.2.12 Power supply requirement of all the required computational and support equipment including UPS back-up power for a minimum period of 30 minutes for computational system.
- 2.10.2.13 A set of special tools and test equipment shall be provided, as may be required for day-to-day operation and maintenance of Bogie Testing Unit and associated sub-systems.
- 2.10.2.14 Any other accessory considered essential for the operation of the plant to meet the purpose and capability.
- 2.10.2.15 All information or documents related to the Rolling Stock, Track Work, Civil and other designated Contractors deemed necessary shall be obtained from the respective Contractor.
- 2.10.2.16 The Contractor shall demonstrate the testing & commissioning of the machine with all types of bogies of multiple rolling stock.

2.10.3 Not Used

2.10.4 Specific Requirements and Description.

The machine shall be designed to ensure an effective and efficient work sequence. Each work phase shall be reliable, durable and safe in operations. Following is a description of the operation of the Bogie Test Stand that represents the expected level of functions of the equipment to be supplied under this Contract. Functionality and performance range of offered Bogie Test Stand shall not be restricted to minimum requirement specified herein but shall be capable to fulfil and satisfy overall performance standard and accuracy.

2.10.5 Description of Rolling Stock and Bogie

The Contractor shall obtain the details on below assemblies, component from Rolling Stock Contractor to design the machine accordingly :

- i. Details of Bogie
- ii. Bogie Frame
- iii. Primary suspension
- iv. Secondary suspension
- v. Traction motor
- vi. Wheel set
- vii. Brake
- viii. Any other details as applicable and required.

2.10.6 Operating Parameter

- 2.10.6.1 The Bogie Test Stand shall be capable of load testing all the types of bogies of CMRL Rolling Stocks on various loads.
- 2.10.6.2 The Bogie Test Stands shall be used to carry out the height adjustment of trailer and motor bogies, to check distribution of loads, measurements of axle distance and parallelism and air suspension test, etc.
- 2.10.6.3 The Bogie Test Stands shall be capable to carry out the required tests on bogies having new wheel (maximum diameter of 860 mm) and till the wheel get fully worn-out condition (minimum wheel diameter of 780 mm) from tare weight to fully loaded conditions.
- 2.10.6.4 The designed axle load bogies shall be 16 t. The Bogie Test Stand shall be designed for putting 20 tonnes of load at one test point, i.e., 40 tonnes of total load capacity.
- 2.10.6.5 The Bogie Test Stand shall measure all the critical bogie parameters automatically and ensure storage of measured data for traceability and analyse.
- 2.10.6.6 The Bogie Test Stand shall be capable to measure the parameters of bogie like air leakage, parallelism, wheel run out, wheel diameter and compression of primary springs, crown height measurement, etc. under different loading conditions.
- 2.10.6.7 The load testing shall be done after overhauling of bogies or otherwise whenever warranted. Various types of clearances are required to checked during above testing.
- 2.10.6.8 After taking the various measurements, the data is recorded and stored in a PC along with the respective bogie number for future references or printing of the records.

2.10.7 Setting Up of Bogie

- 2.10.7.1 The bogie has to be moved and positioned manually underneath the stand. For this the rail level at workshop floor and the test surface of the Bogie Test Stand shall be at the same level.
- 2.10.7.2 Centring of the bogie is done before testing of the bogie, thus making it possible to make adjustment in the X and Y positions. It is necessary that the Bogie Test Stand precisely centres the bogie automatically during the final setting up phase before load testing is done. The Contractor shall explain in detail the bogie loading procedure proposed in the Offer.
- 2.10.7.3 The Bogie Test Stand is operated via a MMI control panel so that operator has continuous access and display to all of the functions of Bogie Test Stand.
- 2.10.7.4 The testing shall be user friendly. Bogie Test Stand shall be capable of load testing of the parameters of CMRL Rolling Stock Bogies and also capable of test all the critical parameters of bogies having axle load within Bogie Test Stand limit in future.
- 2.10.7.5 The details of measurement cycles expected in the Bogie Test Stand are mentioned hereinafter.

2.10.8 Calibration Cycle and Bogie Preload Test Measurements:

- 2.10.8.1 On start of the Bogie Test Stand, a preload test shall be carried out before any measurement is done. Supply and commissioning of this preload test stand shall form integral part of supply under this Contract.

2.10.8.2 Centre adaptor and bogie adaptor shall be part of stand for initial calibration measurements. All the four wheels load cells must show 'zero' value at this stage. If the value is not 'zero' it should be re-set to 'zero' by the reset button.

2.10.8.3 Further the height measurement of pressing spindle shall be done with spindle retracted in top position.

2.10.8.4 The details of preload test shall be explained by the Contractor in his offer.

2.10.9 Not Used

2.10.10 Bogie Testing

2.10.10.1 To carry out the testing, either through hydraulic system or electromechanical system, Bogie Test Stand shall be controlled by PLC system in manual or automatic mode. The testing load parameters are set in man machine interface (MMI). Once the set load is applied on the load point of bogie, the resultant impact of bogie parameters, like displacement and various clearances shall be measured and recorded automatically.

2.10.10.2 There should be provision in the system of Bogie Test Stand to enter bogie number, type of bogie, name of the operator, test sheet number, etc., before starting the measurement. Without entering this information, the control system should not allow to start testing and measuring cycle.

2.10.10.3 In case of automatic test procedure, only if the "automatic" position and "test procedure" is selected, the plant should go into "touch load position". Before starting the "automatic test procedure" the system shall be capable to check the following different conditions:

- i. Test sheet number, type of bogie, bogie number, and name of operator has been entered.
- ii. For motor bogie, gear box oil level checked has been and entered manually.
- iii. Units in 'touch mode' on every hydraulic cylinder or electro mechanic system.
- iv. Bogie is on wheel load scales.
- v. Operation mode should be in the "automatic" position.

2.10.10.4 The system shall be capable to carry out the selected test procedure and should take the measurements of required parameters automatically. The test procedure should be continued until report is confirmed. If all values are entered and are correct, then the examination should be competed with the help of "complete" button of the system. The system shall be capable to test that all parameters of bogie and show status of each parameter with reference to set value and its tolerance.

2.10.10.5 After the end of test procedure, the protocol can be printed with button "print". The test protocol shall include all the following data as well as status:

- i. Manual examination results.
- ii. Automatic examination results which are outside the tolerance limit.
- iii. Inspection result of automatic examinations which are within the tolerance limit.

2.10.11 Rework From Measurement

System shall be incorporated to correct the measurement and there should be a provision in the system to have a correction measurement. Further processing after all measurements have been taken, shall be available in the correction menu then the test report can be printed again.

2.10.12 Result Editing

After the load testing or measurement operations on the bogies have been performed (from 1 to 4 wheels), the pre-and post –testing measurement results shall be possible to be edited or printed in table form. Data shall be transferred to a micro-computer via interface software.

2.10.13 Parameters of Bogie to be Measured and tolerances

At least following parameters shall be measured and displayed on the screen of the Bogie Test Stand:

- 2.10.13.1 Wheel Load on Tare and Loaded Conditions: The Bogie Test Stand shall measure the actual wheel load in tare and loaded conditions automatically. Also, it shall indicate deviation of load from the average value of all the four wheels.
- 2.10.13.2 Wheelbase: The Bogie Test Stand shall automatically measure the wheelbase, i.e., the distance between two axle centres of the bogie. If the wheelbase obtained at left and right side of the bogie are not within ± 1 mm, the Bogie Test Stand shall highlight this.
- 2.10.13.3 Wheel Back-to-Back Spacing: For Rolling Stock the wheel back-to-back distance is 1358 mm, tolerance $+2.0 / -0.0$ mm and thus wheel back-to-back distance may vary from 1358 mm to 1360 mm. The mode of measurement shall be automatic. Measuring shall be done preferably through laser sensors or any other alternate measuring device, the output of which shall be fed to recording system and displayed automatically.
- 2.10.13.4 Measurement of Axle Parallelism: The mode of operation of axle parallelism measurement cycle shall be automatic and is one of the most important characteristics, which influence running behaviour of a bogie. A measuring accuracy of ± 0.1 mm or better is desirable.
- 2.10.13.5 Height of Air Suspension from Rail Level: This data shall be measured automatically. The Bogie Test Stand shall make this measurement taking into account the thickness of the adopter inserted between the hydraulic cylinder and top of the air suspension. The above details are indicative, actual details shall be obtained from Rolling stock Contractor.
- 2.10.13.6 Wheel Diameter: This data shall be measured by the machine automatically, with synchronized motorized drive fitted with machine or any other industrially proven practice of wheel measurement and will be displayed on Bogie Test Stand. Max diameter of new wheel is 860 mm and diameter of fully worn wheel is 780 mm. Automatic centring of bogie during the wheel measurement shall be done.

Contractor shall describe the details of automatic wheel measuring process along with the details of the measuring device.
- 2.10.13.7 Shim Height at Secondary Suspension: The shim height shall be measured by the machine automatically. Bogie Test Stand shall advise this based on wheel load distribution and other measurements. Shims at secondary suspension are inserted to meet the bogie height variations due to wheel diameter reduction.
- 2.10.13.8 The permissible range of shims to be inserted at Secondary suspension is 0 to 35mm. Bogie Test Stand shall advise the shim height to be inserted after other measurements are taken.

Note: These values as mentioned above are indicative only. It is the responsibility of the Contractor to ascertain and collect Rolling Stock details from the Rolling Stock Contractor.
- 2.10.13.9 Primary Suspension Gap: This dimension is to be measured at tare load conditions. The value of gap and maximum permissible variation among the four points of measurement on the bogie will be provided during design stage.
- 2.10.13.10 Shim Height of Primary Suspension: The shim height shall be measured by the machine automatically. Bogie Test Stand shall advise this requirement based on wheel load distribution and other measurements. Bogie Test Stand to advise to the shim height to be inserted within the permissible range of 0 - 20mm.
- 2.10.13.11 Height Difference of Shaft Centres between Motor and Pinion: This shall be measured in tare load conditions and that too only for motor bogie. This shall be measured manually. The permissible range is 7 ± 1.5 mm. The information shall then be fed in the PLC of Bogie Test Stand.
- 2.10.13.12 Note: The values as mentioned above are indicative only. It is the responsibility of the BTS Contractor to ascertain and collect correct Rolling Stock details from Rolling Stock Contractor.
- 2.10.13.13 Gear Case Oil Check for Motor Bogies: This shall be done manually. The information shall

then be fed in the PLC of Bogie Test Stand.

2.10.13.14 Air Leakage Test: This shall be done automatically with each side individually. The information shall then be fed in the PLC of Bogie Test Stand.

2.10.13.15 Testing Parameters and Mode of Operation: Testing parameters and mode of operation of Bogie Test Stand are summarized below:

Parameters	Mode of Operation
Wheel Load under tare and loaded condition	Fully automatic
Wheelbase (axle distance)	Fully automatic
Wheel back-to-back distance	Fully automatic
Axle parallelism	Fully automatic
Height of air suspension above top of rail	Fully automatic
Wheel diameter	Fully automatic
Calculation of shim height at Secondary suspension	Fully automatic
Calculation of shim height at primary suspension	Fully automatic
Different heights under the bogie	Manual
Air leakage test	Fully automatic

2.10.13.16 Accuracy of Measurements: Measuring range, steps and tolerances for Bogie Test Stand are mentioned below:

Parameters	Range, step and Accuracy
Test load	1 to 40 tonnes in steps on 0.01 tonnes
Rail scales	1 to 40 tonnes in steps on 0.01 tonnes
Height measurement	Work height of 500 mm in partial steps of 0.1 mm
Axis of measurement	X, Y, Z
Accuracy of indication	0.1 mm
Accuracy of indicating instrument	± 0.05 mm
Accuracy of measurement	± 1.0%
Accuracy of measuring system	0.01 ton
Accuracy of wheel positioning	± 0.1 mm

2.10.14 Construction Of the Bogie Test Stand

2.10.14.1 Mechanical Part of Test Stand

This Bogie Test Stand installation should make it possible to load test the bogies before and after overhaul and repair, new or fully worn-out wheels on various types of load. In case of new wheel, maximum diameter will be 860 mm and for fully worn-out minimum wheel diameter will

be 780 mm. The constructions details of various mechanical parts of the Bogie Test Stand are given hereinafter.

- 2.10.14.2 Construction of the Load Yoke: The mechanical structure of the Bogie Test Stand shall be of the design, which requires minimum construction activities during installation and commissioning. For this, rigid “Circulating Steel Structure” shall be used for mechanical structure. The horizontal girders, supported by the vertical columns, carry both hydraulic cylinders, horizontal distance measuring units, etc. While deigning the size of the steel construction of the Bogie Test Stand, own weight of Bogie Test Stand shall be taken in the consideration in addition to the loading requirements. All the Bogie Test Stand subparts shall be installed above floor level and no equipment (except load sensing devices) shall be installed in a pit below Bogie Test Stand. Own total weight of the Bogie Test stand is to be furnished in the offer. The “Circulating Steel Structure” shall be modular in nature. The Contractor shall explain the details of structure in his offer document.
- 2.10.14.3 Foundation: Foundation details for the installation of the Bogie Test Stand including General and Electrical Layout shall be submitted in the offer. The foundation details shall be prepared considering the version of test stand, which suits CMRL requirement of manual loading of bogie. The Contractor shall provide Industrial safety fencing (min 2 m height) around the pit for Bogie Test Stand. The material of the same shall be decided during design stage.
- 2.10.14.4 Wheel Load Sensing Device: The load sensing devices shall be installed at a suitable location for precise sensing of applied load on each wheel. Weighing shall be done on each of the wheel by individual load sensing device to measure up to 40 tonnes (maximum of 10 tonnes on each point). The Contractor shall clarify the location of each load sensor and description of load sensing device shall be explained in the offer.
- 2.10.14.5 Horizontal Movement of Spindles
- i. Because of the higher capability of the pressing cylinders, the pressure within the hydraulic / electropneumatic system shall be limited to prevent the bogies and the preload stand from overload or damage.
 - ii. The pressure range within the hydraulic or electropneumatic system will be pre-adjusted automatically based on set parameters so that the load applied on the bogie is not exceeded.
 - iii. The movement of hydraulic cylinder ram or electropneumatic system shall be capable for lateral / horizontal adjustment to cover the specified parameters on the moving crossbeam to maintain accuracy within ± 0.1 mm.
 - iv. The vertical hydraulic cylinders or electropneumatic system shall be movable horizontally with spindle gear by hand. These shall be equidistant from the centre line of track and always move synchronously.
 - v. Proper arrangement shall be made so that the aforesaid accuracy of the movement can be maintained over a long period of time .
 - vi. The position of vertical cylinders or electropneumatic system shall be shown by a scale on the horizontal beam of “Circulating Steel Structure” and also by display on PLC system.
 - vii. A suitable locking arrangement shall be provided to lock the hydraulic cylinder ram at any position to cover the specified distances.
 - viii. The system shall be fully explained in the offer through supporting drawings / diagrams.
- 2.10.14.6 Load Sharing on Pressure Points of the Bogie: The methodology adopted for the load sharing of the test load on pressure points by using the pressure pads / pressure bevels of the bogie shall be explained in the offer.
- 2.10.14.7 Load Adapters and Height Adjustment of Bogie: Suitable machine measurement adaptors shall be mounted for the testing of bogie, for interface of loading spindles with pressure points, which shall be adjusted through these adapter / pressure levels. Such system parts shall be made to automatically compute the height of the bogie by the Bogie Test Stand. Any other alternative

system, if provided, shall be fully explained in the offer.

- 2.10.14.8 Bogie Centring: After automatic or manual loading of the bogie on to test stand, the BTS shall automatically carry out final centring of the bogie under test spindles. The details of the mechanism for automatic centring of bogie shall be provided in the offer document. During load testing, the axis of the bogie shall not move, in any case whatsoever, in the track direction. The Contractor shall give full details on the method used to impede any longitudinal movement.
- 2.10.14.9 Axle Parallelism Measurement Device: Bogie Test Stand shall have an axle parallelism measuring system. The accuracy desired for it shall be 0.1 mm or better. The details of axle parallelism measuring system of bogie shall be explained in the offer.
- 2.10.14.10 Wheel Back-to-back Measurement System: Laser sensors shall be used for assessing the back spacing of wheels. The output of this measurement shall be picked up by PLC control system automatically. The accuracy desired is 0.1mm or better. The details of the measuring system shall be explained by the Contractor in the offer.
- 2.10.14.11 Calibration System: The Contractor shall explain the requirement of the calibration of the system for various measurements. Bogie Test Stand should be able to calibrate itself at regular intervals. The Bogie Test Stand shall be capable to calibrate on all the required axes, load cells, measuring software, etc. If any special test piece is required for this purpose, it shall be covered under the scope of supply of Bogie Test Stand.
- 2.10.14.12 Rails: The rails within the pit as required for usage in the Bogie Test Stand, the same shall be covered in the scope of supply of the Contractor. Full details of the proposed rail system shall be explained during detailed design .
- 2.10.14.13 Final Finish of the Installation Area: After the installation of the machine, the uncovered area surrounding the machine shall be covered with hot dip GI chequered plates of 12 mm thickness, matching with the aesthetics of the area. The plates should be able to withstand normal workshop loads. The plates shall be painted with PU paint, the colour of which shall be determined during detailed design or execution stage.

2.10.15 Hydraulic Installation

2.10.15.1 Hydraulic Test Unit: Hydraulic test unit of this equipment shall consist of following:

- i. Hydraulic pump shall be of suitable capacity. Hydraulic tank of suitable storage capacity shall be part of hydraulic unit. The unit shall be integrated into the Bogie Test Stand and mounted at a sufficient height for easy drainage.
- ii. Two (2) hydraulic cylinders including operator's console and manual control. Cylinder shall be double-acting hydraulic cylinders with hard-chrome plated piston rod with ground surface having surface finish of 0.25 microns or better. These shall be provided with attached force / way-measuring unit. Surface hardness shall not be less than 65 HRC. Cylinders shall be of suitable diameter and up to 500 mm stroke length.
- iii. Control block (4/3 approach valve, holding valve).
- iv. Valve adjustable pressure control for test pressure
- v. Suitable pressure gauge & display.
- vi. The unit shall be fitted with temperature and level control systems. Filters shall be compatible with distribution and regulation apparatus and pumps (filtering less than 12 microns). A pan shall be provided to recover fluid in the event of leakage. Hydraulic unit tank filling shall be via a port protected with a filter (12 microns). Filter clogging alarms shall be provided to warn the operator.
- vii. Any other component to make the Bogie Test Stand fully functional, shall form part of its supply.

2.10.15.2 Hydraulic Gear

- i. Hydraulic gear shall be homogeneous throughout the entire installation.
- ii. As far as possible gear shall be installed close to the Bogie Test Stand and shall be

grouped on distribution blocks for easy access for maintenance purpose.

- iii. Piping shall be integrated within the Bogie Test Stand enclosure or run in the gutter and the technical ducting. It should be concealed and suitably protected.
- iv. Each hydraulic circuit shall be fitted with an easy to access test plug.
- v. All supplies, assembly of pipes and connection components concerning the hydraulic installation are the responsibility of the Contractor.
- vi. All supplies shall be physically identified (riveted labels or numbers stamped on components). The same identification shall be indicated on electrical and hydraulic diagrams and in supply nomenclatures.

2.10.15.3 Hydraulic Layout: Two hydraulics load yokes of minimum load capacity 20 tonnes each with working stroke up to 500 mm (stroke under pressure) shall be part of the Bogie Test Stand. Fast speed operation shall be possible by means of hand-controlled pendant. The hydraulic cylinder ram assembly should be effectively sealed to prevent any leakage of oil. Full details of the system shall be explained in the offer by the Contractor.

2.10.15.4 Pressure Sensors: Pressure sensors shall be installed on the load measurement system. Sensors shall be connected to the converters, which shall indicate the load in tons with a precision up to two decimal points. Calibration shall provide a zero-display reading when the wheels are not loaded, or load is lifted. The converters shall be integrated in the control panel. Pressure sensors shall be installed on any hydraulic circuit requiring permanent monitoring for good machine operation.

2.10.15.5 Pneumatic System

- i. This system shall be used for applying the required pressure to the air springs for leakage test, etc. Pneumatic supply and installation including air compressor of suitable capacity, pressure regulation, pipe, air gun if required, shall be under the scope of supply of the successful Contractor. Its control shall be integrated on the operator's control system. It shall have all the required interlocks, safety provisions for the smooth working.
- ii. The details of proposed pneumatic system of the Bogie Test Stand shall be explained during the design stage.

2.10.15.6 Electrical parts

The power requirement of the Bogie Test Stand shall be furnished during the design stage. Following is a description of different electrical accessories expected from Contractor:

2.10.15.7 Power Stabilizing Unit: Power stabilising device shall be provided and integrated into the equipment installation to stabilize the power in particular the fluctuation of the voltage of the supply of control equipment.

2.10.15.8 Control Panels: Panels shall be provided for control and monitoring of the Bogie Test Stand and shall be sized to take environmental conditions into account. On one outside of a column and lateral side of the yoke, an electric control unit with a panel inclusive of a display shall be fixed in an ergonomically working position. This arrangement shall be provided for better utilization of shop floor.

All panels shall be designed to work satisfactorily under all ranges of ambient temperature and humidity conditions and if appropriate, by having panel air conditioning systems, which shall be under the scope of the Contractor.

- i. Electrical Switch boards
 - a) All control and regulation electronics and electrical devices, etc., shall be mounted in dust-proof switchboards and shall have termination facility to connect an earthing terminal.
 - b) Switchboards shall be designed for easy inspection, repair, and maintenance by providing user friendly doors.
 - c) Switchboards shall be in accordance with the regulations in force and on the front

fitted with 'power on' indicators.

- d) A suitable three-pole isolating switch, latch-able in open position, shall be supplied along with the installation.
- e) The inside of the switchboards shall be illuminated by means of led bulbs controlled by door opening .
- f) Doors shall be locked with removable keys.

ii. Switch board equipment

- a) Electronic cards or blocks must be designed for quick and easy replacement without requiring disassembly of other apparatus or gear, or the movement of a cable or bundle of cables.
- b) Subassemblies performing the same function must be fully interchangeable and identical to the extent possible.
- c) Machine electronics must be designed to facilitate repair and troubleshooting.
- d) In particular, with regard to the technical cards
- e) Functions shall be distributed on cards connected to cabling with connectors,
 - Distribution shall be studied to limit the troubleshooting and repair time (functions effectively limited per card),
 - During card replacement, adjustments must be limited to those which are strictly necessary,
 - Technologies used by the various sub-Contractors must be homogeneous (same card format, same connectors, etc.).

Note: A time counter shall be installed on the Bogie Test Stand control to count the time taken during complete measurement of the Bogie testing.

iii. Bogie Test Stand Wiring

- a) Bogie Test Stand, panel and electrical switchboard wiring shall be laid inside the Bogie Test Stand frame.
- b) Protection systems shall be installed in the areas which are prone to hazards.
- c) Power supply cables to the nearest distribution board shall be in the Contractor's scope of supply. Cables shall be laid in trenches, covered with suitable trench covers.

2.10.16 Control & Data Protection Equipment

2.10.16.1 Industrial PC and Electronic Control: The control system consists of an Industrial Personal Computer (PC) with a latest man-machine-interface (MMI) and a state-of-art PLC. All data shall be stored in Database. If the main computer of the Bogie Test Stand does not store and process the data, the Contractor shall provide separate equipment for measurement data processing and storage. The PC shall be industrial type and integrated into the Bogie Test Stand. The main features of control cubicle are as under:

- i. Lockable PC control cubicle, which will have view windows for monitor. All parts shall be installed in an ergonomic electric cabinet and shall be placed nearest to the Bogie Test Stand
- ii. Weighing electronic system, including PC interface
- iii. IPC to the connection of load sensing devices, etc.,
- iv. Measuring cards for data analysis of the heights and length measuring facilities,
- v. Industrial grade Laser printer or equivalent
- vi. Industry-specific windows-based software, including a dynamic process visualization, and Connectors for the addition of a data input keyboard, an RS 232 connector output and a

printer shall also be provided. The software shall be designed to enable integration of complete equipment.

- vii. General Navigator: General Navigator shall also be provided in the IPC for easy operation for Sorting the data, Search the data, Navigation to first data, Navigation to previous data, Navigation to next data, Navigation to last data, Navigation for Delete a record after confirmation, Edit data sheet, Inserting data sheet, Only view, Accept / continue, Cancel edit, data update, Prints, Window close, Grid View, Form View, Calculator etc.
- viii. Computer system shall have latest hardware suitable for industrial application, keyboard, mouse, display monitor, drives, UPS and antivirus software.
- ix. PLC control: The PLC control shall be built to satisfy the technical specification. The workstation screen is proposed to be 10 to 12 inches, colour. The Contractor shall give the standard scheme available with their design of Bogie Test Stand
- x. Automatic switching: Adjustment of the test load nominal value at the OP (given by the operator) on PC shall adjust the test load automatically during the test.
- xi. Adjusting of the software: In software, the current values, test pressure, wheels load, axis measures, inclusive of the defined permissible deviation, etc., which are visible, are to be permanently stored. The software should have flexibility to change them whenever warranted. The possibility to possess a work protocol or printing a termination log should be provided.
- xii. Screen page: The screen page displays the pre- and post-testing values to the operator. It shall be operator friendly.

Display principle (OP - given by the operator & NC - given by the PLC control system)

- a. Test sheet No.: NC
- b. Date: NC, operator correction Possible
- c. Bogie Type : OP
- d. Line number : OP
- e. Car number : OP
- f. Bogie number : OP
- g. Wheel No. (1, 2, 3, 4): OP in tabular index
- h. Wheel diameter (1, 2, 3, 4): NC
- i. Oil check (for motor bogie), Gear case 1&2: OP
- j. Air leakage test: OP
- k. Wheel load applied (Axle 1&2; Left & Right): NC
- l. Actual deviations from mean value: NC
(Axle 1 & 2; Left & Right)
- m. Measurements: Both OP and NC

(Rated value, measured value, deviation remarks)

This information enables the operator to display the testing details pre- and post-testing. The Contractor shall however propose the scheme used by him for display of measurements.

- xiii. Remote Diagnostics: The Bogie Test Stand shall have remote diagnostics feature to enable the Purchaser remotely to interact with manufacturer / supplier end for rectification of a fault. The Contractor shall provide the software and hardware for remote diagnostic & provide hands on training of CMRL staff to enable the same. The machine supplier shall be responsible for the provision of communication set up to enable the supplier and CMRL to interact remotely with machine computer for rectification of a fault. Required internet connectivity will be in scope of the Contractor.

- xiv. Maintenance and Upkeep Conditions: All components of the Bogie Test Stand must be appropriately protected to stop ingress of metal dust and dirt. All covers, slide caps, hoods and neighbouring boxes of tool holders shall be made sufficiently hermetic to stop dust from entering into these areas. All covers and hoods shall be easy to remove. The Bogie Test Stand and its accessories (hydraulic unit, electrical switchboards, PLC control system cabinets, etc.) shall be designed to facilitate maintenance operations. All anomalies shall be reported to the operator by means of messages on the PLC control system screen.

2.10.17 Protection and Safety:

2.10.17.1 The following conditions must be satisfied before load is applied on bogie:

- i. Correct positioning of the bogie on the track provided where the bogie to be placed for load testing.
- ii. X-Y centring of the bogie.
- iii. All mobile parts of the Bogie Test Stand shall be in retracted position.
- iv. Safety devices shall be provided to impede any damage to the Bogie Test Stand and serious personnel injury in the event of false manoeuvres.
- v. When the load is applied on the bogie, it shall not be able to move.
- vi. The Bogie Test Stand shall be provided will suitable protection for the operator. The testing area and workstation at workshop are appropriately illuminated by the lighting provided on the workshop truss. If any further local illumination is considered necessary, the Bogie Test Stand Contractor shall provide it as part of his supplies without any extra cost on CMRL.
- vii. Emergency stop pushbuttons (key lockable) shall be provided on the Bogie Test Stand at following locations:
 - a) On the control panel,
 - b) At suitable location on the workplace
- viii. The Contractor shall provide complete details of safety provision provided on the Bogie Test Stand during the detailed design.
- ix. Considering Koyambedu depot is situated at flood prone area, therefor the Contractor shall deign the machine vital components (PLC, sensor, electrical & control panel etc) at minimum height of 1m from floor level.

2.11 ELECTRIC OVERHEAD TRAVELING (EOT) CRANES

2.11.1 Purpose of the machine

The main purpose of EOT crane is to lift and move the heavy weight parts / items / components in the workshop line from one location to other.

2.11.2 Functional Requirement:

EOT cranes shall perform the following basic function:

- i. Hoisting
- ii. Longitudinal traveling at specified speeds in both loaded and unloaded conditions.
- iii. Cross traveling at specified speeds in both loaded and unloaded conditions.

2.11.3 Basic Parameters for the design of EOT crane:

2.11.3.1 General Data

EOT type	Double Girder (15/5t Crane)	Single Girder Crane (5t Capacity)
Gantry Span**	Category 1 Approximately : 13m Category 2 Approximately : 22 m	Approximately : 10 m, EOT Crane Depot Store
Working environment & temperature	In-door & 45° C	In-door & 45° C
Class and Duty	Class II M5	Class II M5
Gantry length	Category 1&2, Approx. 160 m**	Approx. 70 m**
Location	Koyambedu depot – Chennai	Koyambedu Depot, Chennai
Height from the ground level to top of the longitudinal travel rail of EOT (approx.) (Gantry height from workshop Floor/Rail top)	Approx. 8.5-9 m**	Approx. 7.5 -8 m **
Max. Permissible height of the EOT frame structure, control panel and accessories from the ground level.	Approx. (10.5 – 11.0 m**)	Approx (8.0 – 10m**)
No. of hoist in a trolley	2 Hoist	1 Hoist
Distance between main hoist hook center to auxiliary hoist hook center.	800 – 1200 mm	NA

**** All dimensions as mentioned above are referred as Indicative only .**

The Contractor shall measure as built dimensions of building prior to starting the fabrication of each crane therefore shall closely coordinate with the respective Interface Contractor (Civil, MEP etc).

2.11.3.2 Hoist details

Parameters	Main Hoist (MH)	Auxiliary Hoist (AH)	5t Crane Single girder
Capacity (SWL)	15 t	5 t	5t
No of Hoists	1 No	1 No	1 No
No.of motors	1 No.	1 No.	1 No
Max. Speed	4 – 5m/min,	4– 5m/min	4-5m/min
Creep speed	0.5 -1.0 m/min.	0.5 – 1.0 m/min	0.5 – 1.0 m/min
Drive/pole changing	Yaskawa, Demag, Siemens, and any other proven make	Yaskawa, Demag, Siemens, and any other proven make	Yaskawa, Demag, Siemens, and any other proven make
Limit switch	Rotary Geared and Gravity Limit Switch	Rotary Geared and Gravity Limit Switch	Rotary Geared and Gravity Limit Switch
No. of falls & reeving	4/1	4/1	4/1
Lifting height from ground level**	7 – 8.5 m	7 – 8.5 m	7-8 m

**** All dimensions as mentioned above are referred are Indicative only and actual may vary.**

2.11.3.3 Crane travel details for 15t/5t Crane -Double Girder Workshop Crane

Parameters	Long travel (LT)	Cross Travel (CT)
No. of motors	2 Nos.	2 Nos.
Max. Speed	At least 20m/min	At least-20 m/min
Creep Speed	At least 5m/min	At least-5M/Min
Drive	Yaskawa, Demag, Siemens, and any other proven make	Yaskawa, Demag, Siemens, and any other proven make
Limit switch	2 Way Lever Type	2 Way Lever Type
No. Of wheels	4 Nos.	4 Nos.

2.11.3.4 Crane travel details for 5t EOT Crane -Single Girder (Depot Store)

Parameters	Long travel (LT)	Cross Travel (CT)
No. of motors	2 Nos.	1 Nos.
Max. Speed	At least 20m/min	At least-20 m/min
Creep Speed	At least 5m/min	At least-5m/Min
Drive	Yaskawa, Demag, Siemens, and any other proven make	Yaskawa, Demag, Siemens, and any other proven make

Parameters	Long travel (LT)	Cross Travel (CT)
Limit switch	2 Way Lever Type	2 Way Lever Type
No. Of wheels	4 Nos.	4 Nos.

2.11.4 Design Requirements for Mechanical parts:

2.11.4.1 Structural requirements:

- i. The crane shall be rigid, robust and of sturdy construction.
- ii. The maximum vertical deflection of the girders produced by the dead load, weight of trolley and the rated load shall conform to the latest version of IS 3177/DIN.
- iii. The crane bridge shall comprise of double girders of box type for 15/5t capacity crane and single girder of box type for 5t capacity crane. Camber in the box girder shall be as per the relevant IS code.
- iv. All welded subassemblies of box girder shall be stress relieved before the final welding of the box girder.
- v. All welds on structural members under tensile stress shall be checked by Radiographic examination.
- vi. Materials used for equipment and structures shall be free from cracks, blow holes, laminations, pitting etc. the material shall be as conform to the latest version of IS 2062/DIN
- vii. Suitable buffers shall be provided to prevent over travel of the crane mechanism in both longitudinal and cross traverse directions.
- viii. The box girders shall be so constructed as to eliminate any possibility of accumulation of water or oil inside them.
- ix. The supplier shall take special care in the design of the mechanical structure, welding and components against the corrosive environment.

2.11.4.2 End carriages

- i. End carriages shall be designed to be strong enough to resist all stresses likely to be imposed upon them under varied service conditions, including collision with stops. The length of the end carriages shall be such that no other part of the crane is damaged in the event of a collision. The material used shall conform to the latest version of IS 2062 /DIN.
- ii. Suitable jacking pads shall be provided on each end carriage for jacking up the crane while changing track wheels. These jacking pads shall not interfere with the replacement of track wheels.
- iii. The end carriages shall be fitted with suitable safety stops / Buffers. These safety stops / buffers shall not interfere with the removal of track wheels.
- iv. Interlock shall be provided to prevent single motor operation at any time.

2.11.4.3 Crane rails

- i. A square / rectangular bar of suitable dimension as crane rails for longitudinal travel (LT) and cross travel (CT) shall be supplied, installed and tested by the supplier.
- ii. CMRL's respective Contractor is providing a cantilever slab and runway girder for installing the EOT crane. In addition to cantilever beam and runway girder, if any other beam is required to fix the above rails shall also be supplied and installed by EOT Contractor.

2.11.4.4 Trolley frame

- i. The trolley frame shall be welded section, designed to transmit the load to the bridge rails without undue deflection. The material used shall conform to the latest version of IS

2062/DIN

- ii. The bearing housing shall be designed for easy removal of wheels and bearings for maintenance.

2.11.4.5 Rail wheels

- i. The wheels shall be forged double flanged wheel
- ii. The Hardness of the machined rail wheel (for both CT and LT) shall be checked with portable hardness tester and value shall be verified with the test reports during the factory acceptance test (FAT)

2.11.4.6 Rope drums

- i. The rope drum shall be machined and stress relieved after fabrication or as per latest equivalent.
- ii. The drum shall be designed to take the entire length of the rope in a single layer and shall conform to the latest version of IS 3177, /FEM
- iii. The material used shall conform to the latest version of IS 2062/FEM

2.11.4.7 Wire ropes

The wire rope shall conform to the latest version of IS 2266 and IS 3938,/FEM

2.11.4.8 Deleted.

2.11.4.9 Gearboxes

- i. All gears shall be of helical type and heat treated.
- ii. All gearboxes shall be of completely enclosed splash lubricated type and oil sealed with O rings.
- iii. All the gearboxes shall be provided with breather vents, easily accessible drain plugs, and a suitable oil level indicator such as a dipstick.
- iv. Designed for easy assembly and maintenance activities.
- v. The gearbox shall conform to the latest version of IS 3177,/FEM

2.11.4.10 Brakes

- i. For Longitudinal travel (LT): Fail safe Inbuilt DC Disc Brakes
- ii. For cross travel (CT): Fail safe-Inbuilt DC Disc Brakes
- iii. For Main hoist (MH):
 - The hoisting motion shall be provided with
 - Fail-safe In built DC Disc brakes
- iv. For Auxiliary hoist (AH):
 - The hoisting motion shall be provided with
 - Fail-safe Inbuilt DC Disc brakes
- v. Safety interlock: All the above said brakes shall be applied automatically when the power supply to the drive motor is cut-off or fails.

2.11.4.11 Lifting hook (Main hoist hook and Auxiliary hoist hook)

- i. The lifting hook shall be a single “C” type forged steel and standard plain shank with a trapezoidal section. These hooks shall conform to the latest version of DIN / IS 15560.
- ii. The test certificate shall indicate serial no., the date of testing and the same shall be submitted to CMRL.
- iii. The hook shall be provided with spring loaded Safety latch and freely swivelling.

2.11.4.12 Buffers

- i. Suitable buffers shall be fitted on the four corners of the crane also at the four ends of the bridge girders.
- ii. All buffers shall have sufficient energy absorbing capacity to stop the crane movement (longitudinal travel) and trolley movement (cross travel) in either direction.

2.11.5 Design Requirement for Electrical parts:

2.11.5.1 Motors

All the motor in crane shall be three phase squirrel cage induction geared brake motor.

Motor	CDF	Insulation	Starts per hour
Longitudinal travel (LT)	40%	F- class	150
Cross Travel (CT)	40%	F- class	150
Main hoist (MH)	60%	F- class	150
Auxiliary hoist (AH)	60%	F- class	150

2.11.5.2 Shrouded bus bar system

- i. The conductor system shall be provided with IP 21 (finger safe) rating and suitable insulation.
- ii. Conductors shall be supported by the four pole hangers.
- iii. The current collector arm shall be insulated and the connection cable shall be fully enclosed and double insulated within the collector arm.
- iv. Protection guards to live electrical wirings / conductors shall be provided.
- v. The Shrouded bus bar with LED lamps for three phase power indication.

2.11.5.3 EOT Crane controls

- i. All the operations of the crane, such as longitudinal travel, cross travel, main hoist motion, auxiliary hoist motion and luminaries shall be controlled from the following:
 - a) Pendant push button control
 - b) Radio remote control.
- ii. A pendant and radio remote control shall be provided with push buttons, switches and indicators.
- iii. The pendant shall locate at height of approximately 1 meter above the operating floor.
- iv. Two numbers of radio remote controls shall be supplied along with the each crane and the range of operation shall be minimum of 100 meters.
- v. There shall be an override provision on the pendant to disconnect / deny the remote-control operation.

2.11.5.4 Circuit protective switchgear

- i. Each control circuit shall be provided with an isolation and protection against short circuits and the overloads.
- ii. MPCB (Motor protection circuit breaker) shall be used for each drive motor.

2.11.5.5 Limit switches and locks

- i. The main hoist and auxiliary hoist motion shall be provided with a heavy duty limit switches to prevent the crane from over hoisting and over lowering.

- ii. Two limit switches shall be provided for proper backup protection in the main hoist and another two limit switches shall be provided for proper backup protection in the auxiliary hoist.
- iii. The Longitudinal travel and cross travel motions shall be provided with two way limit switches at each end to stop the power supply to relevant motor for further motion and without impacts at the end stops.
- iv. Limit switches shall be set such that there would be a minimum gap between crane ends and buffers. In any case, the crane shall not touch the buffers.
- v. Indication audio and visual alarm shall be provided for crane operation.

2.11.5.6 Emergency stop push buttons

Emergency stop push button shall be provided on the pendant as well as on the radio remote control and the main control panel.

2.11.5.7 Control panel

- i. All power and aux contactors shall be mounted in the cubical with lockable hinged doors. Each motion shall have its individual panel. However, a common panel with a separate compartment for each motion shall be acceptable.
- ii. All the equipment shall be mounted in the panel to enable its easy removal / replacement from the front.
- iii. All the panels and cabinets shall also be provided with interior illumination.
- iv. The Control panel shall have instrument cooling fan with panel filter preferably.
- v. 3 phase power indicators and drive ON / TRIP indicating lamps shall be mounted on the door
- vi. The electrical components panel shall be FLAMEPROOF type and the panel shall be IP55 protection and vermin proof.
- vii. Drive and control panel shall be arranged in separate panel with adequate ventilation with IP55 protection.
- viii. Terminal blocks assembly shall have 20% spare terminals for future usage.
- ix. The main disconnect switch shall have the provision of pad-locking in the OFF position.

2.11.5.8 Cabling

- i. All wiring for the power control circuit shall be carried out with Flame Retardant Low Smoke (FRLS) cables as conform to the latest version of the IS 694 and IS 1554 or as per latest standard.
- ii. All cables shall be of reputed make and approved ISI brands.
- iii. CT cables of the crane shall run on the cable drag chain.
- iv. The longitudinal travel power supply cables shall be supplied through flexible festoon cable system with PVC clamping.

2.11.5.9 Safety and Regulation:

- i. Suitable guards or enclosures shall be provided on the crane to prevent inadvertent contact with down shop leads (DSL) or any other exposed electrical conductors and cables.
- ii. Suitable isolation switches and stop buttons shall be provided to isolate the electric supply for maintenance or in the event of an emergency.
- iii. Access walkways of minimum 500mm clear inside width with hand railings on both sides of double girders and one side for single girder for the full span length for inspection and maintenance of the crane shall be provided. Walkways shall be of rigid construction, non-slip steel surface and designed to sustain a distributed live load of not less than

300.kgs/sq. Meter.

- iv. A safety hand railing of tubular construction shall be provided on bridge footwalls, end carriages, trolley and any other places where access has been provided. Hand railings shall not be less than 1000 mm height with an intermediate member.
- v. Toe boards / falling object protection shall be provided along the entire length of the platform which shall be not less than 200 mm wide
- vi. The crane shall comply with the relevant safety regulations under the Factories Act, Indian Electricity Rules and other statutory regulations as applicable.
- vii. Where there is more than one EOT crane within the same bay, both cranes shall incorporate a safety device to avoid risk of collision.

2.11.5.10 Earthing: All the electrical equipment in the Crane shall be earthed as conform to the latest version of IS 3043.

2.11.5.11 Identification of components:

- i. Labels of permanent nature shall be provided on supports of all switches, fuses, contactors, relays and other electrical component for easy identification.
- ii. All power control cable and other cables shall be ferruled at both ends as per the cables numbers indicated in the supplier's drawing. All equipment terminals shall also be marked likewise.

2.11.5.12 Miscellaneous: The design of EOT shall ensure the following points.

- i. Indicating lamp: any movement of the crane shall be indicated by LED lamps with appropriate protection.
- ii. During the Crane operation (LT, CT and hoist), a sound alarm shall have sufficient dB level such that it would be audible in the crane operating area.
- iii. Main current Collectors (one in forward and another in rear)
- iv. Power disconnecting switch.
- v. Protective Switch gears
- vi. Motor control panels.
- vii. Socket outlets –3 pin industrial socket shall be provided on the trolley and bridge.
- viii. Power and control cables CT motion cables shall run in the cable drag chain (IGUS Drag link)/ festooning cables.
- ix. Pendant type & Radio remote control for crane operation:
- x. Earth wire on crane portion as per relevant IS and IE rules.
- xi. Shrouded bus bar conductor along with Isolator switch at the ground level. Cabling from the Isolator to the shrouded bus bar shall be in the Contractor's scope.
- xii. Atleast 3 numbers of suitable capacity LED lamps shall be provided under the crane and the same shall be operated from the pendant and Radio remote control.
- xiii. All electrical equipment, accessories and wiring shall have "tropical protection" involving special treatment of insulation and metal against fungus, insects and corrosion.

2.11.5.13 Maintainability

- i. Safe accesses for maintenance and removal of all mechanical, electrical and structural components must be ensured. All parts requiring replacement, inspection and lubrication shall easily be accessible without the need for dismantling other equipment or components.
- ii. All electrical cables shall be so laid that they are not liable to damage and can be easily inspected and maintained.

- iii. All the fasteners shall be easily removable from the top of the platform.
- iv. All grease points shall be visible and accessible for lubrication and it shall be provided with closed end caps.
- v. Sufficient lighting to access and attend maintenance works.
- vi. Inspection cage shall be provided on inside of end carriage for maintenance of the LT wheels and main current collector and the load carrying capacity not less than 300 kgs/sq. meter.
- vii. Only antifriction type bearings shall be used in the crane.
- viii. Bearings shall be enclosed with suitable housing or shielding to prevent any ingress of dirt.

2.11.5.14 Testing and qualification

All the followings shall be carried out in the manufacture's place.

- i. The crane manufacturer must submit a detailed Testing and quality assurance program indicating quality assurance plan (QAP) applicable at various stages of crane fabrication starting from raw material to final crane testing.
- ii. Testing & Inspection at vendor's works and site shall be carried out in line with the approved QAP.
- iii. All the mandatory and optional tests as specified under the latest version of the FEM/IS 3177 and IS 807 shall be performed by the supplier / manufacture and test certificate shall be submitted before commissioning.
- iv. Radiography test, die penetration, ultrasonic tests and other tests as required are to be carried out and certified.
- v. Crane motors should be Tested for Acceptance & routine test as per relevant FEM/ IS standard.
- vi. All electrical and mechanical equipment shall be subjected to routine tests in accordance with the appropriate Indian Standard.
- vii. Tooling, tackle, slings, gauges, measuring instruments and test loads required for qualification of the crane shall be arranged by the supplier.
- viii. All butt welds on structural members of bridge girders subjected to tension shall be radio graphically tested. All other welds shall be subjected to Magnetic particle test or Dye Penetration Test.
- ix. All 'T' joints shall be covered with spot radiography.

2.11.5.15 Erection, commissioning, and final testing

All the following shall be carried out in CMRL Koyambedu depot.

- i. The supplier shall be the responsible for complete installing of crane in the depot, tapping of power supply, routing of cable, required material handling equipment, tools, Unloading, erection, commissioning and testing of the crane as per relevant IS standard.
- ii. All the In-house testing documents and Test certificates shall be submitted to CMRL before the erection work.
- iii. The crane performance shall be demonstrated after successful commissioning.
- iv. Any equipment / instruments found defective during the test, after installation or during operation shall be replaced and reinstalled by the manufacturer without delay and free of charge.
- v. After erection work completed at the site, the following test shall be carried out in EOT crane as per latest version of the IS 3177 and IS 807 (or FEM).
 - a) Load test: The trials shall be carried out initially under no load conditions and on

satisfactory completion trials shall be repeated for various loads until the full rated load and operating range are covered. Load required for conducting test at site shall be in scope of EOT Contractor.

- b) Overload test
- c) Brake test: Main Hoist brakes, auxiliary hoist brake, CT brake and LT brake.
- d) Movement test: LT and CT movements.
- e) Safety checks, interlock checks, limit switch operation, smooth movement of hook and rope.
- f) Deflection test
- vi. Operation of the crane with no skewness during longitudinal travel and cross travel motions.
- vii. The insulation test and the earthing test of the crane and control equipment, to be tested as per Indian Electricity Rules and relevant Indian specification.
- viii. All the mandatory tests and optional tests shall be performed by the supplier as per the latest version of IS 3177 and IS 807 (or FEM). The Equipment shall meet the performance requirements specified in this specification.
- ix. Necessary testing procedure fully complying with the relevant standard shall be submitted to CMRL for approval before conducting the test.

2.11.5.16 Accessories: The following accessories shall be supplied along with each EOT crane supply:

Description	Capacity(t)	Qty(nos.)
15/5-ton EOT Crane		
Nylon sling	15	4
D shackle / bow shackle suitable for lifting bogie frame.	15	4
Nylon sling	5	4
D shackle / bow shackle	5	4
5-ton EOT Crane		
Nylon sling	5	4
D shackle / bow shackle	5	4

Test certificates for the above-mentioned lifting accessories shall be submitted to CMRL before EOT crane Testing in CMRL Koymbedu depot.

2.11.5.17 Interfaces:

- i. The EOT crane Contractor will suggest and supply necessary accessories to implement interlock (Electrical and Mechanical) with UFWL.
- ii. In addition Chapter- 3 Section VIB Part-2 shall be referred for the interface with other system Interfacing Contractors for respective EOT crane.

2.11.5.18 Drawing: List of Drawing and details provided in Chapter 4 – Employer's drawing

2.11.5.19 Standards*:

- i. The EOT crane shall be designed, manufactured, erected and tested in accordance with the following of their latest versions of IS / DIN / FEM Codes or equivalent International

Standards:

- ii. IS 3177 / FEM 1.001/DIN- Code of Practice for electric overhead traveling cranes and gantry cranes other than steel cranes.
- iii. IS 807 / FEM / ISO - Code of Practice for design, manufacture, erection and testing (structural portion) of cranes and hoists
- iv. IS 2266 / FEM 1.001/ FEM 9.811-Specification for Steel Wire Ropes for General Engineering Purposes and Electric wire rope hoists.
- v. IS 13834 (Part 1) Cranes-classifications.
- vi. IS 13834 (Part 5) Overhead Travelling and Portal Bridge Cranes
- vii. IS 325 - Specification for Three Phase Induction Motors
- viii. ISO 12488-1, Cranes-Tolerance for wheels and travel and traversing tracks.
- ix. IS 800-2007, General construction in steel – code of practice.
- x. IS 3443 - specifications for crane rail sections.
- xi. IS 15560:2005 - specification for Point hooks with shank up to 160 tons.
- xii. IS 3813 -Specification for 'C' Hooks for Use with Swivels
- xiii. IS 3938 - Specification for Electric Wire Rope Hoists
- xiv. IS 3043 – Code of practice for earthing.
- xv. All electrical installation work shall comply with the provisions of Indian Electricity Act and Indian Electricity Rules as amended up to date.

**Please note that Contractor shall follow the latest standard for the design and manufacturing etc of all EOT cranes. CMRL reserve the right for the procurement of EOT cranes as per latest industry standard as indicated in the requirement (but not limited to).*

1

2.12 Double Cylinder Hydraulic Wheel Press DELETED

2.12.1 Purpose of the machine:

The Double Cylinder Hydraulic Wheel Press is required for mounting and demounting multiple types of wheel disc, gear box etc automatically at Koyambedu depot. The press shall be a heavy-duty machine of the best performance and well proven technology.

2.12.2 Detailed Scope of Works :

Design, Manufacture, Supply, Installation, Testing & Commissioning of Double Cylinder Hydraulic Wheel Press at Koyambedu Depot of CMRL Phase-I. The supply shall include all equipment and accessories required to make the machine fully functional when connected to a power source but not limited to :

- 12.2.1.1 Electrical cables for connecting Power point to Control cabinet of machine & with in the machine shall be supplied and installed by the Contractor as per the requirement.
- 12.2.1.2 Wheel Press shall be equipped with all hardware and software (attachments, programmes etc) required for mounting and dismounting of all types of wheels, brake disc, gear etc of multiple type rolling stocks.
- 12.2.1.3 Tooling for mounting and dismounting of wheel discs, gear and brake disc.
- 12.2.1.4 Basic tool to reduce the gap in the resistance column for normal pressing-off operations. This tool shall be capable of accommodating all necessary tool inserts required for different wheels and various operations.
- 12.2.1.5 Computer based system for recording ram force and parameters.
- 12.2.1.6 Digital readout for indicating ram force.
- 12.2.1.7 Compatible forced air cooled heat accessories.
- 12.2.1.8 Lifting and Handling system.
- 12.2.1.9 Set of 60 degree and 90 degree retractable hydraulic centers.
- 12.2.1.10 High pressure oil pumping unit for injecting oil in the wheel bore during pressing-off operation for wheel discs.
- 12.2.1.11 Wheel gauge measuring arrangement.
- 12.2.1.12 Spare PLC cards: All PLC card used in the machine shall be Included in the set.
- 12.2.1.13 Pre-fitting stand.
- 12.2.1.14 Carriage to loading/unloading the wheel set. Any other accessories to make the machine fully functional deemed included with machine.

2.12.3 Design Responsibility

- 2.12.2.1 The Wheel Press shall be a horizontal design with three column structure suitable for mounting and dismounting of wheel discs, gears, gear units etc with both sides in one setting without reversing the axle, as well as independent mounting operation. The machine shall be automatically controlled by one man operation.
- 2.12.2.2 The machine shall have high production output, high engineering accuracy, least vibration and noise level and energy saving by cold pressing.
- 2.12.2.3 The machine shall consist of two hydraulic rams mounted in reaction frame and a motorised resistance head, fitting device, assembling system, hydraulic unit and electric control unit. The machine shall be double cylinder press fit equipment. The structure shall have adequate rigidity and strength, good shock resisting and absorbing capacity to keep smooth movement to ensure the press fit accuracy.

The machine shall be capable for following Job Parameters:

*Wheel tread diameter 780 to 1000 mm

*Axle length 2300 mm to 2800mm

** The Contractor shall interface with RS Contractor to verify and get the valid data to design the machine accordingly.*

2.12.2.4 Considering Koyambedu depot is situated at flood prone area, therefor the Contractor shall design the machine vital components (PLC, sensor, electrical & control panel etc) at minimum height of 1m from floor level.

2.12.4 Design Requirement of Wheel Press

2.12.3.1 Cylinder Column and Pressure Cylinder

- i. The Wheel Press shall consist of two hydraulic rams mounted on 2 reaction frames and shall be placed right and left of the centre.
- ii. The cylinder column shall be a steel casting, duly stress relieved, ultrasonically tested for cracks and machined to accommodate the piston cylinder assembly.
- iii. In case a fabricated cylinder column, all critical welds shall be tested for weld defects and the structure shall be duly stress relieved. Method of testing weld defects and method of stress relieving shall be explained during design stage. Detailed section calculations shall be furnished to establish rigidity and adequacy of the structure. A cross sectional schematic diagram shall be furnished to indicate the constructional features. Welding procedures shall conform to IS-822 and IS-823 or contemporary European norms.
- iv. The main pressure cylinder shall be solid steel casting, seamless pipe or forging, bored and honed to a surface finish of 0.3 microns or better. The cylinder shall be ultrasonically tested for cracks.

2.12.3.2 Main Piston/Ram

- i. The ram shall be machined from a steel casting or forging duly stress relieved and ultrasonically tested for cracks. It shall be hard chrome plated and ground to a surface finish of 25 microns or better. Hardness of the ram shall be at least HRC65 and thickness of chrome plating shall be at least 25 microns. Material specification of the ram shall be described during design stage.
- ii. Arrangement shall be provided to prevent ram rotation during operation of the machine.
- iii. Replaceable inserts of highly wear resistant material shall be provided on the ram face.
- iv. The piston/ ram assembly shall be effectively sealed to prevent leakage of oil.

2.12.3.3 Resistance Column

- i. The resistance column shall be machined out of stress relieved steel casting, ultrasonically tested for cracks, shall have sufficient structural rigidity and be adequately mounted to withstand heavy mounting forces.
- ii. In case a fabricated resistance column is offered, all critical welds shall be tested for weld defects and the structure shall be duly stress relieved. Detailed section calculations and stress distribution calculations shall be furnished to establish rigidity and adequacy of the structure. A cross sectional schematic diagram shall be furnished during design stage to indicate the constructional features. Welding procedures shall conform to IS-822 and IS-823 or contemporary European norms.
- iii. The resistance column shall have balanced, guided and motorised movement between the rear column and the cylinder column without stick-slip effect.
- iv. The machine shall have top and bottom clamping of the resistance column on the guide members with a push button control for clamping/ release. The clamping arrangement shall utilize maximum surface of the guide member for reduced contact pressure. Suitable interlocking to prevent power clamping during traverse of the resistance column shall be

provided.

- v. ~~The resistance column guide members shall not support the weight of the resistance column. Separate arrangement for supporting the weight shall be provided.~~
- vi. ~~It shall be possible to adjust the distance between the cylinder column and the resistance column so that the mounting operation can be carried out with minimum ram overhang. The guide members of the resistance column shall be provided with suitable bellow covers for protection from dust etc.~~
- vii. ~~A safety device to prevent damage to the machine shall be provided in case resistance column encounters and obstruction during its powered travel.~~
- viii. ~~The gap in the resistance column shall be large enough so that parts like transmission system on the Axle of Rolling Stock and gears already mounted do not obstruct the mounting and dismounting operations for wheels. Sizing of the gap in the resistance column shall be made as per rolling stock wheel assembly drawing.~~
- ix. ~~The resistance column shall have an inclined front face. The top and bottom guide members shall not be in the same vertical plane. The gap in the resistance column shall be so designed that the wheel set does not roll out of the machine during mounting operation and the wheel set can be easily front loaded with the help of the overhead crane unit of the machine.~~

2.12.3.4 ~~Wheel Set Rotation Device~~

- i. ~~The Wheel set rotation device or suitable arrangement shall be provided to check the radial deviation in tread circle and axial deviation of the internal face.~~
- ii. ~~The rotation device shall compose of a roller motorised by geared motor, The roller shall automatically putted on contact with the wheel so that the motor can drag the wheel on rotation then put the complete wheel set, positioned between the two cylinders, in rotation. During the wheelset rotation the assembling system shall check the radial deviation in tread circle and the axial deviation of the internal face by the laser device, the result shall be shown in screen.~~

2.12.5 ~~Hydraulic Part~~

- 2.12.5.1 ~~Positive displacement hydraulic pumps shall be provided for the high pressure oil circuit. Oil flow shall be pulsation free. Number of pumps provided, their type, make, model no. and capacity shall be furnished during design stage. The hydraulic system shall be provided with an air breather, oil level gauge, over flow and drainage connections.~~
- 2.12.5.2 ~~Filters of 10 microns shall be provided to prevent entry of dust and foreign particles. Type, make and model no. of each filter element shall be furnished during design stage.~~
- 2.12.5.3 ~~The filtering system shall be provided with a bye-pass valve, which shall operate in case of clogged filters. A clogging indicator shall be provided to indicate clogged filters.~~
- 2.12.5.4 ~~Cold bent, solid drawn, seamless steel tubes shall be used in the hydraulic circuit with the only exception that the resistance head shall be connected with high pressure flexible rubber hoses to enable its movement. The pipes shall be treated for corrosion prevention.~~
- 2.12.5.5 ~~The hydraulic system shall be capable of performing efficiently in ambient temperature range from 0 degree C to 50 degree C, relative humidity up to 80% and dusty environment. A compatible forced air-cooled heat exchanger for cooling the hydraulic oil shall be incorporated to ensure that oil temperature does not exceed 60 degree C. A~~

~~thermostat shall be provided in the hydraulic system to prevent overheating and automatic connection to heat exchanger.~~

~~2.12.5.6 The hydraulic oil used shall be non-corrosive, stable and safe for human handling. It shall be indigenously available.~~

~~2.12.5.7 A motorized high pressure oil pump with pressure gauge, safety valve, oil tank and other requisite accessories for injecting oil in the wheel bore through the oil nipple during pressing off operations shall be offered as a concomitant accessory. The pump shall be capable of generating pressure upto 3000 Kg./cm². The pump shall be push button controlled.~~

~~2.12.5.8 Pre adjustment of pressing force shall be easy.~~

~~2.12.5.9 Fitting and clamping system shall be adjustable from the workstation.~~

~~2.12.5.10 Work speeds and high speeds for feed and return shall be adequate. These speeds shall be approximately as under:~~

~~———— high speed feed (approach): ————— 15mm/s~~

~~———— work speed (mounting): ————— 0.5 to 5mm/s~~

~~———— high speed return: ————— 30mm/s~~

~~2.12.5.11 Press shall also have inching control. Fitting and removal loads shall be displayed on a pressure gauge, with loads indicated directly in tons. The machine shall record the force with respect to ram travel. Following shall be min capabilities of machine.~~

~~Ram force ————— 300 T (minimum)~~

~~Piston stroke ————— 600mm (minimum)~~

2.12.5.12 Hydraulic Centre

~~i. The axle is to be held between hydraulic centers fitted in the main ram and the resistance head.~~

~~ii. The main ram shall carry a hydraulic, retractable, hardened center capable of supporting wheel sets weighing upto 2500 Kg.~~

~~iii. The resistance head shall carry a hydraulic retractable, hardened center to hold the axle in conjunction with a similar center fitted in the main ram.~~

~~iv. 60 degree and 90 degree centers shall be provided with the machine. Details of hydraulic centers in the main ram and resistance head shall be furnished during design stage with a sketch of the arrangements.~~

2.12.6 Assembly System

~~2.12.6.1 The device with laser sensor shall be able to assembly, on the requested position, a component pair without to turn the axle 180 degree. The system shall be able to position automatically, all the components on the axle.~~

~~2.12.6.2 After one press fit, all the data shall be printed automatically. Mounting operation shall be in accordance with the UIC standard.~~

~~2.12.6.3 Man-machine interface shall be provided as display of operation, thus being able to directly~~

monitor the dynamic press-fit process.

- ~~2.12.6.4 The device shall allow the recorder to monitor the wheel press force and the ram distance, and plot the press force diagram (press force versus wheel axle displacement) on a screen. The diagram shown on the screen shall be capable of being sent to the printer.~~

~~2.12.7 Positioning Accuracy~~

The wheel press shall be capable of:

- ~~2.12.7.1 Controlling the ram stroke within ± 0.1 mm to interrupt the mounting process. Achieving a positioning accuracy of ± 0.2 mm with respect to the datum for obtaining the required wheel gauge (measured as the distance between inner faces of wheel flanges) and inter-component distances.~~
- ~~2.12.7.2 The machine shall have electronic positioning system for axle assembly. All measurements and positioning shall be done from this datum to ensure that there are minimal variations from the desired value of wheel gauge. The system should be such that there is no need of exact positioning of the probe, etc. by the operator i.e. it should be possible to obtain this accuracy independent of the operator's skill. The mounting operation should automatically stop when the pre-selected wheel gauge or inter-component distance is reached. The positioning system shall also be capable of finding and indicating the axle centre to ensure that the inner faces of both wheel discs are equidistant from the axle centre to an accuracy of ± 0.2 mm. The distance of the inner faces of wheel disc from the axle centre shall be shown on a DRO and shall be recorded by the computer system.~~
- ~~2.12.7.3 Mounting of wheel discs upto a pre-set distance from the journal end. Pressing shall stop immediately when the wheel disc reaches the pre-set position.~~

~~2.12.8 Measuring System~~

- ~~2.12.8.1 A wheel gauge (back to back wheel spacing) measuring system capable of automatically measuring the wheel gauge at three or more points on the inner face of wheel discs shall be provided. The system shall be with ac servo nmotors and lasers operated. Wheel gauge shall be measured by electronic sensors and read on a DRO. Details of the arrangement shall be furnished in the bid.~~

~~2.12.9 Back Pressure (thrust) test~~

- ~~2.12.9.1 The machine shall have a software able to verify the mounting operation carried out with oil. The test has to be carried out more than two hours after mounting and requires the cylinder to press the component at least for 30 sec in order to verify if the diagram force/time remain constant for all the time. This system shall verify the fitment of components, if result does not achieve the components has to be removed~~

~~2.12.10 Automatic calibration~~

- ~~2.12.10.1 The press shall be equipped with automatic Calibration equipment to guarantee a correct calibration by means of load cell, steel bush positioned between pressure cylinders and the resistance head.~~

~~2.12.10.2 The machine shall be equipped with a software able to guide the operator, step by step, through the calibrating procedure.~~

~~2.12.11~~ **Wheel Set Carriage**

~~2.12.11.1 The press shall have motorised and PLC controlled wheel set carriage. The carriage to support and transfer the wheel set from the pre-fitting area to the center of the press (loading) and from the centre to the offloading area (unloading) shall be consist of~~

- ~~—— Automatic vertical and lateral movements~~
- ~~—— screw jacks for vertical movement~~
- ~~—— interface frame for the different types of wheel set~~

~~2.12.12~~ **Lubrication**

~~—— An automatic, centralised, adjustable lubrication system shall be provided.~~

~~2.12.13~~ **Electrical Part**

~~The available power supply shall be 360 — 440V AC, 48.5 to 51.5 Hz, three-phase 4/5 wires. Cables shall be of flame-retardant type and are fitted into suitable trenches, conduit, cable trace or protective sheaths.~~

~~2.12.14~~ **Electrical Switch board**

~~2.12.14.1 The electric switches and protection devices shall be housed in a protected switchboard. This switchboard shall be accessible and designed for inspection. In particular, it shall include:~~

- ~~● isolating switch, latchable in open position,~~
- ~~● protection devices for motors fuses on each of the three motor phases and control systems to avoid single-phase operation,~~
- ~~● transformer(s) supplying low voltage for the control circuit if applicable.~~

~~2.12.14.2 All terminals and supply cable shall be identified in accordance with the electrical diagrams. The switchboard earth shall be connected to the machine earth by means of a copper braid.~~

~~2.12.15~~ **Motors & Wiring**

~~Motors shall include protection min IP 55 with Class — F insulation and shall be suitable for operation the available power supply of 360 — 440V AC, 48.5 to 51.5 Hz, three-phase 4/5 wires. The Contractor shall specify:~~

- ~~● the characteristics of the motors,~~
- ~~● starting current.~~

~~The Contractor shall identify the types of power and control cables used. All cables shall be protected with insulating ferrules at the entry into and exit from the pipes.~~

~~2.12.16~~ **Control Console**

- ~~2.12.16.1 The control panel shall be a pensile one in order to allow the operator to move in to useful working position of operator to unobstructed all around visibility and monitor machine function. The machine control shall be assured by a well proven PLC Siemens controller at least STEP 7—serie 300.~~
- ~~2.12.16.2 The entire operation of mounting and dismounting shall require only one operator who, from his workstation, shall be able to monitor the operations and able to read the pressing force on the screen.~~
- ~~2.12.16.3 The software shall supply a graphical description of machine working in English language. The picture displayed on screen shall conduct operator in simple way during working phases. The software shall get the signal from the different transducers and valves on the machine and it will show them on the screen.~~
- ~~2.12.16.4 The parameters will be survey and show on appropriate pictures on the screen. The data shall be possible to print out on the printer in a report. The configuration of the display and of the printout can be modified to suit the operator needs~~
- ~~2.12.16.5 Remote assistance shall be part of the supply.~~
- ~~2.12.16.6 All data shall be automatically stored in the computer, and it shall be possible to fetch them again later. The data saved during the tests can be stored on external so that they can be later revised with Microsoft Excel software or better format.~~
- ~~2.12.16.7 For each type of wheel set can be insert the relative parameters, so that they can be stored and used at future operation for the same type of wheel set.~~
- ~~2.12.16.8 The machine shall be operated in both automatically and manual mode. In case of fault or damage shall be showed appropriate alarm picture on the screen. Then the control system shall stop automatically the machine. Scheduled checks and maintenance shall be provided on the screen.~~

~~2.12.17~~ Panel

~~PLC Siemens Control devices shall be mounted on a sealed and unbreakable control panel with IP 55 installed one metre above the ground. The location of the panel shall be indicated by the Contractor. Pushbuttons and indicators shall be grouped function-wise and shall be identified by means of engraved stainless steel labels mechanically secured to the control panel.~~

~~2.12.18~~ Recording and measuring instruments

~~The machine shall be fitted with computer based equipment for recording pressing force in relation to ram travel in addition to the force indicating gauge. The details/configuration of the computer system shall be latest as per industry and shall be submitted during design stage for approval by Employer/Engineer.~~

~~2.12.19~~ Data

~~The operator of wheel press shall be able to enter, using his own password, operator name, axle type, axle serial no. and working pressure.~~

~~The following data automatically put in by the software are:~~

~~-date and time~~

~~workshop name~~

The measured values that shall be displayed are:

- ~~max force,~~
- ~~resistance head position,~~
- ~~graph indicating the mounting curve, referring to the force and the travelled length,~~
- ~~back pressure test (diagram force / time)~~
- ~~result of the components mounting position and wheel gauge,~~
- ~~radial and axial run-out.~~

2.12.20 Output accuracy

The machine shall be capable at least the following production volume :

- ~~2 wheels with brake discs assembly less than 20 minutes.~~

2.12.21 Software

~~Machine HMI backup shall be supplied for maintenance purpose.~~

2.12.22 Handling System

~~2.12.22.1 The machine will incorporate suitable arrangement for loading unloading and handling of wheel sets, wheel discs and axles.~~

~~2.12.22.2 The machine shall be supplied with an overhead travelling crane unit consisting of three electrically operated hoists. The hoists shall have coarse as well as fine hoisting speeds. The end hoists shall have synchronized as well as independent movements. All the three hoists shall be provided with cross traverse movement, which shall be in coarse as well as fine speed ranges. The crane bridge shall also have coarse and fine speeds, which shall be same as hoist cross traverse speeds. VVVF controlled motors will be preferable.~~

~~2.12.22.3 The handling system shall be capable of lifting a wheel set from a distance 3000mm from the stroke axis in front of the press. In the rear, the crane hook shall be capable of lifting a load upto a distance of 500mm from the stroke axis. The lifting system shall be suitable for the axles and wheel sets mentioned. The overall height of the crane and structure unit shall not exceed 4500mm from floor level.~~

~~2.12.22.4 The crane design shall generally conform to Class II of IS-807 or contemporary European norms.~~

~~2.12.22.5 Suitable and sufficient web sling shall be supplied with the machine.~~

2.12.22.6 Crane Unit speeds

i. Hoisting speed

a. Coarse 8 to 9m/min.

b. Fine 0.6 to 0.8m/min.

ii. Cross traverse speed

- a. Coarse 18 to 20m/min.
- b. Fine 4 to 5m/min.

iii. Carrying capacity

- a. Left & right hoists 1500 Kg. Each (min.)
- b. Central hoist 3000 Kg. (min.)

2.12.23 Operation Sequence

The bidder shall include description of work methods used to fit the components at a precise location and operational sequence for mounting and dismounting of wheel discs and other items during design stage, including loading, mounting, gauging and unloading operations. Total cycle time for the operation shall also be described.

2.12.24 Other Parameters

The bidder shall furnish information regarding guide member, pump capacity, machine dimension, working pressure etc of the machine during design stage:

2.12.25 Other Requirements

2.12.25.1 Axle carriage shall be single gear control.

2.12.25.2 The pit shall be completely closed by non-slip plates in every position during travel.

2.12.25.3 The power unit shall have a heat exchanger and an electric fan for oil cooling in order to allow the machine to continuously work for minimum 3 shifts (8 hrs each shift) hours without any problems in terms of oil temperature.

2.12.25.4 Where possible, the connecting lines between the power unit and the cylinders shall be made by means of rigid hydraulic tubing. All moving parts connected hoses of suitable reinforced burst proof.

2.12.26 Protection and Safety

2.12.26.1 The equipment shall be in accordance with the safety legislation in force at order time.

2.12.26.2 Emergency stop pushbuttons of the key lockable type shall be mounted on the control panels and close to the fitting jacks.

2.12.26.3 Moving component protection devices and guards shall be removable with special tools.

2.12.26.4 Malfunction and alarm system shall be provided.

2.12.27 Drawings:

List of civil layout Drawing and details provided in Chapter 4 Part 2 section VIB Employer's drawing.

2.12.28 Interface:

The Contractor shall refer Interface matrix / specification Chapter 3 Section VIB Part 2 for the interface with other system Interfacing Contractors for Wheel Press.

2.12.29 Standard

Work related to the design and manufacturing of the Wheel Press shall comply with relevant international standard or equivalent Indian standards, Codes of Practice and the latest statutory requirements of India including as mentioned in General requirement and scope Chapter 1 Section VIB Part 2 but not limited to.

1

2.13 Vertical Turning Lathe DELETED

2.13.1 Purpose of the machine:

- 2.13.1.1 ~~The Vertical Turning Lathe shall be required for boring, taper boring, turning, and taper turning, facing, grooving (inside/outside) on different types of wheels of Standard gauge (1435 mm) metro cars, locomotive and CMV etc.~~

2.13.2 Detailed Scope of Work

~~Design, Manufacture, Supply, Installation, Testing & Commissioning of Vertical Turning Lathe at Koyambedu Depot of CMRL Phase-I. The supply shall include all equipment and accessories required to make the machine fully functional when connected to a power source but not limited to:-~~

- 2.13.2.1 ~~Electrical cables for connecting Power point to Control cabinet of machine shall be supplied by the Contractor as per the requirement.~~
- 2.13.2.2 ~~The machine shall be equipped with all hardware and software (attachments, programmes etc).~~
- 2.13.2.3 ~~3-jaw power operated self-centering chuck with one set each of hard jaws and soft jaws~~
- 2.13.2.4 ~~Fixture(s) for holding wheels for machining~~
- 2.13.2.5 ~~Lifting tackle for handling all type wheel disc through EOT crane~~
- 2.13.2.6 ~~ATC with tool magazine~~
- 2.13.2.7 ~~A calibrating masterpiece for machine adjustments and for subsequent periodical checks.~~
- 2.13.2.8 ~~Adopter, tool holders, boring bars and tools for all types turning/facing/grooving etc.~~
- 2.13.2.9 ~~Coated Inserts for each type of tool/shank~~
- 2.13.2.10 ~~Any other cutting tool essential for machining of wheel sets~~
- 2.13.2.11 ~~Chip conveyor system to remove swarf/chip generated by the machine during cutting/profiling alongwith swarf crusher.~~
- 2.13.2.12 ~~Coolant system for cutting tools if required.~~
- 2.13.2.13 ~~Lifting and Handling system (Wheel Loading and Unloading equipment).~~
- 2.13.2.14 ~~Low Voltage hand pump~~
- 2.13.2.15 ~~Swivelling electrical control pendant with lead of min 5 m.~~
- 2.13.2.16 ~~Tool wear monitoring system~~
- 2.13.2.17 ~~Wheel bore and profile measurement system~~
- 2.13.2.18 ~~Any other and necessary accessories shall be included even if not particularly mentioned but are considered necessary to achieve installation & operating condition to make the machine fully functional.~~

2.13.3 Design and Functional Requirement

- 2.13.3.1 ~~The installation shall be designed to be operated by a single operator.~~
- 2.13.3.2 ~~The machine shall be dimensioned for machining with chips of maximum cross section of 5mm² and shall be designed for provision of disposable tool inserts and chip breakers.~~
- 2.13.3.3 ~~The machining profile, depth of cut, speed of the work piece and feed of the tool post shall be CNC controlled which shall be amenable to programming by the operator as required.~~
- 2.13.3.4 ~~A memory unit capable of storing the dimensions and profile both before and after machining and the depth of cut required for finish machining shall be part of the control unit.~~
- 2.13.3.5 ~~The table speeds shall be continuously infinitely variable and programmable over the specified~~

- ~~range to ensure optimum cutting speeds of all jobs. Suitable provision shall exist for precise control of feed and depth of cut both manually and through programmable command.~~
- ~~2.13.3.6 The design shall provide for operation of the entire equipment in, Manual mode if required. Each elementary function shall also be controlled by manual push buttons in a sequentially interlocked system.~~
- ~~2.13.3.7 The equipment shall have necessary safeguards to avoid conflicting and/or unsafe operations during machining.~~
- ~~2.13.3.8 Measuring and dimension system adopted shall be metric system. Display and programming shall be in English.~~
- ~~2.13.3.9 Provision shall be made to draw the attention of the operator to the faults developed in operation by audio visual indications. For each type of failures, a failure code to be displayed in the LED display which will be clearly documented in the manual along with its diagnostics.~~
- ~~2.13.3.10 The equipment shall have clear and easy access for maintenance with necessary safety guards/railings for the moving components.~~
- ~~2.13.3.11 The hot chips falling from the machining head shall be suitably handled to avoid injury to the operator. Chip conveyor system shall be provided for the disposal of the chips.~~
- ~~2.13.3.12 Suitable system shall be provided to prevent the job from fly off in the event of power shut down.~~
- ~~2.13.3.13 A RAM head capable of holding tools required for normal external and internal machining operations on a lathe like rough turning, finish turning, facing, chamfering etc., shall form part of the system.~~
- ~~2.13.3.14 The system resolution in shall be in metric mode and shall be of the order of 0.001 mm. The system shall have capability for absolute and incremental programming.~~
- ~~2.13.3.15 Facility of self diagnosis of the machine and the controls system faults and display of self diagnostic results shall exist.~~
- ~~2.13.3.16 Facility for macro programming multiple repetitive cycles shall be available.~~
- ~~2.13.3.17 An identification page shall be available on the screen to the operator. It shall allow, before starting the cycles, manual entry of identification data such as Log in/user name with password, date, operator's name, operator's code/No/Employee No., wheel stock name, wheel serial no., reference of the wheel to be machined. These entry details shall be recorded in memory and be reflected on wheel boring report.~~
- ~~2.13.3.18 The memory unit of the control system should have capacity to store data for at least 10000 operations. The stored data/reports shall be able to download for print purpose.~~
- ~~2.13.3.19 A power operated 3-jaw or better self-centering chuck shall be provided. The self-centering of wheel shall be automatic. An automatic measurement system or provision to verify the self-centering of wheel shall be provided and it shall be displayed on HMI through graph &~~

- parametric values. It shall be possible to load concentric as well as non-concentric jobs on the table either with adjustable individual jaws on a 3 jaw selfcentering chuck or with the help of a fixture directly mounted on face of the table. The radial chuck jaws shall be of quick setting type and include an arrangement for independent micro adjustment to maintain concentricity without re-grinding.
- 2.13.3.20 The clamping operation shall be interlocked so that the table cannot be started when chuck jaws are unclamped.
- 2.13.3.21 Illuminating arrangement of 400 lux for the tooling area shall be in-built in the system.
- 2.13.3.22 An automatic measuring system probe type shall be provided to measure all wheel bore parameters like wheel bore diameter, conicity, roundness at three different places i.e., at the face, at the mid of hub bore, at the end of hub bore shall be provided. This measuring system shall measure and provide all wheel re-profiling parameters. The measurements shall be displayed on the machine's HMI and in wheel boring report.
- 2.13.3.23 The wheel boring/re-profiling operation should be automated and parametric values after each operation should be displayed on HMI for information of the operator.
- 2.13.3.24 A suitable probe arrangement to measure the wear of tool cutting edge shall be provided. Before finish boring operation, wear on tool cutting edge will be checked and automatic tool wear compensation shall be done in CNC system to control the bore size. Suitable protection shall be provided to safe guard probe from cutting chips.
- 2.13.3.25 Work area shall be heavy duty & robust. Enclosure shall be provided with heavy duty metallic door with transparent windows. The work area should be completely enclosed and interlocked so that no cutting operation in auto mode can take place as long as its door is open except for motions in jog mode.
- 2.13.3.26 The machine table diameter shall be minimum 1400 mm and shall be able to accommodate wheel diameter upto 1000 mm and wheel load of 500Kg approx. The Contractor shall interface with RS contractor to get the relevant data of all types of wheels.
- 2.13.3.27 The machine shall have Swarf Crusher system to crush the longer chips.
- 2.13.3.28 Considering Keyambedu depot is situated at flood prone area, therefor the Contractor shall deign the machine vital components (PLC, sensor, electrical & control panel etc) at minimum height of 1m from floor level.

2.13.4 Operating Requirements

- 2.13.4.1 Machine performance and accuracy
- Turning Diameter : 1000mm (Maximum)
 - Table diameter : 1400mm(minimum)
 - Table speed (Infinitely variable) : 6 – 300 rpm
 - Working height under ram with tool holder : 600 mm(minimum)
 - Vertical travel of the ram head (Z-axis) : 600 mm

- Guiding parameters: Horizontal traverse of ram head 50/±750mm (X-axis traverse) to left/right of table centre
- Feed rate : 1 3000 mm/min
- Rapid traverse rate for X & Z axes : 5000 mm/min
- Accuracy of X & Z axis 0.012 mm over complete travel as per VDI/DGQ 3441 or latest
- Repeatability of X & Z axis 0.007 mm as per VDI/DGQ 3441 or latest
- Other parameters as per requirement shall be achieved

2.13.4.2 Surface finish achievable for various operations:

- For turning : 6.3 microns Ra or better
- For facing : 6.3 microns Ra or better
- For boring : 6.3 microns Ra or better

2.13.4.3 Surface finish required after machining for wheel disc shall be as follows:

- Hub bore : 1.6 microns Ra
- Hub face : 6.3 microns Ra
- Conicity : max 0.02 mm
- Out of roundness : max 0.02 mm

2.13.4.4 The finished bore must be perpendicular to the plane of the wheel and concentric with the tread of the wheel. Difference between any two readings shall not exceed 0.02mm, when hub bore is checked at any three points.

2.13.4.5 Different detailed dimensions and parameters of wheels, rough and finish, shall be furnished by the Rolling Stock Contractor during interface stage.

2.13.5 Productivity

2.13.5.1 The tenderer shall furnish the time required for various operations including mounting, machining, removal of the wheel discs and replacement of tools if any required during the cycle and based on these timings, the number of wheel discs that can be machined in one shift. The machine shall be capable of machining wheels with productivity of at least for 7-8 wheels discs in eight hours shift.

2.13.5.2 The floor-to-floor cycle time for complete operations of loading / unloading, clamping/de-clamping, machine setting, hub boring (rough & finish), hub facing including radius cutting (on top & bottom faces), inside rim face machining shall not exceed 60 minutes for a solid wheel. The floor to floor cycle time 60 minutes is considered assuming 5mm depth of cut for boring (rough plus finish cuts) and 3mm depth of cut for facing.

2.13.6 Other Characteristics

2.13.6.1 Wheel discs are of the single-piece type. The most of wheel discs machined on this machine will be of metro cars. The manufacture will have to ensure that wheel discs of all other types of rolling stock procured by CMRL can also be machined this machine. The wheel discs could be forged or rolled or even casted steel.

2.13.6.2 Tread and Flange Turning

~~The inner face of wheel shall be machined. The flange and tread shall be turned with CNC profiling. One turning operation shall be completed in one setting. Turning of bore, shall be possible with the same mounting arrangement.~~

2.13.6.3 Bore Machining

~~Machine shall have capability of Wheel boring, one side hub facing, and inside face machining in one setting only.~~

2.13.6.4 Wheel centering

~~The wheel shall be centered automatically in relation to the running table (outside diameter), machined in accordance with the standards in force. The bore axis of the wheel shall be concentric to the wheel tread within a maximum of 0.05mm tolerance.~~

2.13.6.5 Perpendicularity

~~The inside of the wheel shall be used as a reference for wheel straightening. The wheel bore axis shall be perpendicular to the inner side of the wheel and the maximum accepted tolerance shall be 0.05mm.~~

~~2.13.7 Machine Construction~~

2.13.7.1 Base

- ~~i. The machine bed should be made from a casting preferably. It should incorporate suitable design features for high damping, high rigidity and continued dimensional stability over the life of the machine i.e. thick wall, thermo symmetric feature optimum ribbing and full stress relieving. The casting should be made of stabilized cast iron as per Gr GG25/GG30 of DIN 1691 or equivalent JIS standards or ISO standard.~~
- ~~ii. The design of the bed shall be such as to provide the operator easy access for loading and unloading of jobs, gauging, tool changing and other related functions.~~
- ~~iii. An “acrylic” shield swing open or shutter type table guard (with glass and protecting bars) should be provided to protect the operator from flying chips coming out of the revolving table. Adequate clearance should be provided between the column and the table to ensure un-interrupted flow of chips.~~

2.13.7.2 Column

- ~~i. The table should be of a single column construction with thermo symmetric design to minimize thermal distortion of machine frame. Column shall be in cast construction as per IS:210 Grade FG 260, Gr GG25/GG30 of DIN 1691 or equivalent JIS standards or ISO standard. The column shall be of sturdy design to withstand heavy machining operations. It should be integral with the base or rigidly connected to it to ensure vibration free operation.~~
- ~~ii. The saddle guideways on cross rail should be hardened and ground or should be provided with steel plates of adequate thickness. The hardness of the guide ways should be indicated in the offer. Any other better arrangement for smooth movement of guide ways like LM guide ways from reputed make shall be considered.~~

2.13.7.3 Cross Rail

- i. ~~The cross rail shall be of fixed type. Widely spaced guide ways hardened and ground (to ensure square guidance of the head) and large front guide ways (to take and dampen the main cutting forces) shall be provided. The arrangement should ensure the highest accuracy and rigidity. The guide ways/slideways shall be properly lined with antifriction lining like tucite or hardened and ground steel plates of adequate thickness should be provided. Hardness of the guide ways or steel plates should not be less than HRC 58 +/- 2 & case depth of 1.5-2 mm. Any other better arrangement for smooth movement of guide ways like LM guide ways from reputed make shall be considered.~~
- ii. ~~The cross rail guide ways should be properly protected from ingress of dust and swarf. The wipers/telescopic covers shall be of reputed make.~~

2.13.7.4 Ram Head

- i. ~~The ram should be made of forged steel /cast iron. A ram head shall have enclosed type hardened and ground guide ways properly lined with antifriction lining like tucite or hardened and ground steel plates of adequate thickness should be provided. Hardness of the guideways or steel plates should not be less than HRC 58 +/- 2 & case depth of 1.5-2 mm. The grinding accuracy should be 4-5 micron/metre or better. Any other better arrangement for smooth movement of shall be considered.~~
- ii. ~~The tool holders shall be automatically clamped in the tool location of the ram head. The tool clamping system should provide high stiffness and tool change repeatability. Cutting forces should not influence the tool clamping. The ram head shall be hydraulically balanced.~~
- iii. ~~A 12 station automatic tool changer with a round disc type magazine (Floor mounted / cross rail mounted) shall be provided. Tool magazine movement shall be bi-directional. All the tool selection and transfer motors shall be completely automatic through CNC command.~~

2.13.7.5 Table

- i. ~~The table shall be capable of taking the thrust and radial loads under maximum feeds /speeds, depth of cut and thereby ensuring high degree of accuracy during the life of the machine.~~
- ii. ~~The table base should be stiff and rigid machine base with large space for mounting the machine column confirming to IS 210 or Equivalent international standard.~~
- iii. ~~The table should be supported on a precision preloaded antifriction bearing system consisting of thrust roller bearing for vertical loads and precision taper roller bearing for taking up radial loads. Bearing should be of reputed make. Re-circulating lubrication system shall be provided for the table bearings.~~
- iv. ~~A hydraulically operated 3 jaw self-centering chuck which can be controlled through CNC program as well as through a foot operated switch should be provided. It should~~

~~be possible to load concentric as well as non-concentric jobs on the table either with adjustable individual jaws on a 3 jaw self-centering chuck or with the help of a fixture directly mounted on face of the table.~~

- ~~v. “Clamping and resting arrangement for wheel disc on the base should be such that wheel disc should not lift upwards while clamping through jaws”.~~
- ~~vi. The foot-operated switch should be ineffective while machine is working in CNC mode. It should be possible to adjust chucking pressure according to the job requirements.~~
- ~~vii. The radial chuck jaws shall be of quick setting type and include an arrangement for independent micro-adjustment to maintain concentricity without re-grinding.~~
- ~~viii. The clamping operation should be electrically/ hydraulically interlocked so that the table cannot be started when chuck jaws are unclamped.~~
- ~~ix. Table should derive its rotation from the variable speed AC spindle motor through a two stage gearing. The drive shall be further transmitted through flat belt & a two speed gearbox. The speed range selection shall be through CNC system. Electric safety limit switch should be provided so that table does not rotate unless range selection has been completed.~~
- ~~x. The table drives elements such as pinion and gears should be made of Nickel chromium steel such as 18 Ni Cr Mo7 (as per DIN grade) /20 MnCr2/15 CrNi6 or Spec/VTL/R3/05-04-2023 equivalent ISO grade. The gear should be of helical type and should be hardened (preferably induction) and ground. The hardness value should be HRC 58 +/- 2. The accuracy of gearing should be preferably DIN6 class or better.~~
- ~~xi. Suitable dynamic or regenerative braking for quick stoppage of the table should be provided. Table drive elements such as Pinion & Gear should be properly lubricated.~~

2.13.7.6 Feed

- ~~i. Adequate speed and feed ranges should be provided for machining different components.~~
- ~~ii. The feed drive for vertical movement of the ram head and cross movement should be through hardened and ground precision pre-loaded re-circulating ball screw of G3 class or better of adequate diameter. The ball screws should be supported on both ends by precision bearings.~~
- ~~iii. The size, precision level and class of ball screws should be reputed make. The feed movement should preferably be transmitted from the motor to the ball screws through a direct coupling overload safety interlock or other latest device ensuring protection of machine elements.~~
- ~~iv. The complete range of infinitely variable speed shall be operative for table movement and programmable over the entire range to ensure optimal cutting speeds. It shall be possible to change the speed while machining is in progress by override.~~

2.13.7.7 Drive

~~Feed drives for ram slide vertical and cross movements should be from digital control AG servomotors. The servo motor and associated control systems should be of the same make as that of CNC control system. The motor should be provided with inbuilt rotary encoders.~~

2.13.7.8 Work Light

~~A lighting unit for illumination of the working area should be fixed at a convenient location. The provision shall not have any stroboscopic effect. The minimum illumination at work/tool interface should be 400 lux or higher.~~

2.13.7.9 Measuring System

~~The machine should be equipped with a suitable error actuated closed loop feedback system to ensure accuracies specified in tender. Suitably designed encoder of reputed make should be provided to register slide positions within fine limits, commensurate with the requirement of the control system. The Contractor shall furnish the details of means provided for protection of linear scales during design stage.~~

2.13.7.10 Chip Conveyor

~~The machine should be provided with a suitable motor driven swarf conveyor system for collection and removal of swarf from the machine without stopping it. The chip conveyor capacity should be adequate to cater for maximum metal removal rate. There should be provision to start and stop the conveyor either by manual mode or CNC Part programme. The chip conveyor should conform to relevant DIN/ISO specifications. The system should be designed in such a way that the coolant is completely drained off from the swarf without carrying any residual contents along with it to the coolant tank.~~

2.13.7.11 Hydraulic System

- ~~i. System should be provided with suitable in-line gas accumulators, to safeguard against pressure surges and chucking jaws to hold the job while machining in case of hydraulic failures.~~
- ~~ii. The pump aggregate should be provided with suction side filter having filtration capacity up to 125 microns or less at the inlet of the pump. Line filter capacity should be 25 microns or better for the return line filter.~~
- ~~iii. A magnetic drain plug at the lowest portion of the tank should be provided. The tank should be located on such a way that oil can be drained without disconnection of pipes. The tank shall be provided with topping up arrangement and dip stick.~~
- ~~iv. Suitable filters should be provided to ensure clean supply of oil. Re-usable filter after due cleaning will be preferred. These filters should be located at easily approachable points.~~
- ~~v. Acoustic covering shall be provided for hydraulic unit so that sound should not cause inconvenience to operator.~~

2.13.7.12 Lubrication

~~An automatic lubrication system covering all the bearings, driving gears, feed screws, guide~~

~~ways of the cross rails, saddle and sideways and all other moving parts and components should be provided. Details of the lubrication system offered shall be furnished during design stage. Protection against over pressure and low lube Oil pressure should be provided.~~

2.13.7.13 Tooling

- ~~i. Complete pre-set tooling/qualified tooling to cover machining requirement should be supplied with the machine. Details of tooling including tool post, boring bars, tool holders, and throw away carbide tipped, inserts their grades should be furnished during design stage. Tooling shall be designed to automatically break the chip to restrict the chip length.~~
- ~~ii. Tool holders and cutting tools offered should conform to ISO standards and should be from Indian proven reputed manufacturers having vast network of sales and service organization in India as well established design and research.~~

2.13.8 Control Panel

- ~~2.13.8.1 CNC Control system should be proven make and of latest version.~~
- ~~2.13.8.2 The CNC and electrical control equipment cabinet for the machine should be provided with compact air conditioning equipment consisting of filter, fan, de-humidifier and temperature control. The system should be capable of withstanding ambient temperature conditions up to 50-degree C. The air conditioning system should be equipped with environment friendly refrigerant.~~
- ~~2.13.8.3 The control panel should be from reputed make and have minimum degree of protection minimum IP-55.~~
- ~~2.13.8.4 All apparatus, terminal strips and metal parts of the control panel shall be connected to the earth circuit.~~
- ~~2.13.8.5 Each electrical cable shall be carefully marked in accordance with the electrical diagram.~~
- ~~2.13.8.6 The supply, wiring and installation of these control panels is the responsibility of the Contractor. This includes the control panel links, terminal strips, and centralizing apparatus of the machine and equipment switchboard.~~
- ~~2.13.8.7 The reports that are stored in the machine hard drive shall be possible to be exported to an Industrial laptop/ microcomputer via interface software with hardware like USB port (wired) and as well as thru Wi-Fi (wireless).~~
- ~~2.13.8.8 All panels shall be designed to accommodate ambient temperature and humidity conditions, by having heating cum compact air conditioning systems of reputed makes only.~~

2.13.9 Electrical Equipment Switchboard

- ~~2.13.9.1 Key lock doors shall provide access to apparatus and gear located inside the switchboard, i.e. electrical protection equipment, relays etc. The switchboard shall have ingress protection of minimum IP55 protection. In addition, the switchboard shall include:~~
 - ~~• one general isolating switch with an external lockable control with door open,~~
 - ~~• one differential general circuit breaker,~~

- ~~circuit breakers including magnetic/thermal protection relays for each motor, operating on all three phases;~~
- ~~one control transformer (for the control circuit) protected by fuses on the primary circuit and the secondary circuit.~~

~~2.13.9.2 All outgoing cables shall be grouped on a generously sized terminal strip located at the bottom of the switchboards and accessible from the front. Terminals, cables shall be appropriately identified with their functions in accordance with the diagrams to be provided.~~

~~2.13.9.3 The characteristics of the electrical cables, power and control, shall be specified by the Contractor. All electrical cables shall be FRLS or better type.~~

~~2.13.9.4 A compartment shall be provided in the cabinet to accommodate complete diagrams.~~

~~2.13.9.5 The switchboard and door earth shall be connected to the earth. The inside of the switchboard shall be illuminated with filament/fluorescent tubes controlled by door opening.~~

~~2.13.9.6 A power socket shall be installed with a supply separate from that of the switchboard for soldering iron, lighting, charging etc.~~

~~2.13.9.7 Connectors for peripheral links shall be secured to the outside of the switchboard.~~

~~2.13.10 Chips Guard~~

~~— A chips guard will be mounted as close as possible to the machining station and will prevent chips from flying around the workstation. The guard shall be designed so that the operator can monitor the machine in operation.~~

~~2.13.11 Calibration~~

~~— The contractor shall preferably provide the calibrations test piece to check machine's all intended functions along with the documents mentioning details procedures for calibrations.~~

~~2.13.12 Handling System~~

~~A complete loading and unloading system for wheel shall be provided with the machine.~~

~~2.13.13 Chip Crusher~~

~~2.13.13.1 An integrated chip crusher of proven design shall be provided to crush the chips produced from turning the wheels to small chips with a maximum length of 100 mm.~~

~~2.13.13.2 The chip crusher shall be capable to handling a volume of chips produced under any machining condition of the machine.~~

~~2.13.13.3 The crusher shall be a box type steel casing with number of high grade special steel blades running at slow speed. It shall be mounted under the machine hopper. The construction of a linking duct between this hopper and the crusher shall form part of the supply.~~

~~2.13.13.4 The structure of the crusher shall have strength for long lasting operation without denting and deformation. The plate thickness shall not be less than 3 mm.~~

~~2.13.13.5 Atleast 5 numbers chip bin trolley shall be provided to store and transport the chips from one location to another location in the depot.~~

~~2.13.14 Remote diagnostic system~~

~~The control system shall be provided with a wide remote diagnostic of the operating conditions for the machines tool & its equipment diagnostic as well as the information on the actions necessary to be performed. The CNC system shall be equipped with own~~

~~diagnostic procedures. The machine tool operating condition shall be checked during power on test. Remote diagnostic feature for Data exchange between machine and nominated service department of manufacturer in case of machine break down or any other malfunction of software or hardware is required internet connection(Wi-Fi /wired).~~

~~2.13.15 Protection and Safety provision:~~

- ~~2.13.15.1 Removable protection systems and guards shall be mounted around all moving parts.~~
- ~~2.13.15.2 Safety devices shall be mounted on doors giving access to dangerous components.~~
- ~~2.13.15.3 General emergency pushbuttons shall be mounted at each end of the machine and at the workstation.~~
- ~~2.13.15.4 The machine shall be provided with suitable interlocking against:
 - ~~• Retraction of tools in case of sudden power failure~~
 - ~~• Faulty tool changing operation~~~~
- ~~2.13.15.5 When feed hold is 'ON' all slide motions are to be inoperative.~~
- ~~2.13.15.6 Software limit switches are to be provided to restrict the total slide travel, maximum feed velocity and maximum spindle speed. Hardware features should also be available for controlling the above movements.~~
- ~~2.13.15.7 Improper job clamping in the spindle nose should inhibit spindle rotation and error is to be displayed on the control screen.~~
- ~~2.13.15.8 The work piece should not get unclamped in the event of power failure or an emergency stop.~~
- ~~2.13.15.9 Load meter should be provided to indicate the load on spindle drive motor, so that the load on the motor can be maintained within the safe limits. The safe zone should be indicated in green colour, the danger zone in red and intermittent zone in yellow colour.~~
- ~~2.13.15.10 When any of the machine functions like spindle rotation, slide movement etc. come to a stop without being programmed to stop, the machine should come to a stop and should be operative only in the manual mode till the fault is rectified.~~
- ~~2.13.15.11 In case of failure of powered clamping system or sudden power failure, a suitable safety interlock system should be provided to prevent loosening of chuck jaws when table is rotating.~~
- ~~2.13.15.12 Safety against ingress of Swarf on all sliding surfaces.~~
- ~~2.13.15.13 All operating controls should be located preferably on a swivel able pendent or positioned within easy reach of the operator and should be of push button type clearly colour coded and marked with user friendly symbols.~~
- ~~2.13.15.14 Suitable interlocks should be provided to protect the machine in the event of hydraulic oil failure, lubrication failure, coolant failure, pneumatic system failure, fluctuation in voltage and frequency.~~
- ~~2.13.15.15 The safety feature shall include safety device against over loading of any drive, over travel of any slide and interlock against conflicting motion.~~
- ~~2.13.15.16 Mushroom type emergency stop shall be provided on the machine, which shall be easily accessible and capable of disabling the machine, drives in case of any emergency.~~
- ~~2.13.15.17 Suitable tool condition monitoring arrangement may be provided with the control system to protect the job surface against failure of tools due to wear, breakage and accidental removal.~~
- ~~2.13.15.18 Status of all interlocking should be displayed on the machine screen, if machine is operated in manual mode. After proper interlocking only, the operator to be permitted to start the operation.~~

~~2.13.16 Interface:~~

~~The Contractor shall refer Interface matrix / specification Chapter 3 Section VIB Part 2 for the interface with other system Interfacing Contractors for Vertical Turning Lathe.~~

~~2.13.17 Standard:~~

~~Work related to the design and manufacturing of the Lathe shall comply with relevant international standard or equivalent Indian standards, Codes of Practice and the latest statutory requirements of India including as mentioned in General requirement and scope Chapter 1 Section VIB Part 2 but not limited to.~~

2.14 Tunnel & Track Cleaning Vehicle

2.14.1 Purpose of the machine:

The Tunnel and Track Cleaning Vehicle (TTCV) is required for cleaning / washing of the tunnel (all directions) as well as the track bed of elevated sections and the depot areas when required for CMRL phase 1&2 track network.

The TTCV will also be used for Vacuum Cleaning of the track bed throughout the network. The TTCV shall be an automated high-end product that integrates mechanical, electrical, electronics, pneumatic and hydraulic components. The TTCV shall be driven on rail as well as on the road.

2.14.2 Scope of Works:

The Works, shall include but not limited to the following scope:

2.14.2.1 Design, Manufacture, Supply, Testing & Commissioning of the TTCV.

2.14.2.2 Training of nominated CMRL O&M staff for operations and maintenance.

2.14.2.3 The Contractor shall provide all necessary support to allow CMRL to obtain Speed Certification for the TTCV from any relevant statutory authority / RDSO.

2.14.2.4 The Contractor shall get the TTCV vehicle registered in the name of CMRL in the applicable RTO (Regional Transport Office) of Tamil Nadu. Cost of registration of vehicle shall be borne by the Contractor.

2.14.2.5 The Contractor shall be responsible for all recurring and non-recurring costs required to keep the TTCV vehicle eligible to travel on public roads throughout the entire duration of the Project Periods. This shall include but not be limited to vehicle fitness, permit, Insurance, pollution certificate and any taxes payable.

2.14.2.6 Provision for the installation of a Mobile Radio Device shall be provided in driver's cab. The Telecom & Radio Contractor shall supply the Radio Device and will coordinate with RRV Contractor for installation, testing and commissioning.

2.14.2.7 The TTCV shall be designed and manufactured in India.

2.14.2.8 Operation of TTCV shall be carried out by CMRL upon issuance of Taking Over Certificate.

2.14.3 Reference Data of Track

The TTCV shall be operated with pay load on the tracks with the following specifications. The track specification may however vary, and the Contractor shall obtain the details/clarification during design stage/approval.

Track Gauge	1435 mm (Standard Gauge)
Curve radius	Main Line 120 m, Depot 100m, Viaduct 120m, Tunnel 200m
Turn Out	1 in 7 and 1 in 9
Max. Gradient	4%
Max Permissible Cant	125mm
Inclination of Rail	1 in 20

Note: The above data are indicative only & actual data for phase 1&2 will be supplemented during detailed design stage

2.14.4 General Design Requirements :

The TTCV shall be powered by a suitable engine of adequate capacity. The rail-to-road and vice-versa changeover functions shall be easy and effortless. The Contractor shall be responsible for the design of the TTCV and any other equipment considered essential for satisfactory operation of vehicle, which shall include but not be limited to the following:

2.14.4.1 Engine:

- vi. EURO VI/ Bharat Stage VI standard or better standard as applicable during the time of registration.
- vii. Electronic accelerator, hand throttle and governed max speed.
- viii. Adequate cooling system for Engine.
- ix. Noise dampening arrangement as per EU regulation 70/157/EU or equivalent as applicable in India.

2.14.4.2 Transmission:

- iv. Synchromesh reversing transmission equipped with gear box inverter or fully synchronized automatic transmission.
- v. Right Hand Steering wheel to suit left hand driving practice in India.
- vi. Forward and Reverse gear arrangement.

2.14.4.3 Suspension

- i. Suspension system shall be suitable for all condition of operation on road and rail.
- ii. Necessary calculations shall be furnished during the design stage to justify the stability of the TTCV vehicle during run at the maximum speed in both condition i.e rail and road mode.

2.14.4.4 Chassis:

- vi. Designed to withstand an overload condition of 25% of payload capacity and shall be capable of withstanding the maximum static and dynamic stresses under loaded conditions.
- vii. The under frame shall be fitted with towing hook at both ends (front & rear) of the TTCV vehicle similar to towing hook provided in road truck.
- viii. Fuel tank lockable of light material having adequate capacity for movement of TTCV vehicle for at least 150 kms of running on rail or road whichever is higher while non-washing/cleaning operation.
- ix. Anti-slip steps with handle for wind shield cleaning shall be provided at a suitable location.

2.14.4.5 Electrical System:

- iii. Low Maintenance Batteries (capacity as per requirements),
- iv. Centrally located electric box, protected within cab.
- v. Suitable capacity alternator/dynamo
- vi. Individual horn for Rail (pneumatic pressure horn /electrical horn) and Road mode.

2.14.4.6 Driver's Cab /Personnel Compartment shall consist minimum (but not limited to):

- xiii. Robust, fully weather and waterproof when closed.
- xiv. Cab / Personnel compartment for accommodating 3 persons including the TTCV driver.
- xv. Access door for Cab on both sides with safety lock. The access door shall be designed suitable to meet the requirements of its functioning inside tunnel / mainline.
- xvi. Height of the Cabin including other accessories mounted on TTCV vehicle shall not be more than 3500 mm above top of rail while in rail mode. The width of TTCV Vehicle with all accessories shall be within 2800mm.
- xvii. Large storage compartment under dashboard,

- xviii. Storage area behind driver's seat / rear cab wall,
- xix. Provision of speedometer-recorder,
- xx. Driver's seat height tilt, backrest tilt and longitudinal adjustable,
- xxi. Large rear window,
- xxii. Air Conditioning of driver's cab and personnel compartment for prevailing ambient temperature up to 45 °C,
- xxiii. Interior lighting with reading light for driver and accompanying staff,
- xxiv. Effective windshield with wind-shield wipers, 3-setting with intermittent setting and windshield washer,
- xxv. All Seats cushioned & Leather material, and with integrated safety belts,
- xxvi. Sun visors

2.14.4.7 Instruments:

- vii. TTCV shall have electric controls located in centre console preferably,
- viii. Adjustable dashboard illumination,
- ix. Multi-combination lever,
- x. Functions of the Levers on left and right Side of Steering Column shall consist of hand throttle, exhaust brake, headlight beams, blinker, windshield wash / wipers, and horn etc.
- xi. Large instrument panel LCD/LED displays, and gauge shall indicate the minimum following configurations but will not be limited to:
 - a. gauges for Speedometer kmph, RPM,
 - b. brake reservoir pressure,
 - c. coolant temperature,
 - d. fuel level, hydraulic oil temperature,
 - e. differential locks, brake pad wear,
 - f. coolant level,
 - g. steering fluid level,
 - h. air filter maintenance,
 - i. engine oil level,
 - j. windshield wiper fluid level,
 - k. transmission gear,
 - l. service hour counter,
 - m. Km and trip Km counter, clock, etc.
- xii. Vehicle shall have facility of GPS based location monitoring system, which shall enable location monitoring of the vehicle from Depot Control Centre / Operation Control Centre.

2.14.4.8 TTCV shall be fitted with Lights* as follows (but not limited to):

- xi. Dual Lighting System (Road- Rail): The vehicle shall have preferably 2 ways of lighting system with automatic change over when the vehicle changes from road to rail and vice-versa. When driving on rail, the vehicle uses specific light for rail driving and when on road it shall use the obligatory lights for road driving.
- xii. Headlights,
- xiii. Headlight range adjustment,
- xiv. Additional side indicators,
- xv. Clearance lamps,
- xvi. Blinkers,
- xvii. Rear lights,

- xviii. Fog lights,
- xix. Rear reflector reversing light,
- xx. Emergency Light on the cabin of truck.
- xxi. Front and Rear working lights to illuminate the working area.
- xxii. 2 rotating warning beacons in orange shall be provided at front and rear separately.

*All above Lights shall be of LED types.

2.14.4.9 Speed

- iii. Maximum Running speed (Forward) on roads ≥ 80 kmph,
- iv. Maximum Running speed (Reverse) on roads ≥ 10 kmph,
- v. Maximum Running speed (Forward & Reverse) on rails ≥ 30 kmph while non-cleaning mode with full load.
- vi. Slow speed shall be adopted while Vehicle running on rails in Cleaning/Washing mode to enable adequate wash preferably to speed of 3-5 kmph.

2.14.4.10 TTCV Vehicle shall be equipped with minimum following Accessories & Tools:

- xvii. Suitable number of cameras in the rear of vehicle and coloured monitor screen in the driver's cab for reverse direction movement,
- xviii. Air bags for driver cabin (for driver and co-driver)
- xix. Rear mounting brackets,
- xx. Spare Wheel,
- xxi. Battery main switch at battery box,
- xxii. Fine dust and pollen filter,
- xxiii. First aid box,
- xxiv. Wide angle rear mirror,
- xxv. Fire extinguisher, ABC Type, 5 kg - 2 Nos. with bracket,
- xxvi. Air filling hose with manometer,
- xxvii. Hydraulic jack -suitable capacity,
- xxviii. Warning triangle,
- xxix. Signal lamp,
- xxx. Portable Search light 2 Nos with rechargeable spare batteries.
- xxxi. 2 nos. of tri-colour torch,
- xxxii. On-board tools, wheel chokes.

2.14.4.11 Hydraulic hand pump:

Hydraulic hand pump of suitable capacity shall be provided for emergency operation of rail guidance system in case of failure of vehicle hydraulic system.

2.14.4.12 Earthing:

Earthing connection shall be from the mounting parts to the vehicle frame. It shall be connected to flexible Copper-cable with one ball pin at the front side and one at the rear side of the vehicle.

2.14.4.13 Exhaust , silencer and pipe work shall be flexibly connected. Exhaust discharge shall be along with track while vehicle is running on rails and shall meet the emissions standard regulations in vogue.

2.14.4.14 Super Structure:

The complete vehicle with its cabin, water storage tank, pump, water sprinkler, vacuum system and other associated accessories shall be designed to conform to the Kinematic Envelope of the respective SOD for both CMRL Phase-I and CMRL Phase-II.

2.14.4.15 Bodywork construction:

- iii. Bodywork construction (including cabin & chassis) shall be of proven material which shall provide adequate strength and protected from the corrosion.
- iv. The Contractor shall justify the selection of material and construction in the design stage.

2.14.4.16 Coupling System:

- v. For rail mode, one number suitable coupler adopter / head to match Rolling stock couplers of multiple types shall be provided along with a tow bar to rescue the TTCV with another rail borne vehicle in case of emergency. The coupler with its tow bar shall be detachable type and shall be used at both ends of vehicle for shunting by another vehicle. The TTCV Contractor shall interface with rolling stock Contractor for the coupler type / details.
- vi. Height of coupler shall be manually adjustable if required to match with automatic coupler height of rolling stock or any other rail vehicle for proper coupling.
- vii. For Road mode : The TTCV shall be equipped with cranked tow bar with flange or any other proven arrangement as per industry standard at both ends (Front and Rear) to tow the vehicle in the event of failure.

2.14.4.17 Design Requirements of Vacuum and Washing System

- i. The TTCV shall be equipped with suitable Vacuum and Washing system (i.e Multiple Water Jet)
- ii. The Vacuum System shall vacuum and remove debris (including grinding dust, carbon dust and metallic dust from the steel wheel/rail contact etc) on the track bed preferably before commence washing of the tunnel and track bed.
- iii. The Vacuum System shall include a container, adequate suction hoods and a hydraulically driven fan for the suction unit.
- iv. During the suction procedure, blow air shall be used to loosen dirt which is then taken up by high suction force. The blow air shall be produced by a compact air compressor, which do not need additional reservoirs. The blowing jets are mounted in front respectively behind the suction hoods.
- v. The suction of debris from the track bed is required to store in a container mounted on truck chassis. The fan unit shall produce the necessary vacuum to suck loose dust/debris . The suction performance of the system shall be rated to remove all accumulated loose material on track bed, while operating at the working speed in cleaning mode. The Vacuum System shall be able to remove minimum 90% of the dust/debris at the track bed.
- vi. The Suction hoods shall be selectable to be lifted and lowered individually.
- vii. A handheld suction hose shall be provided for the manual cleaning of critical area (including near frog areas in the turnouts and crossings etc)
- viii. The TTCV shall be equipped with a high-pressure water jet cleaning system for the cleaning of UIC rail tracks & fastenings, Tunnel walls both sides, catenary area, Tunnel cross passages, Track bed etc
- ix. The Contractor shall ensure that cleaning equipment offered and installed on the TTCV provides a complete working system for track and tunnel cleaning.
- x. A fully laden TTCV with water storage tanks filled to capacity shall not exceed the axle load limit of 16 tonnes.
- xi. The TTCV shall be equipped with PTO (Power Take-Off) to power the auxiliary equipment mounted on vehicle (High pressure Water pump(s), Vacuum System etc). Control to operate PTO shall be provided inside the driver's cabin.
- xii. The water pump(s) proposed shall be of robust design, fit for the purpose and have sufficient capacity to provide a maximum output at each water jet nozzle.
- xiii. A suitably rated pressure gauge shall be provided to measure pump(s) output pressure.
- xiv. Adequate numbers of Water jet nozzles shall be mounted on stainless steel mounting brackets of a robust design.
- xv. The mounting angles of all Water jet nozzles shall be manually adjustable.

- xvi. The cleaning units shall be controlled from the control panel in the driver cabin.
- xvii. The water tank shall be located at rear of driver's cabin. The capacity of water tank shall be at least 10000L. The tank, pipes, fitting etc shall be made of Stainless steel at least 316L grade. The design consists of cellular construction providing the water tank with high rigidity.
- xviii. Adequate number of suitably designed baffles shall be provided inside the water storage tank to prevent rapid and excessive movement of water inside the tank during acceleration, movement up to designed speed and braking.
- xix. The water storage tank shall be pressure tested to 200% of the designed pressure while static and running on road & rail at a maximum speed.
- xx. Adequate number of suitably designed filling point(s), tank vent(s) and drain valve(s) shall be provided to reduce time required for filling and drainage to a practicable minimum.
- xxi. Quick coupling shall be provided at both sides of the tank to connect the filling hose.
- xxii. Tank opening (Min diameter 600mm) with lockable cover shall be provided at top of the Tank.
- xxiii. The water filling level Indicator of tank shall be provided in the driver cab for the effective monitoring.
- xxiv. One removable handheld water jet cleaning gun with pump shall be provided at rear end of TTCV with at least 10m length of hose for manual cleaning tasks. The cleaning guns shall be stowed in an appropriate location when not in use.

2.14.5 Requirements Specific to Bogie Drive (BD) Type TTCV Proposal:

- i. The TTCV shall incorporate rail drive and guidance system which shall ensure that the vehicle can be operated on rail with maximum payload and including simultaneous cleaning operation in a safest way.
- ii. The TTCV movement over rail shall be through a bogie system (each bogie consists of 2 axles arrangement) both in front and rear, and with driven rear bogie pivoting in order to facilitate on tracking on level crossing. The driven rear bogie shall be pivoting approx. 180 degree (2 x 90 degree).
- iii. The rail wheels shall be directly driven from the suitable engine through reliable hydraulics/electrical motors with adequate safety margins.
- iv. The bogie frame shall be welded construction with swivel frame and mounting brackets. The mounting bracket shall be welded with mounting frame. The welded structure shall be adequately tested.
- v. The profile of rail wheels shall conform to equivalent UIC standard. The Contractor shall get the required wheel profile data from CMRL during design stage.
- vi. The rail wheels shall be solid cast/forged wheels preferably shrink fitted.
- vii. The rail bogie drive shall be raised or lowered by controls in the driver's cab by means of swivelling frame with pressure controlled hydraulic cylinder system.
- viii. The operation of rail guidance system shall be achieved hydraulically and shall be operated by control mounted in the driver's cab.
- ix. The brakes shall be provided in each rail axle with brake disc integrated and enclosed inside the rail axle housing or any other equivalent braking system. The brake activation shall be by means of standard foot brake pedal .
- x. In addition there shall be a Spring Applied Parking Brake (SAPB) acting on rail axles activated through standard parking brake lever in the cab. This shall comply with the SAPB requirements described in Clause 2.6(i).
- xi. The bogie shall be suitably designed for speed ≥ 30 kmph on rail in both directions.
- xii. The hydraulic supply shall be through electrically operated hydraulic valve system for lifting and lowering motion of the rail driven system and pressure supply through pump combination at vehicle engine Power Take Off.
- xiii. The details of bogie drive system shall be furnished during the design stage.
- xiv. Vehicle shall be provided with suitable braking system for stopping the vehicle on road within

- the stopping distance as stipulated for heavy road trucks. The service brake of vehicle shall be of vacuum assisted hydraulic, drum brakes with tandem master cylinder and auto slack adjuster. Braking shall be power assisted.
- xv. Vehicle shall be provided with proven brake system to ensure that emergency braking distance at 30 kmph speed under loaded condition is within maximum 40 meter on level section while running on rail in dry and wet condition. Pressure gauge shall be provided at suitable location.
 - xvi. Provision of cameras and monitor inside the cabin for ease in checking of proper positioning of rail wheels to help the driver in changeover from road to rail operation,
 - xvii. Locking of steering wheel in rail mode,
 - xviii. Locking of rail axles against lowering during road operation,
 - xix. The hydraulic system shall be provided with constantly pressurized control valves for maximum safety against derailment in every driving situation.

2.14.6 Protection and Safety

The Vehicle shall be incorporated all safety devices so as to provide complete protection to operating staff and vehicle from all possible operational failure. Minimally, the TTCV vehicle shall have (but not be limited to) the following safety features :

- i. Spring Applied Parking Brakes (SAPB) shall be rated to meet the following requirements in when the TTCV vehicle is in a fully loaded condition:-
 - a. **On Track:** shall hold the vehicle indefinitely on a max gradient of 4%
 - b. **On Road:** shall hold the vehicle indefinitely on a max gradient of 15%
- ii. All moving parts shall be securely guarded.
- iii. Hydraulic hoses shall be capable of working safely at pressure up to double the normal operating pressure.
- iv. Pipes and hoses shall be properly secured to avoid rubbing and vibrations.
- v. Protection against any hydraulic cylinder pressure failure.
- vi. Fail safe brake system shall be provided in the event of failure of hydraulic/pneumatic system.
- vii. Diesel engine shall be shut down or brought to idling speed in case of : Engine speed too high, Cooling water temp too high, Radiator water level too low, Transmission oil temp too high, Low Lube oil etc.
- viii. The Vehicle shall be fitted with a protection system to automatically shut down driven water pump(s) to prevent damage due to low water level in the water storage tank.
- ix. The protection system shall also activate an audio and visual alarm which shall be audible and visible to the equipment operator on the TTCV.
- x. Suitably rated filtration devices shall be provided to minimise the risk of excessive wear and damage to high pressure water pump(s) and clogging of water jet nozzles.
- xi. The water pump(s) shall be fitted with protection features to prevent damage and overheating.
- xii. Full details of all safety features shall be provided during the design stage and demonstrated at site during testing and commissioning.

2.15 Driver Desk Simulator

2.15.1 Purpose of the machine

The Driver Desk Simulator (without motion system) shall be required to provide a realistic immersive experience for the trainee with accurate representation of the visual, audio and actual functionality of the train & associated systems for the lines being simulated. The simulator shall be multipurpose, and desk controls shall be designed for atleast 2 types of rolling stock (existing and new Rolling Stock), at CMRL phase-1 corridors/Lines.

2.15.2 Scope of Works

2.15.2.1 Design, Manufacture, Supply, Installation, Testing & Commissioning of Driver Desk Simulator (Multi-Purpose - without motion) alongwith Instructor station & Observer station at Koyambedu Depot of CMRL phase-I. The Simulator shall be desk type. The supply shall include all equipment and accessories including UPS etc, required to make the machine fully functional when connected to a power source.

1 2.15.2.2 Driving console (with single cabin) – multipurpose driving console similar controls as provided in the Rolling Stock.

2.15.2.3 Minimum 46” LED touch screen monitor (HD), suitable for displaying Computer Generated Graphic Images (CGI). To display the general operating simulation screen including a rail video.

2.15.2.4 Virtual panels for fault troubleshooting.

2.15.2.5 Programmable sound system to simulate the train movements. High quality headset shall be provided for machine with volume control.

2.15.2.6 HD video camera with recorder for recording video of workstation. Provision for indexing and storage of the video footage of the trainee in suitable compact state-of-the-art (both fixed and portable) storage devices.

2.15.2.7 Provision for communication (voice & text) with other station/ Instructor station.

2.15.2.8 All controls and indicators including the functional interfaces with other onboard subsystems e.g. Signalling & Telecommunication

2.15.2.9 Simulator Controller shall record not only the video images/files but shall also create “Response” file with log of the actions initiated by the trainee in response to each fault/condition loaded.

2.15.2.10 Simulators covering up to 15 different scenarios such as coupling, rescue operation, isolation of defective equipment, evacuation of passengers in the section etc. shall be provided with animation, graphics, flow chart and simple to explain instructions.

2.15.2.11 Instructor station & Observer station

2.15.2.12 Representative vehicle control circuit & representative pneumatic circuit

2.15.2.13 Suitable furniture as required.

2.15.2.14 Any other accessories to make the machine fully functional

2.15.3 General Requirement and provisions

2.15.3.1 The simulator shall facilitate programming weather events such as fog, rain, cloudy weather, sunshine and night conditions. These scenarios should be programmable both at the beginning and during the execution of any exercise depending on time of day and continuity of an exercise.

2.15.3.2 It shall simulate elevated, undergoing, at-grade sections and the depot with full realism to simulate the actual terrain, and features of landscape during day, night, morning and evening conditions.

2.15.3.3 Capable of training on nominal and the degraded mode scenarios.

2.15.3.4 The programmed weather shall have a realistic effect on the behaviour of the rolling stock

such as wheel slip/slide etc.

2.15.3.5 The simulator shall have different lighting levels, including glare.

2.15.3.6 The simulator shall have a wide variety of passengers who each behave differently and who get on and off the rolling stock and wait on the platform (children, elderly people, people with pushchairs, etc.)

2.15.3.7 The simulator shall facilitate efficient driving training and will generate driving parameters through graphs which can also be compared with parameters from other standard exercise.

2.15.3.8 Suitable capacity UPS, server and networks.

2.15.3.9 Exhaustive library of images for generating CGI. The library shall be expandable in future.

2.15.3.10 Exhaustive Operation exercise for the train operator and Rolling Stock controllers.

2.15.3.11 Exhaustive troubleshooting directory covering all major equipments, complete with standard expected response for faults upto two hundred (200) Nos. to be included.

2.15.3.12 Provision shall be available with increasing the number of faults with facility for editing / augmenting the fault scenario.

2.15.3.13 Suitable package with Interactive graphics shall be provided for indicating the exact location of any component on the train. Detailed instructions (with graphics interface) shall be provided to enable access to the specified component.

2.15.3.14 Data Base Management System for organizing the detailed record trainees response and evaluation thereof.

2.15.3.15 Complete software package of all the functions covering list of faults and fault activation & response thereon.

2.15.3.16 The simulator shall be capable of providing advanced and detailed training to improve:

- i. Driving techniques of train operators.
- ii. Troubleshooting technique of train operators
- iii. Preparing the train for service (in depot / designated stabling point on main line and removing the train from service including starting and stopping the train etc).
- iv. General development of train handling skills
- v. Operation of the train under normal service conditions in all operating modes, while adhering to rules, signals, timetable and efficiency objectives
- vi. Training of accurate station stops, Cab change and time optimisation
- vii. Route familiarization
- viii. Correct response to train failures and efficient troubleshooting capabilities
- ix. Coupling and uncoupling of trains and movements related to rescue operation of a failed train.
- x. Boarding and de-boarding of passengers including accurate stopping of trains at platforms and nominated stopping points during reversals.
- xi. Correct and safe response to critical situations, emergencies and abnormal situations.
- xii. Others as applicable shall be detailed during design stage and shall be implemented by the Contractor without additional cost.

2.15.4 Design Requirements

2.15.4.1 Driving Console and Controls

- i. The driving console and controls alongwith screen shall be equipped inside a covered cabin/enclosure.

- ii. The desk controls shall mean generally similar equipments set of cab controls and indications as provided in the RS and shall be highly realistic in terms of audio-visual fidelity.
- iii. The multipurpose driving simulator shall be able to simulate at least a minimum of two types of rolling stock models at CMRL Ph-1 corridor.
- iv. The change of controls if required, from one rolling stock to another must be done without the need for any tools and with the utmost simplicity.
- v. The system shall have automatic detection of incorrect control boards/console, so that it will not be possible to simulate any train with incorrect installations.
- vi. The system shall have a metro driver's seat.
- vii. There shall be trainee-passenger, trainee-control center and trainee-instructor communications for action/communication protocols that improve training. The simulated on-board communication system shall be made using the same elements and in the same way they would in a real RS cabin. The instructor shall play the roles of ticket officer, control center and instructor as required.

2.15.4.2 Audio-Visual System

- i. The display system will replicate the frontal view of the scenario using one current generation LED TV (HD) with at least 46-inch and with computer-generated images (CGI) is required. Hardware architecture shall be PC-based
- ii. The forward view visual system shall include, dynamic cloudy, stormy, rainy and foggy weather and heat haze and the time of day, which shall vary from daylight to dusk to night.
- iii. The left and right-side cab window view shall be suitably simulated keeping the ergonomics and the driver's viewing angle. Suitable digital screen shall be provided as per scenario.
- iv. All the metro routes are modelled in databases, which are to be used in scenario generation.
- v. High quality audio performance for trainee must be guaranteed which will accurately reproduce sounds related to the vehicle systems and their operation.(not limited to Traction motor, Air brake, brake pad, horn, detonators, bomb blast, passing train noise, wheel squeal on curve, warning
- vi. The images of the rear-view mirrors will be shown on the screens. The vehicle design will be faithfully represented on the visual system.
- vii. The cabin will have a webcam to monitor the trainee.
- viii. During simulation, the image will refresh at a frequency of 60 Hz, synchronized with the frequency of the displays. The screen will have sufficient resolution, brightness, and contrast to allow the operator to distinguish between the infrastructure signage, and the characteristics and different aspects of the light signals at a reasonable distance. The visual system will allow the visualization of objects/buildings/vehicles located at least 1-2 km away from driver.
- ix. The maximum speed of the train shall be modelled as per maximum design speed of train.
- x. All routes that are available shall be filmed for the CGI. Those sections which will be under construction, either available data may be extrapolated, or artist's impressions may be used and the actual images on CGI should be updated after functioning of line without additional cost.

2.15.4.3 Instructor Station

- i. The system will have an Instructor Station that allows the instructor to control one or more driving stations. The instructor will be able to manage all the simulation equipment from their station and will have access to any tools they need to personalize the training to each trainee.

- ii. This station shall be equipped with a simple user interface that will allow to at least:
- Carry out the design, planning, execution and monitoring of the training.
 - Freely design the exercises that drivers will need to address, being able to create them from scratch or modify existing ones.
 - Configure parameters for the simulated rolling stock, routes, weather conditions, passenger density, breakdowns or events that will take place, etc.
 - View the geographical scheme of the tracks to be able to monitor the exercise in real time.
 - View any perspective as a 360° scenario view (bird's eye view) through a virtual camera.
 - There will also be a variety of permanent views to facilitate management for the instructor.
- Monitor the screens of the selected trainee in real time. The user will also be able to interact with those screens to help the trainee and select that option without the trainee noticing.
 - Evaluate the simulation sessions, both automatically and manually.
 - Create different types of reports for each trainee.
 - Select/organise exercises from a library and launch them into a specific - or several - simulation station(s); or even launch different exercises into different driving stations simultaneously.
 - Record all sessions for later playback.
 - Being able to view the playback should be intuitive and should be reproduced on a simple interface. And where possible it should be possible to start, stop, pause, rewind and fast-forward, etc.
 - The exercise must be recorded in its entirety, from beginning to end. Play of this recording should allow the user to not only view the exercise, but also to reproduce all the simulator parameters and screens.
 - Manage both instructors and trainee' users and databases, with different access permission levels.
 - The user management system will facilitate associating a simulation session with the trainee who carried it out, so that student progression reports, and reports on the didactic effectiveness in each exercise, can be generated.
 - The results of the simulations will be recorded so they can be used in the future, for statistical studies that lead to the fulfilment of objectives such as: extraction of driver profiles, history of errors committed, correlation between type of operator and type of error, etc.
 - The system interface will have a simple function that creates backups to external disks, of the exercises in the didactic library, trainee' simulation sessions, and the trainee and instructors' databases, etc

For all this, the instructor's desk must have four panoramic screens of 21 inches each or better screen arrangement, a microphone, and speakers to communicate with the driver, an ergonomic chair, and a printer to extract the final session report or any other document. Suitable facility in Instructor station to enable video calling with trainee on the driver desk simulator.

The trainee shall be able to train rescue operations of a broken-down train as a specific incidence. The instructor will be able to place a broken-down train anywhere in the line. This broken-down train will not be functional. The trainee shall drive his train, approach the

broken-down train, couple to the broken train and pull/push the broken train to the area specified by the instructor. All types of furniture shall be in scope of the Contractor.

2.15.4.4 Observer Station :

- i. The system must have an Observation Station from where other trainee/students who are not driving in the simulator at that moment, can carry out complementary training with the instructor.
- ii. For this they will have one or more 55-inch screen in which they can view the same screens that the instructor is observing, or where they can view reproductions of past sessions.
- iii. All type of furniture shall be in scope of the Contractor.

2.15.4.5 Signalling, Track and Power Supply Models

- i. The simulator shall correctly simulate signalling interlocks for the mainline and depot, Balises and Axle Counter Functions etc to allow the signalling system to be simulated as on the CMRL ph-1 metro system. The ATP, ATO and other driving modes will be simulated accurately.
- ii. The instructor will have the facility to set routes, skip stations and change signal status to simulate the reaction of the on-board system. The features of track and OHE system will be accurately programmed in the system including power gaps in the OHE system

2.15.4.6 Faults

The simulator shall allow programming of faults to simulate system failures and will simulate the results of such faults realistically. Such faults can be pre-programmed or can be triggered on-line during simulator sessions. The driver/trainee shall be able to rectify the faults using the defined troubleshooting procedures defined in the manuals. It should be possible to simulate upto 200 different faults.

2.15.4.7 Software and System Administration Features

- i. The simulation system will replicate real routes. The routes to simulate will be the following:
 - Line 1 (Blue Line) : Wimco Nagar to the Airport Chennai Central
 - Line 2 (Green Line) : Chennai Central to St. Thomas Mount
- ii. The multipurpose driving station will simulate all lines in CMRL ph-1.
- iii. The scenario will recreate as realistically as possible the scenarios and situations operating personnel experience, both in normal conditions and in the event of an incident or breakdown. The scenario will be very detailed and realistic.
- iv. The scenario will be real in terms of topology, layout and Signalling, taking into account precise geometric modelling and real textures, including relevant infrastructure and superstructure items at operation level. There will even be realistic landscapes and buildings based on an accurate topographic description. Points of interest such as well-known buildings or areas on the route will have a particularly high degree of detail.
- v. The simulator will faithfully reproduce real traffic conditions, whether in nominal or degraded modes, under which the operation is to be carried out, including blockages, Signalling, maneuvers, train protection systems, cabin Signalling, automatic circulation of other vehicles and the control of the entire system of signals, points, etc.
- vi. The logic of each line's Signalling system will be pre-programmed by the simulator manufacturer, so the instructor will not have to program them for each exercise.
- vii. Training on the action and/or communication protocols to be carried out in the event of breakdowns typical of rolling stock will be facilitated. The number of breakdowns to simulate for each rolling stock is upto 200.
- viii. Training on the action and/or communication protocols to be carried out in the event of interaction between the driver and infrastructure 'incidents' will be facilitated, such as, for

example, the towing of a train or an obstacle on the track. The total number of simulated incidents is 15. Examples of incidents include (but not limited to):

- Objects on the track.
- Presence of workers carrying out tasks on the line.
- Train held-up.
- Signal switched-off.
- Others

2.15.5 Interface Management

The Contractor will be required to interface with the following contractors to attain all relevant information as required and applicable :

- Rolling Stock
- Signalling and Telecommunication
- Platform Screen Doors
- Power Supply
- Track works
- Civil works
- Depot Equipment
- Any Other as applicable

2.16 Maintenance Desk Simulator

2.16.1 Purpose of the machine

The Maintenance Desk Simulator shall be required to provide training and virtual experience to maintenance personals for Rolling Stock sub-system at Koyambedu depot CMRL phase-1. The Maintenance Desk Simulator shall be supplied with CBT (Computer based Tutorials).

2.16.2 Scope of Works

2.16.2.1 Design, Manufacture, Supply, Installation, Testing & Commissioning of Maintenance Desk Simulator alongwith Instructor station at Koyambedu Depot of CMRL phase-I. The Simulator shall be desk type. The supply shall include all equipment and accessories required to make the machine fully functional when connected to a power source.

2.16.2.2 Computer-Based Tutorials (CBT) equipment comprising 10 PC workstations

2.16.2.3 One Instructor Station (for all Maintenance Desk Simulator & CBT modules)

2.16.2.4 Two independent hardware with the suitable configuration shall be used one as Master and other as backup server.

2.16.2.5 The CBT software package shall comprise training and assessment modules.

2.16.2.6 Sub-system maintenance Simulator module for following major sub-systems shall be developed & supplied to provide training and virtual experience to maintenance personals:

- a) HVAC
- b) Doors ~~including detrainment door~~
- c) TCMS
- d) HV system and Traction/propulsion system
- e) Auxiliary power supply and battery
- f) Brake and pneumatics system
- g) Complete Bogie system
- h) PAPIS & PSSS
- i) Vehicle Control Circuit
- j) Couplers & Gangways

2.16.3 General Requirement

2.16.3.1 The Maintenance simulators for all major sub-system shall be capable of providing advanced and detailed training to improve:

- i. Understanding of system behaviour under Normal working condition along with the basic philosophy of each system, flow of logical commands and the detailed view of Vehicle Control Circuit.
- ii. Troubleshooting and maintenance techniques for the maintenance personnel.
- iii. Replacement (Assembly and disassembly) of all major parts in each subsystem
- iv. Upload and download software of relevant systems and usage of test points.
- v. Subsystem virtual tour
- vi. Subsystem behaviour simulation
- vii. By watching a fault or symptom, reach to actual failure by means of support of all actual instruments and test points and software as used in real train to identify a reason of fault and then to troubleshooting solution.

2.16.4 Design Requirement

- 2.16.4.1 Each module shall provide computer based interactive training (using replica/original equipment of major sub-system) to maintenance personnel on system Description, System operation, Circuit simulation, fault/event troubleshooting and 3D virtual maintenance, 3D cut sections of equipment/subsystem. The supply and integration of original/replica major subsystems is in scope of the Contractor.
- 2.16.4.2 Detailed system description with Graphics and 3D module to explain the complete sub-system.
- 2.16.4.3 Detailed description and function of each part including electronic cards in text, graphics, logic diagrams etc.
- 2.16.4.4 System operation to simulate the different operating scenarios with 3D animation and graphics.
- 2.16.4.5 Circuit simulation along with touchable icons and visual effect to show the how the circuits energize' s, it's interlocking and protection.
- 2.16.4.6 Troubleshooting of faults/events with touchable icons and visual effect to show how the fault is to be troubleshoot along with detailed instructions.
- 2.16.4.7 Detailed instructions with 3D animation and video graphics for assembling / dismantling of the subsystems and critical equipments on 46" LED backlit touch screen monitor for each subsystem module.
- 2.16.4.8 Detailed instructions with 3D animation and video graphics for carrying out preventive and corrective maintenance actions with linked tools, spares and maintenance schedule.
- 2.16.4.9 Detailed data base (manuals, special instructions, safety, previous investigation reports, part catalogue, drawings etc) of the various parts/components.
- 2.16.4.10 Detailed description of the software with graphics, detailed flow diagrams, logic diagrams etc.with detailed narrative explanation.
- 2.16.4.11 Extensive library of faults and standardized response for rectification of faults. The number of faults in the library of each module would be average 250. Provision shall also be available for recording of the actions initiated by the trainee for rectification of the faults.
- 2.16.4.12 Simulator software packages shall capable and support for additional modules in future for different kind of Rolling Stock, which will operate in the same ph-1 corridor.
- 2.16.4.13 Detailed Testing procedure of different equipments/subsystem (including provisions in the relevant standards) with graphics.
- 2.16.4.14 Each subsystem module shall provide audio video content with a duration of at least 30 minutes.
- 2.16.4.15 Use of original equipment or replica models shall be to maximum extent and shall be ensured unless specifically got approved from Engineer/CMRL. For training on trouble shooting and diagnostics etc. these sub systems shall be suitably integrated.
- 2.16.4.16 Any other feature that would assist in training of the maintenance personnel
- 2.16.4.17 All equipment's such as 46" LCD touch screen including server, UPS, networking provision and associated power cable and adequate all types of furniture etc shall be included with supply and shall be installed and commissioned at Koyambedu depot.

2.16.5 Computer Based Tutorials (CBT)

- 2.16.5.1 The CBT modules (atleast 10 nos) shall be developed to provide general training to all the operation and maintenance personal. Module shall include the following:
 - i. Computer based tutorials (CBTs) on system description to enable trainee to acquire the knowledge of Rolling Stock and its sub-systems.
 - ii. Computer based tutorials (CBTs) on train operation and operation of various sub-systems.
 - iii. Each module shall provide audio video content with a duration of at least 30 minutes.

- iv. CBT shall consist of quotation bank to evaluate the trainee's performance after completion of each session. Provision shall be made to update the quotation bank by the employer authorised personal.
- v. CBT packages shall be designed to operate on any workstation/window-based desk computer.
- vi. CBT software package shall suitable and support for additional modules in future for different kind of Rolling Stock, which may operate in the same corridor, without additional cost.
- vii. All associated equipment's such as 10 nos Computers of 24" screen, server, UPS and associated power connections and associated furniture etc shall be supplied and commissioned at Koyambedu depot.

2.17 ULTRASONIC FLAW DETECTOR (UFD)

2.17.1 Purpose of the machine:

The Ultrasonic flaw detector is a potable digital type equipment required for testing of axles of rolling stock based on A- scan pulse echo technique at CMRL designated depot. The unit shall be supplied with all accessories to make the equipment fully functional.

2.17.2 Accessories (included with supply):

- i. Lithium-ion rechargeable battery pack- 01no
- ii. Battery charger cum mains power pack with charge status indicator and power
- iii. cord- 01no
- iv. Probe cable 2 m long RG-58 coaxial cable fitted with BNC plugs on both sides- 01 no
- v. Leather protective case with shoulder slings- 01 no.
- vi. 2.5 MHz 20 mm element size with BNC socket on top aluminium casing- 01 no.
- vii. Plastic moulded foam fitted carrying case with numerical lock for storage and
- viii. transportation of complete kit- 01 no.
- ix. Transfer software on CD-ROM- 01 no.
- x. Data cord to interface with PC- 01 no.
- xi. Data cord to interface with printer- 01 no.

2.17.3 Technical Parameters:

UFD shall comply the below parameters (but not limited to)

S. No.	Parameters
1	Test range: 10 mm to 5 m in steel adjustable in 1 mm or 10 mm step
2	Velocity: 1000- 9999 m/s adjustable in 1 m/s or 10 m/s step
3	Delay: up to 3 m adjustable in 0.5 mm to 5 mm step
4	Gain: 100 dB calibrated gain adjustable in 0.5dB and higher dB step
5	Scan: Reference A-Scan pattern of standard test object to be saved and recalled in background for easy comparison during testing, A-Scan memory 200 trace patterns to be stored, recalled, print or transferred to PC via RS-232 serial port
6	Full wave rectified with filtering, 0.5-10 MHz, pulse echo and transmit / receive, dual gate adjustable in 1% of screen width with positive / negative logic gate expand mode, expand range to width of gate
7	50 different calibrations set up to be stored and reconciled
8	Thickness / depth should be displayed in digital readout when using a normal probe and beam path, surface distance and depth are directly displayed when angle probe is in use.
9	Details of operator's name, depot / workshop, axle type and no, defect location to be keyed in by operator.

S. No.	Parameters
10	Suitable interface software for transferring A-Scan to PC, By pressing zoom key A- Scan can be displayed in full screen area 110 x 85 mm (minimum) color LCD/ TFT display or better for visibility with option of different color sets, PC printer with serial port can be attached for instant print out of trace pattern
11	Lithium-ion battery pack 14.4 V DC, 4 AH to provide minimum 8 hours continuous operation from fully charged battery with charger
12.	Scope covers supply of probes and attachments for operation of equipment (but not limited to) i. Normal single crystal probes sturdy aluminium casing with top-entry BNC Socket, frequency, crystal size and serial no. permanently engraved on casing. ii. Dual Crystal Probe sturdy aluminium casing with integral co-axial cable (RG 174) 2m length fitted with BNC plugs with frequency, crystal size and serial no engraved on casing- 2.5 MHz, element size 20 mm diameter, surface of probe with curvature. iii. Low angle wedge attachment- Perspex wedges with aluminium casing for direct attachment to any normal single crystal probe, angle and exit point engraved on wedge iv. High angle wedge attachment- Perspex wedges with aluminium casing for direct attachment to any normal single crystal probe, angle and exit point engraved on wedge.
13	Scope covers spares for operation of equipment. i. IIW type reference / calibration block, type V1 as per IS 4904-82- 01 no. ii. Miniature calibration block type V2 as per IS 4904-82- 01 no. iii. 14.4 Volts/ 4 AH Li-Ion rechargeable battery pack- 01no. iv. Battery charger cum mains power pack with charge status indicator & power cord- 1 no. v. Probe cable- 01 no.

2.17.4 Standards:

The equipment shall be designed according to relevant / applicable industry standards.

2.18 BATTERY-OPERATED PLATFORM TRUCK (BOPT)

2.18.1 Purpose of the machine:

The BOPT shall be used for carrying and transporting of various equipment, loads, heavy tools, heavy spare parts and accessories in and around Depot during maintenance / overhauling of metro trains.

2.18.2 Scope of Supply:

2.18.2.1 Design, Manufacture, Supply, Installation, Testing, Training and Commissioning of BOPTs.

2.18.2.2 The BOPT shall be supplied complete with all accessories to make the Battery-Operated Platform Truck fully functional, Battery Charger and a set of service and special tools sufficient for operation and maintenance of the Truck. BOPT shall be equipped with operator cabin. The cost of these items shall be included in the basic price of the machine.

2.18.3 Technical Requirements:

The Technical requirements of Battery-Operated Platform Truck are given below (but not limited to):

Parameter	Required
Capacity	2000 kg uniformly distributed
Platform size	1850 X 1250 X 600 mm approx.
Platform type	Fixed
Overall length	2900-3000 mm
Outer turning radius	Not more than 3200 mm
Ground clearance	110-120 mm
Wheelbase	1800- 1950 mm
Gradeability-laden	1:15
Gradeability-unladen	1:10
Tyre front & rear	450-550 X 120-150 mm approx. 2 Front and 2 Rear
Travel speed-laden	6-9 KM/HR
Travel speed-unladen	9-11 KM/HR
Traction motor	2HP (Min)
Battery	36V, 180 AH (Minimum) of reputed make. Battery shall be coupled with suitable plug and receptacle of required capacity
Chassis	Heavy duty & Robust chassis, fabricated from good quality steel suitably designed to withstand shock loads. The Chassis shall be rigid with easy access to various parts and protection to the driver.
Drive unit and	Variable speed DC motor. Gear Box transmission with fully integrated helical gear giving low noise, high load bearing capability

Parameter	Required
transmission	and smooth running at high circumferential speeds.
Accelerator	For smooth speed control efficient accelerator with micro switch arrangement shall be provided.
Steering	Effortless, fully powered steering.
Brake	Drum & Shoe type hydraulic service brake and parking brake easily accessible by the driver.
Suspension	Rear suspension shall be by leaf springs
Electrical system	Control circuit shall provide smooth, silent, efficient and cost-effective speed control. Electronic controls for soft start and jerk free transmission, no wastage of battery power, lower maintenance cost and down time of equipment shall be provided. All terminal and wiring shall be marked in accordance with electrical diagram provided by the firm.
Controls	Controls for forward / reverse motion, horn, light and emergency cut off & key switch are to be mounted on dashboard(cabin control). Accelerator and hydraulic brake shall be foot operated.
Battery charge & discharge indicator	Indication lamp for charging of battery shall be provided on the truck. To protect the over discharge of the battery, a red warning light / lamp shall be provided in the truck that glows when the battery reaches a predetermined safe discharge level. Moreover the speed of the truck also drops down considerably at that time but easy enough to drive the truck to the charging bay for recharging.
Safety/ protection devices	The truck shall be equipped with safety devices to prevent any mis-happening. The truck shall not move when parking brake is on.
Seat	Comfortable cushioned seat
Identification	A plate indicating serial no. with details of motor and batteries and manufacturer's name shall be mounted on the truck.
Sound level	Less than 70 dB
Standard	Truck shall confirm all relevant IS standards specifications or equivalent international standards.
Battery charger	The 36 V, 12 hours recharge time rating battery charger shall be provided. Cable length from charger to cell shall be minimum 3m and adequate cable length from the supply point to charger.

2.18.4 Standards:

The entire supply shall comply with the requirements of the standards in force.

2.19 BATTERY-OPERATED SELF-PROPELLED SCISSOR LIFT

2.19.1 Purpose of the machine

The main purpose of this machine is to access the roof parts of the Rolling stock such as saloon doors mounting assembly, rain gutters during the preventive and corrective maintenance including other allied activities within the maintenance depot of CMRL. This equipment shall include a travelling base accommodating the hydraulic system and electric system for lifting the platform and moving the assembly.

2.19.2 Technical Requirements (but not limited to below):

2.19.2.1 Lifting platform parameters

Working height	at least 7770 mm
Platform height in elevated condition	at least 5770 mm from the ground level
Platform height in lowered condition	Not more than 1000 mm from the ground level
Platform length – outside	1600 to 1700 mm
Platform extension deck	at least 900 mm
Platform width – outside	700 to 800 mm
Platform guard rail height	at least 1100 mm.
Platform Toe board height	at least 150 mm
Overall Length	1800 to 2000 mm
Overall Width	750 to 780 mm
Wheelbase	at least 1300 mm
Ground clearance – center	at least 60 mm
Ground clearance with pothole guards deployed	not more than 20 mm
Platform capacity	At least for 2 persons

2.19.2.2 Power and Control System

Power source	24V, DC (Battery)
Battery capacity	Not less than 220 Ah.
Battery charging system	Inbuilt battery charging
Raise time	10 to 20 seconds
lower time	10 to 20 seconds
Platform operation	Hydraulic System. Raising and lowering shall be smooth and step less in no load and full load condition

2.19.2.3 Load details

Lift capacity	At least 225 Kgs.
Lift capacity - extension deck	At least 110 Kgs.

2.19.2.4 Traction parameters

Drive	Dual front wheel
Drive speed in lowered condition	Minimum 3.8 kmph
Drive speed in elevated condition	Minimum 0.7 kmph
Gradeability	Minimum 25%
Turning radius - inside	Zero
Turning radius – outside	Not more than 1600 mm
Tyres	Solid and Non-marking

2.19.2.5 Brake Requirements

- i. Rear Wheel shall be Provided with Multiple disc brakes.
- ii. Front Wheel shall be Provided with hydraulic Dynamic Braking.
- iii. Manual hydraulic brake release shall be provided.

2.19.2.6 Preferred colour – Blue / Red will be finalised during design stage.

2.19.3 Accessories

The following minimum (but not limited to) accessories shall be provided with the scissorlift.

- i. Necessary cables with industrial socket for Battery charging.
- ii. Folding rails with half-height swing gate
- iii. Platform control with battery charge indicator and diagnostic display
- iv. Hour meter
- v. Emergency stop at both platform and ground control.
- vi. Tilt level sensor with an audible alarm
- vii. Manual platform lowering valve.
- viii. Dual Flashing beacons
- ix. Lanyard attachment points
- x. Motion alarm
- xi. Electronic horn
- xii. Pothole guards
- xiii. Safety bracket- Useful during maintenance activity
- xiv. Overload Sensor
- xv. Battery Cut-off Protection
- xvi. Maintenance free Battery

2.19.4 Machine Construction:

2.19.4.1 Platform:

The platform shall be made of anti-skid plates. The platform shall include guard rails and a safety access gate with automatic return to closed position.

2.19.4.2 Travelling Base:

Four solid non marking tyres shall be provided out of which two would be used for steering

and the other two for driving the scissor lift.

2.19.4.3 Lifting Element:

- i. The lifting element shall consist of three or four scissors actuated by hydraulic jacks.
- ii. The strongly braced scissors mechanism shall be able to support the full load and shall be hinged on self-lubricated journals. The parts and the assembly shall be designed so that horizontal and parallel lifting of the platform in relation to the travelling base is possible.

2.19.4.4 Electrical Part (Battery and Charger):

The Electric Scissor Lift shall be electrically operated by 24 V batteries. The supply shall include automatic on-board charger. The capacity of the battery shall be adequate for at least 30 lifting operations to maximum height with the maximum load after full charge. 220 V AC socket provision on the platform shall be provided.

2.19.4.5 Control Post:

- i. The control post shall include a control panel installed on the platform for control and monitoring of the machine. The Control panel shall be designed to impede any unwanted operation due to an unwanted involuntary movement of the operator.
- ii. The panel shall be designed to accommodate ambient temperature and humidity conditions:
- iii. The control Post shall be consist of following minimum items:
 - a Joystick for all movement and direction controls,
 - an up and down switch,
 - a dead man pushbutton slaving all functions,
 - an emergency stop pushbutton,
 - a contact key,
 - All motion audible alarm
- An operator horn.

2.19.4.6 Electric Motor Part:

Scissor Lift shall be provided with an Electric Motor for driving the lifting platform and an Electric Motor-Pump to operate the hydraulic system for lifting mechanism. 24 V batteries as specified above operated both motors.

2.19.4.7 Hydraulic Part

- i. An electric motor pump shall operate a hydraulic unit that convey fluid to a gradual distributor and a bleed tank.
- ii. The pump shall be fitted with a pressure limiting device. The equipment shall be provided with a manual emergency device for the down movement only. The Hydraulic system shall consist minimum of
 - Hydraulic motor - pump of suitable capacity.
 - Hydraulic cylinders - Contractor to propose & justify as per design requirements.
 - Pressure control valve adjustable for desired pressure.
 - Pressure relief valve.

2.19.5 Safety and Protection:

2.19.5.1 Braking shall be provided preferably by 2 circuits actuated simultaneously and automatically as soon as the movement control is stopped.

2.19.5.2 The position of the platform shall not change in the event of failure or breakage of a hydraulic

pipe. Each jack shall be provided with an independent circuit and the cylinder ends are provided with a check valve.

2.19.5.3 The equipment shall be provided with a flashing signalling light.

2.19.5.4 Safety devices shall be provided to impede any damage to the machine and serious personnel injury in the event of false maneuvers.

2.19.5.5 The equipment shall incorporate all necessary safety devices to protect the equipment, operators, and all other people and things in the vicinity of the equipment.

2.19.5.6 No failure of the equipment shall cause or give rise to any damage or catastrophe of any nature whatsoever.

2.19.6 Standards:

The Scissor lift shall be designed to ANSI A92.6, CSA B354.2, AS 1418.10, CE EN-280.

2.20 HIGH-PRESSURE WASH PUMP

2.20.1 Purpose of the machine:

The High-Pressure Wash Pumps are required for cleaning of the coaches and miscellaneous small parts of the rolling stocks and other items with a handheld jet of water at CMRL depot. The equipment shall be capable of spraying hot (through inbuilt hot water generator) as well as cold water for cleaning with pressurized water having controls fitted in the spray gun. The equipment shall include a wheel mounted travelling base with handle accommodating all sub-assembly.

2.20.2 Accessories per equipment (included with supply):

2.20.2.1 High-pressure & high temperature withstanding hose pipe 10m long with quick screw.

i. couplings of steel, Brass or gunmetal on both ends - 1 no.

2.20.2.2 Water inlet pipe 10m with quick screw couplings of steel, Brass or gunmetal on both ends – 1 no.

2.20.2.3 Detergent / scale inhibitor

2.20.2.4 Electrical cable with suitable plug top for connecting the machine to mains supplies socket – minimum 10m.

2.20.2.5 Rubber hand gloves - 2 pair.

2.20.2.6 Any other accessories (if not listed) to make this system fully functional to be provided with supply and included with the equipment.

2.20.3 Technical Requirements (but not limited to below):

Parameters	Required
Water Flow rate l/h	600–1300
Pressure bar / MPa	30–200 / 3–20 (adjustable from min to max)
Steam Flow rate l/h	600-650
Steam pressure bar	32
Max. temperature °C	140-155 Deg C
Power rating kW	7 kw to 9.5kw
Fuel oil consumption, full load kg/h	8 to 9.5 approx.
Fuel tank	25 L
Cleaning agent tank	30 litres or 20+10 L (two tanks)
Three piston axial pump	Ceramic piston
Dry running protection	Yes
Type of protection	IPX5 to IP 47 or latest

2.20.4 Design Features:

2.20.4.1 Rigidity & Control

- i. The equipment shall be robust and of sturdy construction.
- ii. All controls of the equipment shall be ergonomically designed and conveniently located. Suitable LED display and indication of controls to facilitate the operator for correct and quick decisions.
- iii. The equipment shall be fitted with ergonomic push handles, wheels & castors to facilitate operator for shifting of machine from one place to another conveniently. It should have locks for stopping wheels to roll when equipment is being used or parked.
- iv. The equipment shall have minimum vibrations and noise when run at full load. The Contractor shall specify machine vibration & noise level (not to exceed 80db at 1m).

2.20.4.2 Main Body

- i. The equipment shall be modular in construction & the chassis should be made up of strong galvanized steel and powder coated for corrosion free longer service life.
- ii. The equipment should have lightweight hinged / screwed hood for protection from dirt and water. There shall be additional opening for filling in detergent and scale inhibitor without opening the hinged hood.
- iii. It shall have supports suitable located for hp-hose, spray gun and power cable for neatly storing and ready to use.
- iv. It shall have special compartments for storage of nozzles and tools.
- v. It shall preferably fitted with heavy duty castor wheels for easy manoeuvrability.

2.20.4.3 High pressure pump and motor unit

- i. The equipment shall have one-piece motor-pump housing for unsurpassed heat transfer.
- ii. The design should be compact with a direct drive separate motor for high-pressure pump, blower and separate motor for blower / fuel pump of Hot water boiler.
- iii. Motor-Three-phase, 4-pole motor with air / water cooling, thermal protection, long-life drive system with overload protection, rotation control & easy change of direction.
- iv. Pump-Three piston pump (axial / crankshaft) having steel pistons with ceramic sleeves, swash, detergent and corrosion proof pistons, direct drive with minimum of moving parts having high efficiency and long life. The cylinder head shall be of brass with inlet and outlet valves from high-grade steel and a safety valve. The pump shall be protected from overload and steam stage.

2.20.4.4 Hot water generator

- i. A high-performance burner with permanent ignition, preferably vertical heating coil of double turn steel pipe in order to minimize the equipment size for even heat distribution and no corrosion due to condensation. The spark electrodes shall be on support for perfect adjustment of electrode distance.
- ii. The emission values should be within standards and no risk of explosions.
- iii. Low water cut-out protection shall be provided which will automatically switch off in the event of low water supply.

2.20.4.5 Spray gun

- i. The spray gun shall be fitted with heatproof extension with soft grip and long double lance in stainless steel with pressure, detergent feed control device. Remote control water flow and temperature.
- ii. The spray gun shall be fitted with high pressure steel nozzle and brass nozzle for chemicals.
- iii. The spray gun shall be fitted with high pressure & high temperature withstanding hose and quick screw couplings. The hoses shall withstand any permanent damage.

2.20.4.6 Storage tanks

The unit shall have suitable capacity integrated tanks for storage of heating oil and chemicals and shall be suitable isolated from heating unit. The supply piping and connectors shall be of reputed make and easily serviceable.

2.20.5 Safety and protection

2.20.5.1 The equipment shall incorporate all safety features to provide complete protection to the operator and the equipment against all operational / machine failures.

2.20.5.2 The equipment shall include (but not to be limited only to) the following safety features with suitable interlocks to prevent machine operation on the event of: -

- i. Failure of power
- ii. Harmful fluctuation in the supply voltage.
- iii. Exceeding maximum water temperature range.
- iv. Protection against short circuit & thermal overload.
- v. Low water cut out & burner automatically switched off.
- vi. High pressure generation to risk bursting of swirl chamber.

2.20.6 Standards

The equipment shall be designed according to relevant / applicable industry standards.

2.21 HAND PALLET TRUCK

2.21.1 Purpose of the machine:

The Hand Pallet Truck shall be used for carrying and transport / shifting of different types of material, heavy tools, heavy spare parts, pallets, and other equipment manually on shop floor of depot cum workshop of CMRL phase-I. The Hand Pallet Truck shall be capable to withstand dynamic load of 2500 Kg weight of material / equipment required for the maintenance of metro train and other activities.

2.21.2 Basic parameters for the design of each Hand Pallet Truck (but not limited to):

Parameter	Dimensions
Capacity	2500 kg (minimum)
Fork width:	150mm
Minimum fork length:	1100mm,
Height in lowered position	75mm approx.
Height in lifted position:	185-200mm
Width over the fork :	520-550 mm
Angle of steering lock:	2 x 100 degree,
Wheel type:	Polyurethane
Overall Height:	1200mm
Overall Length:	1450mm
Steering wheels:	180dia x 70 width (in mm)
Load wheels(mm):	80-85dia x 70-80 width (Tandem)

Note: Pallet truck with tandem bolted rollers to facilitate and ensure stability. Control-lifting / lowering / translation shall be via a single lever.

2.21.3 Design Requirement

2.21.3.1 Main features of the equipment shall be,

- facilitate the personnel's task for storage operations,
- have an adequate angle of steering lock to offer optimum manoeuvrability,
- be capable of handling loads up to 2500 kg minimum,
- guarantee the stability of loads during handling,

2.21.4 Mechanical part

The frame and forks shall be built-in of heavy-duty steel.

2.21.5 Hydraulic part

The hydraulic block shall be built of graphite cast iron. The hydraulic mechanism shall be air and dust tight.

2.21.6 Standard:

The equipment shall be designed in compliance with the presently valid European / international regulations.

2.22 BATTERY-OPERATED FORKLIFT TRUCK

2.22.1 Purpose of the machine:

The Battery-operated forklift truck shall be required to lift and move desired item (with in capacity of machine) inside the workshop area as well as inside the depot premises from one location to another location. The Forklift Truck shall be electrically powered and shall be supplied with battery charger for each truck along with connecting charging cables.

2.22.2 General Requirements:

Parameters for -Battery Operated Forklift Truck (3t) but not limited to below:		
S. No	Technical parameters	Required
1	Normal load	3 t
2	Rated Load center	500mm
3	Maximum fork height	Min 4200 mm
4	Load in raised position at rated load center	3 t
5	Length of forks	1000 mm
6	Overall Height lowered (max.)	2100-2200 mm
7	Turning radius (max.)	Max 2250 mm
8	Mast tilt angle forward	Min 5 degrees
9	Mast tilt angle backward	Min 5 degrees
10	Drive motor rating	Min AC -12Kw
11	Drive motor make	Reputed Indian make
12	Lift motor make	Reputed Indian make
13	Gradeability unladen	17%-20%
14	Gradeability laden	15%-18%
15	Battery voltage ,Ah	80V/360 Ah min
16	Travel Speed, laden/unladen	Min 10/10 Kmph
17	Lift speed , laden/unladen	Min 0.3/0.45 m/s
18	Lowering speed , laden/unladen	Min 0.40m/s
19	Tyres	Solid rubber tyres (Front-2 , Rear- 2)

2.22.3 Accessories:

The following minimum accessories shall be provided with each forklift :

- Head & Taillights
- Signal Lights,

- Reverse Alarm,
- Rear View Mirror
- Flashing light
- Seat Belt
- Horn of suitable capacity
- Load Back Rest, Toolkit, Canopy
- 1500 mm fork extension – 1 pair
- Operator Presence System – The truck shouldn't start unless the operator is seated on the forklift.
- Preferred color – shall be finalized during design stage.

2.22.4 Other technical requirements:

- Lifting of the forks shall be hydraulic operated.
- The sound level in the cabin shall be less than 77dBA.
- The control cab shall be fitted with an operating hour meter and battery discharge indicator.
- The steering shall be powered.
- The forklift shall be powered provided with solid tires.

2.22.5 Mechanical part and Braking

2.22.5.1 Chassis : The chassis shall be rigid and at the same time provide easy access to various parts and protection to the driver. It shall be made by welding steel plates and constitute a distortion resistant assembly. The backside control cover shall have high quality manufacturing duly complying all relevant manufacturing and painting requirements with aesthetic looking.

2.22.5.2 Braking: The forklift truck braking shall be through electric regenerative braking during releasing of accelerator. In addition, the truck shall also be fitted with a hydraulic brake and a parking brake.

2.22.6 Electrical Part (Battery and Charger)

2.22.6.1 The battery charger shall be suitable for working on standard 3phase supply and fulfil all the standard specifications as per industrial norms. The electrical equipment shall be provided in a cabinet. All terminal and wiring shall be marked in accordance with electrical diagram.

2.22.6.2 The specification of the battery charger should be suitable to the supplied battery and capable of charging the battery not exceeding 8 hours from 20% to 100% charge.

2.22.7 Hydraulic part

The supply shall comprise(minimum) of :

- a motor pump unit with oil tank with filter.
- A lifting cylinder with a system maintaining a constant lowering speed whatever the load.
- A mast angle tilt cylinder.
- The hydraulic cylinder shall be chrome plated for corrosion protection and fitted with a scraper joint to prevent any dust getting in.

2.22.8 Safety features and Protection equipped with Forklift :

- Speed reduction at turns – Reduced speed while turning
- Anti-rollback system - Ramp hold
- Equipped with Hose burst valve.

- Stop tilt forward movement when truck is off.
- Driver's overhead guard for driver's safety.
- Provision to prevent operation when the driver is not seated.
- Device to prevent any movement when the parking brake is on.
- Bright LED lights offered as standard.
- Seat belt interlock.
- Red Halo Safety light
- Blue Safety Light
- Biometric Access System & Access Card system shall be provided for operating the Forklift.

2.22.9 Standards:

The forklift shall satisfy the requirement of standards and regulations in force and comply with the following standards:

Over Head Guard test	ISO 6055 / IS 7621
Brake test	ISO 6292 / IS 9701
Stability test	ISO 22915/ IS 4357

2.23 MOBILE LIFTING TABLES (MLT)

2.23.1 Purpose of the machine:

The Mobile Lifting Tables required for removal of equipment / component / assembly etc. fitted on the under frames of train /coaches and shall be located in the workshop bay of CMRL depot. The table shall be designed for carrying the CI / APS / equipment after removal from the coach to the repair section as the case may be. The lifting tables shall comprise (but not limited to):

- the elevator part,
- the telescopic arms and lifting jacks,
- the basic chassis, travelling wheels.
- the motor pump unit.
- lateral movement way (width wise left or right) on either side (250mm)

2.23.2 Technical Requirements (but not limited to below):

Parameters	For 5t Required	For 2t Required
Raised position Platform Height	1500 mm	1500 mm
Lowered position Height (including power pack, electrical unit)	600 mm	600 mm
Pay load	5000 kg or more	2000 kg or more
Platform dimension	As per Rolling Stock Transformer dimension . The Contractor shall submit detailed design stage for employer approval.	As per Rolling Stock CI & APS dimension. The Contractor shall submit detailed design stage for employer approval.
Front and rear wheels	300 mm diameter and 80 mm width or better, Nylon wheels	300 mm diameter and 80 mm width or better, Nylon wheels
Lifting of platform	Manual and electric operated	Manual and electric operated
Lateral movement	250 mm either way (width wise left or right)	250 mm either way (width wise left or right)

2.23.3 Machine configuration:

2.23.3.1 Lifting Table

- i. The lifting table shall comprise the platform, scissor beams, the telescopic arms, the basic chassis, traveling wheels, motor, pump, hydraulic unit, control unit, driving handle and any other accessories that are required to make the equipment fully functional.
- ii. Items like oil tank, motor, control unit, hydraulic pump etc. shall be optimum located at front of the table. These items shall be properly mounted on the bottom frame.
- iii. A mechanical stopper up to 1 meter height of movable platform shall be provided.
- iv. The lifting table shall be free of rust, mill scale, dirt, oil etc. and thoroughly cleaned, if needed with chemical solution and rinsed.
- v. The painted surface of the table / part shall be free from wrinkles, irregular painting,

dripping, scratches and irregularities in coloring.

- vi. The platform shall be able to move laterally of 250mm on either side with least effort. The Contractor shall quote the mechanism for this lateral movement in their offer.

2.23.3.2 Chassis and Platform

- i. The framework and scissor arms shall be of robust, rigid construction and fabricated out of structural steel conforming to IS 2062:1992. Top / bottom frame members shall be made out of rolled / hollow steel sections (IS 808:1989 and IS 4923:1985 respectively). The same shall be designed to take of all stresses arising due to the loads for safe and efficient working of the equipment.
- ii. The platform shall be covered with GI chequered (IS 3502:1981) plate or better at least 5mm thick. The frame of chassis and platform shall be constructed out of MS Channel of minimum 5mm thickness. Two numbers of additional supports shall be provided at the frame of the platform. Suitable reinforcement shall be provided to the frame to bear loading capacity.
- iii. The chassis shall have 4 lifting points for easier handling with a hoist or forklift truck. The lifting points should be such that the upper chassis should not interfere in placing the slings for lifting.
- iv. Handle shall be made from mild steel tubular pipes confirming to IS: 1239:1990.
- v. Heavy duty foldable type safety railing shall be provided on the back side of top platform.

2.23.3.3 Hydraulic Mechanism:

- i. The hydraulic mechanism shall consist of hydraulic cylinder of suitable length and capacity, oil pump, electric motor, valves, hoses etc of reputed make to lift the platform manually as well as electrically with full load. The hydraulic mechanism shall preferably consist of two numbers of hydraulic cylinder jacks at both sides for lifting of the load with platform.
- ii. The robustly braced telescopic arms shall be hinged on self-lubricating pads. The sizing of the parts and the assembly shall enable horizontal, parallel lifting of the plate in relation to the basic chassis. The plate shall be elevated by actuating 2 single-action hydraulic jacks acting directly on the lifting arms guided by the roller bearings.
- iii. The scissor of the lifting table shall be designed to take the load. All the accessories of the lifting / Hydraulic mechanism shall be of reputed make. All the assemblies of the hydraulic system shall be properly mounted at suitable place with base frame.
- iv. Position of double check valve shall be made on top side. All hoses shall be systematically secured with suitable clamps.

2.23.3.4 Wheel and Brake

- i. The MLT shall have four Nylon wheels with suitable bearing / bush.
- ii. Two numbers of wheels shall be at the back side of the bottom frame and set of two numbers of wheels put together with manoeuvring handle of suitable length at front centre of bottom frame of the table. Pulling handle shall be foldable type.
- iii. The movement of the table should be smooth & coherent with load without applying much effort.
- iv. Ground clearance shall be at least 100mm.
- v. Bearings of the wheels shall be of reputed with cap.
- vi. The table shall be immobilize while loading / unloading by suitable brakes arrangement.

2.23.3.5 Electrical

- i. The electrical power supply is 415 V, 50 Hz, three-phase. The Contractor shall provide

all electrification of the equipment from the sockets located in the vicinity. The power supply shall be by a cable reel in a casing containing 35 meters of flexible three-phase electrical cable with earthing in a self-rolling drum.

- ii. The supply, installed beneath the basic chassis, shall comprise:
 - the electrical cabinet,
 - the power and control cables,
 - the control systems,
 - the operating and safety switch gear required.
- iii. All electrical and electronic control, regulation and other equipment shall be placed in this cabinet whose protection index shall be IP 54. Ventilation shall be provided by means of sufficiently large louvers.
- iv. All terminals and wiring shall be marked in accordance with the electrical schematic diagrams.
- v. The Lifting Motor will be three phase motor and the capacity will be minimum 2.0 KW of reputed make. Power cable of five core copper of 4sq.mm with 16-amp plug shall be provided with the cable.
- vi. The pump shall be equipped with a pressure-limiting device. The hydraulic circuit shall be fitted with a non-return valve electrically controlled and placed at the jack output. The reservoir drain plug shall be accessible from underneath the table. The cabinet shall comprise:
 - a main, three-pole isolating switch with fuses preventing single-phase operation,
 - a main contactor-circuit breaker,
 - contactors and relays used for operation of the elevator table,
 - magnetic / thermal protection of the motor pump unit.

2.23.3.6 Control Box

- i. Control box shall have voltage indicating lamp, ON / OFF button / MCB, Up / Down button, and one emergency stop button.
- ii. Remote control with 3 meters of cable length shall be provided for Up / Down movement and Emergency stop.
- iii. The lifting time at the nominal load shall be less than 120 Seconds.
- iv. The lowering time at the nominal load shall be less than 80 Seconds.
- v. Suitable limit switches arrangement shall be provided to auto cut power supply when platform raising limit (lower / Upper) is reached for safety purpose.

2.23.4 Safety and protection

2.23.4.1 The equipment shall incorporate all safety devices to provide complete protection to the operator from all possible operational failures.

2.23.4.2 Suitable interlocking arrangements against faulty sequence of operation, sudden power failure, fluctuation in power supply voltage should be provided besides the following:

- protection of personnel against hazards resulting from moving mechanical parts and the presence of powered electrical parts,
- motors shall be dust-tight having atleast IP 55 or better rating,
- all metal parts shall be earthed,
- All steel tube cable outlets shall be protected by an insulating ferrule
- Workstation ergonomic.

2.23.5 Standards

The equipment shall be designed according to relevant / applicable industry standards.

2.24 KEY MANAGEMENT SYSTEM

2.24.1 Purpose of the machine:

The Key management system require to secure keys to physical assets of Koyambedu depot including building, facilities, equipment, machines and vehicles etc and avoid keys going missing, getting misplaced or getting into the wrong hands. Only authorized staff are allowed access to the key cabinet.

2.24.2 Basic features for design of Key Management System:

The Key Management System shall have following minimum features (but not limited to):

Parts / items	Required Details
Cabinet Type	Key Cabinet
Cabinet capacity	100 keys (min)
Mounting Type	Wall mounting
Key fobs	Multi color and reusable
Access	Bio-metric and RFID type
RFID reader (Reading distance)	5-10 cm
Power	230V AC 50-60Hz
Battery backup	Min 2hrs
Surge Protection	As per norms
User enrolment	Min 200 staff personnel

2.24.2.1 Accessories (included with supply):

- Biometric (Finger) +RFID card (at least 100Nos) based with cabinet.
- Software for Key Management System
- Key fobs
- Any other accessories (if not listed) to make this system fully functional to be provided with supply and included with the system.

2.24.2.2 Specification for Key Cabinet:

- The construction of Cabinet should be modular in nature, consisting of a single user console with ID card reader, 3.5" or bigger Colour TFT /LCD Display, Numeric robust capacitive touch Keypad and multiple Key holding modules.
- The cabinet should identify users, by Fingerprint Scan + ISO14443 standard ID cards.
- Cabinet should be made from proven metal as per applicable industry standard.
- Conventional mechanical keys should be RFID tagged to identify uniquely in the cabinet. These tags should be ergonomic, handy & have inbuilt groove for mechanical locking purpose.
- Each key slot should be able to detect the RFID tag and lock the Key automatically inside.
- The system should be positively checking presence of keys in cabinet, by scanning the attached RFID tags. Alarms to be generated in case of any tampering.
- Dimension of the cabinet shall be compact, to be able to accommodate at CMRL depot

desired site / location.

2.24.3 Technical Requirement:

- 2.24.3.1 Keys should be released only against valid identification of the personnel and released key should be indicated by illuminated slot by LED flashing with audible tone and display message on TFT / LCD Screen, identifying slot.
- 2.24.3.2 It should have interface for connecting to PC.
- 2.24.3.3 It should have Graphic TFT / LCD display for displaying messages and keypad for user interface. Keypad should be rugged for easy cleaning & unobstructed performance.
- 2.24.3.4 The cabinet should have provision to release Keys one by one, by administrative control on single command. Also, provide facility to administrator to release key in any slot or release any particular key.
- 2.24.3.5 The cabinet should have provision to archive minimum 10000 Key transaction history.
- 2.24.3.6 The cabinet should have provision of backup power supply from battery to operate minimum 2 Hours on mains power failure.

2.24.4 Cabinet Management Software:

- 2.24.4.1 The Software shall have provision of report generation on following aspects but not limited to:
 - i. Keys not returned to the system,
 - ii. Keys Present in the System,
 - iii. Key usage report in a month or given period of at least a year,
 - iv. Key daily transactions,
 - v. List of all users, Keys in the system,
 - vi. Key and User transaction report.
- 2.24.4.2 Software should have provision to maintain (add, edit, delete, save) the database of Keys mapped to employee name. Provision for employee photos should exist to incorporate in the aforesaid database.
- 2.24.4.3 It should have provision to upload key Numbers and employee details like Employee no, PIN and other user defined parameters to cabinet.
- 2.24.4.4 The software should have provision for logging of all transaction events (login /log out data with time stamp) of all users including administrator.
- 2.24.4.5 The software should have provision to display all alarm events.
- 2.24.4.6 The Software shall run on Windows.

2.24.5 Standards / Certifications:

The design of the Key management system shall conform to CE, ROHS or equivalent standard / certifications.

2.25 VERTICAL STORAGE SYSTEM (VSS)

2.25.1 Purpose of the machine:

The Automated Vertical Storage system is required for automatic stacking, securing and automated retrieving of small items of various sizes and shapes inside the CMRL Koyambedu depot. The material to be stored might be spares parts (Mechanical / electrical / electronic etc) / consumables of trains / tools and any other critical items.

2.25.2 Basic features for design of Automated Vertical Storage system:

The Automated Vertical Storage system shall have following minimum features (but not limited to):

Description / Parameters	Required
Number of Tray in the lift	atleast 50 nos
Tray width	Min 2500 mm $\pm$ 50 mm
Tray depth	Min 850mm $\pm$ 50 mm
Tray spacing	120 mm or more and adjustable asper usage
Tray loading capacity	Atleast 750kg or more without dead weight
Vertical speed	0.4 m/s or more adjustable (unloaded)
Extraction speed	0.4 m/s or more adjustable (loaded)
Control	Logi control / microprocessor control / PLC
Overall height	7000 $\pm$ 100 mm
Max. Access time	Not more than 45 sec per tray/shelf
Bay type	Single External Bay External tray should be delivered outside the access opening.

2.25.2.1 Accessories (included with supply):

- A carrier trolley to carry the tray to workstation or to transfer the loaded tray to the retriever storage shall be in scope of supply.
- Power cable of suitable length with required rated connector to connect the nearby power supply source.
- Any other accessories (if not listed) to make this system fully functional to be provided with supply and included with the system.
- Suitable rating of Isolated Transformer with Stabilizer having surge arrestor of proven make should be supplied along with unit.

2.25.3 Design requirement of Mechanical parts:

2.25.3.1 The system shall be constructed of a rigid and sturdy self-supporting frame and designed for industrial use. The housing shall be sheet steel panels with an impact resistance. The machine shall have uniform tray / shelf support to the entire height of system.

2.25.3.2 The storage system shall consist of two static columns on rear and front sides of the systems with extractor at center (lift) capable of moving vertically to retrieve the desired pan to the access

point.

- 2.25.3.3 The system shall be suitable for continuous working through at least 12 hours a day, 365 days in a year.
- 2.25.3.4 The design shall take into consideration of fire prevention, the elimination of dust and dirt traps, and easy access for cleaning and routine maintenance.
- 2.25.3.5 Automatic front Door should be provided in access opening and lift system should operate only in closed condition.
- 2.25.3.6 The unit shall have central extractor guiding system for higher travel speed, which shall travel along a fixed guide rail. The Extractor shall be suspended at each corner by sturdy arrangement and shall be driven by an electric motor through suitable mechanism. Provision shall be available for its adjustments.
- 2.25.3.7 All fasteners and piping work shall be of stainless steel.

2.25.4 Design requirement of Electrical Parts:

- 2.25.4.1 The control shall incorporate a 'Mains ON-OFF' isolator master switch and a 'Main-ON' indication light
- 2.25.4.2 A worktop illumination light ON-OFF switch shall be provided.
- 2.25.4.3 The extractor unit of shuttle shall be with PLC and other electrical, electronic hardware's like relays, Contractors, MCB's etc. The PLC shall control the operation by taking inputs from various sensors and giving outputs to different motors.
- 2.25.4.4 The equipment shall be suitable for working on 360- 440V, three phase 4 wire, and frequency 47.5 to 51.5 Hz power supply.
- 2.25.4.5 The motor control shall be through a variable frequency converter to avoid start or stop with jerks. Motor preferably 100% duty cycle.

2.25.5 Control System (Automatic):

- 2.25.5.1 The system shall have a computerized control system which shall have an on-board visual display unit with an alpha-numerical keypad, enabling the user to cross reference part's stock codes for its locations and to pick.
- 2.25.5.2 The system shall be LOGICCONTROL / Microprocessor / PLC control unit for storing and retrieval of tray through part no. / part name which should have independent alphanumeric keys for each operations. The system shall have inbuilt memory and facility to call each item by part number / part name by search parameters and self-location with or without external PC.
- 2.25.5.3 Location management will indicate the storing location on the display TFT / LCD / LED at the control panel and will guide the operator to the same.
- 2.25.5.4 The control system (HMI type) alongwith the Industrial PC(IPC) of latest configuration shall be swivel type installed with the frame of Vertical storage system. It shall be easily accessible by Operator for ease of operation. External keyboard and mouse shall be provided for data entry, control, functions etc.
- 2.25.5.5 System shall be loaded with necessary inventory management software with atleast below given features but not limited to:
- Location graphics
 - FIFO functions with different storage methods
 - Quantity updating facility.
 - Compatibility with ERP and Asset management software
 - Provision to access the database through LAN.
 - Shall generate stock report, user report, order report, item report etc.
 - Reports shall be generated in excel format or any other relevant formatdecided

during design phase.

- Software source code shall be provided.

- 2.25.5.6 The system shall have suitable provision / compatible & interface to connect an external PC, barcode reader, camera, printer etc.
- 2.25.5.7 Positioning of tray shall be automatic and accurate depending on variable heights of material. The tray shall be automatically placed in the best possible location with optimization in height. Positioning of tray must be by absolute positioning system using suitable design.
- 2.25.5.8 An electronic height detection system shall measure all items to be stored and automatically place them in the optimum location.
- 2.25.5.9 The machine shall have an on-board weight management system to control tray / machine load and instantaneous checking of tray load. And if it exceeds it shall reject the tray.
- 2.25.5.10 The stock code shall be of at least 20 alpha-numerical digits. The unit shall have the facility to input a list of minimums of 8000 different stock codes or locations with an option to pick in list order, or shortest route selection.
- 2.25.5.11 Minimum Inventory control with low-stock warning and a printable re-order recommendation list shall be available in the system. Suggestions of empty storage locations by the control unit, while replenishing, shall be available to the operator.
- 2.25.5.12 The system shall be fully automated with integrated machine control and inventory management software loaded into the PLC / Microprocessor. An external device, if required, such as Pen drives / Hard discs to activate the software / take back up etc. shall be provided. Suitable battery back-up shall be provided for PLC / Processor.
- 2.25.5.13 In case of power failure or system failure, the extractor shall remain at its position and should not FREE FALL to the access opening even with the full load. After power resumption the extractor shall resume operation and complete task from same position.
- 2.25.5.14 Redundancy system for uninterrupted functioning of the unit shall be provided.

2.25.6 Protection and Safety

- 2.25.6.1 The control console shall be fitted with a security pass code, enabling only the authorised personnel to operate the system. The pass codes shall be changeable by the user.
- 2.25.6.2 At least 1 set of light barriers shall be positioned exactly at the entrance of the access of the service aperture. The system drive mechanism shall be de-activated if either one of the light beams is impaired or broken.
- 2.25.6.3 An emergency stop push buttons shall be provided and suitably located on the control console. Either one of the emergencies stop pushbuttons, when pushed, shall shut off all machine functions. When re-set by the operator, the machine function shall be restored to 'on' position and shall await the operator to re-start. No memory or picking list input prior to an emergency stop shall be lost when the machine is re-started.
- 2.25.6.4 By passing mode for working in case of emergency shall be provided.
- 2.25.6.5 Inspection door with safety interlocks shall be provided.
- 2.25.6.6 All the subsystems shall be provided with suitable safety precautions for over voltage, overdrive, single-phase prevention etc. Details shall be provided in the offer.
- 2.25.6.7 The system shall be designed rodent protections or equivalent and relevant protections for fire safety.
- 2.25.6.8 The machine and its accessories shall ensure safety of the equipment, operator and other personnel at all times and special precautions shall be incorporated against electrocution by live overhead equipment.
- 2.25.6.9 Adequate safe clearances shall be maintained from the overhead equipment (If any) by the machine during working and non-working modes. All the electrical equipment including structures shall be earthed as per the latest standard of the Indian electricity rule IS 3043.

2.25.6.10 All the operational overrides shall be facilitated with proper interlock system.

2.25.7 Standards:

The design of the Vertical storage system should conform to EN15095 or equivalent standards applicable for such automatic Vertical storage and retrieval system.

2.26 MOBILE AIR COMPRESSOR

2.26.1 Purpose of the machine:

The Mobile Air compressor mounted on trolley is required for production of compressed air required for the Inspection / Light Repair Shed and Overhaul Workshops. The compressed air shall be used for blowing and cleaning of rolling stock equipment and other machinery and plant items in CMRL depot cum workshop.

2.26.2 Scope of Supply:

2.26.2.1 Design, Manufacture, Supply, Installation, Testing, Training and Commissioning of Air Compressor complete with oil separator, oil cooler, oil filter, refrigerated air dryers (preferable inbuilt), air cooled type, air reservoirs, air filters, pipes and pipe couplings, electric controls panel and pressure gauge and all other accessories to make the equipment fully functional.

2.26.2.2 The complete unit of compressor along with other controlling equipment shall be mounted on a carrier trolley (wheel mounted) to transfer the whole compressor unit from one place to another place.

2.26.2.3 The supply shall include a flexible pipe 15 meters approximate and an operator gun of high thrust nozzle.

2.26.3 Technical Requirements (but not limited to below):

Compressor Configuration	a. The system shall be equipped with inlet air filter, inlet check valve, compressor, oil separator element and minimum pressure valve. b. The compressors shall be of the self-lubricating, rotary screw type and shall be mounted on steel deck suitable for 100% continuous duty. c. The system shall have heavy duty dry type inlet air filter, conveniently located for quick and easy replacement with cyclonic separation and arrangement for pre filter separation. The compressor unloading assembly shall be provided with piston type unloader to release safe inside pressure. The unit shall have non-return valve at suction element. d. The supply shall include pressure regulation safety valve, pressure regulator outlet valve, pressure gauge, periodic electronic condensate drain and pre piped. All connections shall be optimised to minimise pressure drop & reduce the potential for air leaks.
Capacity	Compressor shall be capable of giving an output of 21 cfm or more of air at an operating pressure of 10 bar.
Operating pressure	10 bar
Air / Oil Separator	a. The system shall have provision for oil reservoir, oil cooler, thermostatic valve block and oil filter. The system shall have oil level indicator and oil filling arrangement. b. Oil separator shall be mounted outside air tank, minimizing the oil carry over, integrated minimum pressure valve, safety valve and oil draining arrangement. c. The system shall consist of electro pneumatic regulating system with air / oil receiver blow down mechanism to reduce No-load power consumption and pressure switch to set discharge air pressure to desired limits. d. All oil lines shall be of rigid steel pipe and with minimum number of high temperature hoses.
Reservoir	The compressor package with electro pneumatic control panel shall be mounted on a 200L air reservoir (ISI / ASME approved as standard or latest

	equivalent).
Refrigerated Dryer	a. The unit shall have full feature variants with integrated Refrigerated air dryer capable of cooling the compressed air and completely remove water vapour before entering compressed air network. b. System shall have provision for Compact air to air and air to refrigerant heat exchangers for maximum heat transfer and minimal pressure drop. c. Integrated water separator (moisture trap) shall be provided with automatic and manual drain options. d. Hot Gas bypass valve shall be provided to keep evaporator pressure above a certain level at part load and unload condition. e. Condenser shall be provided to convert refrigerant gas into liquid for efficient cooling.
Electrical installation	a. Compressor unit shall be driven by V-belts with XPZ profile, coupled with atleast 5.5 KW motor of Power supply 3 phase AC. b. Motor shall have TEFC square cage, F class insulation with IP 55 standard. Motor bearing shall be greased for life long.
Control Panel	The Control Panel shall comprise of: Suitable proven make DOL starter with Contractor and relays for overload and single-phase protection. - Dryer ON / OFF button. - Regulator with relays. - Hour-meter to indicate total hours of operation. - Start / Stop button with lamp indicating compressor operation. - Indicator for auto operation. - Easy access for service points.
Carrier Trolley	The whole unit of compressor shall be mounted on a carrier trolley to move from one place to another place. Trolley shall consist of a basic chassis, set of wheels and steering etc. Polyurethane or better type wheel shall be provided. Contractor shall provide details of trolley during the design stage.
Other Requirements	a. The system shall be designed to operate at the normal workshop temperature. Arrangement shall also be incorporated for automatic shutdown in the event of prolonged off-load operation. b. The sound level for the overall of the installation shall not exceed 65 dB at a distance of one meter and shall, in no case whatsoever, create vibrations in the ground or in the partitions. c. Anti-Vibration Mountings shall be provided with sound proofing treatment

2.26.4 Protection and Safety:

All equipment shall be designed for operation in a railway environment as well as against power supply anomalies such as high undulation rates, high over-voltages, and slow voltage variations. Following safety features shall be included:

- Overload Motor protection
- Discharge safety valve
- Oil discharge temperature trip at the outlet.

- Oil level indicator.
- In-built protection against starting on load.
- Pressure transducer mounted at the downstream of moisture trap and upstream of oil separator.

2.26.5 Standards

The entire supply shall comply with the requirements of the standards in force.

2.27 INDUCTION HEATER

2.27.1 Purpose of the machine:

Induction Heater shall be used for efficiently heating bearings and workpieces,

2.27.2 Technical Parameters for Induction Heater:

Specification			Requirement
Handling capacity of Work piece / Bearing	Bore Diameter- minimum (mm)		20 or lower
	Maximum Bore diameter (mm)		150 (or higher)
	Max Weight (kg)		Upto 25Kgs
Heated Bearing Type	Can heat pre-heated bearing		Yes
	Can Heat Sealed Bearing		Yes
Max Power consumption (kVA)			Upto 3kVA
Control Specifications	Temperature control mode	Range (min)	+40 °C to +180 °C
		Accuracy	± 3 °C or better
		Sensor Type	K – type
	Time control mode	Range (min)	0-60 minutes
		Accuracy	± 0.04 sec or better
	Demagnetization		<2 A/cm
Thermal overload protection			Yes
Control Panel	Control panel with integrated LED display. (wired and wireless remote model also acceptable)		
Heating capacity	Capable of heating 1- 25 kg bearing of bore dia (as mentioned above) from 20 °C to 110 °C in 20 minutes or lesser		

2.27.3 Other Requirements

- Induction bearing heater shall be supplied with suitable and sufficient number of yokes to heat the bearing of various bore diameter within the specified range.
- Bearing support arm shall be of foldable type and equipped with internal storage provision for smaller yokes.
- Induction bearing heater must be capable of automatic demagnetization after each heating cycle.
- Temperature sensor shall be of K-Type / Suitable High temperature Magnetic Temperature probe.
- Product must be CE Certified.

2.28 BATTERY OPERATED CART/BUGGY (6-SEATER)

2.28.1 Purpose of the machine:

This is battery operated electric vehicle required for transport and movement of passenger/staff inside the depot premises.

2.28.2 Technical specification :

Description / Parameters	Required (Minimum)
Drive type	Electric drive
Gear Ratio	1:16
Motor Power	4 kW
Controller	CURTIS or better
Battery	Lithium Ion 48V, 150AH
Speed	18-20 kmph
Turning Radius	4500 +/- 200mm
Range per charge	45 Kms
Dimensions (mm) Min	L 3565 +/- 40 x W 1250+/- 10 x H 2010+/- 20
Wheelbase	2380+/- 20 mm
Ground Clearance	150 +/- 10 mm
Display	Multifunction LED
Wheel Size (Alloy Wheel)	205/50-10
Seats	6 Seater
Ergonomics	• High raise hand brake • Comfortable cushioned seats • Large Leg space • Steering mounted controls
Safety	• Emergency Stop • Seat Belts • Reverse buzzer • Safety beacon • Proximity sensor • Fire extinguisher

Description / Parameters	Required (Minimum)
	Grab handles
Utility	- Cabin lights - Rain cover - Wiper - Charging port - Basket
Other Accessories	- Spare tyre assembly - Jack - Foot Air pump - Tool Kit - Side indicator with horn - Side view mirror

2.29 RS PUSHER (BATTERY OPERATED)

2.29.1 Purpose of the machine:

This machine is required to push the rolling Stock from Wheel to enable the Rolling Stock to place at a required distance on track within the limit of the machine.

2.29.2 Technical Specifications :

Description / Parameters	Required (Minimum)
Type of Product	Battery Operated RS pusher
Traction capacity	130 ton to 150 ton on straight track
Pushing capacity	Upto 500m in single charge
Weight	Max 50Kgs
Brake Wedge	Yes (Integrated with machine)
Wedge Dimension	L 300mm , Height 130mm from rail head
Gear Box Clearance	100mm from surface
Battery type	Li-ion (Life atleast 6-7 years). On-board 24 V lithium battery supply with a charge indicator, charging socket, and general switch
Battery Charger	Standalone Charger shall be supplied. Battery shall be charged without removing from the machine.
Full Charging time	Not more than 3 hrs
Operator Requirement	Designed to be operated by Single Operator
Application Area	• Shall be designed for pushing RS at Workshop track, ballasted track and outdoor track in depot. • Shall be used in rough terrain
Safety	• Automatic overload switch • Emergency push button
Accessories	The machine shall be supplied with all accessories to make the machine fully functional at all track condition (Indoor workshop, Outdoor workshop ballasted as well as Ballastless track but not limited to): • Battery operated RS Pusher • Battery • Charger • SS Roller protection casing

Description / Parameters	Required (Minimum)
	Other attachment required to push RS at all track condition as applicable

2.30 HYDRAULIC FLOOR CRANE (2T)

2.30.1 Purpose of the machine:

This machine is required to lift and move various parts/components in the workshop upto capacity of 2 ton. This is manually operated machine.

2.30.2 Technical Specifications :

Description / Parameters	Required (Minimum)
Capacity	Min 2000 kgs
Maximum Height when BOOM in top position:	2100 mm to 2300 mm
Height of vertical column/pillar:	1500 mm to 1600 mm
Overall length of base	1600 mm to 1700
Overall width of base	800 mm to 1000 mm
JIB position	a. Inner : 2000 Kg. b. Middle : not less than 1400 Kg. c. Outer : not less than 1000 Kg
Toeing Handle	The toeing handle of the Hydraulic Floor Crane shall be positioned in a suitable location so that the trolley can be easily manoeuvred
Handle Grip	The toeing handle of the Hydraulic Floor Crane shall be provided with a soft and durable rubber grip for comfort of the operator.
Wheels	Adequate Numbers of Wheels to be provided for easy manoeuvring.
Wheel lock	Wheel lock & guard shall be provided for safety.
Hydraulic Cylinder	Sufficient number of hydraulic cylinders to be provided to lift minimum 2000 kgs of weight

2.31 TRACTION MOTOR DRYING OVEN

2.31.1 Purpose of the machine:

The oven is required for drying/baking the traction motor.

2.31.2 Technical Specifications :

Description / Parameters	Required (Minimum)
Heating Media	Electric
Usage / Application	For Drying/Baking Traction Motors
Working Size	1800mm (H) X 1500mm (W) X 1500mm (D)
Outer Size	2100mm (H) X 1850mm (W) X 1700mm (D)
Temperature	Ambient To 250°C
Trolley	1NOS PLATFORM TYPE (1500KG CAPACITY)
Power	18 KW-3PHASE, 415 VOLTS 4 WIER, 50HZ, AC Supply
Oven Construction	The oven shall be fabricated out of 40 x 40 x 5mm M.S. Angel frame structure and 1.2mm M.S.sheet outside & 1.2mm M.S. Sheet at inside. The body shall be insulated with 100mm thick 96kg/M3 Mineral wool from all the sides. The oven shall have Double doors at front side with heavy duty Hinges and special locking arrangement.
Trolley Construction	The trolley shall be fabricated out of 75 x 40mm M.S. “I” type channel with 4nos heavy duty (SKF) ZZ bearing wheels. It has manually worked his separate track inside of the oven and also provides 1800mm extra track of outside of the oven for easily moving trolley in and out. 3 mm Plate shall be welded on top side of the Trolley with capacity 1500kg Weight. Approximate Trolley height 300mm. Trolley Working Platform Size (1350mm (D) X 1350mm (W))
Air Circulation	Air shall be circulated with a 1nos of Three Phase 2HP 1440RPM motorized Belt Drive Blower with NTN Pillow block bearing on top side of the oven. It shall be done by dynamically and mechanically balanced for uniformly hot air circulating in whole chamber area. Air flow shall be applied to direct job placed on Trolley.
Heater	Heating of the oven shall be achieved by S.S.304 Tubular “U” & “L” type 1000mm long 18Nos Finned type Air heaters. Heater designed shall be Low watts & Long-Life Type. Heater shall be fitted on right and left side of the oven. Heater rating 1KW per each heater all the terminal of heating element shall be connected with the help of suitable capacity heat proof Bakelite Connector. The terminals of suitable capacity of lugs for spark free tight connections. All Heaters connection at both

Description / Parameters	Required (Minimum)
	Side of the oven. Heater Wiring shall be done by 2mm thick Heavy-Duty Fiber Glass Wire with ceramic elements.
Safety Devices	Interlocking between the Blower and heaters so that in case of failure of Blower the supply to the heater shall cut off the automatic temperature controller to have built in safety for broken thermocouple. Limit switch shall be provided on the door.
Control Panel	Electrical Control Panel shall be in a separate enclosure which will be mounted on the oven. Adequate earthing shall be done. Control panel shall consists of Digital Temperature controller Timer, CTR ammeter, Volt meter, Current transformer, Push button for motor start/stop with indication, Motor start/stop contactor, Over Load relay for motor, rotor switch heater ON/OFF with indication, LED Type indication lamp R/ Y/ B, MCBs and sensors as per design,
Finishing	The complete oven angle structure shall be degreased and acid pickling and painted with two coat of red oxide primer coating. Similarly, the M.S. sheet shall be also chemically treated for removal of corrosion. It shall be applying on two coat of red oxide primer and after apply paint color as per CMRL recommendation at outside. 300-degree Heat Resistance Aluminium Paint shall apply at inside of the oven.

2.32 WHEEL PROFILE MEASUREMENT DEVICE - HAND HELD CONTACT TYPE

2.32.1 Purpose of the machine:

This Hand Held Contact-type Wheel Profile Measurement Device shall be used for measuring the complete wheel profile and provide measurement of wheel parameters like flange height, flange thickness and root thickness etc of Metro Cars. The supply shall also include one number Wheel Back to Back measurement device (Hand held).

2.32.2 Technical Specifications :

Description / Parameters	Required
Device Type	Automatic Digital Wheel Profile Measurement Device- Hand Held
Profile	Metro Car Wheel Profile (Minimum 10 types of different wheel profiles shall be measured from this device)
Measuring Type	Direct Contact Based
Connection Feature	Bluetooth and Wired Connection
Battery charge	At least 08 hours of continue work
Wheel Parameter Measurement (but not limited to)	• Flange Thickness • Flange Height • Slope qR • Flange Wear • Root Wear • Tread Wear
Measuring Accuracy	$\pm 10 \mu\text{m}$
Repeatability	$\pm 2.5 \mu\text{m}$
Measuring Speed	<5 second per profile measurement
Additional Feature	Compare several saved measured profile with reference to new wheel reference profile. Graphical comparison shall be generated by device itself.
Storage	Measuring and save complete digital profile with unlimited storage of profile.
Weight of measuring device	< 1.5 Kg
Software	Envision software(for mobiles, tablet & PCs) with complete trending and analysis including derivation of wheel conicity with high flexible printing report.
Software Installation Limit	Minimum 5 users Envision software installation along with

and License.	license key and free software updates.
File export capability	Measurement file can be exported exchanged for research and support purpose documentation on USB key
Measurement result	PDF and Excel
Accessories	• Device Charger- 1 Nos. • Data USB Cable- 2m Length -1 Nos. • Pen drive -1 Nos. • Rugged waterproof Equipment transport case with IP67-1 nos. • Industrial Laptop of latest configuration (min Screen size Minimum 14”) of superior reputed make. Alongwith required interface software as applicable. • Quick Guide • Wheel Back to Back Measurement device – 1nos
Miscellaneous	All other items required for full function of device shall also be provided without additional cost.
Atmospheric Condition	Machine should work in Ambient temperature at site from - 15°C to +50°C over the year
Material of Equipment	"Titanium" or a superior alternative for high-temperature applications requiring precise measurements and durability under rough conditions.
Manual	03 Set clear visible manual printed in English may be provided
Calibration	OEM calibration & service centre facility should be available in India.
Additional Features	All type of wheel profile history data shall be capable to transfer any other Local computer/server thru USB (Wired) as well as WiFi (Wireless connection)

2.33 INDUSTRIAL VIDEOSCOPE

2.33.1 Purpose of the machine

The Videoscope shall be required for industrial inspections of traction motor etc.

2.33.2 Technical Specification :

The device shall comply the below stated parameters (but not limited to) :

- The videoscope designed to stand up to the dirtiest, most harsh environments.
- High-definition probe with dual-view camera, Minimum camera resolution : 1200 x 720 (864,000 pixels)
- Processing speeds that render a smooth, clear, consistent image, 7" LCD screen for easy viewing.
- Macro to micro zoom function, Adjustable lighting to capture the best image, regardless of the probe location.
- The device allows to save and share images directly from the diagnostic scope, Detachable, semi-ridged and waterproof videoscope.
- Battery operated.
- The device supply shall consist of High resolution diagnostic videoscope with 1.2m, 8.5 mm semi-ridged probe, Hand strap, USB cable, AC power supply/battery charger, TPAK magnetic hanger, Protective EVA case.

2.34 TWO POST LIFTING JACK

2.34.1 Purpose of the machine

The machine shall be required to lift and hold the RS HVAC at convenient height for general inspection and required maintenance as and when required.

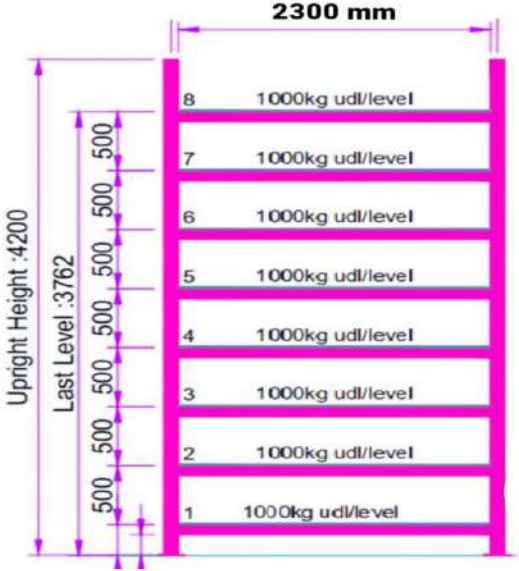
2.34.2 Technical Specifications :

Description / Parameters	Required
Lifting Capacity (Set)	2000 Kgs
Lifting Capacity (each jack)	1000 Kgs
Type	2 Post Lifting Jacks
Drive	Electro-hydraulic
Lifting height	Max 1800 mm
Lowering height	Approx 140 mm
Lift configuration	Symmetric
Type of mounting	Surface mounted
Lifting Time	55 to 60 Second (for Maximum height)
Swivelling Arms	- Front arm Reach Minimum to Maximum 700-1050 mm - Front arm Reach Minimum to Maximum 800-1130 mm Note : The given dimension is indicative only. The Contractor shall interface with RS Contractor to design the Lifting Jacks accordingly. (Lifting pad of suitable material).
Material of Structure	Structural Steel
Finish	Powder Coated
Hydraulic Power Unit	Shall consists of, but not limited to: - Electric motor - Geared hydraulic pump - Oil tank and other accessories as applicable to make machine fully functional
Control Box	Shall consists of, but not limited to: - Main Switch - Rise push button - Down push button Other accessories as applicable to make machine fully

	functional
Safety Mechanism	Automatic lock restraints, Relief Valve, Automatic stops on the approach end
Safety features to avoid automatic lowering of elevated loads due to sudden power failure	Yes
Capable of stopping and safely holding the load at any point between the minimum and maximum permissible height limits	Yes

2.35 VARIOUS STORAGE ITEMS

2.35.1 Storage Racks

Sample sketch 	Product specification (minimum parameters): : Storage rack; Beam width : 2300 ± 20 mm(min); Load capacity per level : 1000 kg . Racks shall be equipped with decking panels, Back / pallet stopper, Foot plate, brace, Upright Guard, row guard, Column Guard, and other accessories as necessary. Equivalent to Godrej / Nilkamal Long Span Shelving System or other equivalent proven (Heavy-duty). Frame Height : 4200 mm, 3762 mm (± 20 mm) Loading Levels : 8 Shelving Depth : 1000 mm Load per level : 1000 kg Other : Panel height shall be adjustable as per requirement

2.35.2 Mechanical Work Bench

Product Specification(minimum parameters):	
Overall dimension	1500 Lx 800 W x 850H
Type of worktop	Multiplex or better
Thickness of top	50mm (min) thickness MDF or better, with 2mm thickness SS (stainless steel) Sheet on top of the MDF
Load capacity	1000 kg
Drawer	Cabinet below workbench with 3 drawer normal extension with central locking



Sample picture

2.35.3 Storage Bins

Description of Items	Dimension
Storage Bins -Type1	(400X300X120)
Storage Bins -Type2	(230X150X125MM)
Storage Bins -Type3	(300X210X160MM)
Product Specification (minimum parameters):: Above bins shall be: - HDPE or better material - Non-toxic and Environment friendly - Odourless - Resistant to solvent and acids - Washable and sterilisable - Easy to lift with load - Durable and robust for multipurpose	

2.35.4 Pallet (Heavy duty)

Description of Items	Dimension
Pallet (Heavy duty)	(1200 X 1000X 160MM)
Product Specification (minimum parameters):: Above pallets shall be: - HDPE or better material - Rackable purpose with racking load -1000kg - Dynamic Loading weight : min 1000kg - Type : 2-way entry for pallet truck and 4-way entry for Forklift - Suitable for forklift and pallet truck handling	

2.35.5 Storage Cabinet

Description of Items	Dimension (in mm)
Storage Cabinet (Almirah type)	900 W x 400D x 1800 H
Product Specification (minimum parameters):: Above cabinet shall be: - heavy duty - Welded structure of steel - Min 0.7 mm steel sheet with powder coated finish - Shelves: 1 fixed at bottom + 4 height adjustable type	

- Load capacity: min 50 kg/Shelf

2.35.6 Personnel Lockers Cabinet

Description of Items	Dimension (in mm)
Personnel Locker cabinet	1800H x 900W x 400D (minimum per set)
Product Specification(minimum parameters):: - One set shall comprise 18 lockers with door - Each Locker with provision of padlock - Locker units shall be mounted with steel Stand - Welded structure of steel - Steel sheet of adequate thickness with powder coated finish or better - Provided with labelling for identification	

2.35.7 Flammable Liquid storage cabinet

Description of Items	Dimension (mm)
Flammable Liquid storage cabinet	1650Hx1090Wx860D (minimum) ± 10mm
Product Specification: Cabinet shall have following minimum key features: - Cabinet shall be constructed of sturdy min 18 gauge(1mm) thick double wall welded steel with min 35mm (± 5mm) of insulating air space for fire resistance. - High performance, self-latching doors close easily and securely for maximum protection under fire condition. - Cylinder lock (key) - Bottom spill tray for routine cleaning - Ventilation vents and internal flame arrestor mesh - Litre capacity: 340L min - No of Doors: 2 - Door Type: Manual - No of Shelves: 2 (Adjustable) - External hazard stickers in accordance with relevant standards. - Color: Yellow	

2.35.8 Stand for HVAC Filter Cleaning Trolley

- Product specification(minimum parameters)::**
- Suitable for accommodating RS HVAC filter (all type) for wet cleaning and drying

- Material : Fabricated out of SS316
- Filter size shall be interfaced with RS Contractor to design the trolley accordingly
- Trolley shall be designed to accommodate and wash/dry atleast 3 car with different dimension of filters in one time.
- 02 nos of 150mm dia wheel with brake and 02 nos of 150mm dia wheels without brakes shall be equipped with trolley.
- Design of trolley shall sustain the load of all filter in loaded condition and shall be movable without trouble.

2.35.9 Industrial Vacuum Cleaner

Product specification(minimum parameters)::

- Suitable for Wet and Dry cleaning,
- Supply Voltage (Ph/V/Hz) 220-240 V, 50-60Hz,
- Vacuum 22.5kPa,
- Container content 70Litre,
- Container Material : Stainless steel,
- Rated Input power : 2300W,
- Cable Length : 7.5m cable length, Noise Not more than 76 dB(A),
- Machine shall consists of (but not limited to) : Suction hose 2.5m, Bend : Plastic, Suction tube 2pcs, Wet/dry floor nozzle : 360mm, Dry floor nozzle : 360mm, Crevice nozzle, filter, Drain hose, SS Container, Push handle, Water resistant filter tank, any other accessories required to make machine fully functional.

2.35.10 Movable Platform(Upto train Door Level)

Product specification(minimum parameters)::

- Total Height with hand rails : 2000mm
- Height till platform : 1100mm
- Base Frame Length : 2000mm
- Base Frame Width : 650mm
- Platform Dimension : 670 X 650mm
- Total steps : 5 nos excluding platform
- Step dimension : 250 X 570mm
- Wheel (Nylon or better) : 4 nos with brake, foot operated (2 front & 2 rear)
- Material : Aluminium (Industrial grade)

2.35.11 Manual Mobile Ladder for window glass access

Product specification(minimum parameters)::

Design shall include

- Platform 670 X 650mm
- Hand rail
- Total Height : Shall be Interfaced with RS Contractor

- Base Frame
- Adequate steps of suitable width and depth
- Wheel (Nylon or better) : 4 nos with brake, foot operated (2 front & 2 rear)
- Purpose : Suitable for access RS window for inspection, cleaning etc
- Material : Aluminium (Industrial grade)

2.36 TOOLS AND OTHER ITEMS

2.36.1 Weighing Machine (Capacity 1000kg)

Product specification(minimum parameters)::

- Weighing capacity: 1000kg
- Indicator housed in a sturdy metal enclosure
- Bright LED display
- Overload and shock load protection
- Operates on single phase 230v AC supply with Inbuilt sealed maintenance free rechargeable Battery and Battery charger
- Incorporates multiple number of high-quality SS shear beam loadcells.
- Pan Size: 1000mm * 1000mm
- Material: Stainless Steel (SS)
- Multiple weighing units

2.36.2 Piece Counting Weighting Machine

Product specification (minimum parameters)::

- Weighing capacity: Upto 200kg
- Shall store unit weight of multiple items (not less than 400 items)
- 3 bright LED display to display weight, unit weight and pieces
- Automatic count calibration mode
- Indicator housed in a sturdy metal enclosure
- Operates on single phase 230v AC supply with Inbuilt sealed maintenance free rechargeable Battery and Battery charger
- Pan Size: 1000mm * 1000mm
- Material: Stainless Steel (SS)
- Multiple weighing units
- Print out option with Date / Time, count and weight

2.36.3 Welding Machine Portable (200 Amp single phase ARC welding)

Product specification (minimum parameters):

- Rated input Voltage: AC 230V+15% single
- Phase: 50 / 60 HZ
- Rated Input power KVA: 8
- Rated Input current A: 35 A
- Duty Cycle: 60%
- Protection class: IP21
- Insulation class F
- Electrode dia. (mm): 1.6- 3.2

2.36.4 Portable Hand Grinder

Product specification (minimum parameters):

- Suitable to grind and cutting as per requirement
- Rating Input: 570 W- 670W
- Depressed Centre Wheel: 100mm (4")
- Abrasive Disc: 100mm (4")
- No load speed: 11500-12500 rpm
- Suitable for metal cutting / grind
- Power supply cord: 2.5 m min

2.36.5 Drilling Machine Portable

Product specification (minimum parameters):

- Power source: Corded electric
- Rated power: 600 Watts
- Multi-function drilling machine upto 13mm to make holes on the wall, concrete etc
- Forward / Reverse switch
- Two-way Hammering / drilling mode selector switch
- Speed trigger with electronic control
- No-Load speed: 0-2800 rpm
- One set of drilling bits shall be provided (upto 13mm)

2.36.6 Pedestal Grinding Machine (2 Disc Type)

Product specification (minimum parameters):

- Power source: Corded electric
- Heavy duty Doubled Wheeled Bench grinder
- Grinding wheel diameter: 200mm
- Rated input power: 600 W
- No-load speed: 3600 rpm

2.36.7 Pillar Drilling Machine

Product specification (minimum parameters):

- Power source: Corded electric
- Motor: 3 phase Induction AC
- Drill capacity: 20mm
- Spindle centre of column: 205mm
- Spindle travel: 130mm
- Max distance between Spindle to table: 570mm
- Max distance between spindle to base: 820mm
- Working surface of table: 268x 275 mm

- Working surface of table: 245x 275 mm
- Shall be stable and shock proof while in use.

2.36.8 Metal Cutting Machine / chop saw

Product specification (minimum parameters)::

- Power source: Corded electric
- Motor: single phase AC 2300w, 220-240V
- Wheel diameter: 14 inch
- Suitable for metal cutting
- Broader base to increase stability
- D-shape handle for better control
- 4000 rpm cutting speed
- Adjustable fence for angled cuts upto 45deg
- Adjustable spark guard for safety
- quick lock vise and on-board wheel change wrench
- Contractor shall provide 5 cutting discs

2.36.9 Dewatering Pump Portable

Description	Requirement
Net Positive Suction Head (NPSH)	Minimum 25 meter
Suction and Delivery Pipe Dimensions (mm x mm)(mm x mm)	80X65
Engine Number of Cylinder	1
Engine Capacity	8 horsepower
Power input to pump at Duty Point (Kilowatt)	5.5 kW
Safety controls to shut down the engine in the event of low lub oil pressure or high cylinder head temperature in case of air cooled engines	Should be available
Temperature Rise	25 deg C
Standard set of tools consisting of set of 3 spanners, one screw driver ,one standard plier and one nose plier of appropriate engine size shall be provided to the consignee along with , free of cost for each of Pump Set	Should be Provided
Generic	
Dewatering Pump set	Complete unit including pump & engine duly coupled along with auto prime system, fuel tank etc shall be mounted on a two wheeled trolley for easy transportability, The trolley shall be equipped with Leaf Springs for Suspension, Support for Rear end and Towing Bar, Parking Brakes etc and The trolley must have minimum ground clearance of 300 mm, below leaf spring
Service/Duty	Continuous
Type of Pump	Back Pull Out
Location	Outdoor application

Fuel supply	Fuel Pump by Gravity Feed through Tank
Starting	Hand Start
Capacity	
Capacity (Rate of Flow) (m ³ /hr)	Minimum 50
Total Head (min) Corresponding to Capacity and Speed(metres)	Minimum 20 meters
Speed in RPM (rpm)	2200
Pump Efficiency at Duty point Corresponding to Capacity and Speed (water delivered / Pump Input) (%)	Minimum 60
Lub Oil Consumption (g/k Wh) : (g/k Wh)	2
Fuel Tank Capacity for min 24 hours continuous running at full load	Minimum 5litre

2.36.10 Coupling/Bearing Puller

Product specification(minimum parameters):

- One set of Coupling/Bearing puller shall consist of one number external & one number internal bearing puller of different capacity/size 150mm to 300 mm
- Operation : Hand operated
- Jaw/Leg (Internal/External) : 2-3 nos
- Material : Forged steel or better
- Handle/Lever to operate : Shall be provided

2.36.11 Tool Cabinet Trolley

Product specification (minimum parameters)::

- Tools cabinet trolley with 7 drawers ,
- Dimension H 1025mm X W 455mm X L770mm (Minimum) ,
- Handle to push/pull the Trolley,
- Reinforced double wall frame with single piece casting enables high strength and long life.
- High quality ball bearing slides enable smooth drawer opening.
- Rear locking system avoids opening of the drawers.
- 4 Castors wheels shall be smooth, strong & chemical resistant and have a load capacity of upto 250Kgs.
- Superior powder coating on the cabinets gives extra rust protection and good looks

2.36.12 Bench Vice 6"

Product specification (minimum parameters)::

- Heavy duty Bench Vice,
- Clamping Size : 150mm Min

- Material : Forged steel/Cast iron
- Without swivel base.
- Swivel lever that allows a smooth shift.
- Accessories shall be Included for fitment on Mechanical Work Bench.

2.36.13 Mechanical hand Tool Kits

Product specification : Each kit shall consists of following tools (but not limited to)::

- 7 x 1/2" Drive Socket Accessories: Heavy Duty Ratchet, 75, 125, 250mm Extensions, Universal Joint, Flex Bar
- 2 x 1/2" Drive Spark Plug Sockets: 5/8, 3/16
- 33 x 1/2" Drive Standard Sockets: Metric: 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 27, 30, 32mm A/F: 3/8, 7/16, 1/2, 9/16, 5/8, 11/16, 3/4, 13/16, 7/8, 15/16, 1, 1-1/16, 1-1/8, 1-3/16, 1-1/4"
- 6 x 1/4" Drive Socket Accessories: Heavy Duty Ratchet, 50, 150mm Extensions, Universal Joint, Socket Driver, Bit Holder
- 16 x 1/4" Drive Standard Sockets: Metric: 4, 4.5, 5, 5.5, 6, 7, 8, 9, 10mm A/F: 3/16, 7/32, 1/4, 9/32, 5/16, 11/32, 3/8"
- 1 x 152mm Diagonal Cutting Pliers, 1 x 152mm Long Nose Pliers, 1 x 178mm Combination Pliers
- 33 x Assorted 1/4" Bits, Screwdriver, Hex & Torx, 1 x Adjustable Wrench: 300mm,
- 19 x Combination Spanners: Metric: 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19mm A/F: 3/8, 7/16, 1/2, 9/16, 5/8, 11/16, 3/4"
- 8 x Hex Key Set – Long Ball Type: 1.5, 2, 2.5, 3, 4, 5, 6, 8, 10mm
- 4 x Screwdrivers: Slotted #5x100mm, #6x150mm Phillips® #1x100mm, #2x150mm

2.36.14 Ratchet socket set

Product specification : Each Set shall consists of following tools (but not limited to)::

- 13 pieces shallow socket: 4, 4.5, 5, 5.5, 6, 7, 8, 9, 10, 11, 12, 13 and 14mm.
- 1 piece universal joint
- 2 pieces extension bars: 2 inch and 4 inch.
- 1 piece 150mm flexible extension.
- piece spinner handle (go through type).
- 4 pieces hex key wrenches: 1.27, 1.5, 2 and 1.5mm.
- 1 piece quick release ratchet handle.
- 1 piece sliding T-bar.
- 22 pieces socket bits (length 37mm) slotted: 4, 5.5 and 7mm. Hex bits: 3, 4, 5, 6, 7 and 8mm. Phillips: No. 1, no. 2 and no. 3. Pozidriver: No. 1, no. 2 and no. 3. Torx driver bits: T-8, t-10, t-15, t-20, t-25, t-30 and t-40.

CHAPTER 3

INTERFACE MANAGEMENT

3.1 INTRODUCTION

- 3.1.1 In conjunction with other associated Contractors the Contractor shall be responsible for all interface matters related to the design, manufacture, supply, testing & commissioning of the respective M&P(s) under their scope of supply.
- 3.1.2 Major Interfacing Contractors for machinery and plant Contractor are (wherever applicable):
- a) Depot Civil Contractors (DC)
 - b) Depot Electrical & Mechanical Contractor (E&M/MEP)
 - c) Rolling Stock Contractor(s) (RS)
 - d) Track Contractor (TRW)
 - e) Signalling & Train control Contractor (STC)
 - f) Overhead Electrical Contractor (OHE)
 - g) Asset Maintenance Management System Contractor (*Refer Part 2 Section VI A*)
 - h) Telecom & Radio (RAD) Contractor
- 3.1.3 If any part of the execution of the Works for the Chennai Phase-I programme should require the Contractor to undertake coordinated interface works and/or exchange information with any other party or Contractor; then the Depot Machinery and Plant Contractor shall provide those services as part of their obligation of this Contract at no addition cost to CMRL. The appointed Interface Manager shall facilitate coordination of the same.
- 3.1.4 The Contractor shall apply best endeavours to resolve all interfaces applicable to the Contract and shall be proactive in seeking out interface issues and to identify their optimal solution.
- 3.1.5 It is foreseen that multiple rolling stock fleets shall serve the Chennai Metro Phase-I network and shall be maintained at Koyambedu Depot. The Depot M&P Contractor is therefore required to coordinate the interface requirements of all fleets during design, manufacturing, testing & commissioning to ensure that all machines are cross-compatible with all fleet types (except for cases where it is explicitly stated otherwise in the machine specification).
- 3.1.6 Interface Responsibilities
- i. The responsibility for specification and provision of the requirements for the works that interface with Designated Contractors' equipment is tabulated in corresponding section of the document.
 - ii. The requirements specified herein are by no means exhaustive and it remains the Contractors responsibilities to develop and execute jointly an Interface Plan after the commencement of the works and throughout the execution of works, to ensure that:
 - a) All interfacing issues between the two Contracts are satisfactorily resolved.
 - b) Supply, installation and testing of equipment and software are fully co-ordinated.
 - c) That all equipment supplied under the respective Contracts are fully compatible with each other, whilst meeting the requirements of the respective Specifications.
 - d) All the construction tolerances at the point of interface shall meet the requirements of the respective specifications relating to the interface points.
 - e) Interfacing Contractors shall mutually respect each other's project timelines with respect to the interface requirements.
 - f) Interfacing Contractors shall finalize their respective interface equipment only after clear agreement on interface requirements with the other designated Contractors.
 - g) Interfacing Contractors shall ensure that in any case, no equipment of their system shall be put

into production or installation without meeting the interface requirements spelt out in this Chapter and/or in the Technical Specification.

- h) Test procedures, troubleshooting manuals and any other documentation shall be updated with technical details from each Contractor and shall be submitted to CMRL.

3.1.7 Interface Management

- i. All Interfacing Contractors (which are listed under clause 3.1.2) with the exception of the Rolling Stock Contractor shall assume the role of Lead Interface Contractor.
- ii. Where the DM&P Contractor is not the Lead Interface Contractor, the DM&P Contractor's role is defined as a Participating Contractor with respect to interface management.
- iii. The Lead Interface Contractor shall be responsible to initiate, plan, coordinate and produce jointly with the Participating Contractors a list of all the required interfaces, interface design documents and shall produce interface progress reports. The Lead Interface Contractor shall also prepare and issue all interface meeting of minutes within 3 days of the meeting and provide bi-weekly interface progress reports to all the participating Contractors for information.
- iv. Participating Contractors shall collaborate fully with the Lead Interface Contractor in the development and finalization of the interface design, joint production of the interface documents and interface progress reports. Participating Contractors share responsibility of ensuring that the Lead Interface Contractor is able to submit a copy of the all-interface design documents (including the Detailed Interface Design (DID) deliverable) to the Engineer/CMRL for approval.
- v. The costs for all interface design and testing works shall be deemed to be included in the Contract sum of respective contracts regardless of the actual extent of effort required or expended by the Contractor.
- vi. The Contractors shall be fully responsible for the management and control of their respective SubContractors in relation to all interfacing activities carried out under the Contract.

3.2 INTERFACE SPECIFICATION: DEPOT MACHINERY & PLANT (DM&P) CONTRACTOR & ROLLING STOCK (RS) CONTRACTOR

Table 3-1: DM&P Contractor & RS Contractor

Item	Responsibility DM&P Contractor	Responsibility of Each RS Contractor
1. Auto Train Wash Plant (ATWP)	a. Shall collect all relevant details i.e train dimensions (Front to Rear end including coupler) etc of RS for the effective design of Wash plant.	a. Shall provide details of RS dimensions as relevant to the design of Wash plant.
	b. Shall collect all relevant information and details of type of detergent and water suitable for RS with a view to avoid any damage to RS surface and design the Wash plant accordingly	b. Shall provide all relevant information and details regarding type of detergent and water suitable for the RS material with other instructions as relevant.
	c. Shall obtain any specific instruction	c. Shall provide specific details e.g infringement objects if any which may hindrance to the washing etc.
	d. Shall conduct joint test with RS Contractor that the wash plant is adapted and compliant to RS requirement.	d. Shall attend and provide necessary support to DM&P Contractor during wash plant testing and commissioning as necessary.
2. Battery Operated Railroad Shunter (BORRS)	a. Shall collect all relevant details regarding RS characteristics including weight for the effective design of BORRS	a. Shall provide all relevant details regarding RS characteristics including weight, dimensions etc.
	b. Shall collect all relevant information and details of type of coupler of RS and	b. Shall provide all relevant information and details of type of coupler of RS.

Item	Responsibility DM&P Contractor	Responsibility of Each RS Contractor
	design/provide the BORRS coupler with compatibility accordingly.	
	c. Shall demonstrate the testing and commissioning with coupling / uncoupling, shunting with 6 coupled car, braking with and without shunting load etc as per tender requirement.	c. Shall attend and provide necessary support to DM&P Contractor during BORRS testing and commissioning as necessary.
3. Synchronised Pit Jacks (SPJ)	a. Shall collect all relevant details regarding RS characteristics including weight, dimensions, lifting pad location and dimension, Bogie wheelbase, Bogie centre to centre, wheel profile etc for the effective design of Pit Jacks.	a. Shall provide all relevant details regarding RS characteristics including weight, dimensions, lifting pad location and dimension, Bogie wheel base, Bogie centre to centre, wheel profile etc
	b. Shall manufacture the equipment ensuring no infringement in the vertical plane below the lifting points.	b. Shall coordinate with Jacks Contractor to provide specific details as required.
	c. Shall demonstrate the testing and commissioning with lifting / lowering / holding etc as per tender with RS 6 car configuration.	c. Shall attend and provide necessary support to DM&P Contractor during Jacks testing and commissioning as necessary.
4. Synchronised Mobile Lifting Jacks (SMPJ) and Car Body Stands	a. Shall collect all relevant details regarding RS characteristics including weight, dimensions, lifting pad location and dimension etc for the effective design of Mobile Jacks and Car body stands.	a. Shall provide all relevant details regarding RS characteristics including weight, dimensions, lifting pad location and dimension etc.
	b. Shall manufacture the equipment ensuring no infringement in the vertical plane below the lifting points.	b. Shall coordinate with Jack and car body stand Contractor to provide specific details as required.
	c. Shall demonstrate the testing and commissioning of jacks with lifting / lowering / holding etc as per 6 RS car configuration.	c. Shall attend and provide necessary support to DM&P Contractor during Jack and car body stand testing and commissioning as necessary.
5. Under floor Wheel Lathe (UFWL)	a. Shall collect the required design related data for Bogie, wheel profile and all relevant information	a. Shall provide the required design related data for Bogie, wheel profile and all relevant information to DM&P Contractor.
	b. Shall take into account RS specification and detailed parameters for designing machine.	b. Shall furnish to DM&P Contractor, all along the design stage, any update, accurate details to enable him to finalise the machine design.
	c. Shall manufacture the equipment ensuring no infringement of bogie component and shunter underframe component which may cause hindrance during rollover, profiling etc.	c. Shall coordinate with DM&P Contractor to provide and confirm specific details as required.
	d. Shall demonstrate the testing and commissioning as per tender requirement.	d. Shall attend and provide necessary support to DM&P Contractor during Wheel lathe testing and commissioning as necessary.

Item	Responsibility DM&P Contractor	Responsibility of Each RS Contractor
6. Diesel Operated Relief and Rescue vehicle (RRV) with Re-railing and Rescue devices	a. Shall collect all relevant details regarding RS characteristics including weight, dimensions for the effective design of RRV.	a. Shall provide all relevant details regarding RS characteristics including weight, dimensions etc.
	b. Shall collect all relevant information and details of type of coupler of RS and provide the RRV coupler with compatibility accordingly.	b. Shall provide all relevant information and details of type of coupler of RS.
	c. Shall demonstrate the testing and commissioning of RRV coupling and uncoupling test with RS, shunting upto 3/6 coupled car with RRV (pulling and pushing), braking etc.	c. Shall attend and provide necessary support to DM&P Contractor during testing and commissioning as necessary.
	d. Shall demonstrate the testing and commissioning of all Re-railing and Rescue devices with and without RS as decided by Engineer/Employer at agreed site/location.	d. Shall attend and provide necessary support to DM&P Contractor during testing and commissioning as necessary.
7. Bogie Turn Table (BTT)	a. Shall collect all relevant details regarding RS weight, bogie weight, Bogie dimensions, wheel profile etc of all types of Bogies for the effective design of BTTs and manufacture the BTTs accordingly.	a. Shall provide all relevant details regarding RS weight, bogie weight, Bogie dimensions, wheel profile etc
	b. Shall demonstrate the testing and commissioning of BTTs turning with and without bogie, alignment of BTTs after locking, rollover of train etc as decided by Engineer/ Employer.	b. Shall attend and provide necessary support to DM&P Contractor during testing and commissioning as necessary.
8. Bogie Manipulator (BFM)	a. Shall collect all relevant details for all types of bogies weight, Bogie dimensions (with wheel and without wheel) and frame weight and dimensions, etc for all types of bogies for the effective design of machine and manufacture the machine accordingly.	a. Shall provide all relevant details regarding bogie weight, Bogie dimensions (with wheel and without wheel) and frame weight and dimensions, etc.
	b. Shall demonstrate the testing and commissioning of BTTs turning with and without bogie, alignment of BTTs after locking, rollover of train etc as decided by Engineer/ Employer.	b. Shall attend and provide necessary support to DM&P Contractor during testing and commissioning as necessary.
9. Bogie Testing Unit (BTU)	a. Shall collect all relevant details regarding bogie weight, dimensions, wheel profile, height etc of all types of Bogies for the effective design of BTU and manufacture the BTU accordingly.	a. Shall provide all relevant details regarding bogie weight, dimensions, wheel profile, height etc
	b. Shall demonstrate the testing and commissioning of BTU with bogie.	b. Shall attend and provide necessary support to DM&P Contractor during testing and commissioning as necessary.

Item	Responsibility DM&P Contractor	Responsibility of Each RS Contractor
1 10. Double Cylinder Hydraulic Wheel Press (DWP) Deleted	a. Shall collect all relevant details regarding wheel set type, wheels, axle, gear, disc, Interference fit parameters etc for the effective design of DWP and manufacture the DWP accordingly.	a. Shall provide all relevant details regarding wheel set type, wheels, axle, gear and disc etc
	b. Shall demonstrate the testing and commissioning of DWP with mounting and dismounting of wheel from axle to axle, gear box, disc (if applicable).	b. Shall attend and provide necessary support to DM&P Contractor during testing and commissioning as necessary.
1 11. Vertical Turning Lathe (VTL) Deleted	a. Shall collect all relevant details regarding wheels and machining parameters as required etc for the effective design of VTL and manufacture the VTL accordingly.	a. Shall provide all relevant details regarding wheel and its machining parameters as required by DM&P contractor to design the machine accordingly.
	b. Shall demonstrate the testing and commissioning of VTL machining of wheels as per required parameters	b. Shall attend and provide necessary support to DM&P Contractor during testing and commissioning as necessary.
12. TTCV	a. Shall collect all relevant information and details of type of coupler of RS and provide the TTCV coupler with compatibility accordingly.	b. Shall provide all relevant information and details of type of coupler of RS.
13. Driver Desk Simulator	a. Shall collect all relevant information and details including desk control, other controls etc of RS and design the simulator accordingly.	b. Shall provide all relevant information and details of RS desk control and other details required to design the Simulator.
14. Maintenance Desk Simulator	a. Shall collect all relevant information and details RS and its subsystem to design the simulator accordingly.	b. Shall provide all relevant information and details of RS and its subsystem required to design the Maintenance Simulator.
15. General	a. DM&P Contractor shall ensure all the interface requirements pertaining to RS Contractor are shared and agreed mutually.	a. RS Contractor shall ensure all the interface requirements pertaining to DM&P Contractor are shared and agreed mutually.
	b. DM&P Contractor shall prepare Detailed Interface document (DID) and shall ensure that it covers Design, Interface Hazard log, Construction, Testing & Commissioning, Test report formats, Maintenance as applicable.	b. RS Contractor shall provide the necessary information and support as requested by DM&P Contractor.

3.3 INTERFACE SPECIFICATION: DEPOT MACHINERY & PLANT (DM&P) CONTRACTOR AND TRACK WORKS (TW) CONTRACTOR

Table 3-2: DM&P Contractor and TW Contractor

Item	DM&P Contractor Responsibility	TW Contractor Responsibility
Under Floor wheel Lathe (UFWL). Synchronised Pit Jack - 3 car lifting (SPJ). Bogie Turn Table (BTT) Bogie Testing Unit (BTU)	a. DM&P Contractor shall provide drawings of equipment's to TW Contractor. b. Marking on the track will be given by DM&P Contractor for UFWL / SPJ / BTT/BTU Contractor and coordinate with TW Contractor for gauge face matching of running rails with equipment.	a. TW Contractor shall provide track geometry details to depot equipment Contractor. b. TW Contractor shall lay the required type of track and coordinate with DM&P Contractor to ensure correct gauge face matching of equipment level with proposed track rail level with alignment of equipment / track. Track cutting as required shall be done by TW Contractor wherever applicable.
Automatic Train Wash Plant (ATWP)	a. DM&P Contractor shall provide drawings of ATWP to TW Contractor. b. Marking with respect to track will be given by DM&P Contractor for ATW Plant and coordinate with TW Contractor for SOD requirement.	a. TW Contractor shall provide Track structure detail to DM&P Contractor including any other relevant specification, design drawings (to ensure ATWP - SOD requirement) b. TW Contractor shall lay the Train wash track and coordinate with DM&P Contractor as per SOD requirements.
Battery Operated Rail cum Road Shunter (BORRS) Diesel operated Relief and Rescue (RRV) with rerailling, rescue device	a. DM&P Contractor shall provide drawings of equipment to TW Contractor to ensure SOD requirement.	a. TW Contractor shall provide Track geometry (type, profile, track gradient, curve etc.) for Mainline & depot yard to DM&P Contractor to ensure SOD requirement.
General	Shall provide the necessary information and support as requested by Track Contractor.	Shall prepare Detailed Interface document (DID) and shall ensure that it covers Design, Interface Hazard log, Construction, Testing & Commissioning, Test report formats, Maintenance as applicable.

3.4 INTERFACE SPECIFICATION: DEPOT MACHINERY & PLANT (DM&P) CONTRACTOR AND DEPOT ELECTRICAL & MECHANICAL CONTRACTOR (E&M / MEP) CONTRACTOR

Table 3-3 : DM&P Contractor and E&M/ MEP Contractor

Item	DM&P Contractor Responsibility	MEP/E&M Contractor Responsibility
1.Auto Train Wash Plant (ATWP)	a. Shall verify with MEP/E&M Contractor for the existing provision of the electrical power (w.r.t to machine starting and full load	a. Shall share the layout drawing and details required by ATWP Contractor. Also provide the provisions for the power input and earthing, cable and routing,

Item	DM&P Contractor Responsibility	MEP/E&M Contractor Responsibility
	current, kW, including lighting, Earthing cable, Routing and location of the power point etc) for ATWP.	DB/Isolator/Industrial socket with circuit breaker, lightning etc till DM&P location. DM&P Contractor shall extend from this point to wash plant.
	b. Shall conduct joint test with MEP/E&M Contractor.	b. Shall attend and provide necessary support to DM&P Contractor before / during wash plant testing and commissioning as necessary.
	c. Shall provide and install pumps in UG tanks including electrical connection etc., all water pipe and cable laying from control room to wash plant and vice -versa.	c. Shall provide necessary support and cooperation.
	d. Shall verify the provision of cable containment with MEP/E&M Contractor. Also shall provide and lay cable (optical fibre etc) from wash plant to DCC.	d. Shall share the required layout drawing and details required by ATWP Contractor. Shall provide cable containment / provision for laying required cable from wash plant to DCC.
	e. Shall verify the freshwater inlet and supply	e. Shall provide the fresh water supply to wash plant
	f. Shall verify the provision of cable and piping containment with MEP/E&M Contractor. Lay water piping and cabling etc from Control room to Wash Plant bed & vice versa accordingly.	f. Shall share the required layout drawing and details required by ATWP Contractor. Shall provide cable & piping containment as per mutually agreed with DM&P Contractor.
2. Battery Operated Railroad Shunter (BORRS)	a. Shall verify with MEP/E&M Contractor for the existing provision of the electrical power for charging Shunter battery. In case if specific Isolator plug / socket required, same shall be arranged and provided by DM&P Contractor.	a. Shall share the layout drawing and details required by DM&P Contractor. Also provide the provisions for the power input and earthing, cable and routing, DB/Isolator/Industrial socket with circuit breaker, lightning at desired location by DM&P contractor. Isolator socket of adequate rating shall be installed by MEP/E&M Contractor
	b. Shall conduct joint test with MEP/E&M Contractor to check / verify the connection for charging.	b. Shall attend and provide necessary support to DM&P Contractor.
3. Synchronized Pit Jacks (SPJ)	a. Shall verify with MEP/E&M Contractor for the existing provision of the electrical power (w.r.t to machine starting and full load current, kW, including lighting, Earthing cable, Routing and location of the power point etc) for SPJ.	a. Shall share the layout drawing and details required by SPJ Contractor. Also provide the provisions for the power input and earthing, cable and routing, DB/Isolator/Industrial socket with circuit breaker, lightning etc till DM&P location. DM&P Contractor shall extend from this point to control console including respective pits.
	b. Shall provide and install the sump pump with flexible pipe inside every pit for water drainage.	b. Shall coordinate and provide the drainage conduit opening in every pit which will be connected to depot / workshop drainage channel etc.

Item	DM&P Contractor Responsibility	MEP/E&M Contractor Responsibility
4. Synchronized Mobile Lifting Jacks(SMPJ)	a. Shall verify with MEP/E&M Contractor for the existing provision of the electrical power (w.r.t to machine starting and full load current, kW, including lighting, Earthing cable, Routing and location of the power point etc) for SMLJ.	a. Shall share the layout drawing and details required by SMLJ Contractor. Also provide the provisions for the power input and earthing, cable and routing, DB/Isolator/Industrial socket with circuit breaker, lightning etc till DM&P location. DM&P Contractor shall extend from this point to control console including till respective jacks.
5. Under floor Wheel Lathe (UFWL)	a. Shall verify with MEP/E&M Contractor for the existing provision of the electrical power (w.r.t to machine starting and full load current, kW, including lighting, Earthing cable, Routing and location of the power point etc) for UFWL.	a. Shall share the layout drawing and details required by UFWL Contractor. Also provide the provisions for the power input and earthing, cable and routing, DB/Isolator/Industrial socket with circuit breaker, lightning etc till DM&P location (inside PWL shed) . DM&P Contractor shall extend from this point to wheel lathe.
	b. Shall provide and install the sump pump with flexible pipe for pit water drainage.	b. Shall coordinate and provide the drainage conduit opening in pit which will be connected to depot/workshop drainage channel etc.
6. Bogie Turn Table (BTT)	a. Shall verify for the drainage of pit water to depot ETP / drainage as applicable.	a. Shall provide the provision in the BTT pit for the adequate drainage of pit water to depot ETP / drainage as applicable.
7. Bogie Manipulator (BFM)	a. Shall verify with MEP/E&M Contractor for the existing provision of the electrical power (w.r.t to machine starting and full load current, kW, including lighting, Earthing cable, Routing and location of the power point etc) for BFM.	a. Shall share the layout drawing and details required by BFM Contractor. Also provide the provisions for the power input and earthing, cable and routing, DB/Isolator/Industrial socket with circuit breaker, lightning etc till DM&P location. DM&P Contractor shall extend from this point to BFM.
8. Bogie Testing Unit (BTU)	a. Shall verify with MEP/E&M Contractor for the existing provision of the electrical power (w.r.t to machine starting and full load current, kW, including lighting, Earthing cable, Routing and location of the power point etc) for BTU.	a. Shall share the layout drawing and details required by BTU Contractor. Also provide the provisions for the power input and earthing, cable and routing, DB/Isolator/Industrial socket with circuit breaker, lightning etc till DM&P location. DM&P Contractor shall extend from this point to BTU.
	b. Shall verify for the drainage of pit water to depot ETP / drainage as applicable.	b. Shall provide the provision in the BTU pit for the adequate drainage of pit water to depot ETP/drainage.
9. EOT Cranes	a. Shall verify with MEP/E&M Contractor for the existing provision of the electrical power (w.r.t to machine starting and full load current, kW, including lighting, Earthing cable, Routing and location of the power point etc) for all EOT crane.	a. Shall share the layout drawing and details required by EOT crane Contractor. Also provide the provisions for the power input and earthing, cable and routing, DB/Isolator/Industrial socket with circuit breaker, lightning etc till DM&P location. DM&P Contractor shall extend from this point to EOT crane.

Item	DM&P Contractor Responsibility	MEP/E&M Contractor Responsibility
10. Double Cylinder Hydraulic Wheel Press (DWP) Deleted	a. ~~Shall verify with MEP/E&M Contractor for the existing provision of the electrical power (w.r.t to machine starting and full load current, kW, including lighting, Earthing cable, Routing and location of the power point etc) for DWP.~~ b. ~~Shall verify for the drainage of pit water to depot ETP / drainage as applicable.~~	a. ~~Shall share the layout drawing and details required by DWP Contractor. Also provide the provisions for the power input and earthing, cable and routing, DB/Isolator/Industrial socket with circuit breaker, lightning etc till DM&P location. DM&P Contractor shall extend from this point to DWP.~~ b. ~~Shall provide the provision in the DWP pit for the adequate drainage of pit water to depot ETP/drainage.~~
11. Vertical Turning Lathe (VTL) Deleted	a. ~~Shall verify with MEP/E&M Contractor for the existing provision of the electrical power (w.r.t to machine starting and full load current, kW, including lighting, Earthing cable, Routing and location of the power point etc) for VTL.~~	a. ~~Shall share the layout drawing and details required by VTL Contractor. Also provide the provisions for the power input and earthing, cable and routing, DB/Isolator/Industrial socket with circuit breaker, lightning etc till DM&P location. DM&P Contractor shall extend from this point to VTL.~~
12. General	a. Shall ensure all the interface requirements pertaining to MEP/E&M Contractor are shared and agreed mutually. b. Shall provide the necessary information and support as requested by MEP/E&M Contractor	a. Shall ensure all the interface requirements pertaining to DM&P Contractor are shared and agreed mutually. b. Shall prepare Detailed Interface document (DID) and shall ensure that it covers Design, Interface Hazard log, Construction, Testing & Commissioning, Test report formats, Maintenance as applicable.

3.5 INTERFACE SPECIFICATION: DEPOT MACHINERY & PLANT (DM&P) CONTRACTOR AND SIGNALLING TRAIN CONTROL (STC) CONTRACTOR

Table 4-3 : DM&P Contractor & STC Contractor

Item	DM&P Contractor Responsibility	STC Contractor Responsibility
1) Auto Train Wash Plant (ATWP)	a. Shall provide all details of train speeds and stopping locations under different situations of trains passing through the wash plant bed. b. Shall design wash plant for multiple RS in CMRL phase-I passing through, complete washing (front, rear, side) when required at wash plant bed.	a. Shall collect all details from DM&P Contractor regarding the movement of train through the wash plant bed for controlling speed, stopping location under different situations and design the train movement accordingly. b. Shall interface and coordinate as necessary for signalling aspects to enable ATWP to utilize for multiple RS washing.
2) General	Shall provide the necessary information and support as requested by STC Contractor.	Shall prepare Detailed Interface document (DID) and shall ensure that it covers Design, Interface Hazard log, Construction, Testing &

Item	DM&P Contractor Responsibility	STC Contractor Responsibility
		Commissioning, Test report formats, Maintenance as applicable.

3.6 INTERFACE SPECIFICATION: DEPOT MACHINERY & PLANT (DM&P) CONTRACTOR AND OVERHEAD EQUIPMENT (OHE) CONTRACTOR

Table 3-5 : DM&P Contractor & OHE Contractor

Item	DM&P Contractor Responsibility	OHE Contractor Responsibility
1) Auto Train Wash Plant (ATWP)	a. Coordinate with OHE Contractor for OHE allowable clearance etc to ensure SOD requirement.	a. Shall provide relevant details to DM&P Contractor to design ATWP accordingly.
2) RRV & TTCV	a. Coordinate with OHE Contractor for OHE allowable clearance etc to ensure SOD requirement.	b. Shall provide relevant details to DM&P Contractor to design vehicle(s) accordingly.
3) General	a. Shall provide the necessary information and support as requested by OHE Contractor.	b. Shall prepare Detailed Interface document (DID) and shall ensure that it covers Design, Interface Hazard log, Construction, Testing & Commissioning, Test report formats, Maintenance as applicable.

3.7 INTERFACE SPECIFICATION: DEPOT MACHINERY & PLANT (DM&P) CONTRACTOR AND TELECOM & RADIO (RAD) CONTRACTOR

Item	DM&P (RRV) Contractor Responsibility	Telecom & Radio (RAD) Contractor Responsibility
Diesel operated Relief and Rescue (RRV) with rerailling, rescue device & Tunnel & Track Cleaning Vehicle(TTCV)	a. Shall interface with RAD Contractor for the Radio device requirements (space proofing, power supply, installation etc) in the driver's cab and incorporate the same into design of Vehicle (s).	a. Shall share the details of onboard radio device, power input , location etc to DM&P Contractor.
	b. Shall install the Radio device in the driver's cab.	b. Shall supply the Radio device with all accessories and interconnecting /interface cables to DM&P Contractor. Also shall guide and support DM&P contractor to install Radio device successfully.
	c. Shall conduct testing jointly with RAD Contractor for the onboard Radio device.	c. Shall attend and provide necessary support to DM&P Contractor during testing and commissioning as necessary to ensure Interface fulfilled and radio device working accurately.
	d. Shall validate the joint maintenance procedures prepared by RAD Contractor.	d. Shall prepare and finalise the join maintenance procedure involving Radio device.
	e. Shall provide the necessary information and support as requested by RAD Contractor.	e. Shall prepare Detailed Interface document (DID) and shall ensure that it covers Design, Interface Hazard log,

Item	DM&P (RRV) Contractor Responsibility	Telecom & Radio (RAD) Contractor Responsibility
		Construction, Testing & Commissioning, Test report formats, Maintenance as applicable

Note: For other tender item/machine Contractor shall ensure to deemed consider and perform the required interface with the other system Contractor as applicable for design, manufacturing, installation, testing commissioning etc of the works and shall deemed included in the quoted price.

CHAPTER 4

4 EMPLOYER'S DRAWINGS

4.1 LIST OF DRAWINGS

Sl. No	Drawing No.	Drawing Title

Link to download the files: **Drawing shall be issued post award of the Contract.**

Note : The reference documents / drawings included under this section are for general information only and any interpretation of the results shall be construed as opinions only and not as representations as to the actual site conditions. The accuracy or reliability of the documents / drawings included under this section and of any other information supplied, prepared at any time by the Employer or others in connection with the Contract is not warranted.



CHENNAI METRO RAIL LIMITED

CHENNAI METRO RAIL PROJECT PHASE 1

Tender No. ARE05

**DESIGN, MANUFACTURE, SUPPLY, TESTING,
COMMISSIONING OF STANDARD GAUGE METRO
ROLLING STOCK (ELECTRICAL MULTIPLE UNITS)
AND DEPOT MACHINERY & PLANT AND
TRAINING OF PERSONNEL.**

**PART - 3 : CONDITIONS OF CONTRACT AND
CONTRACT FORMS**

(SINGLE STAGE TWO ENVELOPE BIDDING)

~~NOV 2025~~ ~~APR 2026~~ **JUN 2026**



CHENNAI METRO RAIL LIMITED

CHENNAI METRO RAIL PROJECT PHASE 1

Tender No. ARE05

BIDDING DOCUMENTS

1

PART 1	Bidding Procedures
	Section - I Instructions to Bidders (ITB) Section - II Bid Data Sheet (BDS) Section - III Evaluation and Qualification Criteria (EQC) Section – IV Bidding Forms Section - V Eligible Source Countries
PART 2	Employer's Requirements
	Section – VI A Employer's Requirements Technical Specifications (ERTS) – Rolling Stock. Section – VI B : ~~Not Used~~ Employer's Requirements Technical Specifications (ERTS) – Depot Machinery & Plant (DM&P). ~~Section – VI C : Employer's Requirements Comprehensive Maintenance Period (CMC) of Rolling Stock and Depot Plant & Machinery.~~
PART 3	Conditions of Contract and Contract Forms
	Section - VII. General Conditions of Contract (GCC) Section - VIII. Particular Conditions of Contract (PCC) Section - IX. Annex to PCC – Contract Forms



CHENNAI METRO RAIL LIMITED

CHENNAI METRO RAIL PROJECT PHASE 1

Tender No. ARE05

TABLE OF CONTENTS

S. No	Section Number	Description	Page Numbers
1	Section – 7	General Conditions (GC) of Contract	GC 1 to GC90
2	Section – 8A	Particular Conditions of Contract (PCC)	PC(CD) 1 to PC(CD) 9
3	Section – 8B	Particular Conditions of Contract (SP)	PC(SP) 1 to PC(SP) 25
4	Section - 9	Annex to PCC – Contract Forms	CF 1 to CF 9

REVISION HISTORY

Rev. No.	Section	Description
0	All	Version Published in CPP
1	PCC	As per Addendum No.1: PCC to GCC (Part A) – Sl. No. 18, Table 1.1 (A) PCC to GCC (Part B) – Clause No. 9.1 (f), 11.1, 14.9, 18.1
2	PCC	As per Addendum No.3: PCC to GCC (Part A) – Table 1.1 (A) PCC to GCC (Part B) – 14.7



CHENNAI METRO RAIL LIMITED

CHENNAI METRO RAIL PROJECT PHASE 1

Tender No. ARE05

**DESIGN, MANUFACTURE, SUPPLY, TESTING,
COMMISSIONING OF STANDARD GAUGE METRO
ROLLING STOCK (ELECTRICAL MULTIPLE UNITS)
AND DEPOT MACHINERY & PLANT AND
TRAINING OF PERSONNEL.**

**PART 3: CONDITIONS OF CONTRACT AND
CONTRACT FORMS**

**SECTION – VII : GENERAL CONDITIONS OF
CONTRACT (GCC)**

~~NOV 2025~~ ~~APR 2026~~ JUN 2026

CONTENTS

1. General Provisions	5
2. The Employer	14
3. The Engineer	16
4. The Contractor	18
5. Design	28
6. Staff and Labor	32
7. Plant Equipment, Materials and Workmanship	37
8. Commencement, Delays and Suspension	40
9. Tests on Completion	44
10. Handover to the Employer	46
11. Defects Liability	48
12. Test after Completion	51
13. Revisions and Adjustments	52
14. Contract Price and Payment	56
15. Termination by Employer	65
16. Suspension and Termination by Contractor	67
17. Risk and Responsibility	69
18. Insurance	73
19. Force Majeure	76

20. Claims, Disputes and Arbitration.....	79
APPENDIX.....	84
General Conditions of Dispute Board Agreement	84
Annex PROCEDURAL RULES.....	89

Definitions listed alphabetically

1.1.4.1	Accepted Contract Amount	1.1.6.5	Laws
1.1.2.11	Bank	1.1.1.3	Letter of Acceptance
1.1.3.1	Base Date	1.1.1.4	Letter of Tender
1.1.3.2	Commencement Date	1.1.4.8	Local Currency
1.1.1.1	Contract	1.1.5.3	Materials
1.1.1.2	Contract Agreement	1.1. 6.10	Notice to Dissatisfaction
1.1.1.10	Contract Data	1.1.2.1	Party
1.1.4.2	Contract Price	1.1.4.9	Payment Certificate
1.1.2.3	Contractor	1.1.3.8	Performance Certificate
1.1.6.1	Contractor's Documents	1.1.6.6	Performance Security
1.1.5.1	Contractor's Equipment	1.1.5.4	Permanent Works
1.1.2.7	Contractor's Personnel	1.1.5.5	Plant
1.1.1.7	Contractor's Proposal	1.1.4.10	Provisional Sum
1.1.2.5	Contractor's Representative	1.1.4.11	Retention Money
1.1.4.3	Cost	1.1.1.6	Schedules
1.1.6.2	Country	1.1.1.10	Schedule of Guarantees
1.1.2.9	DB	1.1.1.10	Schedule of Payments
1.1.3.9	day	1.1.5.6	Section
1.1.3.7	Defects Notification Period	1.1.6.7	Site
1.1.2.2	Employer	1.1.4.12	Statement
1.1.6.3	Employer's Equipment	1.1.2.8	Subcontractor
1.1.2.6	Employer's Personnel	1.1.3.5	Taking-Over Certificate
1.1.1.5	Employer's Requirements	1.1.5.7	Temporary Works
1.1.2.4	Engineer	1.1.1.8	Tender
1.1.2.10	FIDIC	1.1.3.6	Tests after Completion

1.1.4.4	Final Payment Certificate	1.1.3.4	Tests on Completion
1.1.4.5	Final Statement	1.1.3.3	Time for Completion
1.1.6.4	Force Majeure	1.1.6.8	Unforeseeable
1.1.4.6	Foreign Currency	1.1.6.9	Variation
1.1.5.2	Goods	1.1.5.8	Works
1.1.4.7	Interim Payment Certificate	1.1.3.9	year

General Conditions

1 General Provisions

1.1 Definitions

In the Conditions of Contract ("these Conditions"), which include Particular Conditions and these General Conditions, the following words and expressions shall have the meanings stated. Words indicating persons or parties include corporations and other legal entities, except where the context requires otherwise.

1.1.1 The Contract

- 1.1.1.1 "Contract" means the Contract Agreement, the Letter of Acceptance, the Letter of Tender, these Conditions, the Employer's Requirements, the Schedules, the Contractor's Proposal, and the further documents (if any) which are listed in the Contract Agreement or in the Letter of Acceptance.
- 1.1.1.2 "Contract Agreement" means the contract agreement (if any) referred to in Sub-Clause 1.6 [Contract Agreement].
- 1.1.1.3 "Letter of Acceptance" means the letter of formal acceptance, signed by the Employer, of the Letter of Tender, including any annexed memoranda comprising agreements between and signed by both Parties. If there is no such letter of acceptance, the expression "Letter of Acceptance" means the Contract Agreement and the date of issuing or receiving the Letter of Acceptance means the date of signing the Contract Agreement.
- 1.1.1.4 "Letter of Tender" means the document entitled letter of tender or letter of bid, which was completed by the Contractor and includes the signed offer to the Employer for the Works.
- 1.1.1.5 "Employer's Requirements" means the document entitled employer's requirements, as included in the Contract, and any additions and modifications to such document in accordance with the Contract. Such document specifies the purpose, scope, and/or design and/or other technical criteria, for the Works.
- 1.1.1.6 "Schedules" means the document(s) entitled schedules, completed by the Contractor and submitted with the Letter of Tender, as included in the Contract. Such document may include data, lists and schedules of payments and/or prices.
- 1.1.1.7 "Contractor's Proposal" means the document entitled proposal, which the Contractor submitted with the Letter of Tender, as included in the Contract. Such document may include the Contractor's preliminary design.
- 1.1.1.8 "Tender" means the Letter of Tender and all other documents which the Contractor submitted with the Letter of Tender, as included in the Contract.
- 1.1.1.9 "Contract Data" means the pages completed by the Employer entitled contract data which constitute Part A of the Particular Conditions

- 1.1.1.10 "Schedule of Guarantees" and "Schedule of Payments" mean the documents so named (if any) which are comprised in the Schedules.

1.1.2 Parties and Persons

- 1.1.2.1 "Party" means the Employer or the Contractor, as the context requires.
- 1.1.2.2 "Employer" means the person named as employer in the Contract Data and the legal successors in title to this person.
- 1.1.2.3 "Contractor" means the person(s) named as contractor in the Letter of Tender accepted by the Employer and the legal successors in title to this person(s).
- 1.1.2.4 "Engineer" means the person appointed by the Employer to act as the Engineer for the purposes of the Contract and named in the Contract Data, or other person appointed from time to time by the Employer and notified to the Contractor under Sub-Clause 3.4 [Replacement of the Engineer].
- 1.1.2.5 "Contractor's Representative" means the person named by the Contractor in the Contract or appointed from time to time by the Contractor under Sub-Clause 4.3 [Contractor's Representative], who acts on behalf of the Contractor.
- 1.1.2.6 "Employer's Personnel" means the Engineer, the assistants referred to in Sub-Clause 3.2 [Delegation by the Engineer] and all other staff, labour and other employees of the Engineer and of the Employer; and any other personnel notified to the Contractor, by the Employer or the Engineer, as Employer's Personnel.
- 1.1.2.7 "Contractor's Personnel" means the Contractor's Representative and all personnel whom the Contractor utilises on Site, who may include the staff, labour and other employees of the Contractor and of each Subcontractor; and any other personnel assisting the Contractor in the execution of the Works.
- 1.1.2.8 "Subcontractor" means any person named in the Contract as a subcontractor, or any person appointed as a subcontractor, for a part of the Works; and the legal successors in title to each of these persons.
- 1.1.2.9 "DB" means the person or three persons appointed under Sub-Clause 20.2 [Appointment of the Dispute Board] or Sub-Clause 20.3 [Failure to Agree on the Composition of the Dispute Board].
- 1.1.2.11 "Bank" means the financing institution (if any) named in the Contract Data.
- 1.1.2.12 "Borrower" means the person (if any) named as the borrower in the Contract Data.

1.1.3 Dates, Tests, Periods

- 1.1.3.1 "Base Date" means the date 28 days prior to the latest date for submission and Completion of the Tender.

- 1.1.3.2 "Commencement Date" means the date notified under Sub-Clause 8.1 [Commencement of Works].
- 1.1.3.3 "Time for Completion" means the time for completing the Works or a Section (as the case may be) under Sub-Clause 8.2 [Time for Completion], as stated in the Contract Data (with any extension under Sub-Clause 8.4 [Extension of Time for Completion]), calculated from the Commencement Date.
- 1.1.3.4 "Tests on Completion" means the tests which are specified in the Contract or agreed by both Parties or instructed as a Variation, and which are carried out under Clause 9 [Tests on Completion] before the Works or a Section (as the case may be) are taken over by the Employer.
- 1.1.3.5 "Taking-Over Certificate" means a certificate issued under Clause 10 [Employer's Taking Over].
- 1.1.3.6 "Tests after Completion" means the tests (if any) which are specified in the Contract and which are carried out under Clause 12 [Tests after Completion] after the Works or a Section (as the case may be) are taken over by the Employer.
- 1.1.3.7 "Defects Notification Period" means the period for notifying defects in the Works or a Section (as the case may be) under Sub-Clause 11.1 [Completion of Outstanding Work and Remedying Defects], as stated in the Contract Data (with any extension under Sub-Clause 11.3 [Extension of Defects Notification Period]), calculated from the date on which the Works or Section is completed as certified under Sub-Clause 10.1 [Taking Over of the Works and Sections].
- 1.1.3.8 "Performance Certificate" means the certificate issued under Sub-Clause 11.9 [Performance Certificate].
- 1.1.3.9 "day" means a calendar day and "year" means 365 days.

1.1.4 Money and Payments

- 1.1.4.1 "Accepted Contract Amount" means the amount accepted in the Letter of Acceptance for the execution and completion of the Works and the remedying of any defects.
- 1.1.4.2 "Contract Price" means the price defined in Sub-Clause 14.1 [The Contract Price], and includes adjustments in accordance with the Contract.
- 1.1.4.3 "Cost" means all expenditure reasonably incurred (or to be incurred) by the Contractor, whether on or off the Site, including overhead and similar charges, but does not include profit.
- 1.1.4.4 "Final Payment Certificate" means the payment certificate issued under Sub-Clause 14.13 [Issue of Final Payment Certificate].
- 1.1.4.5 "Final Statement" means the statement defined in Sub-Clause 14.11 [Application for Final Payment Certificate].

- 1.1.4.6 “Foreign Currency” means a currency in which part (or all) of the Contract Price is payable, but not the Local Currency.
 - 1.1.4.7 “Interim Payment Certificate” means a payment certificate issued under Clause 14 [Contract Price and Payment], other than the Final Payment Certificate.
 - 1.1.4.8 “Local Currency” means the currency of the Country.
 - 1.1.4.9 “Payment Certificate” means a payment certificate issued under Clause 14 [Contract Price and Payment].
 - 1.1.4.10 “Provisional Sum” means a sum (if any) which is specified in the Contract as a provisional sum, for the execution of any part of the Works or for the supply of Plant, Materials or services under Sub-Clause 13.5 [Provisional Sums].
 - 1.1.4.11 “Retention Money” means the accumulated retention moneys which the Employer retains under Sub-Clause 14.3 [Application for Interim Payment Certificates] and pays under Sub-Clause 14.9 [Payment of Retention Money].
 - 1.1.4.12 “Statement” means a statement submitted by the Contractor as part of an application, under Clause 14 [Contract Price and Payment], for a payment certificate.
- 1.1.5 Works and Goods
- 1.1.5.1 “Contractor’s Equipment” means all apparatus, machinery, vehicles and other things required for the execution and completion of the Works and the remedying of any defects. However, Contractor’s Equipment excludes Temporary Works, Employer’s Equipment (if any), Plant, Materials and any other things intended to form or forming part of the Permanent Works.
 - 1.1.5.2 “Goods” means Contractor’s Equipment, Materials, Plant and Temporary Works, or any of them as appropriate.
 - 1.1.5.3 “Materials” means things of all kinds (other than Plant) intended to form or forming part of the Permanent Works, including the supply-only materials (if any) to be supplied by the Contractor under the Contract.
 - 1.1.5.4 “Permanent Works” means the permanent works to be executed by the Contractor under the Contract.
 - 1.1.5.5 “Plant” means the apparatus, machinery and vehicles intended to form or forming part of the Permanent Works, including vehicles purchased for the Employer and relating to the construction or operation of the Works.
 - 1.1.5.6 “Section” means a part of the Works specified in the Contract Data as a Section (if any).
 - 1.1.5.7 “Temporary Works” means all temporary works of every kind (other than Contractor’s Equipment) required on Site for the execution and completion of the Permanent Works and the remedying of any defects.

1.1.5.8 “Works” mean the Permanent Works and the Temporary Works, or either of them as appropriate.

1.1.6 Other Definitions

1.1.6.1 “Contractor’s Documents” means the calculations, computer programs and other software, drawings, manuals, models and other documents of a technical nature (if any) supplied by the Contractor under the Contract; as described in Sub-Clause 5.2 [Contractor’s Documents].

1.1.6.2 “Country” means the country in which the Site (or most of it) is located, where the Permanent Works are to be executed.

1.1.6.3 “Employer’s Equipment” means the apparatus, machinery and vehicles (if any) made available by the Employer for the use of the Contractor in the execution of the Works, as stated in the Employer’s Requirements; but does not include Plant which has not been taken over by the Employer.

1.1.6.4 “Force Majeure” is defined in Clause 19 [Force Majeure].

1.1.6.5 “Laws” means all national (or state) legislation, statutes, ordinances and other laws, and regulations and by-laws of any legally constituted public authority.

1.1.6.6 “Performance Security” means the security (or securities, if any) under Sub-Clause 4.2 [Performance Security].

1.1.6.7 “Site” means the places where the Permanent Works are to be executed, including storage and working areas, and to which Plant and Materials are to be delivered, and any other places as may be specified in the Contract as forming part of the Site.

1.1.6.8 “Unforeseeable” means not reasonably foreseeable by an experienced contractor by the Base Date.

1.1.6.9 “Variation” means any change to the Employer’s Requirements or the Works, which is instructed or approved as a variation under Clause 13 [Variations and Adjustments].

1.1.6.10 “Notice of Dissatisfaction” means the notice given by either Party to the other under Sub-Clause 20.4 [Obtaining Dispute Board’s Decision] indicating its dissatisfaction and intention to commence arbitration.

1.2 Interpretation

In the Contract, except where the context requires otherwise:

- (a) words indicating one gender include all genders;
- (b) words indicating the singular also include the plural and words indicating the plural also include the singular;

- (c) provisions including the word "agree", "agreed" or "agreement" require the agreement to be recorded in writing, and
- (d) "written" or "in writing" means hand-written, type-written, printed or electronically made, and resulting in a permanent record.
- (e) the word "tender" is synonymous with "bid", and "tender" with "bidder" and the words "tender documents" with "bidding documents".

The marginal words and other headings shall not be taken into consideration in the interpretation of these Conditions.

In these conditions, provisions including the expressions "Cost plus profit" require this profit to be one-twentieth (5%) of this Cost unless otherwise indicated in the Contract Data.

1.3 Communications

Wherever these Conditions provide for the giving or issuing of approvals, certificates, consents, determinations, notices and requests, these communications shall be:

- (a) in writing and delivered by hand (against receipt), sent by mail or courier, or transmitted using any of the agreed systems of electronic transmission as stated in the Contract Data; and
- (b) delivered, sent or transmitted to the address for the recipient's communications as stated in the Contract Data. However:
 - (i) if the recipient gives notice of another address, communications shall thereafter be delivered accordingly; and
 - (ii) if the recipient has not stated otherwise when requesting an approval or consent, it may be sent to the address from which the request was issued.

Approvals, certificates, consents and determinations shall not be unreasonably withheld or delayed. When a certificate is issued to a Party, the certifier shall send a copy to the other Party. When a notice is issued to a Party, by the other Party or the Engineer, a copy shall be sent to the Engineer or the other Party, as the case may be.

1.4 Law and Language

The Contract shall be governed by the law of the country (or other jurisdiction) stated in the Contract Data.

The ruling language for communications shall be that stated in the Contract Data.

The language for communications shall be that stated in the Contract Data. If no language is stated there, the language for communications shall be the ruling language of the Contract

1.5 Priority of Documents

The documents forming the Contract are to be taken as mutually explanatory of one another. For the purposes of interpretation, the priority of the documents shall be in accordance with the following sequence:

- (a) the Contract Agreement (if any),
- (b) the Letter of Acceptance,
- (c) the Letter of Tender,
- (d) the Particular Conditions, - Part A (Contract Data),
- (e) the Particular Conditions – Part B (Specific Provisions),
- (f) these General Conditions,
- (g) the Employer's Requirements,
- (h) the Schedules, and
- (i) the Contractor's Proposal and any other documents forming part of the Contract.

If an ambiguity or discrepancy is found in the documents, the Engineer shall issue any necessary clarification or instruction.

1.6 Contract Agreement

The Parties shall enter into a Contract Agreement within 28 days after the Contractor receives the Letter of Acceptance, unless the Particular Conditions establish otherwise. The Contract Agreement shall be based upon the form annexed to the Particular Conditions. The costs of stamp duties and similar charges (if any) imposed by law in connection with entry into the Contract Agreement shall be borne by the Employer.

1.7 Assignment

Neither Party shall assign the whole or any part of the Contract or any benefit or interest in or under the Contract. However, either Party:

- (a) may assign the whole or any part with the prior agreement of the other Party, at the sole discretion of such other Party, and
- (b) may, as security in favour of a bank or financial institution, assign its right to any moneys due, or to become due, under the Contract.

1.8 Care and Supply of Documents

Each of the Contractor's Documents shall be in the custody and care of the Contractor, unless and until taken over by the Employer. Unless otherwise stated in the Contract, the Contractor shall supply to the Engineer six copies of each of the Contractor's Documents.

The Contractor shall keep, on the Site, a copy of the Contract, publications named in the Employer's Requirements, the Contractor's Documents, and Variations and other communications given under the Contract. The Employer's Personnel shall have the right of access to all these documents at all reasonable times.

If a Party becomes aware of an error or defect in a document which was prepared for use in executing the Works, the Party shall promptly give notice to the other Party of such error or defect.

1.9 Errors in the Employer's Requirements

If the Contractor suffers delay and/or incurs Cost as a result of an error in the Employer's Requirements, and an experienced contractor exercising due care would not have discovered the error when scrutinising the Employer's Requirements under Sub-Clause 5.1 [General Design Obligations], the Contractor shall give notice to the Engineer and shall be entitled subject to Sub-Clause 20.1 [Contractor's Claims] to:

- (a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 8.4 [Extension of Time for Completion], and
- (b) payment of any such Cost plus profit, which shall be included in the Contract Price.

After receiving this notice, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine (i) whether and (if so) to what extent the error could not reasonably have been so discovered, and (ii) the matters described in sub-paragraphs (a) and (b) above related to this extent.

1.10 Employer's Use of Contractor's Documents

As between the Parties, the Contractor shall retain the copyright and other intellectual property rights in the Contractor's Documents and other design documents made by (or on behalf of) the Contractor.

The Contractor shall be deemed (by signing the Contract) to give to the Employer a non-terminable transferable non-exclusive royalty-free licence to copy, use and communicate the Contractor's Documents, including making and using modifications of them. This licence shall:

- (a) apply throughout the actual or intended working life (whichever is longer) of the relevant parts of the Works,
- (b) entitle any person in proper possession of the relevant part of the Works to copy, use and communicate the Contractor's Documents for the purposes of completing, operating, maintaining, altering, adjusting, repairing and demolishing the Works, and
- (c) in the case of Contractor's Documents which are in the form of computer programs and other software, permit their use on any computer on the Site and other places as envisaged by the Contract, including replacements of any computers supplied by the Contractor.

The Contractor's Documents and other design documents made by (or on behalf of) the Contractor shall not, without the Contractor's consent, be used, copied or communicated to a third party by (or on behalf of) the Employer for purposes other than those permitted under this Sub-Clause.

1.11 Contractor's Use of Employer's Documents

As between the Parties, the Employer shall retain the copyright and other intellectual property rights in the Employer's Requirements and other documents made by (or on behalf of) the Employer. The Contractor may, at his cost, copy, use, and obtain communication of these documents for the purposes of the Contract. They shall not, without the Employer's consent, be copied, used or communicated to a third party by the Contractor, except as necessary for the purposes of the Contract.

1.12 Confidential Details

The Contractor's and the Employer's Personnel shall disclose all such confidential and other information as may be reasonably required in order to verify compliance with the Contract and allow its proper implementation.

Each of them shall treat the details of the Contract as private and confidential, except to the extent necessary to carry out their respective obligations under the Contract or to comply with applicable Laws. Each of them shall not publish or disclose any particulars of the Works prepared by the other Party without the previous agreement of the other Party. However, the Contractor shall be permitted to disclose any publicly available information, or information otherwise required to establish his qualifications to compete for other projects.

1.13 Compliance with Laws

The Contractor shall, in performing the Contract, comply with applicable Laws. Unless otherwise stated in the Particular Conditions:

- (a) the Employer shall have obtained (or shall obtain) the planning, zoning or similar permission for the Permanent Works, and any other permissions described in the Employer's Requirements as having been (or being) obtained by the Employer; and the Employer shall indemnify and hold the Contractor harmless against and from the consequences of any failure to do so; and
- (b) the Contractor shall give all notices, pay all taxes, duties and fees, and obtain all permits, licences and approvals, as required by the Laws in relation to the design, execution and completion of the Works and the remedying of any defects; and the Contractor shall indemnify and hold the Employer harmless against and from the consequences of any failure to do so, unless the Contractor is impeded to accomplish these actions and shows evidence of its diligence.

However, the Contractor shall submit, in good time, the details of Goods to the Employer, who shall then promptly obtain all import permits or licences required for these Goods.

The Employer shall also obtain or grant all consents including permits-to-work, rights-of-way and approvals required for the Works.

1.14 Joint Several Liability

If the Contractor constitutes (under applicable Laws) a joint venture, consortium or other unincorporated grouping of two or more persons:

- (a) these persons shall be deemed to be jointly and severally liable to the Employer for the performance of the Contract;
- (b) these persons shall notify the Employer of their leader who shall have authority to bind the Contractor and each of these persons; and
- (c) the Contractor shall not alter its composition or legal status without the prior consent of the Employer.

2 The Employer

2.1 Right of Access to the Site

The Employer shall give the Contractor right of access to, and possession of, all parts of the Site within the time (or times) stated in the Contract Data. The right and possession may not be exclusive to the Contractor. If, under the Contract, the Employer is required to give (to the Contractor) possession of any foundation, structure, plant or means of access, the Employer shall do so in the time and manner stated in the Employer's Requirements. However, the Employer may withhold any such right or possession until the Performance Security has been received.

If no such time is stated in the Contract Data, the Employer shall give the Contractor right of access to, and possession of, the Site within such times as may be required to enable the Contractor to proceed in accordance with the programme submitted under Sub-Clause 8.3 [Programme].

If the Contractor suffers delay and/or incurs Cost as a result of a failure by the Employer to give any such right or possession within such time, the Contractor shall give notice to the Engineer and shall be entitled subject to Sub-Clause 20.1 [Contractor's Claims] to:

- (a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 8.4 [Extension of Time for Completion], and
- (b) payment of any such Cost plus profit, which shall be included in the Contract Price.

After receiving this notice, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine these matters.

However, if and to the extent that the Employer's failure was caused by any error or delay by the Contractor, including an error in, or delay in the submission of, any of the Contractor's Documents, the Contractor shall not be entitled to such extension of time, Cost or profit.

2.2 Permits, Licences or Approvals

The Employer shall provide, at the request of the Contractor, such reasonable assistance as to allow the Contractor to obtain properly:

- (a) copies of the Laws of the Country which are relevant to the Contract but are not readily available, and
- (b) any permits, licences or approvals required by the Laws of the Country:
 - (i) which the Contractor is required to obtain under Sub-Clause 1.13 [Compliance with Laws],
 - (ii) for the delivery of Goods, including clearance through customs, and
 - (iii) for the export of Contractor's Equipment when it is removed from the Site.

2.3 Employer's Personnel

The Employer shall be responsible for ensuring that the Employer's Personnel and the Employer's other contractors on the Site:

- (a) co-operate with the Contractor's efforts under Sub-Clause 4.6 [Co-operation], and (b) take actions similar to those which the Contractor is required to take under sub-paragraphs (a),
- (b) and (c) of Sub-Clause 4.8 [Safety Procedures] and under Sub-Clause 4.18 [Protection of the Environment].

2.4 Employer's Financial Arrangements

The Employer shall submit, before the Commencement Date and thereafter within 28 days after receiving any request from the Contractor, reasonable evidence that financial arrangements have been made and are being maintained which will enable the Employer to pay the Contract Price punctually (as estimated at that time) in accordance with Clause 14 [Contract Price and Payment]. Before the Employer makes any material change to his financial arrangements, the Employer shall give notice to the Contractor with detailed particulars.

In addition, if the Bank has notified to the Borrower that the Bank has suspended disbursements under its loan, which finances in whole or in part the execution of the Works, the Employer shall give notice of such suspension to the Contractor with detailed particulars, including the date of such notification, with a copy to the Engineer, within 7 days of the Borrower having received the suspension notification from the Bank. If alternative funds will be available in appropriate currencies to the Employer to continue making payments to the Contractor beyond a date 60 days after the date of Bank notification of the suspension, the Employer shall provide reasonable evidence in his notice of the extent to which such funds will be available.

2.5 Employer's Claims

If the Employer considers himself to be entitled to any payment under any Clause of these Conditions or otherwise in connection with the Contract, and/or to any extension of the Defects Notification Period, the Employer or the Engineer shall give notice and particulars to the Contractor. However, notice is not required for payments due under Sub-Clause 4.19 [Electricity, Water and Gas], under Sub-Clause 4.20 [Employer's Equipment and Free-Issue Material], or for other services requested by the Contractor.

The notice shall be given as soon as practicable and no longer than 28 days after the Employer became aware, or should have become aware, of the event or circumstances giving rise to the claim. A notice relating to any extension of the Defects Notification Period shall be given before the expiry of such period.

The particulars shall specify the Clause or other basis of the claim, and shall include substantiation of the amount and/or extension to which the Employer considers himself to be entitled in connection with the Contract. The Engineer shall then proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine (i) the amount (if any) which the Employer is entitled to be paid by the Contractor and/or (ii) the extension (if any) of the Defects Notification Period in accordance with Sub-Clause 11.3 [Extension of Defects Notification Period].

This amount may be included as a deduction in the Contract Price and Payment Certificates. The Employer shall only be entitled to set off against or make any deduction from an amount certified in a Payment Certificate, or to otherwise claim against the Contractor, in accordance with this Sub-Clause.

3 The Engineer

3.1 Engineer's Duties and Authority

The Employer shall appoint the Engineer who shall carry out the duties assigned to him in the Contract. The Engineer's staff shall include suitably qualified engineers and other professionals who are competent to carry out these duties.

The Engineer shall have no authority to amend the Contract.

The Engineer may exercise the authority attributable to the Engineer as specified in or necessarily to be implied from the Contract. If the Engineer is required to obtain the approval of the Employer before exercising a specified authority, the requirements shall be as stated in the Particular Conditions. The Employer shall promptly inform the Contractor of any change to the authority attributed to the Engineer.

However, whenever the Engineer exercises a specified authority for which the Employer's approval is required, then (for the purposes of the Contract) the Employer shall be deemed to have given approval.

Except as otherwise stated in these Conditions:

- (a) whenever carrying out duties or exercising authority, specified in or implied by the Contract, the Engineer shall be deemed to act for the Employer;
- (b) the Engineer has no authority to relieve either Party of any duties, obligations or responsibilities under the Contract; and
- (c) any approval, check, certificate, consent, examination, inspection, instruction, notice, proposal, request, test, or similar act by the Engineer (including absence of disapproval) shall not relieve the Contractor from any responsibility he has under the Contract, including responsibility for errors, omissions, discrepancies and non-compliances.
- (d) any act by the Engineer in response to a Contractor's request except as otherwise expressly specified shall be notified in writing to the Contractor within 28 days of receipt.

The following provision shall apply:

The Engineer shall obtain the specific approval of the Employer before taking action under the following Sub-Clause of these Conditions:

- (A) Sub-Clause 4.12: agreeing or determining an extension of time and/or additional cost.
- (B) Sub-Clause 13.1: instructing a Variation, except;
 - (i) in an emergency situation as determined by the Engineer, or
 - (ii) if such a Variation would increase the Accepted Contract Amount by less than the percentage specified in the Contract Data.
- (C) Sub-Clause 13.3: approving a proposal for Variation submitted by the Contractor in accordance with Sub-Clause 13.1 or 13.2.
- (D) Sub-Clause 13.4: specifying the amount payable in each of the applicable currencies.

Notwithstanding the obligation, as set out above, to obtain approval, if, in the opinion of the Engineer, an emergency occurs affecting the safety of life or of the Works or of adjoining property, he may, without relieving the Contractor of any of his duties and responsibility under the Contract, instruct the Contractor to execute all such work or to do all such things as may, in the opinion of the Engineer, be necessary to abate or reduce the risk. The Contractor shall forthwith comply, despite the absence of approval of the Employer, with any such instruction of the Engineer. The Engineer shall determine an addition to the Contract Price, in respect of such instruction, in accordance with Clause 13 [Variations and Adjustments] and shall notify the Contractor accordingly, with a copy to the Employer.

3.2 Delegation by the Engineer

The Engineer may from time to time assign duties and delegate authority to assistants, and may also revoke such assignment or delegation. These assistants may include a resident engineer, and/or independent inspectors appointed to inspect and/or test items of Plant and/or Materials. The assignment, delegation or revocation shall be in writing and shall not take effect until copies have been received by both Parties. However, unless otherwise agreed by both Parties, the Engineer shall not delegate the authority to determine any matter in accordance with Sub-Clause 3.5 [Determinations].

Assistants shall be suitably qualified persons, who are competent to carry out these duties and exercise this authority, and who are fluent in the language for communications defined in Sub-Clause 1.4 [Law and Language].

Each assistant, to whom duties have been assigned or authority has been delegated, shall only be authorised to issue instructions to the Contractor to the extent defined by the delegation. Any approval, check, certificate, consent, examination, inspection, instruction, notice, proposal, request, test, or similar act by an assistant, in accordance with the delegation, shall have the same effect as though the act had been an act of the Engineer. However:

- (a) any failure to disapprove any work, Plant or Materials shall not constitute approval, and shall therefore not prejudice the right of the Engineer to reject the work, Plant or Materials;
- (b) if the Contractor questions any determination or instruction of an assistant, the Contractor may refer the matter to the Engineer, who shall promptly confirm, reverse or vary the determination or instruction.

3.3 Instructions of the Engineer

The Engineer may issue to the Contractor (at any time) instructions which may be necessary for the execution of the Works and the remedying of any defects, all in accordance with the Contract. The Contractor shall only take instructions from the Engineer, or from an assistant to whom the appropriate authority has been delegated under this Clause. If an instruction constitutes a Variation, Clause 13 [Variations and Adjustments] shall apply.

The Contractor shall comply with the instructions given by the Engineer or delegated assistant, on any matter related to the Contract. These instructions shall be given in writing.

3.4 Replacement of the Engineer

If the Employer intends to replace the Engineer, the Employer shall, not less than 21 days before the intended date of replacement, give notice to the Contractor of the name, address and relevant experience of the intended replacement Engineer. If the Contractor considers the intended replacement Engineer to be unsuitable, he has the right to raise objection against him by notice to the Employer, with supporting particulars, and the Employer shall give full and fair consideration to this objection.

3.5 Determinations

Whenever these Conditions provide that the Engineer shall proceed in accordance with this Sub-Clause 3.5 to agree or determine any matter, the Engineer shall consult with each Party in an endeavour to reach agreement. If agreement is not achieved, the Engineer shall make a fair determination in accordance with the Contract, taking due regard of all relevant circumstances.

The Engineer shall give notice to both Parties of each agreement or determination, with supporting particulars, within 28 days from the receipt of the corresponding claim or request except when otherwise specified. Each Party shall give effect to each agreement or determination unless and until revised under Clause 20 [Claims, Disputes and Arbitration].

3.6 Management Meetings

The Engineer or the Contractor's Representative may require the other to attend a management meeting in order to review the arrangements for future work. The Engineer shall record the business of management meetings and supply copies of the record to those attending the meeting and to the Employer. In the record, responsibilities for any actions to be taken shall be in accordance with the Contract.

4 The Contractor

4.1 Contractor's General Obligations

The Contractor shall design, execute and complete the Works in accordance with the Contract, and shall remedy any defects in the Works. When completed, the Works shall be fit for the purposes for which the Works are intended as defined in the Contract.

The Contractor shall provide the Plant and Contractor's Documents specified in the Contract, and all Contractor's Personnel, Goods, consumables and other things and services, whether of a temporary or permanent nature, required in and for this design, execution, completion and remedying of defects.

All equipment, material, and services to be incorporated in or required for the Works shall have their origin in any eligible source country as defined by the Loan Agreement between the Bank and the Borrower..

The Works shall include any work which is necessary to satisfy the Employer's Requirements, Contractor's Proposal and Schedules, or is implied by the Contract, and all works which (although not mentioned in the Contract) are necessary for stability or for the completion, or safe and proper operation, of the Works.

The Contractor shall be responsible for the adequacy, stability and safety of all Site operations, of all methods of construction and of all the Works.

The Contractor shall, whenever required by the Engineer, submit details of the arrangements and methods which the Contractor proposes to adopt for the execution of the Works. No significant alteration to these arrangements and methods shall be made without this having previously been notified to the Engineer

4.2 Performance Security

The Contractor shall obtain (at his cost) a Performance Security for proper performance, in the amount stated in the Contract Data and denominated in the currency(ies) of the Contract or in a freely convertible currency acceptable to the Employer. If an amount is not stated in the Contract Data, this Sub-Clause shall not apply.

The Contractor shall deliver the Performance Security to the Employer within 28 days after receiving the Letter of Acceptance, and shall send a copy to the Engineer. The Performance Security shall be issued by an reputable bank or financial institution selected by the Contractor, and shall be in the form annexed to the Particular Conditions, as stipulated by the Employer, or in another form approved by the Employer.

The Contractor shall ensure that the Performance Security is valid and enforceable until the Contractor has executed and completed the Works and remedied any defects. If the terms of the Performance Security specify its expiry date, and the Contractor has not become entitled to receive the Performance Certificate by the date 28 days prior to the expiry date, the Contractor shall extend the validity of the Performance Security until the Works have been completed and any defects have been remedied.

The Employer shall not make a claim under the Performance Security, except for amounts to which the Employer is entitled under the Contract.

The Employer shall indemnify and hold the Contractor harmless against and from all damages, losses and expenses (including legal fees and expenses) resulting from a claim under the Performance Security to the extent to which the Employer was not entitled to make the claim.

The Employer shall return the Performance Security to the Contractor within 21 days after receiving a copy of the Performance Certificate.

Without limitation to the provisions of the rest of this Sub-Clause, whenever the Engineer determines an addition or a reduction to the Contract Price as a result of a change in cost and/or legislation, or as a result of a Variation amounting to more than 25 percent of the portion of the Contract Price payable in a specific currency, the Contractor shall at the Engineer's request promptly increase, or may decrease, as the case may be, the value of the Performance Security in that currency by an equal percentage.

4.3 Contractor's Representative

The Contractor shall appoint the Contractor's Representative and shall give him all authority necessary to act on the Contractor's behalf under the Contract.

Unless the Contractor's Representative is named in the Contract, the Contractor shall, prior to the Commencement Date, submit to the Engineer for consent the name and particulars of the person the Contractor proposes to appoint as Contractor's Representative. If consent is withheld or subsequently revoked in terms of Sub-Clause 6.9 [Contractor's Personnel], or if the appointed person fails to act as Contractor's Representative, the Contractor shall similarly submit the name and particulars of another suitable person for such appointment.

The Contractor shall not, without the prior consent of the Engineer, revoke the appointment of the Contractor's Representative or appoint a replacement.

The whole time of the Contractor's Representative shall be given to directing the Contractor's performance of the Contract. If the Contractor's Representative is to be temporarily absent from the Site during the execution of the Works, a suitable replacement person shall be appointed, subject to the Engineer's prior consent, and the Engineer shall be notified accordingly.

The Contractor's Representative shall, on behalf of the Contractor, receive instructions under Sub-Clause 3.3 [Instructions of the Engineer].

The Contractor's Representative may delegate any powers, functions and authority to any competent person, and may at any time revoke the delegation. Any delegation or revocation shall not take effect until the Engineer has received prior notice signed by the Contractor's Representative, naming the person and specifying the powers, functions and authority being delegated or revoked.

The Contractor's Representative shall be fluent in the language for communications defined in Sub-Clause 1.4 [Law and Language]. If the Contractor's Representative's delegates are not fluent in the said language, the Contractor shall make competent interpreters available during all working hours in a number deemed sufficient by the Engineer.

4.4 Subcontractors

The Contractor shall not subcontract the whole of the Works.

The Contractor shall be responsible for the acts or defaults of any Subcontractor, his agents or employees, as if they were the acts or defaults of the Contractor. Unless otherwise stated in the Particular Conditions:

- (a) the Contractor shall not be required to obtain consent to suppliers solely of Materials, or to a subcontract for which the Subcontractor is named in the Contract;
- (b) the prior consent of the Engineer shall be obtained to other proposed Subcontractors; and
- (c) the Contractor shall give the Engineer not less than 28 days' notice of the intended date of the commencement of each Subcontractor's work, and of the commencement of such work on the Site.

The Contractor shall ensure that the requirements imposed on the Contractor by Sub-Clause 1.12 [Confidential Details] apply equally to each Subcontractor.

Where practicable, the Contractor shall give fair and reasonable opportunity for contractors from the Country to be appointed as Subcontractors.

4.5 Nominated Subcontractors

In this Sub-Clause, "nominated Subcontractor" means a Subcontractor whom the Engineer, under Clause 13 [Variations and Adjustments], instructs the Contractor to employ as a Subcontractor. The Contractor shall not be under any obligation to employ a nominated Subcontractor against whom the Contractor raises reasonable objection by notice to the Engineer as soon as practicable, with supporting particulars.

4.6 Co-operation

The Contractor shall, as specified in the Contract or as instructed by the Engineer, allow appropriate opportunities for carrying out work to:

- (a) the Employer's Personnel,
- (b) any other contractors employed by the Employer, and
- (c) the personnel of any legally constituted public authorities,

who may be employed in the execution on or near the Site of any work not included in the Contract.

Any such instruction shall constitute a Variation if and to the extent that it causes the Contractor suffer delays and/or to incur Unforeseeable Cost. Services for these personnel and other contractors may include the use of Contractor's Equipment, Temporary Works or access arrangements which are the responsibility of the Contractor.

The Contractor shall be responsible for his construction activities on the Site, and shall co-ordinate his own activities with those of other contractors to the extent (if any) specified in the Employer's Requirements.

If, under the Contract, the Employer is required to give to the Contractor possession of any foundation, structure, plant or means of access in accordance with Contractor's Documents, the Contractor shall submit such documents to the Engineer in the time and manner stated in the Employer's Requirements.

4.7 Setting Out

The Contractor shall set out the Works in relation to original points, lines and levels of reference specified in the Contract or notified by the Engineer. The Contractor shall be responsible for the correct positioning of all parts of the Works, and shall rectify any error in the positions, levels, dimensions or alignment of the Works.

The Employer shall be responsible for any errors in these specified or notified items of reference, but the Contractor shall use reasonable efforts to verify their accuracy before they are used.

If the Contractor suffers delay and/or incurs Cost from executing work which was necessitated by an error in these items of reference, and an experienced contractor could not reasonably have discovered such error and avoided this delay and/or Cost, the Contractor shall give notice to the Engineer and shall be entitled subject to Sub-Clause 20.1 [Contractor's Claims] to:

- (a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 8.4 [Extension of Time for Completion], and
- (b) payment of any such Cost plus profit, which shall be included in the Contract Price.

After receiving this notice, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine (i) whether and (if so) to what extent the error could not reasonably have been discovered, and (ii) the matters described in sub-paragraphs (a) and (b) above related to this extent.

4.8 Safety Procedures

The Contractor shall:

- (a) comply with all applicable safety regulations,
- (b) take care for the safety of all persons entitled to be on the Site,
- (c) use reasonable efforts to keep the Site and Works clear of unnecessary obstruction so as to avoid danger to these persons,
- (d) provide fencing, lighting, guarding and watching of the Works until completion and taking over under Clause 10 [Employer's Taking Over], and
- (e) provide any Temporary Works (including roadways, footways, guards and fences) which may be necessary, because of the execution of the Works, for the use and protection of the public and of owners and occupiers of adjacent land.

4.9 Quality Assurance

The Contractor shall institute a quality assurance system to demonstrate compliance with the requirements of the Contract. The system shall be in accordance with the details stated in the Contract. The Engineer shall be entitled to audit any aspect of the system.

Details of all procedures and compliance documents shall be submitted to the Engineer for information before each design and execution stage is commenced. When any document of a technical nature is issued to the Engineer, evidence of the prior approval by the Contractor himself shall be apparent on the document itself.

Compliance with the quality assurance system shall not relieve the Contractor of any of his duties, obligations or responsibilities under the Contract.

4.10 Site Data

The Employer shall have made available to the Contractor for his information, prior to the Base Date, all relevant data in the Employer's possession on sub-surface and hydrological conditions at the Site, including environmental aspects. The Employer shall similarly make available to the Contractor all such data which come into the

Employer's possession after the Base Date. The Contractor shall be responsible for interpreting all such data.

To the extent which was practicable (taking account of cost and time), the Contractor shall be deemed to have obtained all necessary information as to risks, contingencies and other circumstances which may influence or affect the Tender or Works. To the same extent, the Contractor shall be deemed to have inspected and examined the Site, its surroundings, the above data and other available information, and to have been satisfied before submitting the Tender as to all relevant matters, including (without limitation):

- (a) the form and nature of the Site, including sub-surface conditions,
- (b) the hydrological and climatic conditions,
- (c) the extent and nature of the work and Goods necessary for the execution and completion of the Works and the remedying of any defects,
- (d) the Laws, procedures and labour practices of the Country, and
- (e) the Contractor's requirements for access, accommodation, facilities, personnel, power, transport, water and other services.

4.11 Sufficiency of the Accepted Contract Amount

The Contractor shall be deemed to:

- (a) have satisfied himself as to the correctness and sufficiency of the Accepted Contract Amount, and
- (b) have based the Accepted Contract Amount on the data, interpretations, necessary information, inspections, examinations and satisfaction as to all relevant matters referred to in Sub-Clause 4.10 [Site Data] and any further data relevant to the Contractor's design.

Unless otherwise stated in the Contract, the Accepted Contract Amount covers all the Contractor's obligations under the Contract (including those under Provisional Sums, if any) and all things necessary for the proper design, execution and completion of the Works and the remedying of any defects.

4.12 Unforeseeable Physical Conditions

In this Sub-Clause, "physical conditions" means natural physical conditions and man-made and other physical obstructions and pollutants, which the Contractor encounters at the Site when executing the Works, including sub-surface and hydrological conditions but excluding climatic conditions.

If the Contractor encounters adverse physical conditions which he considers to have been Unforeseeable, the Contractor shall give notice to the Engineer as soon as practicable.

This notice shall describe the physical conditions, so that they can be inspected by the Engineer, and shall set out the reasons why the Contractor considers them to be Unforeseeable. The Contractor shall continue executing the Works, using such proper and reasonable measures as are appropriate for the physical conditions, and shall comply with any instructions which the Engineer may give. If an instruction constitutes a Variation, Clause 13 [Variations and Adjustments] shall apply.

If and to the extent that the Contractor encounters physical conditions which are Unforeseeable, gives such a notice, and suffers delay and/or incurs Cost due to these conditions, the Contractor shall be entitled subject to notice under Sub-Clause 20.1 [Contractor's Claims] to:

- (a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 8.4 [Extension of Time for Completion], and
- (b) payment of any such Cost, which shall be included in the Contract Price

Upon receiving such notice and inspecting and/or investigating these physical conditions, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine (i) whether and (if so) to what extent these physical conditions were Unforeseeable, and (ii) the matters described in sub-paragraphs (a) and (b) above related to this extent.

However, before additional Cost is finally agreed or determined under sub-paragraph (ii), the Engineer may also review whether other physical conditions in similar parts of the Works (if any) were more favourable than could reasonably have been foreseen when the Contractor submitted the Tender. If and to the extent that these more favourable conditions were encountered, the Engineer may proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine the reductions in Cost which were due to these conditions, which may be included (as deductions) in the Contract Price and Payment Certificates. However, the net effect of all adjustments under sub-paragraph (b) and all these reductions, for all the physical conditions encountered in similar parts of the Works, shall not result in a net reduction in the Contract Price.

The Engineer may take account of any evidence of the physical conditions foreseen by the Contractor when submitting the Tender, which may be made available by the Contractor, but shall not be bound by any such evidence.

4.13 Rights of Way and Facilities

Unless otherwise specified in the Contract the Employer shall provide effective access to and possession of the Site including special and/or temporary rights- of-way which are necessary for the Works. The Contractor shall obtain, at his risk and cost, any additional rights of way or facilities outside the Site which he may require for the purposes of the Works.

4.14 Avoidance of Interference

The Contractor shall not interfere unnecessarily or improperly with:

- (a) the convenience of the public, or
- (b) the access to and use and occupation of all roads and footpaths, irrespective of whether they are public or in the possession of the Employer or of others.

The Contractor shall indemnify and hold the Employer harmless against and from all damages, losses and expenses (including legal fees and expenses) resulting from any such unnecessary or improper interference.

4.15 Access Route

The Contractor shall be deemed to have been satisfied as to the suitability and availability of access routes to the Site at Base Date. The Contractor shall use reasonable efforts to prevent any road or bridge from being damaged by the Contractor's traffic or by the Contractor's Personnel. These efforts shall include the proper use of appropriate vehicles and routes.

Except as otherwise stated in these Conditions:

- (a) the Contractor shall (as between the Parties) be responsible for any maintenance which may be required for his use of access routes;
- (b) the Contractor shall provide all necessary signs or directions along access routes, and shall obtain any permission which may be required from the relevant authorities for his use of routes, signs and directions;
- (c) the Employer shall not be responsible for any claims which may arise from the use or otherwise of any access route,
- (d) the Employer does not guarantee the suitability or availability of particular access routes, and
- (e) Costs due to non-suitability or non-availability, for the use required by the Contractor, of access routes shall be borne by the Contractor.

4.16 Transport of Goods

Unless otherwise stated in the Particular Conditions

- (a) the Contractor shall give the Engineer not less than 21 days' notice of the date on which any Plant or a major item of other Goods will be delivered to the Site;
- (b) the Contractor shall be responsible for packing, loading, transporting, receiving, unloading, storing and protecting all Goods and other things required for the Works; and
- (c) the Contractor shall indemnify and hold the Employer harmless against and from all damages, losses and expenses (including legal fees and expenses) resulting from the transport of Goods, and shall negotiate and pay all claims arising from their transport.
- (d) the Contractor shall request the Engineer's permission to deliver any item or Goods to the Site. No Goods shall be delivered without this permission, which shall not relieve the Contractor from any obligation.

4.17 Contractor's Equipment

The Contractor shall be responsible for all Contractor's Equipment. When brought on to the Site, Contractor's Equipment shall be deemed to be exclusively intended for the execution of the Works. The Contractor shall not remove from the Site any major items of Contractor's Equipment without the consent of the Engineer. However, consent shall not be required for vehicles transporting Goods or Contractor's Personnel off Site.

4.18 Protection of the Environment

The Contractor shall take all reasonable steps to protect the environment (both on and off the Site) and to limit damage and nuisance to people and property resulting from pollution, noise and other results of his operations.

The Contractor shall ensure that emissions, surface discharges and effluent from the Contractor's activities shall not exceed the values indicated in the Employer's Requirements or prescribed by applicable Laws.

4.19 Electricity, Water and Gas

The Contractor shall, except as stated below, be responsible for the provision of all power, water and other services he may require for his construction activities and to the extent defined in the Employer's Requirements, for the tests.

The Contractor shall be entitled to use for the purposes of the Works such supplies of electricity, water, gas and other services as may be available on the Site and of which details and prices are given in the Employer's Requirements. The Contractor shall, at his risk and cost, provide any apparatus necessary for his use of these services and for measuring the quantities consumed.

The quantities consumed and the amounts due (at these prices) for such services shall be agreed or determined by the Engineer in accordance with Sub-Clause 2.5 [Employer's Claims] and Sub-Clause 3.5 [Determinations]. The Contractor shall pay these amounts to the Employer.

4.20 Employer's Equipment and Free-Issue Material

The Employer shall make the Employer's Equipment (if any) available for the use of the Contractor in the execution of the Works in accordance with the details, arrangements and prices stated in the Employer's Requirements. Unless otherwise stated in the Employer's Requirements:

- (a) the Employer shall be responsible for the Employer's Equipment, except that
- (b) the Contractor shall be responsible for each item of Employer's Equipment whilst any of the Contractor's Personnel is operating it, driving it, directing it or in possession or control of it.

The appropriate quantities and the amounts due (at such stated prices) for the use of Employer's Equipment shall be agreed or determined by the Engineer in accordance with Sub-Clause 2.5 [Employer's Claims] and Sub-Clause 3.5 [Determinations]. The Contractor shall pay these amounts to the Employer.

The Employer shall supply, free of charge, the "free-issue materials" (if any) in accordance with the details stated in the Employer's Requirements. The Employer shall, at his risk and cost, provide these materials at the time and place specified in the Contract. The Contractor shall then visually inspect them, and shall promptly give notice to the Engineer of any shortage, defect or default in these materials. Unless otherwise agreed by both Parties, the Employer shall immediately rectify the notified shortage, defect or default.

After this visual inspection, the free-issue materials shall come under the care, custody and control of the Contractor. The Contractor's obligations of inspection, care, custody and control shall not relieve the Employer of liability for any shortage, defect or default not apparent from a visual inspection.

4.21 Progress Reports

Unless otherwise stated in the Particular Conditions, monthly progress reports shall be prepared by the Contractor and submitted to the Engineer in six copies. The first report shall cover the period up to the end of the first calendar month following the Commencement Date. Reports shall be submitted monthly thereafter, each within 7 days after the last day of the period to which it relates.

Reporting shall continue until the Contractor has completed all work which is known to be outstanding at the completion date stated in the Taking-Over Certificate for the Works.

Each report shall include:

- (a) charts and detailed descriptions of progress, including each stage of design, Contractor's Documents, procurement, manufacture, delivery to Site, construction, erection, testing, commissioning and trial operation;
- (b) photographs showing the status of manufacture and of progress on the Site;
- (c) for the manufacture of each main item of Plant and Materials, the name of the manufacturer, manufacture location, percentage progress, and the actual or expected dates of:
 - (i) commencement of manufacture,
 - (ii) Contractor's inspections,
 - (iii) tests, and
 - (iv) shipment and arrival at the Site;
- (d) the details described in Sub-Clause 6.10 [Records of Contractor's Personnel and Equipment];
- (e) copies of quality assurance documents, test results and certificates of Materials;
- (f) list of Variations, notices given under Sub-Clause 2.5 [Employer's Claims] and notices given under Sub-Clause 20.1 [Contractor's Claims];
- (g) safety statistics, including details of any hazardous incidents and activities relating to environmental aspects and public relations; and
- (h) comparisons of actual and planned progress, with details of any events or circumstances which may jeopardise the completion in accordance with the Contract, and the measures being (or to be) adopted to overcome delays.

4.22 Security of the Site

Unless otherwise stated in the Particular Conditions:

- (a) the Contractor shall be responsible for keeping unauthorised persons off the Site, and
- (b) authorised persons shall be limited to the Contractor's Personnel and the Employer's Personnel; and to any other personnel notified to the Contractor, by the Employer or the Engineer, as authorised personnel of the Employer's other contractors on the Site.

4.23 Contractor's Operations on Site

The Contractor shall confine his operations to the Site, and to any additional areas which may be obtained by the Contractor and agreed by the Engineer as additional working areas. The Contractor shall take all necessary precautions to keep Contractor's Equipment and Contractor's Personnel within the Site and these additional areas, and to keep them off adjacent land.

During the execution of the Works, the Contractor shall keep the Site free from all unnecessary obstruction, and shall store or dispose of any Contractor's Equipment or surplus materials. The Contractor shall clear away and remove from the Site any wreckage, rubbish and Temporary Works which are no longer required.

Upon the issue of a Taking-Over Certificate, the Contractor shall clear away and remove, from that part of the Site and Works to which the Taking-Over Certificate refers, all Contractor's Equipment, surplus material, wreckage, rubbish and Temporary Works. The Contractor shall leave that part of the Site and the Works in a clean and safe condition. However, the Contractor may retain on Site, during the Defects Notification Period, such Goods as are required for the Contractor to fulfil obligations under the Contract.

4.24 Fossils

All fossils, coins, articles of value or antiquity, and structures and other remains or items of geological or archaeological interest found on the Site shall be placed under the care and authority of the Employer. The Contractor shall take reasonable precautions to prevent Contractor's Personnel or other persons from removing or damaging any of these findings.

The Contractor shall, upon discovery of any such finding, promptly give notice to the Engineer, who shall issue instructions for dealing with it. If the Contractor suffers delay and/or incurs Cost from complying with the instructions, the Contractor shall give a further notice to the Engineer and shall be entitled subject to Sub-Clause 20.1 [Contractor's Claims] to:

- (a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 8.4 [Extension of Time for Completion], and
- (b) payment of any such Cost, which shall be included in the Contract Price.

After receiving this further notice, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine these matters.

5 Design

5.1 General Design Obligations

The Contractor shall carry out, and be responsible for, the design of the Works. Design shall be prepared by qualified designers who are engineers or other professionals who comply with the criteria (if any) stated in the Employer's Requirements. Unless otherwise stated in the Contract, the Contractor shall submit to the Engineer for consent the name and particulars of each proposed designer and design Subcontractor.

The Contractor warrants that he, his designers and design Subcontractors have the experience and capability necessary for the design. The Contractor undertakes that the designers shall be available to attend discussions with the Engineer at all reasonable times, until the expiry date of the relevant Defects Notification Period.

Upon receiving notice under Sub-Clause 8.1 [Commencement of Works], the Contractor shall scrutinise the Employer's Requirements (including design criteria and calculations, if any) and the items of reference mentioned in Sub-Clause 4.7 [Setting Out]. Within the period stated in the Contract Data, calculated from the Commencement Date, the Contractor shall give notice to the Engineer of any error, fault or other defect found in the Employer's Requirements or these items of reference.

After receiving this notice, the Engineer shall determine whether Clause 13 [Variations and Adjustments] shall be applied, and shall give notice to the Contractor accordingly. If and to the extent that (taking account of cost and time) an experienced contractor exercising due care would have discovered the error, fault or other defect when examining the Site and the Employer's Requirements before submitting the Tender, the Time for Completion shall not be extended and the Contract Price shall not be adjusted

5.2 Contractor's Documents

The Contractor's Documents shall comprise the technical documents specified in the Employer's Requirements, documents required to satisfy all regulatory approvals, and the documents described in Sub-Clause 5.6 [As-Built Documents] and Sub-Clause 5.7 [Operation and Maintenance Manuals]. Unless otherwise stated in the Employer's Requirements, the Contractor's Documents shall be written in the language for communications defined in Sub-Clause 1.4 [Law and Language].

The Contractor shall prepare all Contractor's Documents, and shall also prepare any other documents necessary to instruct the Contractor's Personnel. The Employer's Personnel shall have the right to inspect the preparation of all these documents, wherever they are being prepared.

If the Employer's Requirements describe the Contractor's Documents which are to be submitted to the Engineer for review and/or for approval, they shall be submitted accordingly, together with a notice as described below. In the following provisions of this Sub-Clause, (i) "review period" means the period required by the Engineer for review and (if so specified) for approval, and (ii) "Contractor's Documents" exclude any documents which are not specified as being required to be submitted for review and/or for approval.

Unless otherwise stated in the Employer's Requirements, each review period shall not exceed 21 days, calculated from the date on which the Engineer receives a Contractor's Document and the Contractor's notice. This notice shall state that the Contractor's Document is considered ready, both for review (and approval, if so specified) in accordance with this Sub-Clause and for use. The notice shall also state that the Contractor's Document complies with the Contract, or the extent to which it does not comply.

The Engineer may, within the review period, give notice to the Contractor that a Contractor's Document fails (to the extent stated) to comply with the Contract. If a Contractor's Document so fails to comply, it shall be rectified, resubmitted and reviewed (and, if specified, approved) in accordance with this Sub-Clause, at the Contractor's cost.

For each part of the Works, and except to the extent that the prior approval or consent of the Engineer shall have been obtained:

- (a) in the case of a Contractor's Document which has (as specified) been submitted for the Engineer's approval:

- (i) the Engineer shall give notice to the Contractor that the Contractor's Document is approved, with or without comments, or that it fails (to the extent stated) to comply with the Contract;
 - (ii) execution of such part of the Works shall not commence until the Engineer has approved the Contractor's Document; and
 - (iii) the Engineer shall be deemed to have approved the Contractor's Document upon the expiry of the review periods for all the Contractor's Documents which are relevant to the design and execution of such part, unless the Engineer has previously notified otherwise in accordance with sub-paragraph (i);
- (b) execution of such part of the Works shall not commence prior to the expiry of the review periods for all the Contractor's Documents which are relevant to its design and execution;
 - (c) execution of such part of the Works shall be in accordance with these reviewed (and, if specified, approved) Contractor's Documents; and
 - (d) if the Contractor wishes to modify any design or document which has previously been submitted for review (and, if specified, approval), the Contractor shall immediately give notice to the Engineer. Thereafter, the Contractor shall submit revised documents to the Engineer in accordance with the above procedure.

If the Engineer instructs that further Contractor's Documents are required, the Contractor shall prepare them promptly. Any such approval or consent, or any review (under this Sub-Clause or otherwise), shall not relieve the Contractor from any obligation or responsibility

5.3 Contractor's Undertaking

The Contractor undertakes that the design, the Contractor's Documents, the execution and the completed Works will be in accordance with:

- (a) the Laws in the Country, and
- (b) the documents forming the Contract, as altered or modified by Variations.

5.4 Technical Standards and Regulations

The design, the Contractor's Documents, the execution and the completed Works shall comply with the Country's technical standards, building, construction and environmental Laws, Laws applicable to the product being produced from the Works, and other standards specified in the Employer's Requirements, applicable to the Works, or defined by the applicable Laws.

All these Laws shall, in respect of the Works and each Section, be those prevailing when the Works or Section are taken over by the Employer under Clause 10 [Employer's Taking Over]. References in the Contract to published standards shall be understood to be references to the edition applicable on the Base Date, unless stated otherwise.

If changed or new applicable standards come into force in the Country after the Base Date, the Contractor shall give notice to the Engineer and (if appropriate) submit proposals for compliance. In the event that:

- (a) the Engineer determines that compliance is required, and
- (b) the proposals for compliance constitute a variation,

then the Engineer shall initiate a Variation in accordance with Clause 13 [Variations and Adjustments].

5.5 Training

The Contractor shall carry out the training of Employer's Personnel in the operation and maintenance of the Works to the extent specified in the Employer's Requirements. If the Contract specifies training which is to be carried out before taking-over, the Works shall not be considered to be completed for the purposes of taking-over under Sub-Clause 10.1 [Taking Over of the Works and Sections] until this training has been completed.

5.6 As-Built Documents

The Contractor shall prepare, and keep up-to-date, a complete set of "as-built" records of the execution of the Works, showing the exact as-built locations, sizes and details of the work as executed. These records shall be kept on the Site and shall be used exclusively for the purposes of this Sub-Clause. Two copies shall be supplied to the Engineer prior to the commencement of the Tests on Completion.

In addition, the Contractor shall supply to the Engineer as-built drawings of the Works, showing all Works as executed, and submit them to the Engineer for review under Sub-Clause 5.2 [Contractor's Documents]. The Contractor shall obtain the consent of the Engineer as to their size, the referencing system, and other relevant details

Prior to the issue of any Taking-Over Certificate, the Contractor shall supply to the Engineer the specified numbers and types of copies of the relevant as-built drawings, in accordance with the Employer's Requirements. The Works shall not be considered to be completed for the purposes of taking-over under Sub-Clause 10.1 [Taking Over of the Works and Sections] until the Engineer has received these documents.

5.7 Operation and Maintenance Manuals

Prior to commencement of the Tests on Completion, the Contractor shall supply to the Engineer provisional operation and maintenance manuals in sufficient detail for the Employer to operate, maintain, dismantle, reassemble, adjust and repair the Plant.

The Works shall not be considered to be completed for the purposes of taking-over under Sub-Clause 10.1 [Taking Over of the Works and Sections] until the Engineer has received final operation and maintenance manuals in such detail, and any other manuals specified in the Employer's Requirements for these purposes.

5.8 Design Error

If errors, omissions, ambiguities, inconsistencies, inadequacies or other defects are found in the Contractor's Documents, they and the Works shall be corrected at the Contractor's cost, notwithstanding any consent or approval under this Clause.

6 Staff and Labour

6.1 Engagement of Labour

Except as otherwise stated in the Employer's Requirements, the Contractor shall make arrangements for the engagement of all staff and labour, local or otherwise, and for their payment, feeding, transport and, when appropriate, housing.

The Contractor is encouraged, to the extent practicable and reasonable, to employ staff and labour with appropriate qualifications and experience from sources within the Country.

6.2 Rates of Wages and Conditions of Labour

The Contractor shall pay rates of wages, and observe conditions of labour, which are not lower than those established for the trade or industry where the work is carried out. If no established rates or conditions are applicable, the Contractor shall pay rates of wages and observe conditions which are not lower than the general level of wages and conditions observed locally by employers whose trade or industry is similar to that of the Contractor.

The Contractor shall inform the Contractor's Personnel about their liability to pay personal income taxes in the Country in respect of such of their salaries, wages, allowances and any benefits as are subject to tax under the Laws of the Country for the time being in force, and the Contractor shall perform such duties in regard to such deductions thereof as may be imposed on him by such Laws.

6.3 Persons in the Service

The Contractor shall not recruit, or attempt to recruit, staff and labour from amongst the Employer's Personnel.

6.4 Labour Laws

The Contractor shall comply with all the relevant labour Laws applicable to the Contractor's Personnel, including Laws relating to their employment, health, safety, welfare, immigration and emigration, and shall allow them all their legal rights.

The Contractor shall require his employees to obey all applicable Laws, including those concerning safety at work.

6.5 Working Hours

No work shall be carried out on the Site on locally recognised days of rest, or outside the normal working hours stated in the Contract Data, unless:

- (a) otherwise stated in the Contract,
- (b) the Engineer gives consent, or

- (c) the work is unavoidable, or necessary for the protection of life or property or for the safety of the Works, in which case the Contractor shall immediately advise the Engineer.

6.6 Facilities for Staff and Labour

Except as otherwise stated in the Employer's Requirements, the Contractor shall provide and maintain all necessary accommodation and welfare facilities for the Contractor's Personnel. The Contractor shall also provide facilities for the Employer's Personnel as stated in the Employer's Requirements.

The Contractor shall not permit any of the Contractor's Personnel to maintain any temporary or permanent living quarters within the structures forming part of the Permanent Works.

6.7 Health and Safety

The Contractor shall at all times take all reasonable precautions to maintain the health and safety of the Contractor's Personnel. In collaboration with local health authorities, the Contractor shall ensure that medical staff, first aid facilities, sick bay and ambulance service are available at all times at the Site and at any accommodation for Contractor's and Employer's Personnel, and that suitable arrangements are made for all necessary welfare and hygiene requirements and for the prevention of epidemics.

The Contractor shall appoint an accident prevention officer at the Site, responsible for maintaining safety and protection against accidents. This person shall be qualified for this responsibility, and shall have the authority to issue instructions and take protective measures to prevent accidents. Throughout the execution of the Works, the Contractor shall provide whatever is required by this person to exercise this responsibility and authority.

The Contractor shall send, to the Engineer, details of any accident as soon as practicable after its occurrence. The Contractor shall maintain records and make reports concerning health, safety and welfare of persons, and damage to property, as the Engineer may reasonably require.

HIV-AIDS Prevention. The Contractor shall conduct an HIV-AIDS awareness programme via an approved service provider, and shall undertake such other measures as are specified in this Contract to reduce the risk of the transfer of the HIV virus between and among the Contractor's Personnel and the local community, to promote early diagnosis and to assist affected individuals.

The Contractor shall throughout the contract (including the Defects Notification Period): (i) conduct Information, Education and Communication (IEC) campaigns, at least every other month, addressed to all the Site staff and labour (including all the Contractor's employees, all Subcontractors and any other Contractor's or Employer's personnel, and all truck drivers and crew making deliveries to Site for construction activities) and to the immediate local communities, concerning the risks, dangers and impact, and appropriate avoidance behaviour with respect to, of Sexually Transmitted Diseases (STD) - or Sexually Transmitted Infections (STI) in general and HIV/AIDS in particular; (ii) provide male or female condoms for all Site staff and labour as appropriate; and (iii) provide for STI and HIV/AIDS screening, diagnosis, counselling and referral to a dedicated national STI and HIV/AIDS programme, (unless otherwise agreed) of all Site staff and labour.

The Contractor shall include in the programme to be submitted for the execution of the Works under Sub-Clause 8.3 an alleviation programme for Site staff and labour and their families in respect of Sexually Transmitted Infections (STI) and Sexually Transmitted Diseases (STD) including HIV/AIDS. The STI, STD and HIV/AIDS alleviation programme shall indicate when, how and at what cost the Contractor plans to satisfy the requirements of this Sub-Clause and the related specification. For each component, the programme shall detail the resources to be provided or utilised and any related sub-contracting proposed. The programme shall also include provision of a detailed cost estimate with supporting documentation. Payment to the Contractor for preparation and implementation this programme shall not exceed the Provisional Sum dedicated for this purpose.

6.8 Contractor's Superintendence

Throughout the design and execution of the Works, and as long thereafter as is necessary to fulfil the Contractor's obligations, the Contractor shall provide all necessary superintendence to plan, arrange, direct, manage, inspect and test the work.

Superintendence shall be given by a sufficient number of persons having adequate knowledge of the language for communications (defined in Sub-Clause 1.4 [Law and Language]) and of the operations to be carried out (including the methods and techniques required, the hazards likely to be encountered and methods of preventing accidents), for the satisfactory and safe execution of the Works.

6.9 Contractor's Personnel

The Contractor's Personnel shall be appropriately qualified, skilled and experienced in their respective trades or occupations. The Engineer may require the Contractor to remove (or cause to be removed) any person employed on the Site or Works, including the Contractor's Representative if applicable, who:

- (a) persists in any misconduct or lack of care,
- (b) carries out duties incompetently or negligently,
- (c) fails to conform with any provisions of the Contract, or
- (d) persists in any conduct which is prejudicial to safety, health, or the protection of the environment.

If appropriate, the Contractor shall then appoint (or cause to be appointed) a suitable replacement person.

6.10 Records of Contractor's Personnel and Equipment

The Contractor shall submit, to the Engineer, details showing the number of each class of Contractor's Personnel and of each type of Contractor's Equipment on the Site. Details shall be submitted each calendar month, in a form approved by the Engineer, until the Contractor has completed all work which is known to be outstanding at the completion date stated in the Taking-Over Certificate for the Works.

6.11 Disorderly Conduct

The Contractor shall at all times take all reasonable precautions to prevent any unlawful, riotous or disorderly conduct by or amongst the Contractor's Personnel, and to preserve peace and protection of persons and property on and near the Site.

6.12 Foreign Personnel

The Contractor may bring in to the Country any foreign personnel who are necessary for the execution of the Works to the extent allowed by the applicable Laws. The Contractor shall ensure that these personnel are provided with the required residence visas and work permits. The Employer will, if requested by the Contractor, use his best endeavours in a timely and expeditious manner to assist the Contractor in obtaining any local, state, national, or government permission required for bringing in the Contractor's personnel.

The Contractor shall be responsible for the return of these personnel to the place where they were recruited or to their domicile. In the event of the death in the Country of any of these personnel or members of their families, the Contractor shall similarly be responsible for making the appropriate arrangements for their return or burial.

6.13 Supply of Foodstuffs

The Contractor shall arrange for the provision of a sufficient supply of suitable food as may be stated in the Employer's Requirements at reasonable prices for the Contractor's Personnel for the purpose of or in connection with the Contract.

6.14 Supply of Water

The Contractor shall, having regard to local conditions, provide on the Site an adequate supply of drinking and other water for the use of the Contractor's Personnel.

6.15 Measures against Insect and Pest Nuisance

The Contractor shall at all times take the necessary precautions to protect the Contractor's Personnel employed on the Site from insect and pest nuisance, and to reduce their danger to health. The Contractor shall employ with all the regulations of the local health authorities, including use of appropriate insecticides.

6.16 Alcoholic Liquor or Drugs

The Contractor shall not, otherwise than in accordance with the Laws of the Country, import, sell, give, barter or otherwise dispose of any alcoholic liquor or drugs, or permit or allow importation, sale, gift, barter or disposal thereto by Contractor's Personnel.

6.17 Arms and Ammunition

The Contractor shall not give, barter, or otherwise dispose of, to any person, any arms, or ammunition of any kind, or allow Contractor's Personnel to do so.

6.18 Festivals and Religious Customs

The Contractor shall respect the Country's recognized festivals, days, of rest and religious or other customs.

6.19 Funeral Arrangements

The Contractor shall be responsible, to the extent required by local regulations, for making any funeral arrangements for any of his local employees who may die while engaged upon the Work.

6.20 Forced Labour

The Contractor shall not employ "forced or compulsory labour" in any form. "Forced or compulsory labour" consists of all work or service, not voluntarily performed, that is extracted from an individual under threat of force or penalty.

6.21 Child Labour

The Contractor shall not employ any child to perform any work that is economically exploitative, or is likely to be hazardous to, or to interfere with, the child's education, or to be harmful to the child's health or physical, mental, spiritual, moral, or social development. Where the relevant labour laws of the Country have provisions for employment of minors, the Contractor shall follow those laws applicable to the Contractor. Children below the age of 18 years shall not be employed in dangerous work.

6.22 Employment Records of Workers

The Contractor shall keep complete and accurate records of the employment of labour at the Site. The records shall include the names, ages, genders, hours worked and wages paid to all workers. These records shall be summarized on a monthly basis and submitted to the Engineer, and these records shall be available for inspection by Auditors during normal working hours. These records shall be included in the details to be submitted by the Contractor under Sub-Clause 6.10 [Records of Contractor's Personnel and Equipment].

6.23 Worker's Organizations

In countries where the relevant labour laws recognize worker's rights to form and to join workers' organizations of their choosing without interference and to bargain collectively, the Contractor shall comply with such laws. Where the relevant labour laws substantially restrict workers' organizations, the Contractor shall enable alternative means for the Contractor's Personnel to express their grievances and protect their rights regarding working conditions and terms of employment. In either case described above, and where the relevant labour laws are silent, the Contractor shall not discourage the Contractor's Personnel from forming or joining workers' organizations of their choosing or from bargaining collectively, and shall not discriminate or retaliate against the Contractor's Personnel who participate, or seek to participate, in such organizations and bargain collectively. The Contractor shall engage with such workers' representatives. Workers' organizations are expected to fairly represent the workers in the workforce.

6.24 Non-Discrimination and Equal Opportunity

The Contractor shall not make employment decisions on the basis of personal characteristics unrelated to inherent job requirements. The Contractor shall base the employment relationship on the principle of equal opportunity and fair treatment, and shall not discriminate with respect to aspects of the employment relationship, including recruitment and hiring, compensation (including wages and benefits), working conditions and terms of employment, access to training, promotion, termination of employment or retirement, and discipline. In countries where the relevant labour laws provide for non-discrimination in employment, the Contractor shall comply with such laws. When the relevant labour laws are silent on non-discrimination in employment, the Contractor shall meet this Sub-Clause's requirements. Special measures of protection or assistance to remedy past discrimination or selection for a particular job based on the inherent requirements of the job shall not be deemed discrimination.

7 Plant, Materials and Workmanship

7.1 Manner of Execution

The Contractor shall carry out the manufacture of Plant, the production and manufacture of Materials, and all other execution of the Works:

- (a) in the manner (if any) specified in the Contract,
- (b) in a proper workmanlike and careful manner, in accordance with recognised good practice, and
- (c) with properly equipped facilities and non-hazardous Materials, except as otherwise specified in the Contract.

7.2 Samples

The Contractor shall submit the following samples of Materials, and relevant information, to the Engineer for review in accordance with the procedures for Contractor's Documents described in Sub-Clause 5.2 [Contractor's Documents]:

- (a) manufacturer's standard samples of Materials and samples specified in the Contract, all at the Contractor's cost, and
- (b) additional samples instructed by the Engineer as a Variation.

Each sample shall be labelled as to origin and intended use in the Works.

7.3 Inspection

The Employer's Personnel shall at all reasonable times:

- (a) have full access to all parts of the Site and to all places from which natural Materials are being obtained, and
- (b) during production, manufacture and construction (at the Site and elsewhere), be entitled to examine, inspect, measure and test the materials and workmanship, and to check the progress of manufacture of Plant and production and manufacture of Materials.

The Contractor shall give the Employer's Personnel full opportunity to carry out these activities, including providing access, facilities, permissions and safety equipment. No such activity shall relieve the Contractor from any obligation or responsibility.

The Contractor shall give notice to the Engineer whenever any work is ready and before it is covered up, put out of sight, or packaged for storage or transport. The Engineer shall then either carry out the examination, inspection, measurement or testing without unreasonable delay, or promptly give notice to the Contractor that the Engineer does not require to do so. If the Contractor fails to give the notice, he shall, if and when required by the Engineer, uncover the work and thereafter reinstate and make good, all at the Contractor's cost.

7.4 Testing

This Sub-Clause shall apply to all tests specified in the Contract, other than the Tests after Completion (if any).

Except as otherwise specified in the Contract, the Contractor shall provide all apparatus, assistance, documents and other information, electricity, equipment, fuel, consumables, instruments, labour, materials, and suitably qualified and experienced staff, as are necessary to carry out the specified tests efficiently. The Contractor shall agree, with the Engineer, the time and place for the specified testing of any Plant, Materials and other parts of the Works.

The Engineer may, under Clause 13 [Variations and Adjustments], vary the location or details of specified tests, or instruct the Contractor to carry out additional tests. If these varied or additional tests show that the tested Plant, Materials or workmanship is not in accordance with the Contract, the cost of carrying out this Variation shall be borne by the Contractor, notwithstanding other provisions of the Contract.

The Engineer shall give the Contractor not less than 24 hours' notice of the Engineer's intention to attend the tests. If the Engineer does not attend at the time and place agreed, the Contractor may proceed with the tests, unless otherwise instructed by the Engineer, and the tests shall then be deemed to have been made in the Engineer's presence.

If the Contractor suffers delay and/or incurs Cost from complying with these instructions or as a result of a delay for which the Employer is responsible, the Contractor shall give notice to the Engineer and shall be entitled subject to Sub-Clause 20.1 [Contractor's Claims] to:

- (a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 8.4 [Extension of Time for Completion], and
- (b) payment of any such Cost plus profit, which shall be included in the Contract Price.

After receiving this notice, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine these matters.

The Contractor shall promptly forward to the Engineer duly certified reports of the tests. When the specified tests have been passed, the Engineer shall endorse the Contractor's test certificate, or issue a certificate to him, to that effect. If the Engineer has not attended the tests, he shall be deemed to have accepted the readings as accurate.

7.5 Rejection

If, as a result of an examination, inspection, measurement or testing, any Plant, Materials, design or workmanship is found to be defective or otherwise not in accordance with the Contract, the Engineer may reject the Plant, Materials, design or workmanship by giving notice to the Contractor, with reasons. The Contractor shall then promptly make good the defect and ensure that the rejected item complies with the Contract.

If the Engineer requires this Plant, Materials, design or workmanship to be retested, the tests shall be repeated under the same terms and conditions. If the rejection and retesting cause the Employer to incur additional costs, the Contractor shall subject to Sub-Clause 2.5 [Employer's Claims] pay these costs to the Employer.

7.6 Remedial Work

Notwithstanding any previous test or certification, the Engineer may instruct the Contractor to:

- (a) remove from the Site and replace any Plant or Materials which is not in accordance with the Contract,
- (b) remove and re-execute any other work which is not in accordance with the Contract, and
- (c) execute any work which is urgently required for the safety of the Works, whether because of an accident, unforeseeable event or otherwise.

The Contractor shall comply with the instruction within a reasonable time, which shall be the time (if any) specified in the instruction, or immediately if urgency is specified under sub-paragraph (c).

If the Contractor fails to comply with the instruction, the Employer shall be entitled to employ and pay other persons to carry out the work. Except to the extent that the Contractor would have been entitled to payment for the work, the Contractor shall subject to Sub-Clause 2.5 [Employer's Claims] pay to the Employer all costs arising from this failure.

7.7 Ownership of Plant and Materials

Except otherwise specified in the Contract, each item of Plant and Materials shall, to the extent consistent with the Laws of the Country, become the property of the Employer at whichever is the earlier of the following times, free from liens and other encumbrances:

- (a) when it is incorporated in the Works;
- (b) when the Contractor is paid the corresponding value of the Plant and Materials under Sub-Clause 8.10 [Payment for Plant and Materials in Event of Suspension].

7.8 Royalties

Unless otherwise stated in the Employer's Requirements, the Contractor shall pay all royalties, rents and other payments for:

- (a) natural Materials obtained from outside the Site, and

- (b) the disposal of material from demolitions and excavations and of other surplus material (whether natural or man-made), except to the extent that disposal areas within the Site are specified in the Contract.

8 Commencement, Delays and Suspension

8.1 Commencement of Work

Except otherwise specified in the Particular Conditions , the Commencement Date shall be the date at which the following precedent conditions have all been fulfilled and the Engineer's instruction recording the agreement of both Parties on such fulfilment and instructing to commence the Works is received by the Contractor:

- (a) signature of the Contract Agreement by both Parties, and if required, approval of the Contract by relevant authorities in the Country;
- (b) delivery to the Contractor of reasonable evidence of the Employer's Financial arrangements (under Sub-Clause 2.4 [Employer's Financial Arrangements])
- (c) (c) except if otherwise specified in the Contract Data, effective access to and possession of the Site given to the Contractor together with such permission(s) under (a) of Sub-Clause 1.13 [Compliance with Laws] as required for the commencement of the Works; and
- (d) receipt by the Contractor of the Advance Payment under Sub-Clause 14.2 [Advance Payment] provided that the corresponding bank guarantee has been delivered by the Contractor.

If the said Engineer's instruction is not received by the Contractor within 180 days from his receipt of the Letter of Acceptance, the Contractor shall be entitled to terminate the Contract under Sub-Clause 16.2 [Termination by Contractor].

The Contractor shall commence the design and execution of the Works as soon as is reasonably practicable after the Commencement Date, and shall then proceed with the Works with due expedition and without delay.

8.2 Completion

The Contractor shall complete the whole of the Works, and each Section (if any), within the Time for Completion for the Works or Section (as the case may be), including:

- (a) achieving the passing of the Tests on Completion, and
- (b) completing all work which is stated in the Contract as being required for the Works or Section to be considered to be completed for the purposes of taking-over under Sub-Clause 10.1 [Taking Over of the Works and Sections].

8.3 Programme

The Contractor shall submit a detailed time programme to the Engineer within 28 days after receiving the notice under Sub-Clause 8.1 [Commencement of Works]. The Contractor shall also submit a revised programme whenever the previous programme is inconsistent with actual progress or with the Contractor's obligations. Each programme shall include:

- (a) the order in which the Contractor intends to carry out the Works, including the anticipated timing of each stage of design, Contractor's Documents, procurement, manufacture, inspection, delivery to Site, construction, erection, testing, commissioning and trial operation,
- (b) the periods for reviews under Sub-Clause 5.2 [Contractor's Documents] and for any other submissions, approvals and consents specified in the Employer's Requirements,
- (c) the sequence and timing of inspections and tests specified in the Contract, and
- (d) a supporting report which includes:
 - (i) a general description of the methods which the Contractor intends to adopt, and of the major stages, in the execution of the Works, and
 - (ii) details showing the Contractor's reasonable estimate of the number of each class of Contractor's Personnel and of each type of Contractor's Equipment, required on the Site for each major stage.

Unless the Engineer, within 21 days after receiving a programme, gives notice to the Contractor stating the extent to which it does not comply with the Contract, the Contractor shall proceed in accordance with the programme, subject to his other obligations under the Contract. The Employer's Personnel shall be entitled to rely upon the programme when planning their activities.

The Contractor shall promptly give notice to the Engineer of specific probable future events or circumstances which may adversely affect the work, increase the Contract Price or delay the execution of the Works. The Engineer may require the Contractor to submit an estimate of the anticipated effect of the future event or circumstances, and/or a proposal under Sub-Clause 13.3 [Variation Procedure].

If, at any time, the Engineer gives notice to the Contractor that a programme fails (to the extent stated) to comply with the Contract or to be consistent with actual progress and the Contractor's stated intentions, the Contractor shall submit a revised programme to the Engineer in accordance with this Sub-Clause

8.4 Extension of Time for Completion

The Contractor shall be entitled subject to Sub-Clause 20.1 [Contractor's Claims] to an extension of the Time for Completion if and to the extent that completion for the purposes of Sub-Clause 10.1 [Taking Over of the Works and Sections] is or will be delayed by any of the following causes:

- (a) a Variation (unless an adjustment to the Time for Completion has been agreed under Sub-Clause 13.3 [Variation Procedure]),
- (b) a cause of delay giving an entitlement to extension of time under a Sub-Clause of these Conditions,

- (c) exceptionally adverse climatic conditions,
- (d) Unforeseeable shortages in the availability of personnel or Goods caused by epidemic or governmental actions, or
- (e) any delay, impediment or prevention caused by or attributable to the Employer, the Employer's Personnel, or the Employer's other contractors.

If the Contractor considers himself to be entitled to an extension of the Time for Completion, the Contractor shall give notice to the Engineer in accordance with Sub-Clause 20.1 [Contractor's Claims]. When determining each extension of time under Sub-Clause 20.1, the Engineer shall review previous determinations and may increase, but shall not decrease, the total extension of time.

8.5 Delays Caused by Authorities

If the following conditions apply, namely:

- (a) the Contractor has diligently followed the procedures laid down by the relevant legally constituted public authorities in the Country,
- (b) these authorities delay or disrupt the Contractor's work, and
- (c) the delay or disruption was Unforeseeable,

then this delay or disruption will be considered as a cause of delay under sub-paragraph (b) of Sub-Clause 8.4 [Extension of Time for Completion].

8.6 Rate of Progress

If, at any time:

- (a) actual progress is too slow to complete within the Time for Completion, and/or
- (b) progress has fallen (or will fall) behind the current programme under Sub-Clause 8.3 [Programme],

other than as a result of a cause listed in Sub-Clause 8.4 [Extension of Time for Completion], then the Engineer may instruct the Contractor to submit, under Sub-Clause 8.3 [Programme], a revised programme and supporting report describing the revised methods which the Contractor proposes to adopt in order to expedite progress and complete within the Time for Completion.

Unless the Engineer notifies otherwise, the Contractor shall adopt these revised methods, which may require increases in the working hours and/or in the numbers of Contractor's Personnel and/or Goods, at the risk and cost of the Contractor. If these revised methods cause the Employer to incur additional costs, the Contractor shall subject to notice under Sub-Clause 2.5 [Employer's Claims] pay these costs to the Employer, in addition to delay damages (if any) under Sub-Clause 8.7 below.

Additional costs of revised methods, including acceleration measures, instructed by the Engineer to reduce delays resulting from causes listed under Sub-Clause 8.4 [Extension of Time for Completion] shall be paid by the Employer, without generating, however, any other additional payment benefit to the Contractor.

8.7 Delay Damages

If the Contractor fails to comply with Sub-Clause 8.2 [Time for Completion], the Contractor shall subject to notice under Sub-Clause 2.5 [Employer's Claims] pay delay damages to the Employer for this default. These delay damages shall be the sum stated in the Contract Data, which shall be paid for every day which shall elapse between the relevant Time for Completion and the date stated in the Taking-Over Certificate. However, the total amount due under this Sub-Clause shall not exceed the maximum amount of delay damages (if any) stated in the Contract Data.

These delay damages shall be the only damages due from the Contractor for such default, other than in the event of termination under Sub-Clause 15.2 [Termination by Employer] prior to completion of the Works. These damages shall not relieve the Contractor from his obligation to complete the Works, or from any other duties, obligations or responsibilities which he may have under the Contract.

8.8 Suspension of Work

The Engineer may at any time instruct the Contractor to suspend progress of part or all of the Works. During such suspension, the Contractor shall protect, store and secure such part or the Works against any deterioration, loss or damage.

The Engineer may also notify the cause for the suspension. If and to the extent that the cause is notified and is the responsibility of the Contractor, the following Sub-Clauses 8.9, 8.10 and 8.11 shall not apply.

8.9 Consequences of Suspension

If the Contractor suffers delay and/or incurs Cost from complying with the Engineer's instructions under Sub-Clause 8.8 [Suspension of Work] and/or from resuming the work, the Contractor shall give notice to the Engineer and shall be entitled subject to Sub-Clause 20.1 [Contractor's Claims] to:

- (a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 8.4 [Extension of Time for Completion], and
- (b) payment of any such Cost, which shall be included in the Contract Price.

After receiving this notice, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine these matters.

The Contractor shall not be entitled to an extension of time for, or to payment of the Cost incurred in, making good the consequences of the Contractor's faulty design, workmanship or materials, or of the Contractor's failure to protect, store or secure in accordance with Sub-Clause 8.8 [Suspension of Work].

8.10 Payment for Plant and Materials in Event of Suspension

The Contractor shall be entitled to payment of the value (as at the date of suspension) of Plant and/or Materials which have not been delivered to Site, if:

- (a) the work on Plant or delivery of Plant and/or Materials has been suspended for more than 28 days, and

- (b) the Contractor has marked the Plant and/or Materials as the Employer's property in accordance with the Engineer's instructions.

8.11 Prolonged Suspension

If the suspension under Sub-Clause 8.8 [Suspension of Work] has continued for more than 84 days, the Contractor may request the Engineer's permission to proceed. If the Engineer does not give permission within 28 days after being requested to do so, the Contractor may, by giving notice to the Engineer, treat the suspension as an omission under Clause 13 [Variations and Adjustments] of the affected part of the Works. If the suspension affects the whole of the Works, the Contractor may give notice of termination under Sub-Clause 16.2 [Termination by Contractor].

8.12 Resumption of Work

After the permission or instruction to proceed is given, the Contractor and the Engineer shall jointly examine the Works and the Plant and Materials affected by the suspension. The Contractor shall make good any deterioration or defect in or loss of the Works or Plant or Materials, which has occurred during the suspension after receiving from the Engineer an instruction to this effect under Clause 13 [Variations and Adjustments].

9 Tests on Completion

9.1 Contractor's Obligations

The Contractor shall carry out the Tests on Completion in accordance with this Clause and Sub-Clause 7.4 [Testing], after providing the documents in accordance with Sub-Clause 5.6 [As-Built Documents] and Sub-Clause 5.7 [Operation and Maintenance Manuals].

The Contractor shall give to the Engineer not less than 21 days' notice of the date after which the Contractor will be ready to carry out each of the Tests on Completion. Unless otherwise agreed, Tests on Completion shall be carried out within 14 days after this date, on such day or days as the Engineer shall instruct.

Unless otherwise stated in the Particular Conditions, the Tests on Completion shall be carried out in the following sequence:

- (a) pre-commissioning tests, which shall include the appropriate inspections and ("dry" or "cold") functional tests to demonstrate that each item of Plant can safely undertake the next stage, (b)
- (b) commissioning tests, which shall include the specified operational tests to demonstrate that the Works or Section can be operated safely and as specified, under all available operating conditions; and
- (c) trial operation, which shall demonstrate that the Works or Section perform reliably and in accordance with the Contract.

During trial operation, when the Works are operating under stable conditions, the Contractor shall give notice to the Engineer that the Works are ready for any other Tests on Completion, including performance tests to demonstrate whether the Works conform with criteria specified in the Employer's Requirements and with the Schedule of Guarantees.

Trial operation shall not constitute a taking-over under Clause 10 [Employer's Taking Over]. Unless otherwise stated in the Particular Conditions, any product produced by the Works during trial operation shall be the property of the Employer.

In considering the results of the Tests on Completion, the Engineer shall make allowances for the effect of any use of the Works by the Employer on the performance or other characteristics of the Works. As soon as the Works, or a Section, have passed each of the Tests on Completion described in sub-paragraph (a), (b) or (c), the Contractor shall submit a certified report of the results of these Tests to the Engineer.

9.2 Delayed Tests

If the Tests on Completion are being unduly delayed by the Employer, Sub-Clause 7.4 [Testing] (fifth paragraph) and/or Sub-Clause 10.3 [Interference with Tests on Completion] shall be applicable.

If the Tests on Completion are being unduly delayed by the Contractor, the Engineer may by notice require the Contractor to carry out the Tests within 21 days after receiving the notice. The Contractor shall carry out the Tests on such day or days within that period as the Contractor may fix and of which he shall give notice to the Engineer.

If the Contractor fails to carry out the Tests on Completion within the period of 21 days, the Employer's Personnel may proceed with the Tests at the risk and cost of the Contractor. The Tests on Completion shall then be deemed to have been carried out in the presence of the Contractor and the results of the Tests shall be accepted as accurate.

9.3 Retesting

If the Works, or a Section, fail to pass the Tests on Completion, Sub-Clause 7.5 [Rejection] shall apply, and the Engineer or the Contractor may require the failed Tests, and Tests on Completion on any related work, to be repeated under the same terms and conditions.

9.4 Failure to Pass Tests on Completion

If the Works, or a Section, fail to pass the Tests on Completion repeated under Sub-Clause 9.3 [Retesting], the Engineer shall be entitled to:

- (a) order further repetition of Tests on Completion under Sub-Clause 9.3;
- (b) if the failure deprives the Employer of substantially the whole benefit of the Works or Section, reject the Works or Section (as the case may be), in which event the Employer shall have the same remedies as are provided in sub-paragraph (c) of Sub-Clause 11.4 [Failure to Remedy Defects]; or
- (c) issue a Taking-Over Certificate, if the Employer so requests.

In the event of sub-paragraph (c), the Contractor shall then proceed in accordance with all other obligations under the Contract, and the Contract Price shall be reduced by such amount as shall be appropriate to cover the reduced value to the Employer as a result of this failure. Unless the relevant reduction for this failure is stated (or its method of calculation is defined) in the Contract, the Employer may require the reduction to be (i) agreed by both Parties (in full satisfaction of this failure only) and paid before this Taking-Over Certificate is issued, or (ii) determined and paid under Sub-Clause 2.5 [Employer's Claims] and Sub-Clause 3.5 [Determinations].

10 Employer's Taking Over

10.1 Taking Over of the Works and Sections

Except as stated in Sub-Clause 9.4 [Failure to Pass Tests on Completion], the Works shall be taken over by the Employer when (i) the Works have been completed in accordance with the Contract, including the matters described in Sub-Clause 8.2

[Time for Completion] and except as allowed in sub-paragraph (a) below, and (ii) a Taking-Over Certificate for the Works has been issued, or is deemed to have been issued in accordance with this Sub-Clause.

The Contractor may apply by notice to the Engineer for a Taking-Over Certificate not earlier than 14 days before the Works will, in the Contractor's opinion, be complete and ready for taking over. If the Works are divided into Sections, the Contractor may similarly apply for a Taking-Over Certificate for each Section.

The Engineer shall, within 28 days after receiving the Contractor's application:

- (a) issue the Taking-Over Certificate to the Contractor, stating the date on which the Works or Section were completed in accordance with the Contract, except for any minor outstanding work and defects which will not substantially affect the use of the Works or Section for their intended purpose (either until or whilst this work is completed and these defects are remedied); or
- (b) reject the application, giving reasons and specifying the work required to be done by the Contractor to enable the Taking-Over Certificate to be issued. The Contractor shall then complete this work before issuing a further notice under this Sub-Clause.

If the Engineer fails either to issue the Taking-Over Certificate or to reject the Contractor's application with the period of 28 days, and if the Works or Section (as the case may be) are substantially in accordance with the Contract, the Taking-Over Certificate shall be deemed to have been issued on the last day of that period.

10.2 Taking Over of Parts of the Works

The Engineer may, at the sole discretion of the Employer, issue a Taking-Over Certificate for any part of the Permanent Works.

The Employer shall not use any part of the Works (other than as a temporary measure which is either specified in the Contract or agreed by both Parties) unless and until the Engineer has issued a Taking-Over Certificate for this part. However, if the Employer does use any part of the Works before the Taking-Over Certificate is issued:

- (a) the part which is used shall be deemed to have been taken over as from the date on which it is used,
- (b) the Contractor shall cease to be liable for the care of such part as from this date, when responsibility shall pass to the Employer, and
- (c) if requested by the Contractor, the Engineer shall issue a Taking-Over Certificate for this part.

After the Engineer has issued a Taking-Over Certificate for a part of the Works, the Contractor shall be given the earliest opportunity to take such steps as may be necessary to carry out any outstanding Tests on Completion. The Contractor shall carry out these Tests on Completion as soon as practicable before the expiry date of the relevant Defects Notification Period.

If the Contractor incurs Cost as a result of the Employer taking over and/or using a part of the Works, other than such use as is specified in the Contract or agreed by the Contractor, the Contractor shall (i) give notice to the Engineer and (ii) be entitled subject to Sub-Clause 20.1 [Contractor's Claims] to payment of any such Cost plus profit, which shall be included in the Contract Price. After receiving this notice, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine this Cost and profit.

If a Taking-Over Certificate has been issued for a part of the Works (other than a Section), the delay damages thereafter for completion of the remainder of the Works shall be reduced. Similarly, the delay damages for the remainder of the Section (if any) in which this part is included shall also be reduced. For any period of delay after the date stated in this Taking-Over Certificate, the proportional reduction in these delay damages shall be calculated as the proportion which the value of the part so certified bears to the value of the Works or Section (as the case may be) as a whole. The Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine these proportions. The provisions of this paragraph shall only apply to the daily rate of delay damages under Sub-Clause 8.7 [Delay Damages], and shall not affect the maximum amount of these damages.

10.3 Interference with Tests Completion

If the Contractor is prevented, for more than 14 days, from carrying out the Tests on Completion by a cause for which the Employer is responsible, the Employer shall be deemed to have taken over the Works or Section (as the case may be) on the date when the Tests on Completion would otherwise have been completed.

The Engineer shall then issue a Taking-Over Certificate accordingly, and the Contractor shall carry out the Tests on Completion as soon as practicable, before the expiry date of the Defects Notification Period. The Engineer shall require the Tests on Completion to be carried out by giving 14 days' notice and in accordance with the relevant provisions of the Contract.

If the Contractor suffers delay and/or incurs Cost as a result of this delay in carrying out the Tests on Completion, the Contractor shall give notice to the Engineer and shall be entitled subject to Sub-Clause 20.1 [Contractor's Claims] to:

- (a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 8.4 [Extension of Time for Completion], and
- (b) payment of any such Cost plus profit, which shall be included in the Contract Price.

After receiving this notice, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine these matters.

10.4 Surfaces Requiring Reinstatement

Except as otherwise stated in a Taking-Over Certificate, a certificate for a Section or part of the Works shall not be deemed to certify completion of any ground or other surfaces requiring reinstatement.

11 Defects Liability

11.1 Completion of Outstanding Work and Remedying Defects

In order that the Works and Contractor's Documents, and each Section, shall be in the condition required by the Contract (fair wear and tear excepted) by the expiry date of the relevant Defects Notification Period or as soon as practicable thereafter, the Contractor shall:

- (a) complete any work which is outstanding on the date stated in a Taking-Over Certificate, within such reasonable time as is instructed by the Engineer, and
- (b) execute all work required to remedy defects or damage, as may be notified by (or on behalf of) the Employer on or before the expiry date of the Defects Notification Period for the Works or Section (as the case may be).

If a defect appears or damage occurs, the Contractor shall be notified accordingly, by (or on behalf of) the Employer.

11.2 Cost of Remedying Defects

All work referred to in sub-paragraph (b) of Sub-Clause 11.1 [Completion of Outstanding Work and Remedying Defects] shall be executed at the risk and cost of the Contractor, if and to the extent that the work is attributable to:

- (a) the design of the Works, other than a part of the design for which the Employer is responsible (if any),
- (b) Plant, Materials or workmanship not being in accordance with the Contract,
- (c) improper operation or maintenance which was attributable to matters for which the Contractor is responsible (under Sub-Clauses 5.5 to 5.7 or otherwise), or
- (d) failure by the Contractor to comply with any other obligation.

If and to the extent that such work is attributable to any other cause, the Contractor shall be notified promptly by (or on behalf of) the Employer, and Sub-Clause 13.3 [Variation Procedure] shall apply.

11.3 Extension of Defects Notification Period

The Employer shall be entitled subject to Sub-Clause 2.5 [Employer's Claims] to an extension of the Defects Notification Period for the Works or a Section if and to the extent that the Works, Section or a major item of Plant (as the case may be, and after taking over) cannot be used for the purposes for which they are intended by reason of a defect or by reason of damage attributable to the Contractor. However, a Defects Notification Period shall not be extended by more than two years.

If delivery and/or erection of Plant and/or Materials was suspended under Sub-Clause 8.8 [Suspension of Work] or Sub-Clause 16.1 [Contractor's Entitlement to Suspend Work], the Contractor's obligations under this Clause shall not apply to any defects or damage occurring more than two years after the Defects Notification Period for the Plant and/or Materials would otherwise have expired.

11.4 Failure to Remedy Defects

If the Contractor fails to remedy any defect or damage within a reasonable time, a date may be fixed by (or on behalf of) the Employer, on or by which the defect or damage is to be remedied. The Contractor shall be given reasonable notice of this date.

If the Contractor fails to remedy the defect or damage by this notified date and this remedial work was to be executed at the cost of the Contractor under Sub-Clause 11.2 [Cost of Remedying Defects], the Employer may (at his option):

- (a) carry out the work himself or by others, in a reasonable manner and at the Contractor's cost, but the Contractor shall have no responsibility for this work; and the Contractor shall subject to Sub-Clause 2.5 [Employer's Claims] pay to the Employer the costs reasonably incurred by the Employer in remedying the defect or damage;
- (b) require the Engineer to agree or determine a reasonable reduction in the Contract Price in accordance with Sub-Clause 3.5 [Determinations]; or
- (c) if the defect or damage deprives the Employer of substantially the whole benefit of the Works or any major part of the Works, terminate the Contract as a whole, or in respect of such major part which cannot be put to the intended use. Without prejudice to any other rights, under the Contract or otherwise, the Employer shall then be entitled to recover all sums paid for the Works or for such part (as the case may be), plus financing costs and the cost of dismantling the same, clearing the Site and returning Plant and Materials to the Contractor.

11.5 Removal of Defective Work

If the defect or damage cannot be remedied expeditiously on the Site and the Employer gives consent, the Contractor may remove from the Site for the purposes of repair such items of Plant as are defective or damaged. This consent may require the Contractor to increase the amount of the Performance Security by the full replacement cost of these items, or to provide other appropriate security.

11.6 Further Tests

If the work of remedying of any defect or damage may affect the performance of the Works, the Engineer may require the repetition of any of the tests described in the Contract, including Tests on Completion and/or Tests after Completion. The requirement shall be made by notice within 28 days after the defect or damage is remedied.

These tests shall be carried out in accordance with the terms applicable to the previous tests, except that they shall be carried out at the risk and cost of the Party liable, under Sub-Clause 11.2 [Cost of Remedying Defects], for the cost of the remedial work.

11.7 Right of Access

Until the Performance Certificate has been issued, the Contractor shall have the right of access to all parts of the Works and to records of the operation and performance of the Works, except as may be inconsistent with the Employer's reasonable security restrictions.

11.8 Contractor to Search

The Contractor shall, if required by the Engineer, search for the cause of any defect, under the direction of the Engineer. Unless the defect is to be remedied at the cost of the Contractor under Sub-Clause 11.2 [Cost of Remedying Defects], the Cost of the search plus profit shall be agreed or determined by the Engineer in accordance with Sub-Clause 3.5 [Determinations] and shall be included in the Contract Price.

11.9 Performance Certificate

Performance of the Contractor's obligations shall not be considered to have been completed until the Engineer has issued the Performance Certificate to the Contractor, stating the date on which the Contractor completed his obligations under the Contract.

The Engineer shall issue the Performance Certificate within 28 days after the latest of the expiry dates of the Defects Notification Periods, or as soon thereafter as the Contractor has supplied all the Contractor's Documents and completed and tested all the Works, including remedying any defects. A copy of the Performance Certificate shall be issued to the Employer.

Only the Performance Certificate shall be deemed to constitute acceptance of the Works.

11.10 Unfulfilled Obligations

After the Performance Certificate has been issued, each Party shall remain liable for the fulfilment of any obligation which remains unperformed at that time. For the purposes of determining the nature and extent of unperformed obligations, the Contract shall be deemed to remain in force.

11.11 Clearance of Site

Upon receiving the Performance Certificate, the Contractor shall remove any remaining Contractor's Equipment, surplus material, wreckage, rubbish and Temporary Works from the Site.

If all these items have not been removed within 28 days after the Employer receives a copy of the Performance Certificate, the Employer may sell or otherwise dispose of any remaining items. The Employer shall be entitled to be paid the costs incurred in connection with, or attributable to, such sale or disposal and restoring the Site.

Any balance of the moneys from the sale shall be paid to the Contractor. If these moneys are less than the Employer's costs, the Contractor shall pay the outstanding balance to the Employer.

12 Test after Completion

12.1 Procedure for Tests after Completion

If Tests after Completion are specified in the Contract, this Clause shall apply. Unless otherwise stated in the Particular Conditions, the Employer shall:

- (a) provide all electricity, equipment, fuel, instruments, labour, materials, and suitably qualified and experienced staff, as are necessary to carry out the Tests after Completion efficiently, and
- (b) carry out the Tests after Completion in accordance with the manuals supplied by the Contractor under Sub-Clause 5.7 [Operation and Maintenance Manuals] and such guidance as the Contractor may be required to give during the course of these Tests; and in the presence of such Contractor's Personnel as either Party may reasonably request.

The Tests after Completion shall be carried out as soon as is reasonably practicable after the Works or Section have been taken over by the Employer. The Employer shall give to the Contractor 21 days' notice of the date after which the Tests after Completion will be carried out. Unless otherwise agreed, these Tests shall be carried out within 14 days after this date, on the day or days determined by the Employer.

If the Contractor does not attend at the time and place agreed, the Employer may proceed with the Tests after Completion, which shall be deemed to have been made in the Contractor's presence, and the Contractor shall accept the readings as accurate.

The results of the Tests after Completion shall be compiled and evaluated by both Parties. Appropriate account shall be taken of the effect of the Employer's prior use of the Works.

12.2 Delayed Tests

If the Contractor incurs Cost as a result of any unreasonable delay by the Employer to the Tests after Completion, the Contractor shall (i) give notice to the Engineer and (ii) be entitled subject to Sub-Clause 20.1 [Contractor's Claims] to payment of any such

Cost plus profit, which shall be included in the Contract Price.

After receiving this notice, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine this Cost and profit.

If, for reasons not attributable to the Contractor, a Test after Completion on the Works or any Section cannot be completed during the Defects Notification Period (or any other period agreed upon by both Parties), then the Works or Section shall be deemed to have passed this Test after Completion.

12.3 Retesting

If the Works, or a Section, fail to pass the Tests after Completion:

- (a) sub-paragraph (b) of Sub-Clause 11.1 [Completion of Outstanding Work and Remedying Defects] shall apply, and

- (b) either Party may then require the failed Tests, and the Tests after Completion on any related work, to be repeated under the same terms and conditions.

If and to the extent that this failure and retesting are attributable to any of the matters listed in subparagraphs (a) to (d) of Sub-Clause 11.2 [Cost of Remedying Defects] and cause the Employer to incur additional costs, the Contractor shall subject to Sub-Clause 2.5 [Employer's Claims] pay these costs to the Employer.

12.4 Failure to Pass Tests after Completion

If the following conditions apply, namely:

- (a) the Works, or a Section, fail to pass any or all of the Tests after Completion,
- (b) the relevant sum payable as non-performance damages for this failure is stated (or its method of calculation is defined) in the Contract, and
- (c) the Contractor pays this relevant sum to the Employer during the Defects Notification Period,

then the Works or Section shall be deemed to have passed these Tests after Completion.

If the Works, or a Section, fail to pass a Test after Completion and the Contractor proposes to make adjustments or modifications to the Works or such Section, the Contractor may be instructed by (or on behalf of) the Employer that right of access to the Works or Section cannot be given until a time that is convenient to the Employer. The Contractor shall then remain liable to carry out the adjustments or modifications and to satisfy this Test, within a reasonable period of receiving notice by (or on behalf of) the Employer of the time that is convenient to the Employer. However, if the Contractor does not receive this notice during the relevant Defects Notification Period, the Contractor shall be relieved of this obligation and the Works or Section (as the case may be) shall be deemed to have passed this Test after Completion.

If the Contractor incurs additional Cost as a result of any unreasonable delay by the Employer in permitting access to the Works or Plant by the Contractor, either to investigate the causes of a failure to pass a Test after Completion or to carry out any adjustments or modifications, the Contractor shall (i) give notice to the Engineer and (ii) be entitled subject to Sub-Clause 20.1 [Contractor's Claims] to payment of any such Cost plus profit, which shall be included in the Contract Price.

After receiving this notice, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine this Cost and profit.

13 Variations and Adjustments

13.1 Right to Vary

Variations may be initiated by the Engineer at any time prior to issuing the Taking-Over Certificate for the Works, either by an instruction or by a request for the Contractor to submit a proposal. A Variation shall not comprise the omission of any work which is to be carried out by others.

The Contractor shall execute and be bound by each Variation, unless the Contractor promptly gives notice to the Engineer stating (with supporting particulars) that:

- (i) the Contractor cannot readily obtain the Goods required for the Variation,
- (ii) such Variation triggers a substantial change in the sequence or progress of the Works.
- (iii) it will reduce the safety or suitability of the Works, or
- (iv) it will have an adverse impact on the achievement of the Schedule of Guaranties.

Upon receiving this notice, the Engineer shall cancel, confirm or vary the instruction”.

13.2 Value Engineering

The Contractor may, at any time, submit to the Engineer a written proposal which (in the Contractor's opinion) will, if adopted, (i) accelerate completion, (ii) reduce the cost to the Employer of executing, maintaining or operating the Works, (iii) improve the efficiency or value to the Employer of the completed Works, or (iv) otherwise be of benefit to the Employer.

The proposal shall be prepared at the cost of the Contractor and shall include the items listed in Sub-Clause 13.3 [Variation Procedure].

13.3 Variation Procedure

If the Engineer requests a proposal, prior to instructing a Variation, the Contractor shall respond in writing as soon as practicable, either by giving reasons why he cannot comply (if this is the case) or by submitting:

- (a) a description of the proposed design and/or work to be performed and a programme for its execution,
- (b) the Contractor's proposal for any necessary modifications to the programme according to Sub-Clause 8.3 [Programme] and to the Time for Completion, and
- (c) the Contractor's proposal for adjustment to the Contract Price.

The Engineer shall, as soon as practicable after receiving such proposal (under Sub-Clause 13.2 [Value Engineering] or otherwise), respond with approval, disapproval or comments. The Contractor shall not delay any work whilst awaiting a response

Each instruction to execute a Variation, with any requirements for the recording of Costs, shall be issued by the Engineer to the Contractor, who shall acknowledge receipt.

Upon instructing or approving a Variation, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine adjustments to the Contract Price and the Schedule of Payments. These adjustments shall include profit, and shall take account of the Contractor's submissions under Sub-Clause 13.2 [Value Engineering] if applicable

13.4 Payment in Applicable Currencies

If the Contract provides for payment of the Contract Price in more than one currency, then whenever an adjustment is agreed, approved or determined as stated above, the amount payable in each of the applicable currencies shall be specified. For this purpose, reference shall be made to the actual or expected currency proportions of the Cost of the varied work, and to the proportions of various currencies specified for payment of the Contract Price.

13.5 Provisional Sums

Each Provisional Sum shall only be used, in whole or in part, in accordance with the Engineer's instructions, and the Contract Price shall be adjusted accordingly. The total sum paid to the Contractor shall include only such amounts, for the work, supplies or services to which the Provisional Sum relates, as the Engineer shall have instructed. For each Provisional Sum, the Engineer may instruct:

- (a) work to be executed (including Plant, Materials or services to be supplied) by the Contractor and valued under Sub-Clause 13.3 [Variation Procedure]; and/or
- (b) Plant, Materials or services to be purchased by the Contractor, from a nominated Subcontractor (as defined in Sub-Clause 4.5 [Nominated Subcontractors] otherwise; and for which there shall be included in the Contract Price:
 - (i) the actual amounts paid (or due to be paid) by the Contractor, and
 - (ii) a sum for overhead charges and profit, calculated as a percentage of these actual amounts by applying the relevant percentage rate (if any) stated in the appropriate Schedule. If there is no such rate, the percentage rate stated in the Contract Data shall be applied.

The Contractor shall, when required by the Engineer, produce quotations, invoices, vouchers and accounts or receipts in substantiation.

As an exception to the above, the Provisional Sum for the cost of the DB shall be used for payments to the Contractor of the Employer's share (one-half) of the invoices of the DB for its fees and expenses, in accordance with GC 20.2. No prior instruction of the Engineer shall be required with respect to the work of the DB. The Contractor shall produce the DB invoices and satisfactory evidence of having paid 100% of such invoices as part of the substantiation of those Statements submitted under Sub-Clause 14.3, which contain requests for payment under the Provisional Sum toward the cost of the DB. The Engineer's certification of such Statements shall be based upon such invoices and such evidence of payment by the Contractor. Contractor's overhead, profit, etc., shall not be included in the provisional sums for the cost of the DB.

13.6 Daywork

For work of a minor or incidental nature, the Engineer may instruct that a Variation shall be executed on a daywork basis. The work shall then be valued in accordance with the Daywork schedule included in the Contract, and the following procedure shall apply. If a Daywork schedule is not included in the Contract, this Sub-Clause shall not apply.

Before ordering Goods for the work, the Contractor shall submit quotations to the Engineer. When applying for payment, the Contractor shall submit invoices, vouchers and accounts or receipts for any Goods.

Except for any items for which the daywork schedule specifies that payment is not due, the Contractor shall deliver each day to the Engineer accurate statements in duplicate which shall include the following details of the resources used in executing the previous day's work:

- (a) the names, occupations and time of Contractor's Personnel,
- (b) the identification, type and time of Contractor's Equipment and Temporary Works, and
- (c) the quantities and types of Plant and Materials used.

One copy of each statement will, if correct, or when agreed, be signed by the Engineer and returned to the Contractor. The Contractor shall then submit priced statements of these resources to the Engineer, prior to their inclusion in the next Statement under Sub-Clause 14.3 [Application for Interim Payment Certificates].

13.7 Adjustments for Changes in Legislation

The Contract Price shall be adjusted to take account of any increase or decrease in Cost resulting from a change in the Laws of the Country (including the introduction of new Laws and the repeal or modification of existing Laws) or in the judicial or official governmental interpretation of such Laws, made after the Base Date, which affect the Contractor in the performance of obligations under the Contract.

If the Contractor suffers (or will suffer) delay and/or incurs (or will incur) additional Cost as a result of these changes in the Laws or in such interpretations, made after the Base Date, the Contractor shall give notice to the Engineer and shall be entitled subject to Sub-Clause 20.1 [Contractor's Claims] to:

- (a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 8.4 [Extension of Time for Completion], and
- (b) payment of any such Cost, which shall be included in the Contract Price.

After receiving this notice, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine these matters.

Notwithstanding the foregoing, the Contractor shall not be entitled to an extension of time if the relevant delay has already been taken into account in the determination of a previous extension of time and such Cost shall not be separately paid if the same shall already have been taken into account in the indexing of any inputs to the table of adjustment data in accordance with the provisions of Sub-Clause 13.8 [Adjustments for Changes in Cost].

13.8 Adjustments for Changes in Cost

In this Sub-Clause, "table of adjustment data" means the completed table of Changes in adjustment data included in the Schedules. If there is no such table of adjustment data, this Sub-Clause shall not apply.

If this Sub-Clause applies, the amounts payable to the Contractor shall be adjusted for rises or falls in the cost of labour, Goods and other inputs to the Works, by the addition or deduction of the amounts determined by the formulae prescribed in this Sub-Clause. To the extent that full compensation for any rise or fall in Costs is not covered by the provisions of this or other Clauses, the Accepted Contract Amount shall be deemed to have included amounts to cover the contingency of other rises and falls in costs.

The adjustment to be applied to the amount otherwise payable to the Contractor, as valued in accordance with the appropriate Schedule and certified in Payment Certificates, shall be determined from formulae for each of the currencies in which the Contract Price is payable. No adjustment is to be applied to work valued on the basis of Cost or current prices. The formulae shall be of the following general type:

$$P_n = a + bL_n/L_0 + c E_n/E_0 + d M_n/M_0$$

where:

"P_n" is the adjustment multiplier to be applied to the estimated contract value in the relevant currency of the work carried out in period "n", this period being a month unless otherwise stated in the Contract Data;

"a" is a fixed coefficient, stated in the relevant table of adjustment data, representing the non-adjustable portion in contractual payments;

"b", "c", "d", ... are coefficients representing the estimated proportion of each cost element related to the execution of the Works, as stated in the relevant table of adjustment data; such tabulated cost elements may be indicative of resources such as labour, equipment and materials;

"L_n", "E_n", "M_n", ... are the current cost indices or reference prices for period "n", expressed in the relevant currency of payment, each of which is applicable to the relevant tabulated cost element on the date 49 days prior to the last day of the period (to which the particular Payment Certificate relates); and

"L₀", "E₀", "M₀", ... are the base cost indices or reference prices, expressed in the relevant currency of payment, each of which is applicable to the relevant tabulated cost element on the Base Date.

The cost indices or reference prices stated in the table of adjustment data shall be used. If their source is in doubt, it shall be determined by the Engineer. For this purpose, reference shall be made to the values of the indices at stated dates (quoted in the fourth and fifth columns respectively of the table) for the purposes of clarification of the source; although these dates (and thus these values) may not correspond to the base cost indices.

In cases where the "currency of index" is not the relevant currency of payment, each index shall be converted into the relevant currency of payment at the selling rate, established by the central bank of the Country, of this relevant currency on the above date for which the index is required to be applicable

Until such time as each current cost index is available, the Engineer shall determine a provisional index for the issue of Interim Payment Certificates. When a current cost index is available, the adjustment shall be recalculated accordingly.

If the Contractor fails to complete the Works within the Time for Completion, adjustment of prices thereafter shall be made using either (i) each index or price applicable on the date 49 days prior to the expiry of the Time for Completion of the Works, or (ii) the current index or price: whichever is more favorable to the Employer.

The weightings (coefficients) for each of the factors of cost stated in the table(s) of adjustment data shall only be adjusted if they have been rendered unreasonable, unbalanced or inapplicable, as a result of Variations.

14 Contract Price and Payment

14.1 The Contract Price

Unless otherwise stated in the Particular Conditions:

- (a) the Contract Price shall be the lump sum Accepted Contract Amount and be subject to adjustments in accordance with the Contract;
- (b) the Contractor shall pay all taxes, duties and fees required to be paid by him under the Contract, and the Contract Price shall not be adjusted for any of these costs, except as stated in Sub-Clause 13.7 [Adjustments for Changes in Legislation];
- (c) any quantities which may be set out in a Schedule are estimated quantities and are not to be taken as the actual and correct quantities of the Works which the Contractor is required to execute; and
- (d) any quantities or price data which may be set out in a Schedule shall be used for the purposes stated in the Schedule and may be inapplicable for other purposes.

However, if any part of the Works is to be paid according to quantity supplied or work done, the provisions for measurement and evaluation shall be as stated in the Particular Conditions. The Contract Price shall be determined accordingly, subject to adjustments in accordance with the Contract.

Notwithstanding the provisions of sub-paragraph (b), the Contractor's Equipment, including essential spare parts therefor, imported by the Contractor for the sole purpose of executing the Contract shall be exempt from the payment of import duties and taxes upon importation.

14.2 Advance Payment

The Employer shall make an advance payment, as an interest-free loan for mobilisation and design, when the Contractor submits a guarantee in accordance with this Sub-Clause. The total advance payment, the number and timing of instalments (if more than one), and the applicable currencies and proportions, shall be as stated in the Contract Data.

Unless and until the Employer receives this guarantee, or if the total advance payment is not stated in the Contract Data, this Sub-Clause shall not apply.

The Engineer shall deliver to the Employer and to the Contractor an Interim Payment Certificate for the first instalment after receiving a Statement (under Sub-Clause 14.3 [*Application for Interim Payment Certificates*]) and after the Employer receives (i) the Performance Security in accordance with Sub-Clause 4.2 [Performance Security] (ii) a guarantee in amounts and currencies equal to the advance payment. This guarantee shall be issued by an entity and from within a country (or other jurisdiction) approved by the Employer, and shall be in the form annexed to the Contract Data or in another form approved by the Employer.

The Contractor shall ensure that the guarantee is valid and enforceable until the advance payment has been repaid, but its amount may be progressively reduced by the amount repaid by the Contractor as indicated in the Payment Certificates. If the terms of the guarantee specify its expiry date, and the advance payment has not been repaid by the date 28 days prior to the expiry date, the Contractor shall extend the validity of the guarantee until the advance payment has been repaid.

Unless stated otherwise in the Contract Data, the advance payment shall be repaid through percentage deductions from the interim payments determined by the Engineer in accordance with Sub-Clause 14.6 [Issue of Interim Payment Certificates], as follows:

- (a) deductions shall commence in the next interim Payment Certificate following that in which the total of all certified interim payments (excluding the advance payment and deductions and repayments of retention) exceeds 30 per cent (30%) of the Accepted Contract Amount less Provisional Sums; and
- (b) deductions shall be made at the amortisation rate stated in the Contract Data of the amount of each Interim Payment Certificate (excluding the advance payment and deductions for its repayments as well as deductions for retention money) in the currencies and proportions of the advance payment until such time as the advance payment has been repaid; provided that the advance payment shall be completely repaid prior to the time when 90 per cent (90%) of the Accepted Contract Amount less Provisional Sums has been certified for payment.

If the advance payment has not been repaid prior to the issue of the Taking-Over Certificate for the Works or prior to termination under Clause 15 [Termination by Employer], Clause 16 [Suspension and Termination by Contractor] or Clause 19 [Force Majeure] (as the case may be), the whole of the balance then outstanding shall immediately become due and in case of termination under Clause 15 [Termination by Employer] and Sub-Clause 19.6 [Optional Termination, Payment and Release], payable by the Contractor to the Employer”.

14.3 Application for Interim Payment Certificates

The Contractor shall submit a Statement in six copies to the Engineer after the end of the period of payment stated in the Contract (if not stated, after the end of each month), in a form approved by the Engineer, showing in detail the amounts to which the Contractor considers himself to be entitled, together with supporting documents which shall include the relevant report on progress in accordance with Sub-Clause 4.21 [Progress Reports].

The Statement shall include the following items, as applicable, which shall be expressed in the various currencies in which the Contract Price is payable, in the sequence listed:

- (a) the estimated contract value of the Works executed and the Contractor's Documents produced up to the end of the month (including Variations but excluding items described in sub-paragraphs (b) to (g) below);
- (b) any amounts to be added and deducted for changes in legislation and changes in cost, in accordance with Sub-Clause 13.7 [Adjustments for Changes in Legislation] and Sub-Clause 13.8 [Adjustments for Changes in Cost];
- (c) any amount to be deducted for retention, calculated by applying the percentage of retention stated in the Contract Data to the total of the above amounts, until the amount so retained by the Employer reaches the limit of Retention Money (if any) stated in the Contract Data;
- (d) any amounts to be added and deducted for the advance payment and repayments in accordance with Sub-Clause 14.2 [Advance Payment];
- (e) any amounts to be added and deducted for Plant and Materials in accordance with Sub-Clause 14.5 [Plant and Materials intended for the Works];

- (f) any other additions or deductions which may have become due under the Contract or otherwise, including those under Clause 20 [Claims, Disputes and Arbitration]; and
- (g) the deduction of amounts certified in all previous Payment Certificates.

14.4 Schedule of Payments

If the Contract includes a Schedule of Payments specifying the instalments in which the Contract Price will be paid, then, unless otherwise stated in this Schedule:

- (a) the instalments quoted in the Schedule of Payments shall be the estimated contract values for the purposes of sub-paragraph (a) of Sub-Clause 14.3 [Application for Interim Payment Certificates];
- (b) Sub-Clause 14.5 [Plant and Materials intended for the Works] shall not apply; and
- (c) if these instalments are not defined by reference to the actual progress achieved in executing the Works, and if actual progress is found to be less than that on which the Schedule of Payments was based, then the Engineer may proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine revised instalments, which shall take account of the extent to which progress is less or more than that on which the instalments were previously based.

If the Contract does not include a Schedule of Payments, the Contractor shall submit non-binding estimates of the payments which he expects to become due during each quarterly period. The first estimate shall be submitted within 42 days after the Commencement Date. Revised estimates shall be submitted at quarterly intervals, until the Taking-Over Certificate has been issued for the Works.

14.5 Plant and Materials intended for the Works

If this Sub-Clause applies, Interim Payment Certificates shall include, under sub-paragraph (e) of Sub-Clause 14.3, (i) an amount for Plant and Materials which have been sent to the Site for incorporation in the Permanent Works, and (ii) a reduction when the contract value of such Plant and Materials is included as part of the Permanent Works under sub-paragraph (a) of Sub-Clause 14.3 [Application for Interim Payment Certificates].

If the lists referred to in sub-paragraphs (b)(i) or (c)(i) below are not included in the Schedules, this Sub-Clause shall not apply.

The Engineer shall determine and certify each addition if the following conditions are satisfied:

- (a) the Contractor has:
 - (i) kept satisfactory records (including the orders, receipts, Costs and use of Plant and Materials) which are available for inspection, and
 - (ii) submitted a statement of the Cost of acquiring and delivering the Plant and Materials to the Site, supported by satisfactory evidence; and either:
- (b) the relevant Plant and Materials:

- (i) are those listed in the Schedules for payment when shipped,
 - (ii) have been shipped to the Country, en route to the Site, in accordance with the Contract; and
 - (iii) are described in a clean shipped bill of lading or other evidence of shipment, which has been submitted to the Engineer together with evidence of payment of freight and insurance, any other documents reasonably required, and a bank guarantee in a form and issued by an entity approved by the Employer in amounts and currencies equal to the amount due under this Sub-Clause: this guarantee may be in a similar form to the form referred to in Sub-Clause 14.2 [Advance Payment] and shall be valid until the Plant and Materials are properly stored on Site and protected against loss, damage or deterioration; or
- (c) the relevant Plant and Materials:
- (i) are those listed in the Schedule for payment when delivered to the Site, and
 - (ii) have been delivered to and are properly stored on the Site, are protected against loss, damage or deterioration, and appear to be in accordance with the Contract.

The additional amount to be certified shall be the equivalent of eighty percent of the Engineer's determination of the cost of the Plant and Materials (including delivery to Site), taking account of the documents mentioned in this Sub-Clause and of the contract value of the Plant and Materials.

The currencies for this additional amount shall be the same as those in which payment will become due when the contract value is included under sub-paragraph (a) of Sub-Clause 14.3 [Application for Interim Payment Certificates]. At that time, the Payment Certificate shall include the applicable reduction which shall be equivalent to, and in the same currencies and proportions as, this additional amount for the relevant Plant and Materials.

14.6 Issue of Interim Payment Certificates

No amount will be certified or paid until the Employer has received and approved the Performance Security. Thereafter, the Engineer shall, within 28 days after receiving a Statement and supporting documents, issue to the Employer an Interim Payment Certificate which shall state the amount which the Engineer fairly determines to be due, with all supporting particulars for any reduction or withholding made by the Engineer on the Statement if any".

However, prior to issuing the Taking-Over Certificate for the Works, the Engineer shall not be bound to issue an Interim Payment Certificate in an amount which would (after retention and other deductions) be less than the minimum amount of Interim Payment Certificates (if any) stated in the Contract Data. In this event, the Engineer shall give notice to the Contractor accordingly.

An Interim Payment Certificate shall not be withheld for any other reason, although:

- (a) if any thing supplied or work done by the Contractor is not in accordance with the Contract, the cost of rectification or replacement may be withheld until rectification or replacement has been completed; and/or

- (b) if the Contractor was or is failing to perform any work or obligation in accordance with the Contract, and had been so notified by the Engineer, the value of this work or obligation may be withheld until the work or obligation has been performed.

The Engineer may in any Payment Certificate make any correction or modification that should properly be made to any previous Payment Certificate. A Payment Certificate shall not be deemed to indicate the Engineer's acceptance, approval, consent or satisfaction, and shall include any amounts due to or from the Contractor in accordance with a decision by the DB made under Sub-Clause 20.4 [Obtaining Dispute Board].

14.7 Payment

The Employer shall pay to the Contractor:

- (a) the first instalment of the advance payment within 42 days after issuing the Letter of Acceptance or within 21 days after receiving the documents in accordance with Sub-Clause 4.2 [Performance Security] and Sub-Clause 14.2 [Advance Payment], whichever is later;
- (b) the amount certified in each Interim Payment Certificate within 56 days after the Engineer receives the Statement and supporting documents or, at a time when the Bank's loan or credit (from which part of the payments to the Contractor is being made) is suspended, the amount shown on any statement submitted by the Contractor, within 14 days after such statement is submitted, any discrepancy being rectified in the next payment to the Contractor including any amounts due in accordance with a decision by the DB which have been included in the Interim Payment Certificate; and
- (c) the amount certified in the Final Payment Certificate within 56 days after the Employer receives this Payment Certificate or, at a time when the Bank's loan or credit (from which part of the payments to the Contractor is being made) is suspended, the undisputed amount shown in the Final Statement, within 56 days after the date of notification of the suspension in accordance with Sub-Clause 16.2 [Termination by Contractor].

Payment of the amount due in each currency shall be made into the bank account, nominated by the Contractor, in the payment country (for this currency) specified in the Contract.

14.8 Delayed Payment

If the Contractor does not receive payment in accordance with Sub-Clause 14.7 [Payment], the Contractor shall be entitled to receive financing charges compounded monthly on the amount unpaid during the period of delay. This period shall be deemed to commence on the date for payment specified in Sub-Clause 14.7 [Payment], irrespective (in the case of its sub-paragraph (b)) of the date on which any Interim Payment Certificate is issued.

Unless otherwise stated in the Contract Data, these financing charges shall be calculated at the annual rate of three percentage points above the discount rate of the central bank in the country of the currency of payment, or if not applicable, the interbank offered rate, and shall be paid in such currency.

The Contractor shall be entitled to this payment without formal notice or certification, and without prejudice to any other right or remedy.

14.9 Payment of Retention Money

When the Taking-Over Certificate has been issued for the Works, and the Works have passed all specified tests (including the Tests after Completion, if any), the first half of the Retention Money shall be certified by the Engineer for payment to the Contractor. If a Taking-Over Certificate is issued for a Section, the relevant percentage of the first half of the Retention Money shall be certified and paid when the Section passes all tests.

Promptly after the latest of the expiry dates of the Defects Notification Periods, the outstanding balance of the Retention Money shall be certified by the Engineer for payment to the Contractor. If a Taking-Over Certificate was issued for a Section, the relevant percentage of the second half of the Retention Money shall be certified and paid promptly after the expiry date of the Defects Notification Period for the Section.

However, if any work remains to be executed under Clause 11 [Defects Liability] or Clause 12 [Tests after Completion], the Engineer shall be entitled to withhold certification of the estimated cost of this work until it has been executed.

The relevant percentage for each Section shall be the percentage value of the Section as stated in the Appendix to Tender. If the percentage value of a Section is not stated in the Appendix to Tender, no percentage of either half of the Retention Money shall be released under this Sub-Clause in respect of such Section.

Unless otherwise stated in the Contract Data, when the Taking-Over Certificate has been issued for the Works, the Works have passed all specified tests (including the Tests after Completion, if any) and the first half of the Retention Money has been certified for payment by the Engineer, the Contractor shall be entitled to substitute a guarantee, in the form annexed to the Particular Conditions or in another form approved by the Employer and provided by an entity approved by the Employer, for the second half of the Retention Money. The Contractor shall ensure that the guarantee is in the amounts and currencies of the second half of the Retention Money and is valid and enforceable until the Contractor has executed and completed the Works and remedied any defects, as specified for the Performance Security in Sub-Clause 4.2. On receipt by the Employer of the required guarantee, the Engineer shall certify and the Employer shall pay the second half of the Retention Money. The release of the second half of the Retention Money against a guarantee shall then be in lieu of the release under the second paragraph of this Sub-Clause. The Employer shall return the guarantee to the Contractor within 21 days after receiving a copy of the Performance Certificate.

If the Performance Security required under Sub-Clause 4.2 is in the form of a demand guarantee, and the amount guaranteed under it when the Taking-Over Certificate is issued is more than half of the Retention Money, then the Retention Money guarantee will not be required. If the amount guaranteed under the Performance Security when the Taking-Over Certificate is issued is less than half of the Retention Money, the Retention Money guarantee will only be required for the difference between half of the Retention Money and the amount guaranteed under the Performance Security”.

14.10 Statement at Completion

Within 84 days after receiving the Taking-Over Certificate for the Works, the Contractor shall submit to the Engineer six copies of a Statement at completion with supporting documents, in accordance with Sub-Clause 14.3 [Application for Interim Payment Certificates], showing:

- (a) the value of all work done in accordance with the Contract up to the date stated in the Taking-Over Certificate for the Works,
- (b) any further sums which the Contractor considers to be due, and
- (c) an estimate of any other amounts which the Contractor considers will become due to him under the Contract. Estimated amounts shall be shown separately in this Statement at completion.

The Engineer shall then certify in accordance with Sub-Clause 14.6 [Issue of Interim Payment Certificates].

14.11 Application for Final Payment Certificate

Within 56 days after receiving the Performance Certificate, the Contractor shall submit, to the Engineer, six copies of a draft final statement with supporting documents showing in detail in a form approved by the Engineer:

- (a) the value of all work done in accordance with the Contract, and
- (b) any further sums which the Contractor considers to be due to him under the Contract or otherwise.

If the Engineer disagrees with or cannot verify any part of the draft final statement, the Contractor shall submit such further information as the Engineer may reasonably require within 28 days from receipt of the said draft and shall make such changes in the draft as may be agreed between them. The Contractor shall then prepare and submit to the Engineer the final statement as agreed. This agreed statement is referred to in these Conditions as the "Final Statement".

However if, following discussions between the Engineer and the Contractor and any changes to the draft final statement which are agreed, it becomes evident that a dispute exists, the Engineer shall deliver to the Employer (with a copy to the Contractor) an Interim Payment Certificate for the agreed parts of the draft final statement. Thereafter, if the dispute is finally resolved under Sub-Clause 20.4 [Obtaining Dispute Board's Decision] or Sub-Clause 20.5 [Amicable Settlement], the Contractor shall then prepare and submit to the Employer (with a copy to the Engineer) a Final Statement.

14.12 Discharge

When submitting the Final Statement, the Contractor shall submit a discharge which confirms that the total of the Final Statement represents full and final settlement of all moneys due to the Contractor under or in connection with the Contract. This discharge may state that it becomes effective when the Contractor has received the Performance Security and the out-standing balance of this total in which event the discharge will be effective on such date.

14.13 Issue of Final Payment Certificate

Within 28 days after receiving the Final Statement and discharge in accordance with Sub-Clause 14.11 [Application for Final Payment Certificate] and Sub-Clause 14.12 [Discharge], the Engineer shall deliver, to the Employer and to the Contractor, the Final Payment Certificate which shall state:

- (a) the amount which he fairly determines is finally due, and
- (b) after giving credit to the Employer for all amounts previously paid by the Employer and for all sums to which the Employer is entitled, the balance (if any) due from the Employer to the Contractor or from the Contractor to the Employer, as the case may be".

If the Contractor has not applied for a Final Payment Certificate in accordance with Sub-Clause 14.11 [Application for Final Payment Certificate] and Sub-Clause 14.12 [Discharge], the Engineer shall request the Contractor to do so. If the Contractor fails to submit an application within a period of 28 days, the Engineer shall issue the Final Payment Certificate for such amount as he fairly determines to be due.

14.14 Cessation of Employer's Liability

The Employer shall not be liable to the Contractor for any matter or thing under or in connection with the Contract or execution of the Works, except to the extent that the Contractor shall have included an amount expressly for it:

- (a) in the Final Statement and also
- (b) (except for matters or things arising after the issue of the Taking-Over Certificate for the Works) in the Statement at completion described in Sub-Clause 14.10 [Statement at Completion].

However, this Sub-Clause shall not limit the Employer's liability under his indemnification obligations, or the Employer's liability in any case of fraud, deliberate default or reckless misconduct by the Employer.

14.15 Currencies of Payment

The Contract Price shall be paid in the currency or currencies in which the bid price was expressed in the Letter of Bid. If more than one currency is so named, payments shall be made as follows:

- (a) payment of the damages specified in GC 8.7, shall be made in the currencies and proportions specified in the Letter of Bid;
- (b) other payments to the Employer by the Contractor shall be made in the currency in which the sum was expended by the Employer, or in such currency as may be agreed by both Parties;
- (c) if any amount payable by the Contractor to the Employer in a particular currency exceeds the sum payable by the Employer to the Contractor in that currency, the Employer may recover the balance of this amount from the sums otherwise payable to the Contractor in other currencies; and
- (d) the applicable rates of exchange shall be those prevailing on the Base Date and determined by the central bank of the Country.

15 Termination by Employer

15.1 Notice to Correct

If the Contractor fails to carry out any obligation under the Contract, the Engineer may by notice require the Contractor to make good the failure and to remedy it within a specified reasonable time.

15.2 Termination by Employer

The Employer shall be entitled to terminate the Contract if the Contractor:

- (a) fails to comply with Sub-Clause 4.2 [Performance Security] or with a notice under Sub-Clause 15.1 [Notice to Correct],
- (b) abandons the Works or otherwise plainly demonstrates the intention not to continue performance of his obligations under the Contract,
- (c) without reasonable excuse fails:
 - (i) to proceed with the Works in accordance with Clause 8 [Commencement, Delays and Suspension], or
 - (ii) to comply with a notice issued under Sub-Clause 7.5 [Rejection] or Sub-Clause 7.6 [Remedial Work], within 28 days after receiving it,
- (d) subcontracts the whole of the Works or assigns the Contract without the required agreement,
- (e) becomes bankrupt or insolvent, goes into liquidation, has a receiving or administration order made against him, compounds with his creditors, or carries on business under a receiver, trustee or manager for the benefit of his creditors, or if any act is done or event occurs which (under applicable Laws) has a similar effect to any of these acts or events, or
- (f) gives or offers to give (directly or indirectly) to any person any bribe, gift, gratuity, commission or other thing of value, as an inducement or reward:
 - (i) for doing or forbearing to do any action in relation to the Contract, or
 - (ii) for showing or forbearing to show favour or disfavour to any person in relation to the Contract,

or if any of the Contractor's Personnel, agents or Subcontractors gives or offers to give (directly or indirectly) to any person any such inducement or reward as is described in this sub-paragraph (f). However, lawful inducements and rewards to Contractor's Personnel shall not entitle termination.

In any of these events or circumstances, the Employer may, upon giving 14 days' notice to the Contractor, terminate the Contract and expel the Contractor from the Site. However, in the case of sub-paragraph (e) or (f), the Employer may by notice terminate the Contract immediately

The Employer's election to terminate the Contract shall not prejudice any other rights of the Employer, under the Contract or otherwise.

The Contractor shall then leave the Site and deliver any required Goods, all Contractor's Documents, and other design documents made by or for him, to the Engineer. However, the Contractor shall use his best efforts to comply immediately with any reasonable instructions included in the notice (i) for the assignment of any subcontract, and (ii) for the protection of life or property or for the safety of the Works.

After termination, the Employer may complete the Works and/or arrange for any other entities to do so. The Employer and these entities may then use any Goods, Contractor's Documents and other design documents made by or on behalf of the Contractor.

The Employer shall then give notice that the Contractor's Equipment and Temporary Works will be released to the Contractor at or near the Site. The Contractor shall promptly arrange their removal, at the risk and cost of the Contractor. However, if by this time the Contractor has failed to make a payment due to the Employer, these items may be sold by the Employer in order to recover this payment. Any balance of the proceeds shall then be paid to the Contractor.

15.3 Valuation at Date of Termination

As soon as practicable after a notice of termination under Sub-Clause 15.2 [Termination by Employer] has taken effect, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine the value of the Works, Goods and Contractor's Documents, and any other sums due to the Contractor for work executed in accordance with the Contract.

15.4 Payment after Termination

After a notice of termination under Sub-Clause 15.2 [Termination by Employer] has taken effect, the Employer may:

- (a) proceed in accordance with Sub-Clause 2.5 [Employer's Claims],
- (b) withhold further payments to the Contractor until the costs of design, execution, completion and remedying of any defects, damages for delay in completion (if any), and all other costs incurred by the Employer, have been established, and/or
- (c) recover from the Contractor any losses and damages incurred by the Employer and any extra costs of completing the Works, after allowing for any sum due to the Contractor under Sub-Clause 15.3 [Valuation at Date of Termination]. After recovering any such losses, damages and extra costs, the Employer shall pay any balance to the Contractor.

15.5 Employer's Entitlement to Termination for Convenience

The Employer shall be entitled to terminate the Contract, at any time for the Employer's convenience, by giving notice of such termination to the Contractor. The termination shall take effect 28 days after the later of the dates on which the Contractor receives this notice or the Employer returns the Performance Security. The Employer shall not terminate the Contract under this Sub-Clause in order to execute the Works himself or to arrange for the Works to be executed by another contractor or to avoid a termination of the Contract by the Contractor under Sub-Clause 16.2 [Termination by Contractor]. .

After this termination, the Contractor shall proceed in accordance with Sub-Clause 16.3 [Cessation of Work and Removal of Contractor's Equipment] and shall be paid in accordance with Sub-Clause 19.6 [Optional Termination, Payment and Release].

15.6 Corrupt or Fraudulent Practice

If the Employer determines that the Contractor has engaged in corrupt, fraudulent, collusive or coercive practices, in competing for or in executing the Contract, then the Employer may, after giving 14 days notice to the Contractor, terminate the Contractor's employment under the Contract and expel him from the Site, and the provisions of Clause 15 shall apply as if such expulsion had been made under Sub-Clause 15.2 [Termination by Employer].

Should any employee of the Contractor be determined to have engaged in corrupt, fraudulent, collusive or coercive practice during the execution of the Works, then that employee shall be removed in accordance with Sub-Clause 6.9 [Contractor's Personnel].

For the purpose of this Sub-Clause:

- (a) "corrupt practice" means the offering, giving, receiving or soliciting of any thing of value to influence the action of a public official in the procurement process or in the Contract execution.
- (b) "fraudulent practice" means a misrepresentation of facts in order to influence a procurement process or the execution of the Contract to the detriment of the Borrower, and includes collusive practice among Bidders (prior to or after bid submission) designated to establish bid prices at artificial non-competitive levels and to deprive the Borrower of the benefits of free and open competition.
- (c) "collusive practice" means a scheme or arrangement between two or more bidders, with or without the knowledge of the Borrower, designated to establish bid prices at artificial, non-competitive levels.
- (d) "coercive practice" means harming or threatening to harm, directly or indirectly, persons or their property to influence their participation in the procurement process or affect the execution of a contract.

16 Suspension and Termination by Contractor

16.1 Contractor's Entitlement to Suspend Work

If the Engineer fails to certify in accordance with Sub-Clause 14.6 [Issue of Interim Payment Certificates] or the Employer fails to comply with Sub-Clause 2.4 [Employer's Financial Arrangements] or Sub-Clause 14.7 [Payment], the Contractor may, after giving not less than 21 days' notice to the Employer, suspend work (or reduce the rate of work) unless and until the Contractor has received the Payment Certificate, reasonable evidence or payment, as the case may be and as described in the notice.

Notwithstanding the above, if the Bank has suspended disbursements under the loan or credit from which payments to the Contractor are being made, in whole or in part, for the execution of the Works, and no alternative funds are available as provided for in Sub-Clause 2.4 [Employer's Financial Arrangements], the Contractor may by notice suspend work or reduce the rate of work at any time, but not less than 7 days after the Borrower having received the suspension notification from the Bank.

The Contractor's action shall not prejudice his entitlements to financing charges under Sub-Clause 14.8 [Delayed Payment] and to termination under Sub-Clause 16.2 [Termination by Contractor].

If the Contractor subsequently receives such Payment Certificate, evidence or payment (as described in the relevant Sub-Clause and in the above notice) before giving a notice of termination, the Contractor shall resume normal working as soon as is reasonably practicable.

If the Contractor suffers delay and/or incurs Cost as a result of suspending work (or reducing the rate of work) in accordance with this Sub-Clause, the Contractor shall give notice to the Engineer and shall be entitled subject to Sub-Clause 20.1 [Contractor's Claims] to:

- (a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 8.4 [Extension of Time for Completion], and
- (b) payment of any such Cost plus profit, which shall be included in the Contract Price.

After receiving this notice, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine these matters.

16.2 Termination by Contractor

The Contractor shall be entitled to terminate the Contract if:

- (a) the Contractor does not receive the reasonable evidence within 42 days after giving notice under Sub-Clause 16.1 [Contractor's Entitlement to Suspend Work] in respect of a failure to comply with Sub-Clause 2.4 [Employer's Financial Arrangements],
- (b) the Engineer fails, within 56 days after receiving a Statement and supporting documents, to issue the relevant Payment Certificate,
- (c) the Contractor does not receive the amount due under an Interim Payment Certificate within 42 days after the expiry of the time stated in Sub-Clause 14.7 [Payment] within which payment is to be made (except for deductions in accordance with Sub-Clause 2.5 [Employer's Claims]),
- (d) the Employer substantially fails to perform his obligations under the Contract in such manner as to materially and adversely affect the economic balance of the Contract and/or the ability of the Contractor to perform the Contract,
- (e) the Employer fails to comply with Sub-Clause 1.6 [Contract Agreement] or Sub-Clause 1.7 [Assignment],
- (f) a prolonged suspension affects the whole of the Works as described in Sub-Clause 8.11 [Prolonged Suspension], or
- (g) the Employer becomes bankrupt or insolvent, goes into liquidation, has a receiving or administration order made against him, compounds with his creditors, or carries on business under a receiver, trustee or manager for the benefit of his creditors, or if any act is done or event occurs which (under applicable Laws) has a similar effect to any of these acts or events.
- (h) the Contractor does not receive the Engineer's instruction recording the agreement of both Parties on the fulfilment of the conditions for the Commencement of Works under Sub-Clause 8.1 [Commencement of Works]".

In any of these events or circumstances, the Contractor may, upon giving 14 days' notice to the Employer, terminate the Contract. However, in the case of sub-paragraph (f) or (g), the Contractor may by notice terminate the Contract immediately.

In the event the Bank suspends the loan or credit from which part or whole of the payments to the Contractor are being made, if the Contractor has not received the sums due to him upon expiration of the 14 days referred to in Sub-Clause 14.7 [Payment] for payments under Interim Payment Certificates, the Contractor may, without prejudice to the Contractor's entitlement to financing charges under Sub-Clause 14.8 [Delayed Payment], take one of the following actions, namely (i) suspend work or reduce the rate of work, and (ii) terminate his employment under the Contract by giving notice to the Employer, with a copy to the Engineer, such termination to take effect 14 days after the giving of the notice.

The Contractor's election to terminate the Contract shall not prejudice any other rights of the Contractor, under the Contract or otherwise.

16.3 Cessation of Work and Removal of Contractor's Equipment

After a notice of termination under Sub-Clause 15.5 [Employer's Entitlement to Termination], Sub-Clause 16.2 [Termination by Contractor] or Sub-Clause 19.6 [Optional Termination, Payment and Release] has taken effect, the Contractor shall promptly:

- (a) cease all further work, except for such work as may have been instructed by the Engineer for the protection of life or property or for the safety of the Works,
- (b) hand over Contractor's Documents, Plant, Materials and other work, for which the Contractor has received payment, and
- (c) remove all other Goods from the Site, except as necessary for safety, and leave the Site.

16.4 Payment on Termination

After a notice of termination under Sub-Clause 16.2 [Termination by Contractor] has taken effect, the Employer shall promptly:

- (a) return the Performance Security to the Contractor,
- (b) pay the Contractor in accordance with Sub-Clause 19.6 [Optional Termination, Payment and Release], and
- (c) pay to the Contractor the amount of any loss of profit or other loss or damage sustained by the Contractor as a result of this termination.

17 Risk and Responsibility

17.1 Indemnities

The Contractor shall indemnify and hold harmless the Employer, the Employer's Personnel, and their respective agents, against and from all claims, damages, losses and expenses (including legal fees and expenses) in respect of:

- (a) bodily injury, sickness, disease or death, of any person whatsoever arising out of or in the course of or by reason of the design, execution and completion of the Works and the remedying of any defects, unless attributable to any negligence, wilful act or breach of the Contract by the Employer, the Employer's Personnel, or any of their respective agents, and
- (b) damage to or loss of any property, real or personal (other than the Works), to the extent that such damage or loss arises out of or in the course of or by reason of the design, the execution and completion of the Works and the remedying of any defects, unless and to the extent that any such damage or loss is attributable to any negligence, wilful act or breach of the Contract by the Employer, the Employer's Personnel, their respective agents, or anyone directly or indirectly employed by any of them".

The Employer shall indemnify and hold harmless the Contractor, the Contractor's Personnel, and their respective agents, against and from all claims, damages, losses and expenses (including legal fees and expenses) in respect of (1) bodily injury, sickness, disease or death, which is attributable to any negligence, wilful act or breach of the Contract by the Employer, the Employer's Personnel, or any of their respective agents, and (2) the matters for which liability may be excluded from insurance cover, as described in subparagraphs (d)(i), (ii) and (iii) of Sub-Clause 18.3 [Insurance Against Injury to Persons and Damage to Property].

17.2 Contractor's Care of the Works

The Contractor shall take full responsibility for the care of the Works and Goods from the Commencement Date until the Taking-Over Certificate is issued (or is deemed to be issued under Sub-Clause 10.1 [Taking Over of the Works and Sections]) for the Works, when responsibility for the care of the Works shall pass to the Employer. If a Taking-Over Certificate is issued (or is so deemed to be issued) for any Section or part of the Works, responsibility for the care of the Section or part shall then pass to the Employer.

After responsibility has accordingly passed to the Employer, the Contractor shall take responsibility for the care of any work which is outstanding on the date stated in a Taking-Over Certificate, until this outstanding work has been completed.

If any loss or damage happens to the Works, Goods or Contractor's Documents during the period when the Contractor is responsible for their care, from any cause not listed in Sub-Clause 17.3 [Employer's Risks], the Contractor shall rectify the loss or damage at the Contractor's risk and cost, so that the Works, Goods and Contractor's Documents conform with the Contract.

The Contractor shall be liable for any loss or damage caused by any actions performed by the Contractor after a Taking-Over Certificate has been issued. The Contractor shall also be liable for any loss or damage which occurs after a Taking-Over Certificate has been issued and which arose from a previous event for which the Contractor was liable.

17.3 Employer's Risks

The risks referred to in Sub-Clause 17.4 [Consequences of Employer's Risks] below, insofar as they directly affect the execution of the Works in the Country, are:

- (a) war, hostilities (whether war be declared or not), invasion, act of foreign enemies,
- (b) rebellion, terrorism, sabotage by persons other than the Contractor's Personnel, revolution, insurrection, military or usurped power, or civil war, within the Country,
- (c) riot, commotion or disorder within the Country by persons other than the Contractor's Personnel,
- (d) munitions of war, explosive materials, ionising radiation or contamination by radio-activity, within the Country, except as may be attributable to the Contractor's use of such munitions, explosives, radiation or radio-activity
- (e) pressure waves caused by aircraft or other aerial devices travelling at sonic or supersonic speeds,
- (f) use or occupation by the Employer of any part of the Permanent Works, except as may be specified in the Contract,
- (g) design of any part of the Works by the Employer's Personnel or by others for whom the Employer is responsible, if any, and
- (h) any operation of the forces of nature which is Unforeseeable or against which an experienced contractor could not reasonably have been expected to have taken adequate preventative precautions.

17.4 Consequences of Employer's Risks

If and to the extent that any of the risks listed in Sub-Clause 17.3 above results in loss or damage to the Works, Goods or Contractor's Documents, the Contractor shall promptly give notice to the Engineer and shall rectify this loss or damage to the extent required by the Engineer.

If the Contractor suffers delay and/or incurs Cost from rectifying this loss or damage, the Contractor shall give a further notice to the Engineer and shall be entitled subject to Sub-Clause 20.1 [Contractor's Claims] to:

- (a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 8.4 [Extension of Time for Completion], and
- (b) payment of any such Cost, which shall be included in the Contract Price. In the case of sub-paragraphs (f) and (g) of Sub-Clause 17.3 [Employer's Risks], Cost plus profit shall be payable.

After receiving this further notice, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine these matters.

17.5 Intellectual and Industrial Property Rights

In this Sub-Clause, "infringement" means an infringement (or alleged infringement) of any patent, registered design, copyright, trade mark, trade name, trade secret or other intellectual or industrial property right relating to the Works; and "claim" means a claim (or proceedings pursuing a claim) alleging an infringement.

Whenever a Party does not give notice to the other Party of any claim within 28 days of receiving the claim, the first Party shall be deemed to have waived any right to indemnity under this Sub-Clause.

The Employer shall indemnify and hold the Contractor harmless against and from any claim alleging an infringement which is or was:

- (a) an unavoidable result of the Contractor's compliance with the Employer's Requirements, or
- (b) a result of any Works being used by the Employer:
 - (i) for a purpose other than that indicated by, or reasonably to be inferred from, the Contract, or
 - (ii) in conjunction with any thing not supplied by the Contractor, unless such use was disclosed to the Contractor prior to the Base Date or is stated in the Contract.

The Contractor shall indemnify and hold the Employer harmless against and from any other claim which arises out of or in relation to (i) the Contractor's design, manufacture, construction or execution of the Works, (ii) the use of Contractor's Equipment, or (iii) the proper use of the Works.

If a Party is entitled to be indemnified under this Sub-Clause, the indemnifying Party may (at its cost) conduct negotiations for the settlement of the claim, and any litigation or arbitration which may arise from it. The other Party shall, at the request and cost of the indemnifying Party, assist in contesting the claim. This other Party (and its Personnel) shall not make any admission which might be prejudicial to the indemnifying Party, unless the indemnifying Party failed to take over the conduct of any negotiations, litigation or arbitration upon being requested to do so by such other Party.

17.6 Limitation of Liability

Neither Party shall be liable to the other Party for loss of use of any Works, loss of profit, loss of any contract or for any indirect or consequential loss or damage which may be suffered by the other Party in connection with the Contract, other than as specifically provided in Sub-Clause 8.7 [Delay Damages]; Sub-Clause 11.2 [Cost of Remedying Defects]; Sub-Clause 15.4 [Payment after Termination]; Sub-Clause 16.4 [Payment on Termination]; Sub-Clause 17.1 [Indemnities]; Sub-Clause 17.4 (b) [Consequences of Employer's Risks] and Sub-Clause 17.5 [Intellectual and Industrial Property Rights].

The total liability of the Contractor to the Employer, under or in connection with the Contract other than under Sub-Clause 4.19 [Electricity, Water and Gas], Sub-Clause 4.20 [Employer's Equipment and Free-Issue Material], Sub-Clause 17.1 [Indemnities] and Sub-Clause 17.5 [Intellectual and Industrial Property Rights], shall not exceed the sum resulting from the application of a multiplier (less or greater than one) to the Accepted Contract Amount, as stated in the Contract Data, or (if such multiplier or other sum is not so stated), the Accepted Contract Amount.

This Sub-Clause shall not limit liability in any case of fraud, deliberate default or reckless misconduct by the defaulting Party.

17.7 Use of Employer's Accommodation/Facilities

The Contractor shall take full responsibility for the care of the Employer-provided accommodation and facilities, if any, as detailed in the Employer's Requirements, from the respective dates of hand-over to the Contractor until cessation of occupation (where hand-over or cessation of occupation may take place after the date stated in the Taking-Over Certificate for the Works).

If any loss or damage happens to any of the above items while the Contractor is responsible for their care arising from any cause whatsoever other than those for which the Employer is liable, the Contractor shall, at his own cost, rectify the loss or damage to the satisfaction of the Engineer.

18 Insurance

18.1 General Requirements for Insurances

In this Clause, "insuring Party" means, for each type of insurance, the Party responsible for effecting and maintaining the insurance specified in the relevant Sub-Clause.

Wherever the Contractor is the insuring Party, each insurance shall be effected with insurers and in terms approved by the Employer. These terms shall be consistent with any terms agreed by both Parties before the date of the Letter of Acceptance. This agreement of terms shall take precedence over the provisions of this Clause.

Wherever the Employer is the insuring Party, each insurance shall be effected with insurers and in terms acceptable to the Contractor. These terms shall be consistent with any terms agreed by both Parties before the date of the Letter of Acceptance. This agreement of terms shall take precedence over the provisions of this Clause".

If a policy is required to indemnify joint insured, the cover shall apply separately to each insured as though a separate policy had been issued for each of the joint insured. If a policy indemnifies additional joint insured, namely in addition to the insured specified in this Clause, (i) the Contractor shall act under the policy on behalf of these additional joint insured except that the Employer shall act for Employer's Personnel, (ii) additional joint insured shall not be entitled to receive payments directly from the insurer or to have any other direct dealings with the insurer, and (iii) the insuring Party shall require all additional joint insured to comply with the conditions stipulated in the policy.

Each policy insuring against loss or damage shall provide for payments to be made in the currencies required to rectify the loss or damage. Payments received from insurers shall be used for the rectification of the loss or damage.

The relevant insuring Party shall, within the respective periods stated in the Contract Data (calculated from the Commencement Date), submit to the other Party:

- (a) evidence that the insurances described in this Clause have been effected, and
- (b) copies of the policies for the insurances described in Sub-Clause 18.2 [Insurance for Works and Contractor's Equipment] and Sub-Clause 18.3 [Insurance against Injury to Persons and Damage to Property].

When each premium is paid, the insuring Party shall submit evidence of payment to the other Party. Whenever evidence or policies are submitted, the insuring Party shall also give notice to the Engineer

Each Party shall comply with the conditions stipulated in each of the insurance policies. The insuring Party shall keep the insurers informed of any relevant changes to the execution of the Works and ensure that insurance is maintained in accordance with this Clause.

Neither Party shall make any material alteration to the terms of any insurance without the prior approval of the other Party. If an insurer makes (or attempts to make) any alteration, the Party first notified by the insurer shall promptly give notice to the other Party.

If the insuring Party fails to effect and keep in force any of the insurances it is required to effect and maintain under the Contract, or fails to provide satisfactory evidence and copies of policies in accordance with this Sub-Clause, the other Party may (at its option and without prejudice to any other right or remedy) effect insurance for the relevant coverage and pay the premiums due. The insuring Party shall pay the amount of these premiums to the other Party, and the Contract Price shall be adjusted accordingly.

Nothing in this Clause limits the obligations, liabilities or responsibilities of the Contractor or the Employer, under the other terms of the Contract or otherwise. Any amounts not insured or not recovered from the insurers shall be borne by the Contractor and/or the Employer in accordance with these obligations, liabilities or responsibilities. However, if the insuring Party fails to effect and keep in force an insurance which is available and which it is required to effect and maintain under the Contract, and the other Party neither approves the omission nor effects insurance for the coverage relevant to this default, any moneys which should have been recoverable under this insurance shall be paid by the insuring Party.

Payments by one Party to the other Party shall be subject to Sub-Clause 2.5 [Employer's Claims] or Sub-Clause 20.1 [Contractor's Claims], as applicable

The Contractor shall be entitled to place all insurance relating to the Contract (including, but not limited to the insurance referred to Clause 18) with insurers from any eligible source country.

18.2 Insurance for Works and Contractor's Equipment

The insuring Party shall insure the Works, Plant, Materials and Contractor's Documents for not less than the full reinstatement cost including the costs of demolition, removal of debris and professional fees and profit. This insurance shall be effective from the date by which the evidence is to be submitted under subparagraph (a) of Sub-Clause 18.1 [General Requirements for Insurances], until the date of issue of the Taking-Over Certificate for the Works.

The insuring Party shall maintain this insurance to provide cover until the date of issue of the Performance Certificate, for loss or damage for which the Contractor is liable arising from a cause occurring prior to the issue of the Taking-Over Certificate, and for loss or damage caused by the Contractor in the course of any other operations (including those under Clause 11 [Defects Liability] and Clause 12 [Tests after Completion]).

The insuring Party shall insure the Contractor's Equipment for not less than the full replacement value, including delivery to Site. For each item of Contractor's Equipment, the insurance shall be effective while it is being transported to the Site and until it is no longer required as Contractor's Equipment.

Unless otherwise stated in the Particular Conditions, insurances under this Sub-Clause:

- (a) shall be effected and maintained by the Contractor as insuring Party,

- (b) shall be in the joint names of the Parties, who shall be jointly entitled to receive payments from the insurers, payments being held or allocated between the Parties for the sole purpose of rectifying the loss or damage,
- (c) shall cover all loss and damage from any cause not listed in Sub-Clause 17.3 [Employer's Risks],
- (d) shall also cover, to the extent specifically required in the bidding documents of the Contract, loss or damage to a part of the Works which is attributable to the use or occupation by the Employer of another part of the Works, and loss or damage from the risks listed in sub-paragraphs (c), (g), and (h) of Sub-Clause 17.3 [Employer's Risks], excluding (in each case) risks which are not insurable at commercially reasonable terms, with deductibles per occurrence of not more than the amount stated in the Contract Data (if an amount is not so stated, this sub-paragraph (d) shall not apply), and
- (e) may however exclude loss of, damage to, and reinstatement of:
 - (i) a part of the Works which is in a defective condition due to a defect in its design, materials or workmanship (but cover shall include any other parts which are lost or damaged as a direct result of this defective condition and not as described in sub-paragraph (ii) below),
 - (ii) a part of the Works which is lost or damaged in order to reinstate any other part of the Works if this other part is in a defective condition due to a defect in its design, materials or workmanship,
 - (iii) a part of the Works which has been taken over by the Employer, except to the extent that the Contractor is liable for the loss or damage, and
 - (iv) Goods while they are not in the Country, subject to Sub-Clause 14.5 [Plant and Materials intended for the Works].

If, more than one year after the Base Date, the cover described in sub-paragraph (d) above ceases to be available at commercially reasonable terms, the Contractor shall (as insuring Party) give notice to the Employer, with supporting particulars. The Employer shall then (i) be entitled subject to Sub-Clause 2.5 [Employer's Claims] to payment of an amount equivalent to such commercially reasonable terms as the Contractor should have expected to have paid for such cover, and (ii) be deemed, unless he obtains the cover at commercially reasonable terms, to have approved the omission under Sub-Clause 18.1 [General Requirements for Insurances].

18.3 Insurance against Injury to Persons and Damage to Property

The insuring Party shall insure against each Party's liability for any loss, damage, death or bodily injury which may occur to any physical property (except things insured under Sub-Clause 18.2 [Insurance for Works and Contractor's Equipment]) or to any person (except persons insured under Sub-Clause 18.4 [Insurance for Contractor's Personnel]), which may arise out of the Contractor's performance of the Contract and occurring before the issue of the Performance Certificate.

This insurance shall be for a limit per occurrence of not less than the amount stated in the Contract Data, with no limit on the number of occurrences. If an amount is not stated in the Contract Data, this Sub-Clause shall not apply.

Unless otherwise stated in the Particular Conditions, the insurances specified in this Sub-Clause:

- (a) shall be effected and maintained by the Contractor as insuring Party,
- (b) shall be in the joint names of the Parties,
- (c) shall be extended to cover liability for all loss and damage to the Employer's property (except things insured under Sub-Clause 18.2) arising out of the Contractor's performance of the Contract, and
- (d) may however exclude liability to the extent that it arises from:
 - (i) the Employer's right to have the Permanent Works executed on, over, under, in or through any land, and to occupy this land for the Permanent Works,
 - (ii) damage which is an unavoidable result of the Contractor's obligations to execute the Works and remedy any defects, and
 - (iii) a cause listed in Sub-Clause 17.3 [Employer's Risks], except to the extent that cover is available at commercially reasonable terms.

18.4 Insurance for Contractor's Personnel

The Contractor shall effect and maintain insurance against liability for claims, damages, losses and expenses (including legal fees and expenses) arising from injury, sickness, disease or death of any person employed by the Contractor or any other of the Contractor's Personnel.

The insurance shall cover the Employer and the Engineer against liability for claims, damages, losses and expenses (including legal fees and expenses) arising from injury, sickness, disease or death of any person employed by the Contractor or any other of the Contractor's Personnel, except that this insurance may exclude losses and claims to the extent that they arise from any act or neglect of the Employer or of the Employer's Personnel.

The insurance shall be maintained in full force and effect during the whole time that these personnel are assisting in the execution of the Works. For a Subcontractor's employees, the insurance may be effected by the Subcontractor, but the Contractor shall be responsible for compliance with this Clause.

19 Force Majeure

19.1 Definition of Force Majeure

In this Clause, "Force Majeure" means an exceptional event or circumstance:

- (a) which is beyond a Party's control,
- (b) which such Party could not reasonably have provided against before entering into the Contract,
- (c) which, having arisen, such Party could not reasonably have avoided or overcome, and

- (d) which is not substantially attributable to the other Party.

Force Majeure may include, but is not limited to, exceptional events or circumstances of the kind listed below, so long as conditions (a) to (d) above are satisfied:

- (i) war, hostilities (whether war be declared or not), invasion, act of foreign enemies,
- (ii) rebellion, terrorism, sabotage by persons other than the Contractor's Personnel, revolution, insurrection, military or usurped power, or civil war,
- (iii) riot, commotion, disorder, strike or lockout by persons other than the Contractor's Personnel,
- (iv) munitions of war, explosive materials, ionising radiation or contamination by radio-activity, except as may be attributable to the Contractor's use of such munitions, explosives, radiation or radio-activity, and
- (v) natural catastrophes such as earthquake, hurricane, typhoon or volcanic activity.

19.2 Notice of Force Majeure

If a Party is or will be prevented from performing its substantial obligations under the Contract by Force Majeure, then it shall give notice to the other Party of the event or circumstances constituting the Force Majeure and shall specify the obligations, the performance of which is or will be prevented. The notice shall be given within 14 days after the Party became aware, or should have become aware, of the relevant event or circumstance constituting Force Majeure.

The Party shall, having given notice, be excused performance of its obligations for so long as such Force Majeure prevents it from performing them.

Notwithstanding any other provision of this Clause, Force Majeure shall not apply to obligations of either Party to make payments to the other Party under the Contract.

19.3 Duty to Minimise Delay

Each Party shall at all times use all reasonable endeavours to minimise any delay in the performance of the Contract as a result of Force Majeure.

A Party shall give notice to the other Party when it ceases to be affected by the Force Majeure.

19.4 Consequences of Force Majeure

If the Contractor is prevented from performing substantial obligations under the Contract by Force Majeure of which notice has been given under Sub-Clause 19.2 [Notice of Force Majeure], and suffers delay and/or incurs Cost by reason of such Force Majeure, the Contractor shall be entitled subject to Sub-Clause 20.1 [Contractor's Claims] to:

- (a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 8.4 [Extension of Time for Completion], and

- (b) if the event or circumstance is of the kind described in sub-paragraphs (i) to (iv) of Sub-Clause 19.1 [Definition of Force Majeure] and, in the case of sub-paragraphs (ii) to (iv), occurs in the Country, payment of any such Cost, including the costs of rectifying or replacing the Works and/or Goods damaged or destroyed by Force Majeure, to the extent they are not indemnified through the insurance policy referred to in Sub-Clause 18.2 [Insurance for Works and Contractor's Equipment].

After receiving this notice, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine these matters.

19.5 Force Majeure Affecting Sub-contractor

If any Subcontractor is entitled under any contract or agreement relating to the Works to relief from force majeure on terms additional to or broader than those specified in this Clause, such additional or broader force majeure events or circumstances shall not excuse the Contractor's non-performance or entitle him to relief under this Clause.

19.6 Optional Termination, Payment and Release

If the execution of substantially all the Works in progress is prevented for a continuous period of 84 days by reason of Force Majeure of which notice has been given under Sub-Clause 19.2 [Notice of Force Majeure], or for multiple periods which total more than 140 days due to the same notified Force Majeure, then either Party may give to the other Party a notice of termination of the Contract. In this event, the termination shall take effect 7 days after the notice is given, and the Contractor shall proceed in accordance with Sub-Clause 16.3 [Cessation of Work and Removal of Contractor's Equipment].

Upon such termination, the Engineer shall determine the value of the work done and issue a Payment Certificate which shall include:

- (a) the amounts payable for any work carried out for which a price is stated in the Contract;
- (b) the Cost of Plant and Materials ordered for the Works which have been delivered to the Contractor, or of which the Contractor is liable to accept delivery: this Plant and Materials shall become the property of (and be at the risk of) the Employer when paid for by the Employer, and the Contractor shall place the same at the Employer's disposal;
- (c) any other Cost or liability which in the circumstances was necessarily, as well as reasonably, incurred by the Contractor in the expectation of completing the Works;
- (d) the Cost of removal of Temporary Works and Contractor's Equipment from the Site and the return of these items to the Contractor's works in his country (or to any other destination at no greater cost); and
- (e) the Cost of repatriation of the Contractor's staff and labour employed wholly in connection with the Works at the date of termination.

19.7 Release from Performance under the Law

Notwithstanding any other provision of this Clause, if any event or circumstance outside the control of the Parties (including, but not limited to, Force Majeure) arises which makes it impossible or unlawful for either or both Parties to fulfil its or their contractual obligations or which, under the law governing the Contract, entitles the Parties to be released from further performance of the Contract, then upon notice by either Party to the other Party of such event or circumstance:

- (a) the Parties shall be discharged from further performance, without prejudice to the rights of either Party in respect of any previous breach of the Contract, and
- (b) the sum payable by the Employer to the Contractor shall be the same as would have been payable under Sub-Clause 19.6 [Optional Termination, Payment and Release] if the Contract had been terminated under Sub-Clause 19.6.

20 Claims, Disputes and Arbitration

20.1 Contractor's Claims

If the Contractor considers himself to be entitled to any extension of the Time for Completion and/or any additional payment, under any Clause of these Conditions or otherwise in connection with the Contract, the Contractor shall give notice to the Engineer, describing the event or circumstance giving rise to the claim. The notice shall be given as soon as practicable, and not later than 28 days after the Contractor became aware, or should have become aware, of the event or circumstance.

If the Contractor fails to give notice of a claim within such period of 28 days, the Time for Completion shall not be extended, the Contractor shall not be entitled to additional payment, and the Employer shall be discharged from all liability in connection with the claim. Otherwise, the following provisions of this Sub-Clause shall apply.

The Contractor shall also submit any other notices which are required by the Contract, and supporting particulars for the claim, all as relevant to such event or circumstance.

The Contractor shall keep such contemporary records as may be necessary to substantiate any claim, either on the Site or at another location acceptable to the Engineer. Without admitting the Employer's liability, the Engineer may, after receiving any notice under this Sub-Clause, monitor the record-keeping and/or instruct the Contractor to keep further contemporary records. The Contractor shall permit the Engineer to inspect all these records, and shall (if instructed) submit copies to the Engineer.

Within 42 days after the Contractor became aware (or should have become aware) of the event or circumstance giving rise to the claim, or within such other period as may be proposed by the Contractor and approved by the Engineer, the Contractor shall send to the Engineer a fully detailed claim which includes full supporting particulars of the basis of the claim and of the extension of time and/or additional payment claimed. If the event or circumstance giving rise to the claim has a continuing effect:

- (a) this fully detailed claim shall be considered as interim;
- (b) the Contractor shall send further interim claims at monthly intervals, giving the accumulated delay and/or amount claimed, and such further particulars as the Engineer may reasonably require; and

- (c) the Contractor shall send a final claim within 28 days after the end of the effects resulting from the event or circumstance, or within such other period as may be proposed by the Contractor and approved by the Engineer.

Within 42 days after receiving a claim or any further particulars supporting a previous claim, or within such other period as may be proposed by the Engineer and approved by the Contractor, the Engineer shall respond with approval, or with disapproval and detailed comments. He may also request any necessary further particulars, but shall nevertheless give his response on the principles of the claim within the above defined time period.

Within the above defined period of 42 days, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine (i) the extension (if any) of the Time for Completion (before or after its expiry) in accordance with Sub-Clause [Extension of Time for Completion], and/or (ii) the additional payment (if any) to which the Contractor is entitled under the Contract .

Each Payment Certificate shall include such additional payment for any claim as have been reasonably substantiated as due under the relevant provision of the Contract. Unless and until the particulars supplied are sufficient to substantiate the whole of the claim, the Contractor shall only be entitled to payment for such part of the claim as he has been able to substantiate.

If the Engineer does not respond within the timeframe defined in this Clause, either Party may consider that the claim is rejected by the Engineer and any of the Parties may refer to the Dispute Board in accordance with Sub-Clause 20.4 [Obtaining Dispute Board's Decision].

The requirements of this Sub-Clause are in addition to those of any other Sub-Clause which may apply to a claim. If the Contractor fails to comply with this or another Sub-Clause in relation to any claim, any extension of time and/or additional payment shall take account of the extent (if any) to which the failure has prevented or prejudiced proper investigation of the claim, unless the claim is excluded under the second paragraph of this Sub-Clause.

20.2 Appointment of the Dispute Board

Disputes shall be referred to a DB for decision in accordance with Sub-Clause 20.4 [Obtaining Dispute Board's Decision]. The Parties shall appoint a DB by the date stated in the Contract Data.

The DB shall comprise, as stated in the Contract Data, either one or three suitably qualified persons ("the members"), each of whom shall be fluent in the language for communication defined in the Contract and shall be a professional experienced in the type of construction involved in the Works and with the interpretation of contractual documents. If the number is not so stated and the Parties do not agree otherwise, the DB shall comprise three persons.

If the Parties have not jointly appointed the DB 21 days before the date stated in the Contract Data and the DB is to comprise three persons, each Party shall nominate one member for the approval of the other Party. The first two members shall recommend and the Parties shall agree upon the third member, who shall act as chairman.

However, if a list of potential members has been agreed by the Parties and is included in the Contract, the members shall be selected from those on the list, other than anyone who is unable or unwilling to accept appointment to the DB.

The agreement between the Parties and either the sole member or each of the three members shall incorporate by reference the General Conditions of Dispute Board Agreement contained in the Appendix to these General Conditions, with such amendments as are agreed between them.

The terms of the remuneration of either the sole member or each of the three members, including the remuneration of any expert whom the DB consults, shall be mutually agreed upon by the Parties when agreeing the terms of appointment. Each Party shall be responsible for paying one-half of this remuneration.

If at any time the Parties so agree, they may jointly refer a matter to the DB for it to give its opinion. Neither Party shall consult the DB on any matter without the agreement of the other Party.

If a member declines to act or is unable to act as a result of death, disability, resignation or termination of appointment, a replacement shall be appointed in the same manner as the replaced person was required to have been nominated or agreed upon, as described in this Sub-Clause.

The appointment of any member may be terminated by mutual agreement of both Parties, but not by the Employer or the Contractor acting alone. Unless otherwise agreed by both Parties, the appointment of the DB (including each member) shall expire when the discharge referred to in Sub-Clause 14.12 [Discharge] shall have become effective.

20.3 Failure to Agree on the Composition of the Dispute Board

If any of the following conditions apply, namely:

- (a) the Parties fail to agree upon the appointment of the sole member of the DB by the date stated in the first paragraph of Sub-Clause 20.2 [Appointment of the Dispute Board],
- (b) either Party fails to nominate a member (for approval by the other Party) , or fails to approve a member nominated by the other Party, of a DB of three persons by such date,
- (c) the Parties fail to agree upon the appointment of the third member (to act as chairman) of the DB by such date, or
- (d) the Parties fail to agree upon the appointment of a replacement person within 42 days after the date on which the sole member or one of the three members declines to act or is unable to act as a result of death, disability, resignation or termination of appointment,

then the appointing entity or official named in the Contract Data shall, upon the request of either or both of the Parties and after due consultation with both Parties, appoint this member of the DB. This appointment shall be final and conclusive. Each Party shall be responsible for paying one-half of the remuneration of the appointing entity or official.

20.4 Obtaining Dispute Board's Decision

If a dispute (of any kind whatsoever) arises between the Parties in connection with, or arising out of, the Contract or the execution of the Works, including any dispute as to any certificate, determination, instruction, opinion or valuation of the Engineer, either Party may refer the dispute in writing to the DB for its decision, with copies to the other Party and the Engineer. Such reference shall state that it is given under this Sub-Clause.

For a DB of three persons, the DB shall be deemed to have received such reference on the date when it is received by the chairman of the DB.

Both Parties shall promptly make available to the DB all such additional information, further access to the Site, and appropriate facilities, as the DB may require for the purposes of making a decision on such dispute. The DB shall be deemed to be not acting as arbitrator(s).

Within 84 days after receiving such reference, or within such other period as may be proposed by the DB and approved by both Parties, the DB shall give its decision, which shall be reasoned and shall state that it is given under this Sub-Clause. The decision shall be binding on both Parties, who shall promptly give effect to it unless and until it shall be revised in an amicable settlement or an arbitral award as described below. Unless the Contract has already been abandoned, repudiated or terminated, the Contractor shall continue to proceed with the Works in accordance with the Contract.

If either Party is dissatisfied with the DB's decision, then either Party may, within 28 days after receiving the decision, give a Notice of Dissatisfaction to the other Party indicating its dissatisfaction and intention to commence arbitration. If the DB fails to give its decision within the period of 84 days (or as otherwise approved) after receiving such reference, then either Party may, within 28 days after this period has expired, give a Notice of Dissatisfaction to the other Party.

In either event, this Notice of Dissatisfaction shall state that it is given under this Sub-Clause, and shall set out the matter in dispute and the reason(s) for dissatisfaction. Except as stated in Sub-Clause 20.7 [Failure to Comply with Dispute Board's Decision] and Sub-Clause 20.8 [Expiry of Dispute Board's Appointment], neither Party shall be entitled to commence arbitration of a dispute unless a Notice of Dissatisfaction has been given in accordance with this Sub-Clause.

If the DB has given its decision as to a matter in dispute to both Parties, and no Notice of Dissatisfaction has been given by either Party within 28 days after it received the DB's decision, then the decision shall become final and binding upon both Parties.

If the decision of the DAB requires a payment by one Party to the other Party, the DAB may require the payee to provide an appropriate security in respect of such payment.

20.5 Amicable Settlement

Where a Notice of Dissatisfaction has been given under Sub-Clause 20.4 above, both Parties shall attempt to settle the dispute amicably before the commencement of arbitration. However, unless both Parties agree otherwise, the Party giving a Notice of Dissatisfaction in accordance with Sub-Clause 20.4 above should move to commence arbitration after the fifty-sixth day from the day on which a Notice of Dissatisfaction was given, even if no attempt at an amicable settlement has been made.

20.6 Arbitration

Any dispute between the Parties arising out of or in connection with the Contract not settled amicably in accordance with Sub-Clause 20.5 above and in respect of which the DB's decision (if any) has not become final and binding shall be finally settled by arbitration. Arbitration shall be conducted as follows:

- (a) if the contract is with foreign contractors (or if the lead partner is a foreign contractor, in case of JV), international arbitration with proceedings administered by the International Chamber of Commerce (ICC) and conducted under the ICC Rules of Arbitration; by one or more arbitrators appointed in accordance with said arbitration rules.
- (b) if the Contract is with domestic contractors, arbitration with proceedings conducted in accordance with the laws of the Employer's country.

The place of arbitration shall be a neutral location determined in accordance with the applicable rules of arbitration; and the arbitration shall be conducted in the language for communications defined in Sub-Clause 1.4 [Law and Language].

The arbitrators shall have full power to open up, review and revise any certificate, determination, instruction, opinion or valuation of the Engineer, and any decision of the DB, relevant to the dispute. Nothing shall disqualify representatives of the Parties and the Engineer from being called as a witness and giving evidence before the arbitrators on any matter whatsoever relevant to the dispute.

Neither Party shall be limited in the proceedings before the arbitrators to the evidence or arguments previously put before the DB to obtain its decision, or to the reasons for dissatisfaction given in its Notice of Dissatisfaction. Any decision of the DB shall be admissible in evidence in the arbitration.

Arbitration may be commenced prior to or after completion of the Works. The obligations of the Parties, the Engineer and the DB shall not be altered by reason of any arbitration being conducted during the progress of the Works.

20.7 Failure to Comply with Dispute Board's Decision

In the event that a Party fails to comply with any decision of the DB, whether binding or final and binding decision which has become final and binding, then the other Party may, without prejudice to any other rights it may have, refer the failure itself to arbitration under Sub-Clause 20.6 [Arbitration]. Sub-Clause 20.4 [Obtaining Dispute Board's Decision] and Sub-Clause 20.5 [Amicable Settlement] shall not apply to this reference.

20.8 Expiry of Dispute Board's Appointment

If a dispute arises between the Parties in connection with, or arising out of, the Contract or the execution of the Works and there is no DB in place, whether by reason of the expiry of the DB's appointment or otherwise:

- (a) Sub-Clause 20.4 [Obtaining Dispute Board's Decision] and Sub-Clause 20.5 [Amicable Settlement] shall not apply, and
- (b) the dispute may be referred directly to arbitration under Sub-Clause 20.6[Arbitration].

APPENDIX

General Conditions of Dispute Board Agreement

1 Definitions

Each "Dispute Board Agreement" is a tripartite agreement by and between:

- (a) the "Employer";
- (b) the "Contractor"; and
- (c) the "Member" who is defined in the Dispute Agreement as being:
 - (i) the sole member of the "DB" and, where this is the case, all references to the "Other Members" do not apply, or
 - (ii) one of the three persons who are jointly called the "DB" (or "dispute board") and, where this is the case, the other two persons are called the "Other Members".

The Employer and the Contractor have entered (or intend to enter) into a contract, which is called the "Contract" and is defined in the Dispute Agreement, which incorporates this Appendix. In the Dispute Agreement, words and expressions which are not otherwise defined shall have the meanings assigned to them in the Contract.

2 General Provisions

Unless otherwise stated in the Dispute Board Agreement, it shall take effect on the latest of the following dates:

- (a) the Commencement Date defined in the Contract,
- (b) when the Employer, the Contractor and the Member have each signed the Dispute Board Agreement, or
- (c) when the Employer, the Contractor and each of the Other Members (if any) have respectively each signed a dispute board agreement.

This employment of the Member is a personal appointment. At any time, the Member may give not less than 70 days' notice of resignation to the Employer and to the Contractor, and the Dispute Agreement shall terminate upon the expiry of this period.

3 Warranties

The Member warrants and agrees that he/she is and shall be impartial and independent of the Employer, the Contractor and the Engineer. The Member shall promptly disclose, to each of them and to the Other Members (if any), any fact or circumstance which might appear inconsistent with his/her warranty and agreement of impartiality and independence.

When appointing the Member, the Employer and the Contractor relied upon the Member's representations that he/she is:

- (a) experienced in the work which the Contractor is to carry out under the Contract,
- (b) experienced in the interpretation of contract documentation, and
- (c) fluent in the language for communications defined in the Contract.

4 General Obligations of the Member

The Member shall:

- (a) have no interest financial or otherwise in the Employer, the Contractor or the Engineer, nor any financial interest in the Contract except for payment under the Dispute Agreement;
- (b) not previously have been employed as a consultant or otherwise by the Employer, the Contractor or the Engineer, except in such circumstances as were disclosed in writing to the Employer and the Contractor before they signed the Dispute Agreement;
- (c) have disclosed in writing to the Employer, the Contractor and the Other Members (if any), before entering into the Dispute Agreement and to his/her best knowledge and recollection, any professional or personal relationships with any director, officer or employee of the Employer, the Contractor or the Engineer, and any previous involvement in the overall project of which the Contract forms part;
- (d) not, for the duration of the Dispute Agreement, be employed as a consultant or otherwise by the Employer, the Contractor or the Engineer, except as may be agreed in writing by the Employer, the Contractor and the Other Members (if any);
- (e) comply with the annexed procedural rules and with Sub-Clause 20.4 of the Conditions of Contract;
- (f) not give advice to the Employer, the Contractor, the Employer's Personnel or the Contractor's Personnel concerning the conduct of the Contract, other than in accordance with the annexed procedural rules;
- (g) not while a Member enter into discussions or make any agreement with the Employer, the Contractor or the Engineer regarding employment by any of them, whether as a consultant or otherwise, after ceasing to act under the Dispute Agreement;
- (h) ensure his/her availability for any site visit and hearings as are necessary; and (i) treat the details of the Contract and all the DB's activities and hearings as private and confidential, and not publish or disclose them without the prior written consent of the Employer, the Contractor and the Other Members (if any); and

- (k) be available to give advice and opinions, on any matter relevant to the Contract when requested by both the Employer and the Contractor, subject to the agreement of the Other Members (if any).

5 General Obligations of the Employer and the Contractor

The Employer, the Contractor, the Employer's Personnel and the Contractor's Personnel shall not request advice from or consultation with the Member regarding the Contract, otherwise than in the normal course of the DB's activities under the Contract and the Dispute Agreement, and except to the extent that prior agreement is given by the Employer, the Contractor and the Other Members (if any). The Employer and the Contractor shall be responsible for compliance with this provision, by the Employer's Personnel and the Contractor's Personnel respectively.

The Employer and the Contractor undertake to each other and to the Member that the Member shall not, except as otherwise agreed in writing by the Employer, the Contractor, the Member and the Other Members (if any):

- (a) be appointed as an arbitrator in any arbitration under the Contract;
- (b) be called as a witness to give evidence concerning any dispute before arbitrator(s) appointed for any arbitration under the Contract; or
- (c) be liable for any claims for anything done or omitted in the discharge or purported discharge of the Member's functions, unless the act or omission is shown to have been in bad faith.

The Employer and the Contractor hereby jointly and severally indemnify and hold the Member harmless against and from claims from which he/she is relieved from liability under the preceding paragraph.

6 Payment

The Member shall be paid as follows, in the currency named in the Dispute Board Agreement:

- (a) a retainer fee per calendar month, which shall be considered as payment in full for:
 - (i) being available on 28 days' notice for all site visits and hearings;
 - (ii) becoming and remaining conversant with all project developments and maintaining relevant files;
 - (iii) all office and overhead expenses including secretarial services, photocopying and office supplies incurred in connection with his duties; and
 - (iv) all services performed hereunder except those referred to in subparagraphs (b) and (c) of this Clause.

The retainer fee shall be paid with effect from the last day of the calendar month in which the Dispute Board Agreement becomes effective; until the last day of the calendar month in which the Taking-Over Certificate is issued for the whole of the Works.

With effect from the first day of the calendar month following the month in which the Taking-Over Certificate is issued for the whole of the Works, the retainer fee shall be reduced by one third. This reduced fee shall be paid until the first day of the calendar month in which the Member resigns or the Dispute Board Agreement is otherwise terminated.

- (b) a daily fee shall be considered as payment in full for:
 - (i) each day or part of a day up to a maximum of two days' travel time in each direction for the journey between the Member's home and the site, or another location of a meeting with the Other Members (if any);
 - (ii) each working day on Site visits, hearings or preparing decisions; and
 - (iii) each day spent reading submissions in preparation for a hearing.
- (c) all reasonable expenses including necessary travel expenses (air fare in less than first class, hotel and subsistence and other direct travel expenses) incurred in connection with the Member's duties, as well as the cost of telephone calls, courier charges, faxes and telexes: a receipt shall be required for each item in excess of five percent of the daily fee referred to in sub-paragraph (b) of this Clause;
- (d) any taxes properly levied in the Country on payments made to the Member (unless a national or permanent resident of the Country) under this Clause 6.

The daily fee shall be as specified in the Dispute Board Agreement. Unless it specifies otherwise, these fees shall remain fixed for the first 24 calendar months, and shall thereafter be adjusted by agreement between the Employer, the Contractor and the Member, at each anniversary of the date on which the Dispute Board Agreement became effective.

If the parties fail to agree on the retainer fee or the daily fee, the appointing entity or official named in the Contract Data shall determine the amount of the fees to be used.

The Member shall submit invoices for payment of the monthly retainer and air fares quarterly in advance. Invoices for other expenses and for daily fees shall be submitted following the conclusion of a site visit or hearing. All invoices shall be accompanied by a brief description of activities performed during the relevant period and shall be addressed to the Contractor.

The Contractor shall pay each of the Member's invoices in full within 56 calendar days after receiving each invoice and shall apply to the Employer (in the Statements under the Contract) for reimbursement of one-half of the amounts of these invoices. The Employer shall then pay the Contractor in accordance with the Contract.

If the Contractor fails to pay to the Member the amount to which he/she is entitled under the Dispute Board Agreement, the Employer shall pay the amount due to the Member and any other amount which may be required to maintain the operation of the DB; and without prejudice to the Employer's rights or remedies. In addition to all other rights arising from this default, the Employer shall be entitled to reimbursement of all sums paid in excess of one-half of these payments, plus all costs of recovering these sums and financing charges calculated at the rate specified in Sub-Clause 14.8 of the Conditions of Contract.

If the Member does not receive payment of the amount due within 70 days after submitting a valid invoice, the Member may (i) suspend his/her services (without notice) until the payment is received, and/or (ii) resign his/her appointment by giving notice under Clause 7.

7 Termination

At any time: (i) the Employer and the Contractor may jointly terminate the Dispute Board Agreement by giving 42 days' notice to the Member; or (ii) the Member may resign as provided for in Clause 2.

If the Member fails to comply with the Dispute Board Agreement, the Employer and the Contractor may, without prejudice to their other rights, terminate it by notice to the Member. The notice shall take effect when received by the Member.

If the Employer or the Contractor fails to comply with the Dispute Board Agreement, the Member may, without prejudice to his other rights, terminate it by notice to the Employer and the Contractor. The notice shall take effect when received by them both.

Any such notice, resignation and termination shall be final and binding on the Employer, the Contractor and the Member. However, a notice by the Employer or the Contractor, but not by both, shall be of no effect.

8 Default of the Member

If the Member fails to comply with any of his obligations under Clause 4 (a) - (d) above, he shall not be entitled to any fees or expenses hereunder and shall, without prejudice to their other rights, reimburse each of the Employer and the Contractor for any fees and expenses received by the Member and the Other Member (if any), for proceeding or decisions (if any) of the DB which are rendered void or ineffective by the said failure to comply.

If the Member fails to comply with any of his obligations under Clause 4 (e) - (i) above, he shall not be entitled to any fees or expenses hereunder from the date and to the extent of the non-compliance and shall, without prejudice to their other rights, reimburse each of the Employer and the Contractor for any fees and expenses already received by the Member, for proceedings or decisions (if any) of the DB which are rendered void or ineffective by the said failure to comply."

9 Disputes

Any dispute or claim arising out of or in connection with this Dispute Board Agreement, or the breach, termination or invalidity thereof shall be finally settled by institutional arbitration. If no other arbitration institute is agreed, the arbitration shall be conducted under the Rules of Arbitration of the International Chamber of Commerce by one arbitrator appointed in accordance with these Rules of Arbitration".

Annex PROCEDURAL RULES

- 1 Unless otherwise agreed by the Employer and the Contractor, the DB shall visit the Site at intervals of not more than 140 days, including times of critical construction events, at the request of either the Employer or the Contractor. Unless otherwise agreed by the Employer, the Contractor and the DB, the period between consecutive visits shall not be less than 70 days, except as required to convene a hearing as described below.
- 2 The timing of and agenda for each Site visit shall be as agreed jointly by the DB, the Employer and the Contractor, or in the absence of agreement, shall be decided by the DB. The purpose of Site visits is to enable the DB to become and remain acquainted with the progress of the Works and of any actual or potential problems or claims, and, as far as reasonable, to endeavour to prevent potential problems or claims from becoming disputes.
- 3 Site visits shall be attended by the Employer, the Contractor and the Engineer and shall be co-ordinated by the Employer in co-operation with the Contractor. The Employer shall ensure the provision of appropriate conference facilities and secretarial and copying services. At the conclusion of each Site visit and before leaving the site, the DB shall prepare a report on its activities during the visit and shall send copies to the Employer and the Contractor.
- 4 The Employer and the Contractor shall furnish to the DB one copy of all documents which the DB may request, including Contract documents, progress reports, variation instructions, certificates and other documents pertinent to the performance of the Contract. All communications between the DB and the Employer or the Contractor shall be copied to the other Party. If the DB comprises three persons, the Employer and the Contractor shall send copies of these requested documents and these communications to each of these persons.
- 5 If any dispute is referred to the DB in accordance with Sub-Clause 20.4 of the Conditions of Contract, the DB shall proceed in accordance with Sub-Clause 20.4 and these Rules. Subject to the time allowed to give notice of a decision and other relevant factors, the DB shall:
 - (a) act fairly and impartially as between the Employer and the Contractor, giving each of them a reasonable opportunity of putting his case and responding to the other's case, and
 - (b) adopt procedures suitable to the dispute, avoiding unnecessary delay or expense.
- 6 The DB may conduct a hearing on the dispute, in which event it will decide on the date and place for the hearing and may request that written documentation and arguments from the Employer and the Contractor be presented to it prior to or at the hearing.
- 7 Except as otherwise agreed in writing by the Employer and the Contractor, the DB shall have power to adopt an inquisitorial procedure, to refuse admission to hearings or audience at hearings to any persons other than representatives of the Employer, the Contractor and the Engineer, and to proceed in the absence of any party who the DB is satisfied received notice of the hearing; but shall have discretion to decide whether and to what extent this power may be exercised.
- 8 The Employer and the Contractor empower the DB, among other things, to:
 - (a) establish the procedure to be applied in deciding a dispute,
 - (b) decide upon the DB's own jurisdiction, and as to the scope of any dispute referred to it,

- (c) conduct any hearing as it thinks fit, not being bound by any rules or procedures other than those contained in the Contract and these Rules,
- (d) take the initiative in ascertaining the facts and matters required for a decision,
- (e) make use of its own specialist knowledge, if any,
- (f) decide upon the payment of financing charges in accordance with the Contract,
- (g) decide upon any provisional relief such as interim or conservatory measures, and
- (h) open up, review and revise any certificate, decision, determination, instruction, opinion or valuation of the Engineer, relevant to the dispute.

9 The DB shall not express any opinions during any hearing concerning the merits of any arguments advanced by the Parties. Thereafter, the DB shall make and give its decision in accordance with Sub-Clause 20.4, or as otherwise agreed by the Employer and the Contractor in writing. If the DB comprises three persons:

- (a) it shall convene in private after a hearing, if any, in order to have discussions and prepare its decision;
- (b) it shall endeavour to reach a unanimous decision: if this proves impossible, the applicable decision shall be made by a majority of the Members, who may require the minority Member to prepare a written report for submission to the Employer and the Contractor; and
- (c) if a Member fails to attend a meeting or hearing, or to fulfil any required function, the other two Members may nevertheless proceed to make a decision, unless:
 - (i) either the Employer or the Contractor does not agree that they do so, or
 - (ii) the absent Member is the chairman and he/she instructs the other Members not to make a decision.



CHENNAI METRO RAIL LIMITED

CHENNAI METRO RAIL PROJECT PHASE 1

Tender No. ARE05

**DESIGN, MANUFACTURE, SUPPLY, TESTING,
COMMISSIONING OF STANDARD GAUGE
METRO ROLLING STOCK (ELECTRICAL
MULTIPLE UNITS) AND DEPOT MACHINERY &
PLANT AND TRAINING OF PERSONNEL.**

**PART 3: CONDITIONS OF CONTRACT AND
CONTRACT FORMS**

**SECTION – VIII : PARTICULAR CONDITIONS
OF CONTRACT (PCC)**

~~NOV 2025 APR 2026~~ JUN 2026

PARTICULAR CONDITIONS OF CONTRACT

Notes on Particular Conditions

The Particular Conditions (PC) complement the General Conditions (GC) to specify data and contractual requirements linked to the special circumstances of the country, the Employer, the Engineer, the sector, the overall project and the Works. Whenever there is a conflict, the provisions herein shall prevail over those in the GC.

Part A, Contract Data of the PC, includes data to complement the GC in a manner similar to the way in which the Bid Data Sheet complements the Instructions to Bidders.

Part B, the Specific Provisions of the PC should specify country- or project-specific provisions for PC in each case.

Clause numbers in the PC correspond to those in the GC.

PART- A – CONTRACT DATA

S. No.	Conditions	Sub-Clause	Data
1.	Employer's name and address	1.1.2.2 & 1.3	The Managing Director, Chennai Metro Rail Limited METROS Building, No: 327, Anna Salai, Nandanam, Chennai – 600035 Tel no: +91 44 24378000
2.	Engineer's name and address	1.1.2.4 & 1.3	Will be intimated later
3.	Time for Completion	1.1.3.3	1410 days (excluding DNP)
4.	Defects Notification Period	1.1.3.7	730 days.
5.	Sections	1.1.5.6	Refer to 'Table: Summary of Sections' below.
6.	Electronic transmission systems	1.3	+91 44 24378000 Extn. ~~28939~~ 28099 and e-mail rajendran-ar@cmrl.in mani.k@cmrl.in
7.	Governing Law	1.4	Indian Law This Agreement will be governed by and construed in accordance with the laws of the Republic of India and the Courts at Chennai shall have exclusive jurisdiction in all matters relating to this Agreement.
8.	Ruling language	1.4	English
9.	Language for communications	1.4	English
10.	Time for access to, and possession of all parts of, the Site	2.1	<u>For Rolling Stock</u> : 630 days from NTP. <u>For Depot Machinery & Plant</u> : Refer to 'Table 2 Schedule of Access dates' below
11.	Engineer's Duties and Authority	3.1 (B) (ii)	All Variations resulting in change of the Accepted Contract Amount shall require approval of the Employer.
12.	Performance Security	4.2	The Performance Security in the form of Electronic Bank Guarantee, in the amounts of 10% of the Accepted Contract Amount (Excluding Provisional Sum) and in the same currency(ies) of the Accepted Contract Amount. Refer to Part 3, Section VIII, Particular Conditions (Part-B Specific Provisions) Clause 4.2 which is to be read in conjunction with Part 3, Section VII, General Conditions of Contract Clause 4.2

S. No.	Conditions	Sub-Clause	Data
13.	Normal working hours	6.5	Round the clock, but subject to permission from the Relevant Authorities. Obtaining permission from the Relevant Authorities and planning the Works to complete within the Time of Completion shall be the Contractor's responsibility.
14.	Delay damages for the Works	8.7	Refer to 'Table: Summary of Sections' below.
15.	Maximum amount of delay damages	8.7	10% of the Contract Price (Excluding Provisional Sum).
16.	Not Used.		
17.	Total advance payment	14.2	The interest free mobilization advance at the rate of 10% of the Accepted Contract Amount (Excluding Provisional Sum, Taxes & Duties) in the currencies and proportions is payable against production of Bank guarantee from a public sector bank. And the guarantee shall be in the form of a BG for 100% of the advance amount requested plus GST. (in parlance with CVC guidelines). GST on the mobilization advance is not reimbursable. Mobilization advance shall be paid in two equal instalments.
18.	Repayment amortization rate of advance payment	14.2(b)	~~25%~~ 17%
19.	Percentage of Retention	14.3(c)	5% from each IPC
20.	Limit of Retention Money	14.3(c)	5% of Accepted Contract Amount (excluding Provisional sum, taxes & duties).
21.	Not Used		
22.	Periods for submission of insurance:	18.1	
	a. Evidence of insurance.		90 days
	b. relevant policies		120 days
23.	Maximum amount of deductibles for insurance of the Employer's risks	18.2(d)	INR 1,00,000 /-
24.	Minimum amount of third party insurance	18.3	In case of death, INR 1,00,00,000 per person in each case. In case of permanent disability, INR 50,00,000 per person in each case. In case of partial disability, INR 25,00,000 per person in each case.

1

S. No.	Conditions	Sub-Clause	Data
			In case damage to facility, the Contractor shall be responsible for full coverage of damages without limit of occurrences. Hence, the amount shall be decided by the Contractor based on his experience.
25.	Date by which the DB shall be appointed	20.2 (i)	The DB shall be appointed as and when request is raised within 28 days of receipt of such request by the Employer.
26.	The DB shall be comprised of	20.2 (iii)	Three members
27.	Language of Arbitration	20.6	English
28.	Place of Arbitration	20.6	CHENNAI, INDIA.
29.	Arbitration	20.6	Conducted under: Arbitration and Conciliation Act, 1996 as amended from time to time.

Table 1.1: Summary of Sections: Key Date - Rolling Stock**A. Delay Damages for Non-achievement of Main Key Dates**

Key Date No.	Key Date Description (Sub-clause 1.1.5.6)	Time for Completion (Calendar days from NTP) (Sub-clause 1.1.3.3)	Delay Damages (Sub-clause 8.7)	
			1 to 28 days	29 th day onwards
1	Prototype Train			
KD-RS-1-1	Submission of 3D view of prototype train model to allow issue of Notice of No Objection (NONO) / No Objection With Comments (NOWC) by the Engineer	280	0.1% of total value of the amount apportioned to the milestones relevant to the respective key date for each calendar day	0.2% of total value of the amount apportioned to the milestones relevant to the respective key date for each calendar day
KD-RS-1-2	Testing of Prototype train in manufacturing facility	600		
KD-RS-1-3	Manufacturing, Factory Testing, Delivery (including shipment) and receipt of prototype train in Depot	~~630~~ 690		
KD-RS-1-4	Completion of Prototype rolling stock Type Testing in Depot & Mainline to allow issue of Notice of No Objection (NONO) / No Objection With Comments (NOWC) by the Engineer	900		

Key Date No.	Key Date Description (Sub-clause 1.1.5.6)	Time for Completion (Calendar days from NTP) (Sub-clause 1.1.3.3)	Delay Damages (Sub-clause 8.7)	
			1 to 28 days	29 th day onwards
KD-RS-1-5	Completion of Integrated Type Testing with all other systems for Prototype train	1050		
2	Delivery of trains in nominated Depots			
KD-RS-2-1	3 Train Sets (excluding one prototype train) – 1 st lot	780	0.1% of total value of the amount apportioned to the milestones relevant to the respective key date for each calendar day	0.2% of total value of the amount apportioned to the milestones relevant to the respective key date for each calendar day
KD-RS-2-2	3 Train Sets – 2 nd lot	840		
KD-RS-2-3	3 Train Sets – 3 rd lot	900		
KD-RS-2-4	3 Train Sets – 4 th lot	960		
KD-RS-2-5	3 Train Sets – 5 th lot	1020		
KD-RS-2-6	3 Train Sets – 6 th lot	1080		
KD-RS-2-7	3 Train Sets – 7 th lot	1140		
KD-RS-2-8	3 Train Sets – 8 th lot	1200		
KD-RS-2-9	3 Train Sets – 9 th lot	1260		
3	Completion of Rolling stock testing in Depot & Mainline to allow issue of Notice of No Objection (NONO) / No Objection With Comments (NOWC) by the Engineer			
KD-RS-3-1	3 Train Sets (excluding one prototype train) – 1 st lot	900	0.1% of total value of the amount apportioned to the milestones relevant to the respective key date for each calendar day	0.2% of total value of the amount apportioned to the milestones relevant to the respective key date for each calendar day
KD-RS-3-2	3 Train Sets – 2 nd lot	960		
KD-RS-3-3	3 Train Sets – 3 rd lot	1020		
KD-RS-3-4	3 Train Sets – 4 th lot	1080		
KD-RS-3-5	3 Train Sets – 5 th lot	1140		
KD-RS-3-6	3 Train Sets – 6 th lot	1200		
KD-RS-3-7	3 Train Sets – 7 th lot	1260		
KD-RS-3-8	3 Train Sets – 8 th lot	1320		

Key Date No.	Key Date Description (Sub-clause 1.1.5.6)	Time for Completion (Calendar days from NTP) (Sub-clause 1.1.3.3)	Delay Damages (Sub-clause 8.7)	
			1 to 28 days	29 th day onwards
KD-RS-3-9	3 Train Sets – 9 th lot	1360		
4	Completion of Integrated testing with all other systems in ATP & ATO (GoA2) mode of Operation to allow issue of Notice of No Objection (NONO) / No Objection With Comments (NOWC) by the Engineer			
KD-RS-4-1	3 Train Sets (excluding one prototype train) – 1 st lot	1050	0.1% of total value of the amount apportioned to the milestones relevant to the respective key date for each calendar day	0.2% of total value of the amount apportioned to the milestones relevant to the respective key date for each calendar day
KD-RS-4-2	3 Train Sets – 2 nd lot	1095		
KD-RS-4-3	3 Train Sets – 3 rd lot	1140		
KD-RS-4-4	3 Train Sets – 4 th lot	1185		
KD-RS-4-5	3 Train Sets – 5 th lot	1230		
KD-RS-4-6	3 Train Sets – 6 th lot	1275		
KD-RS-4-7	3 Train Sets – 7 th lot	1320		
KD-RS-4-8	3 Train Sets – 8 th lot	1365		
KD-RS-4-9	3 Train Sets – 9 th lot	1410		
5	Completion of Integrated testing with all other systems in UTO (GoA4) mode of Operation to allow issue of Notice of No Objection (NONO) / No Objection With Comments (NOWC) by the Engineer			
KD-RS-5-1	3 Train Sets (excluding one prototype train) – 1 st lot	1780	0.1% of total value of the amount apportioned to the milestones relevant to the respective key date for each calendar day	0.2% of total value of the amount apportioned to the milestones relevant to the respective key date for each calendar day
KD-RS-5-2	3 Train Sets – 2 nd lot	1825		
KD-RS-5-3	3 Train Sets – 3 rd lot	1870		
KD-RS-5-4	3 Train Sets – 4 th lot	1915		
KD-RS-5-5	3 Train Sets – 5 th lot	1960		
KD-RS-5-6	3 Train Sets – 6 th lot	2005		
KD-RS-5-7	3 Train Sets – 7 th lot	2050		
KD-RS-5-8	3 Train Sets – 8 th lot	2095		
KD-RS-5-9	3 Train Sets – 9 th lot	2140		

Note:

1. Please refer Part 2 – VIA: Employer' Requirement Technical Specification – Rolling Stock, Chapter 21 for target dates related to Design Deliverables.
2. Any imposition of Delay damages (Sub clause 8.7) for Non-achievement of Key date No. KD-RS-1-2 will be waived and delay damages amount if deducted will be returned (without interest) provided, the Contractor is able to accomplish the Key date No. KD-RS-1-3 (as per Contracted Schedule).
3. Any imposition of Delay damages (Sub clause 8.7) for Non-achievement of Key date No. KD-RS-2-1 to KD-RS-2-9 will be waived and delay damages amount if deducted will be returned (without interest) provided, the Contractor is able to accomplish the corresponding Key date No. KD-RS-3-1 to KD-RS-3-9 (as per Contracted Schedule).

Table 1.2: Summary of Sections (Key Date) for Depot Machinery & Plant (DM&P)**Delay Damages for Non-achievement of Key Dates:**

Key Date No.	Key Date Description (Sub-Clause 1.1.5.6)	Time for Completion (Calendar days from NTP) (Sub-Clause 1.1.3.3)	Delay Damages (Amount in INR Lakhs per day) (Sub-Clause 8.7)	
			1 to 28 days	29 th day onwards
A	DM&P List -A: - Under Floor Wheel lathe & Automatic Train wash plant - Synchronised pit jacks and Synchronized Mobile Lifting Jacks & Car body stand for 6 car length. - Diesel Operated RRV, Track & Tunnel Cleaning vehicle and Battery-Operated rail cum road shunters.			
A1	Under Floor Wheel lathe & Automatic Train wash plant			
KD-A1-01	Submission of Final Design Documents, Design Approval with NONO/NOWC, Manufacturing, FAT, Delivery of DM&P at Site.	450	1	10
KD-A1-02	Completion of Installation, Commissioning, Testing, Trials, Training, Handing over.	540	1	10
A2	Synchronised pit jacks and Synchronized Mobile Lifting Jacks & Car body stand for 6 car length			
KD-A2-01	Submission of Final Design Documents, Design Approval with NONO/NOWC, Manufacturing, FAT, Delivery of DM&P at Site.	420	1	10
KD-A2-02	Completion of Installation, Commissioning, Testing, Trials, Training, Handing over.	540	1	10
A3	Diesel Operated RRV, Track & Tunnel Cleaning vehicle and Battery-Operated rail cum road shunters			
KD-A3-01	Submission of Final Design Documents, Design Approval with NONO/NOWC, Manufacturing, FAT, Delivery of DM&P at Site.	540	1	10

Key Date No.	Key Date Description (Sub-Clause 1.1.5.6)	Time for Completion (Calendar days from NTP) (Sub-Clause 1.1.3.3)	Delay Damages (Amount in INR Lakhs per day) (Sub-Clause 8.7)	
			1 to 28 days	29 th day onwards
KD-A3-02	Completion of Installation, Commissioning, Testing, Trials, Training, Handing over.	600	1	10
B	DM&P List -B : - Bogie Testing unit - Bogie Turn Tables - Bogie Manipulator - Double Cylinder Hydraulic Wheel Press - Vertical turning Lathe			
KD-B-01	Submission of Final Design Documents, Design Approval with NONO/NOWC, Manufacturing, FAT, Delivery of DM&P at Site.	440	1	10
KD-B-02	Completion of Installation, Commissioning, Testing, Trials, Training, Handing over.	540	1	10
C	DM&P List -C: - EOT Cranes (15t/5t) Category 1&2 - EOT Crane (5t) for Depot Store			
KD-C-01	Submission of Final Design Documents, Design Approval with NONO/NOWC, Manufacturing, FAT, Delivery of DM&P at Site.	410	1	10
KD-C-02	Completion of Installation, Commissioning, Testing, Trials, Training, Handing over.	470	1	10
D	DM&P List -D: - Driver Desk Simulator - Maintenance Desk Simulator			
KD-D-01	Submission of Final Design Documents, Design Approval with NONO/NOWC, Manufacturing, FAT, Delivery of DM&P at Site.	1080	1	10
KD-D-02	Completion of Installation, Commissioning, Testing, Trials, Training, Handing over.	1170	1	10
E	DM&P List -E: Other Machinery and plant: Ultrasonic Flaw detector, BOPTs, Self-propelled Scissor Lifts, High Pressure Water Jet Pumps, Pallet Trucks, Battery Operated Forklifts, Mobile Lifting Tables, Key Management System, Vertical storage system, Mobile Air Compressor, Induction Heater, Battery Operated buggy, RS Pusher, Hydraulic Floor Crane, Traction motor oven, Wheel profile measurement device-Hand held, Industrial videoscope, Two post Lifting Jack & other items if any.			
KD-E-01	Submission of Final Design Documents, Design Approval with NONO/NOWC, Manufacturing, FAT, Delivery of DM&P at Site.	570	1	10

Key Date No.	Key Date Description (Sub-Clause 1.1.5.6)	Time for Completion (Calendar days from NTP) (Sub-Clause 1.1.3.3)	Delay Damages (Amount in INR Lakhs per day) (Sub-Clause 8.7)	
			1 to 28 days	29 th day onwards
KD-E-02	Completion of Installation, Commissioning, Testing, Trials, Training, Handing over. (*Contractor to install and commission Air compressor (Stationary) at Pit Wheel lathe shed on priority along with Wheel lathe)	600	1	10
F	DM&P List -F: All Storage Items (Refer list of items Chapter 1, Part-2, Section 6B, ERTS)			
KD-F-01	Submission of Final Design Documents, Design Approval with NONO/NOWC, Delivery and complete installation/testing/ commissioning at site as applicable	600	1	10
G	DM&P List -G: Tools, Measurement and other items (Refer list of items Chapter 1, Part-2, Section 6B, ERTS)			
KD-G-01	Submission of Final Design Documents, Design Approval with NONO/NOWC, Delivery and complete installation/testing/ commissioning at site as applicable	600	1	10

Table 2: Partial Site access and possession:**Schedule of Access dates:**

Access Date No.	Key Date Description	Calendar days from NTP
Access to Koyembedu Depot		
AD-01	Completion of Civil works and Provide access to Contractor for Installation of Gantry / EOT crane	350
AD-02	Completion of Civil works and Provide access to Depot Equipment Contractor for Installation ATWP	370
AD-03	Completion of Civil works for remaining Depot Equipment and Provide access to Depot Equipment Contractor for Installation works	360

PCC to GCC Clause No.	Description
1.General Provisions	
1.1 Definitions	
1.1.1 The Contract	
1.1.1.4	<u>Delete the entire Sub-Clause 1.1.1.4 and substitute the following:</u> “Letter of Tender” means the document(s) entitled letter of bid, or letters of technical bid and price bid, as appropriate, which was/were completed by the Contractor and include(s) the signed offer to the Employer for the Works.”
<u>1.1.2 Parties and Persons</u>	
1.1.2.13	<u>Add a new Sub-Clause 1.1.2.13:</u> “Designated Interfacing Contractors” means any of the following whose activities or the Works they are engaged to carry out, affect or are affected by the Works, in any way or at any time: (a) Project Contractors, design or specialist consultants engaged on the Project from time to time by the Employer, the Government of India, the Government of Tamil Nadu or the utility providers; (b) Utility providers; (c) Developers or franchisees appointed on the Project from time to time by the Engineer; (d) Sub-contractors of any tier of the Contractors with category (a) above, and Contractors and subcontractors of any tier of utility providers, developers and franchisees within category (b) & (c) above; provided that the definition shall exclude the Contractor and his subcontractors of any tier in relation to the Works.
1.1.3 Dates, Tests, Periods	
1.1.3.2	<u>Add to the end of Sub-Clause 1.1.3.2:</u> “Commencement Date” shall have the same meaning as “Notice To Proceed” or “NTP” as stated in the Bid documents elsewhere.
1.1.3.7	<u>Add to the end of Sub-Clause 1.1.3.7:</u> “Defects Notification Period” or “DNP” shall have the same meaning as “Defects Liability Period” or “DLP”.
1.1.3.10	<u>Add a new Sub-Clause 1.1.3.10:</u> “Contract Period” means the period from the Commencement Date to the date of issuance of Performance certificate.
1.1.3.11	<u>Add a new Sub-Clause 1.1.3.11:</u> “Key Date” means a date by which the activity mentioned under such Key Date is to be completed.

PCC to GCC Clause No.	Description
1.1.3.12	<u>Add a new Sub-Clause 1.1.3.12:</u> “Stage” means level of progress of the Works identified as such and more particularly described in the Employer’s Requirements for which a Key Date for the achievement thereof is stipulated in the Contract.
1.1.4 Money and Payments	
1.1.4.13	<u>Add a new Sub-Clause 1.1.4.13:</u> “Price Centre Amount” means the amount quoted by the Bidder towards a Price Centre.
1.1.4.14	<u>Add a new Sub-Clause 1.1.4.14:</u> “Bank Guarantee” means in the form of ‘eBG’ (Electronic Bank Guarantee) which shall be the only form that is accepted.
1.1.5 Works and Goods	
1.1.5.8	<u>Add the following at the end of Sub-Clause 1.1.5.8 with the following:</u> “Works” will generally mean “DESIGN, MANUFACTURE, SUPPLY, TESTING, COMMISSIONING OF STANDARD GAUGE METRO ROLLING STOCK (ELECTRICAL MULTIPLE UNITS) AND DEPOT MACHINERY & PLANT AND TRAINING OF PERSONNEL”.
1.1.6 Other Definitions	
1.1.6.11	<u>Add a new Sub-Clause 1.1.6.11:</u> “Relevant Authority” means any government department or public body (other than the Engineer) having jurisdiction in relation to the Works.
1.1.6.12	<u>Add a new Sub-Clause 1.1.6.12:</u> “Joint Venture” or “JV” means a joint venture, association, consortium or other unincorporated grouping of two or more persons, whether in the form of a partnership or otherwise.
1.1.6.13	<u>Add a new Sub-Clause 1.1.6.13:</u> “JV Undertaking” means the letter provided to the Employer as part of the Tender setting out the legal agreement between the two or more persons constituting the Contractor as a JV. This letter shall be signed by all the persons who are members of the JV, shall be addressed to the Employer and shall include: each such member’s undertaking to be jointly and severally liable to the Employer for the performance of the Contractor’s obligations under the Contract; identification and authorization of the leader of the JV; and identification of the separate scope or part of the Works (if any) to be carried out by each member of the JV. The words “JV Undertaking” is synonymous with “JV Agreement” and “Joint Venture Agreement”.

PCC to GCC Clause No.	Description
1.2 Interpretations	
1.2	<u>Add the following new points to sub-clause 1.2:</u> (f) The word “Contract Price” is synonymous with “Contract Sum” or “Contract Value”.
1.5 Priority of Documents	
1.5	<u>Replace Sub-Clause 1.5 with the following:</u> The documents forming the Contract are to be taken as mutually explanatory of one another. For the purposes of interpretation, the priority of the documents shall be in accordance with the following sequence: (a) the Contract Agreement along with Schedules, (b) the Letter of Acceptance (LoA), (c) Addendum / Corrigendum to Tender (d) Reply to Bidder Queries issued by the Employer / Engineer (e) the Particular Conditions – Part A (Contract Data) (f) the Particular Conditions – Part B (Specific Provisions) (g) the General Conditions (h) Not used (i) Employer’s Requirements Technical Specifications (ERTS) – Rolling Stock (RS), Employer’s Requirements Technical Specifications (ERTS) – Depot Machinery & Plant (DM&P). (j) Pricing Document & Financial Bid (k) Letter of Technical Bid and Letter of Price Bid (l) Part 1: Bidding Procedures. (m) The Contractor’s proposal and any other documents forming part of the Contract If an ambiguity or discrepancy is found in the documents, the Engineer shall issue any necessary clarification or instruction.
1.6 Contract Agreement	
1.6	<u>Add the following at the end of sub-clause 1.6:</u> Till the execution of Contract Agreement, the Letter of Acceptance (LoA) along with Tender Documents and the accepted offer shall be considered as an Agreement. With regards to the stamping charges like stamp duty, charges have to be borne by the Contractor.
1.8 Care and supply of documents	
1.8	<u>Replace the first paragraph of Sub-clause 1.8 with the following:</u> Each of the Contractor's Documents shall be in the custody and care of the Contractor, unless and until taken over by the Employer. Unless otherwise stated in the Contract,

PCC to GCC Clause No.	Description
	the Contractor shall supply to the Engineer one copy of each of the Contractor's Documents and one copy to the Employer. However, additionally, the Contractor shall supply upto four more copies of the Contractor's Document on the request of the Engineer
1.9 Errors in the Employer's Requirements	
1.9	<u>Replace Sub-clause 1.9 with the following:</u> The Contractor shall verify the Employer's Requirements in totality and if they found any error in the Employer's requirements, those needs to be highlighted during pre-bid meeting or to raise pre-bid queries to obtain the clarifications from the Employer against with. Upon signing the contract agreement, the Contractor is sole responsible for the errors if any left. The contractor is not entitled for extension of time or cost compensation on this account if any error noticed after signing the contract agreement.
1.13 Compliance with Laws	
1.13	<u>Delete the following second paragraph of GC 1.13</u> <i>"However, the Contractor shall submit, in good time, the details of Goods to the Employer, who shall then promptly obtain all import permits or licenses required for these Goods"</i> <u>and replace with</u> "The Contractor shall be solely responsible for all the statutory clearances including customs, excise, taxes, levies, octroi, transportation, all import permits, licenses, technical clearances by the Government, safety audits, etc. required for the successful execution of this Contract. The Employer shall provide the reasonable assistance to the Contractor. The rendering of such assistance by the Employer shall not be interpreted as a pretext by the Contractor as condoning of any delay or non-performance of any of the Contractor's obligations. The following-up of all such requirements shall be the responsibility of the Contractor."
2.2 Permits, Licenses or Approvals	
2.2	<u>Add the following as sub-clause 2.2 (b) (iv):</u> (iv) for the shipment of components / equipment / spares for repair and replacement during the period of Contract including DNP which were shipped / delivered in the name of the Employer.
3. The Engineer	
3.1 Engineer's Duties and Authority	
3.1	<u>Replace sub-clause 3.1 (B) with the following:</u> (B) Sub-Clause 13.1: instructing any Variation under the Contract. (i) deleted

PCC to GCC Clause No.	Description
	(ii) deleted Add sub-clause (E): (E) Approval of sub-contractors of major sub-systems listed in Part-I, Section III EQC, clause 2.5.
3.4 Replacement of the Engineer	
3.4	<u>The following sentence in GC 3.4,</u> “If the Contractor considers the intended replacement Engineer to be unsuitable, he has the right to raise objection against him by notice to the Employer, with supporting particulars, and the Employer shall give full and fair consideration to this objection.” is Deleted.
4 The Contractor	
4.1 Contractor’s General Obligations	
4.1	The following sentence in third paragraph, “have their origin in any eligible source country as defined by the Bank” is replaced with “meet the requirements specified in the Section V: Eligible Source Countries”. <u>Add the following at the end of Sub-clause 4.1:</u> 4.1.1 Spares The Contractor agrees to provide all necessary spares for a period of ten (10) years, at the request of CMRL, at the prices quoted in the tender documents, subject to the Price Adjustment as per sub-clause 13.8 of PCC. The Contractor shall carry sufficient inventories to ensure an ex- stock supply of consumable spares for the plant and equipment. Other spare parts and components shall be supplied as promptly as possible, but at the most within six (6) months of placing the order. In addition, in the event of termination of the production of spare parts, advance notification will be made to the Employer of the pending termination, with sufficient time to permit the Employer to procure the needed requirement. Following such termination, the Contractor will furnish to the extent possible and at no cost to the Employer the blueprints, drawings and specifications of the spare parts, if requested. 4.1.2 Establishment of manufacturing facility in India: The successful bidder shall ensure that 100% of the Rolling Stock ordered in this bid shall be achieved by establishing / in the established metro cars manufacturing facility of their own, in India, to manufacture the Rolling Stock. 4.1.3 Record of Taxes, Duties etc: The Contractor shall maintain complete records in respect of payments made for taxes, duties, octroi, and other levies payable to various authorities and advise the Employer

PCC to GCC Clause No.	Description
	complete details of such payment every month. These records shall remain open for inspection by the Employer / Engineer at any time. In case of any exemptions in GST and Customs etc. in full or part thereof; the Contractor will be advised on the process to be followed to obtain refund of such taxes, etc, from the concerned authority. The Contractor shall arrange for the remittance of the refund so obtained to the Employer. In case of failure by the Contractor to remit the refund to the Employer, the same will be recovered by the Employer from the amounts due for payment to the Contractor or as debt due from the Contractor. If the Contractor fails to take the required action to obtain refund, the Employer may take action under Sub Clause 2.5 [Employer's Claims].
4.2 Performance Security	
4.2	<u>Replace paragraph 2 of GCC Sub-Clause 4.2 with the following:</u> The Contractor shall deliver the Performance Security to the Employer within 28 days after receiving the Letter of Acceptance and shall send a copy to the Engineer. The Performance Security in the form of Electronic Bank Guarantee, in the amounts of 10% of the Accepted Contract Amount and in the same currency(ies) of the Accepted Contract Amount, The Performance Security shall be issued by a Public sector Bank or Scheduled Commercial Bank in India selected by the Contractor or by Foreign Bank having correspondent financial institution located in India or having tie-up with a schedule commercial bank in India and shall be in the form annexed to the Particular Conditions, as stipulated by the Employer, or in another form approved by the Employer.
4.3 Contractor's Representative	
4.3	<u>The sentence in the seventh paragraph of GC 4.3,</u> "If the Contractor's Representative's delegates are not fluent in the said language, the Contractor shall make competent interpreters available during all working hours in a number deemed sufficient by the Engineer" is Deleted.
4.4 Subcontractors	
4.4	<u>The following sub-clause 4.4 (a),</u> the Contractor shall not be required to obtain consent to suppliers solely of Materials, or to a subcontract for which the Subcontractor is named in the Contract; <u>is replaced as,</u> It is a mandatory obligation for the Contractor to obtain Notice of No Objection (NONO) from CMRL for the selection of Subcontractors and/or vendors for all items of Work, including the Subcontractor and/or vendor had already been named in the Contractor's Technical Bid Proposal (Part 1, Section IV, Bidding Forms, Clause 5.13 : Form SUB - Proposed Subcontractors for Major Items of Plant and Installation Service). Purchase of all materials and equipment shall be in accordance with the Standards specified in Part 2 of the Contract. Where the Contractor had proposed more than One (1) Subcontractor for Rolling Stock

PCC to GCC Clause No.	Description
	the Employer / Engineer reserves the right to choose the vendor and/or Subcontractor from the proposed list. The Contractor shall propose minimum Two (2) subcontractor for Depot Machinery & Plant the Employer / Engineer reserves the right to choose the vendor and/or subcontractor from the proposed list. If the Contractor proposes to subcontract the Depot Machinery and Plant scope, then further subcontracting to major Suppliers / Vendors shall also require the prior approval of the Employer / Engineer. The Contractor shall indemnify the Employer / Engineer on losses/claims arising from non-selected vendors and/or subcontractors.
4.6 Co-operation	
4.6	<u>The sentence in second paragraph of GC 4.6,</u> Any such instruction shall constitute a Variation if and to the extent that it causes the Contractor suffer delays and/or to incur Unforeseeable Cost” is Deleted.
4.19 Electricity, Water, and Gas	
4.19	<u>Add the Following at the end of sub-clause 4.19</u> The Contractor shall coordinate with the interfacing Contractors for these services as may be available on the site and may be obtained on mutually agreed terms. At the time of Power-on of the equipment and during testing & commissioning necessary 3 phase power supply, traction power will be made available as the case may be, free of charge.
4.20 Employer's Equipment and Free Issue Material	
4.20	<u>Add the Following at the end of sub-clause 4.20:</u> There are no “Free issue” materials applicable to this Contract. Employer's Equipment or the other Contractor's equipment, if available and shareable during execution may be availed on mutually agreed terms.
4.22 Security of the Site	
4.22	<u>Add the following to the end of Sub-Clause 4.22:</u> (c) The Contractor shall take all measures necessary to ensure such security, including exercising control over all persons and vehicles which are employed or engaged on the Site or in connection with the Works or the other Works comprising the Project and with the security arrangements applicable to any other site within the Project. (d) The Contractor shall arrange the issue of passes for the admission of all persons and vehicles to the Site or to any part thereof and may refuse admission to or remove from the Site any person or vehicle failing to show an appropriate pass on demand to any duly authorized person. (e) If required by the Engineer, the Contractor shall submit a list identifying all persons to whom passes have been issued together with two photographs of each person

PCC to GCC Clause No.	Description
	and all entities to which a pass has been issued in respect of any vehicle and shall satisfy the Engineer of the bonafides of any such person or entity. (f) The Contractor shall provide and maintain all lights, guards, fences, warning signs and security guards/watchmen when and where necessary or required by the Engineer or by laws or by any relevant authority for the protection of the Works and for the safety and convenience of the public and all persons on or in the vicinity of the Site;
5. Design	
5.1 General Design Obligations	
5.1	<u>The following paragraph 3 and 4 of GC 5.1,</u> “Upon receiving notice under Sub-Clause 8.1 [Commencement of Works], the Contractor shall scrutinize the Employer's Requirements (including design criteria and calculations, if any) and the items of reference mentioned in Subclause 4.7 [Setting Out]. Within the period stated in the Contract Data, calculated from the Commencement Date, the Contractor shall give notice to the Engineer of any error, fault or other defect found in the Employer's Requirements or these items of reference. After receiving this notice, the Engineer shall determine whether Clause 13 [Variations and Adjustments] shall be applied, and shall give notice to the Contractor accordingly. If and to the extent that (taking account of cost and time) an experienced contractor exercising due care would have discovered the error, fault or other defect when examining the Site and the Employer's Requirements before submitting the Tender, the Time for Completion shall not be extended and the Contract Price shall not be adjusted.” are Deleted.
5.2 Contractor's Documents	
5.2	The reference of “approval” from the Engineer, wherever specified in entire tender document is changed as “Notice Of No Objection (NONO)”.
5.4 Technical standards and regulations	
5.4	Add the following at the end of 1st paragraph: The Design, construction and standards to be adopted by the Contractor shall be in conformity with the Requirements of “Metro Railway Act for opening of Metro Railway for Public carriageway of Passengers, Rules” (along with amendments), “Metro Railway General rules, 2020” (along with amendments), “Rules for opening of a Railway or a section of a Railway for Public Carriage of Passengers” and “Rules for introduction of New type of Rolling stock” and to the satisfaction of the commissioner of Metro Railway Safety whose sanction is mandatory for commissioning of the system. Sanction of the Commissioner of Metro Railway Safety and other Statutory Authorities will be required for introduction of the systems. The Contractor shall in this regard carry out all statutory tests and trials necessary for obtaining sanction of the Competent Authority for opening the system for public carriage of passengers and provide assistance and information as required by the appropriate statutory authorities in India. The Contractor under the supervision of the Engineer shall also carry out all tests and trial runs and prepare reports and documents required for obtaining all approvals and

PCC to GCC Clause No.	Description
	sanctions of the Commissioner of Metro Railway Safety (CMRS) and any other statutory Authority. This shall also include metro safety certification and technical clearances, safety certification of Rolling stock for public carriage of passenger and all other rules, guidelines, Acts, as specified by the Government of India.
5.6 As-Built Documents	
5.6	The submission of As-Built Documents shall be as per the requirements specified in the Part 2, Section VI A, ERTS-RS clause No. 16.11.8. The same is applicable for Depot Plant & Machinery as per tender conditions.
6 Staff and Labour	
6.7 Health and Safety	
6.7	<u>Last sentence of the last paragraph:</u> “Payment to the Contractor for preparation and implementation this programme shall not exceed the Provisional Sum dedicated for this purpose.” <u>are Deleted.</u> <u>Add the following to Sub-Clause 6.7:</u> The Contract shall allow for continuous audits of the Contractor's compliance with his OHS&E Plan and the requirements of Section VI, of Part-2 Employer's Requirements.
6.9 Contractor's Personnel	
6.9	<u>Add the following at the end of sub-clause GC 6.9</u> The Contractor shall submit the identity proof along with the police verification certificate for all the Contractor's personnel/ staff/ workmen before engaging into the project site.
6.13 Supply of Foodstuffs	
6.13	<u>The following sub-clause GC 6.13,</u> <i>“The Contractor shall arrange for the provision of a sufficient supply of suitable food as may be stated in the Employer's Requirements at reasonable prices for the Contractor's Personnel for the purpose of or in connection with the Contract.”</i> is replaced as, “The Contractor shall arrange for the provision of a sufficient supply of suitable food as per relevant OHSE guidelines and as per applicable Labour welfare standards / guidelines of the country of origin for the Contractor's Personnel for the purpose of or in connection with the Contract.”

PCC to GCC Clause No.	Description
7. Plant Equipment, Materials and Workmanship	
7.3 Inspection	
7.3	<u>The following sentence in GC clause 7.3,</u> <i>“The Contractor shall give notice to the Engineer whenever any work is ready and before it is covered up, put out of sight, or packaged for storage or transport.”</i> is replaced as <i>“The Contractor shall give reasonable notice to the Engineer whenever any work is ready and before it is covered up, put out of sight, or packaged for storage or transport.”</i>
7.4 Testing	
7.4	<u>Replace first paragraph as below,</u> The Sub-clause shall apply to all test specified in the Contract. <u>The sentence in the second paragraph</u> <i>“The Contractor shall agree, with the Engineer, the time and place for the specified testing of any Plant, Materials and other parts of the Works.”</i> is replaced with <i>“The Contractor shall provide personnel (including Train operators and/or Depot Machinery & Plant operators) required for carrying out Testing & Commissioning activities at its own cost and responsibility. The Contractor shall submit the internal test report duly complying with the requirements and shall agree, with the Engineer, the time and place for the specified testing of any Plant, Materials and other parts of the Works.”</i> <u>The following sentence in fifth paragraph,</u> <i>“(b) payment of any such Cost plus profit, which shall be included in the Contract Price”</i> is Deleted
7.7 Ownership of Plant and Materials	
7.7	<u>Replace Sub-clause 7.7 with the following:</u> Ownership of the Plant and Equipment (including spare parts) to be imported into the country where the Site is located shall be transferred to the Employer at high seas. Contractor shall maintain all insurance and bear all risks for safe handling and transport of the cars until delivery to Employer’s depot site. Ownership of the Plant and Equipment (including spare parts) procured in the country where the Site is located shall be transferred to the Employer when the Plant and Equipment are brought on to the Site. Ownership of the Contractor’s Equipment used by the Contractor and its Subcontractors in connection with the Contract shall remain with the Contractor or its Subcontractors. Ownership of any Plant and Equipment in excess of the requirements for the Facilities

PCC to GCC Clause No.	Description
	shall revert to the Contractor upon Completion of the Facilities or at such earlier time when the Employer and the Contractor agree that the Plant and Equipment in question are no longer required for the Facilities. Notwithstanding the transfer of ownership of the Plant and Equipment, the responsibility for care and custody thereof together with the risk of loss or damage thereto shall remain with the Contractor pursuant to GC 17.2 [Contractor's Care of the Works]. In the case of funding of the project through lease model, ownership of the assets will be assigned to the Contractor before signing of the Contract Agreement.
8. Commencement, Delays and Suspension	
8.1 Commencement of Work	
8.1	The date of commencement shall be 35 days from the date of LoA. Thereafter the Contractor shall proceed with due diligence, without delay, and in accordance with the program.
8.2 Completion	
8.2	<u>Add the following Sub-Clauses to the end of Sub-Clause 8.2:</u> <u>8.2.1 Access for Others by Key Dates</u> i. In addition to the Contractor's obligations to Interfacing Contractors contained elsewhere in the Contract, the Contractor shall provide access, occupation, or handover to Interfacing Contractors to those parts of the Works which are subject to Key Dates, by the Key Dates. ii. The Contractor shall complete those parts of the Works, which are subject to Key Dates, by the Key Dates as specified in Part 2 – Employers' Requirement of this Contract. Those parts of the Works subject to Key Dates shall be completed to a state whereby any Interfacing Contractor can immediately commence his Works without the need to make any change, addition or modification to the Contractor's Works. iii. The Engineer acting reasonably shall issue a notice of no objection confirming the date on which any part of the Works subject to a Key Date is in the condition required by the Contract so that access, occupation, or handover can be given to an Interfacing Contractor in accordance with the requirements of the Contract. iv. The Contractor shall give written notice to the Engineer as soon as he can reasonably foresee an event occurring which is liable to cause any delay to the granting of access, occupation, or handover in accordance with the Contract to an Interfacing Contractor by a Key Date. Such notice, which may, if applicable, be combined with a notice given in regard to the Works or any Section in accordance with Clause 8.4 of the General Conditions, shall not in any event be given later than 28 days after the commencement of such an event which is liable to cause delay to the Key Date. v. At the time of giving notice of any delay in accordance with GCC / PCC Clause 8.3, the Contractor shall provide the information required under GCC / PCC Clause 8.3, to the extent applicable to the Key Date.

PCC to GCC Clause No.	Description
	vi. Once occupation is given to an Interfacing Contractor in accordance with this Condition, the Contractor shall only be given access to complete any outstanding work or defective work at the times agreed with the Interfacing Contractor who has occupation. vii. In addition to the obligation to give access, occupation or handover to parts of the Site to Interfacing Contractors, the Contractor shall at all reasonable times allow access to all of the Site to the Interfacing Contractors for the purposes of erecting catenary, laying cables, installing & commissioning of Rolling stock and communications systems and all similar work. viii. The access and occupation referred to in this PCC clause shall include for heavy vehicles at all times. ix. The Contractor shall allow for, and be deemed to have included all related costs, in the Contract Price for access, occupation or handover for Interfacing Contractors on 7 days a week, 24 hours per day basis.
8.5 Extension of Time for Completion	
8.5	<u>Add the following at the end of Sub-clause 8.5:</u> The Contractor shall not be entitled to any extension of time where the instructions or acts of the Employer are necessitated by or intended to cure any default of or breach of Contract by the Contractor or where any delay is due to either of the following: - the failure of the sub-contractor, to commence or to carry out work in due time, - non-availability or shortage of Contractor's equipment, labour, utility services, Plant and Materials, - inclement weather conditions, other than 1 in a 50- year cycle and - the Contractor not fulfilling his obligations under the contract. The Contractor shall submit the EoT assessment using delay analysis with the details on the type of delay, cause & effect, and entitlement as per the relevant clause of the Conditions of Contract.
8.7 Delay Damages	
8.7	<u>The following sentence in first paragraph,</u> <i>"These delay damages shall be the sum stated in the Contract Data, which shall be paid for every day which shall elapse between the relevant Time for Completion and the date stated in the Taking-Over Certificate"</i> is replaced with "These delay damages shall be the sum stated in the Contract Data, which shall be paid for every day, which shall elapse between the Key Dates stated in PCC – Part A: Contract Data – 'Table – Summary of Sections' or any extension thereof under GC clause 8.4 and the actual date of achievement of Key Date" The Employer shall not be required to prove the actual loss incurred due to the delay caused by the Contractor for claiming delay damages.

PCC to GCC Clause No.	Description
9. Tests on Completion	
9.1 Contractor's Obligations	
9.1	<u>Add the following at the end of Sub-clause GC 9.1:</u> The test on completion shall be carried out in the following sequence: <u>Rolling Stock:</u> (a) Design Conformance Testing as per ERTS-RS clause 17.5 of Part 2 - Section VI of tender document (b) Production Conformance Testing as per ERTS-RS clause 17.6 of Part 2 - Section VI of tender document (c) Car Static Testing as per ERTS-RS clause 17.7 of Part 2 - Section VI of tender document (d) Post-Shipment Acceptance Testing as per ERTS-RS clause 17.8 of Part 2 - Section VI of tender document (e) Integrated Testing and Commissioning as per ERTS-RS clause 17.9 of Part 2 - Section VI of tender document (f) Burn-in trials / Service trials in ~~Automatic Train Operation (GoA2)~~ ATO (GoA2) & UTO (GoA4) as per ERTS clause 17.10 of Part 2 - Section VI of tender document (g) RDSO requirements for Contractor's submission and testing as per ERTS-RS clause 17.11 of Part 2 – Section VI of tender document <u>Depot Machinery & Plant:</u> (h) Test requirements specified in Part 2, Section VI-B, ERTS-DM&P. The Contractor shall submit internal test reports before inviting Employer/ Engineer to witness the test.
10. Handover to the Employer	
10.1 Taking care of the Works and sections	
10.1	<u>Add the following at the end of sub-clause 10.1:</u> All the works or section shall be handed over to Employer duly cleaned using suitable agents. The DNP shall be followed as per GC clause 11.1 and PC to GC clause 11.1. Further, the DNP for parts and/or systems /subsystems of the Project Works, which may require further corrective action or design change, the DNP for those respective systems / subsystems shall recommence only after completion of the corrective action to the full satisfaction of the Engineer / Employer.
10.2 Taking over of Parts of the Works	
10.2	<u>Replace last paragraph of Sub-clause 10.2 with the following:</u> If the activities / Works related to a Key Date achievement is completed and certified by the Engineer for only certain number of trains under the relevant milestone, the delay

PCC to GCC Clause No.	Description
	damages thereafter for completion of the remainder number of trains shall be reduced. For any period of delay after the actual Key Dates stated in this Contract, the proportional reduction in these delay damages shall be calculated as the proportion which the value of the trains so certified bears to the value of that milestone activity as a whole. The Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine these proportions. The provisions of this paragraph shall only apply to the daily rate of delay damages under Sub-Clause 8.7 [Delay Damages] and shall not affect the maximum amount of these damages. The Employer can use any part of the works for VIP visits, inauguration functions, mock passenger trials, etc. If so, Contractor shall not claim for Taking- Over Certificate under this sub clause.
10.3 Interference with tests completion	
10.3	<u>Replace Sub-clause 10.3 with the following paragraph:</u> If the Contractor suffers delay by a cause for which the Employer is responsible in carrying out the Tests on Completion, the Contractor shall give notice to the Engineer and shall be entitled subject to Sub-Clause 20.1 [Contractor's Claims] to: (a) an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 8.4 [Extension of Time for Completion] After receiving this notice, the Engineer shall proceed in accordance with Sub- Clause 3.5 [Determinations] to agree or determine these matters. However, the Contractor shall be solely responsible for his scope covered in Interface tests.” In the event of disputes between the interfacing Contractors, the Engineer / the Employer will intervene and will facilitate in resolving the issue.
11 Defects Liability	
11.1 Completion of Outstanding work and Remedying defects	
11.1	<u>Add the following at the end of Sub-clause 11.1:</u> <u>11.1.1 DLP/DNP- Rolling Stock:</u> DLP / DNP for Rolling Stock shall start from the date of issuance of Taking-over Certificate (TOC) for the 1st trainset and the fleet DNP / DLP ends two years after the TOC date of the 28th Trainset. In the case of DLP / DNP for Option Quantity (If exercised) of Rolling Stock shall start from the date of issuance of Taking over Certificate (TOC) for the 1st trainset of Option Quantity and the fleet DNP / DLP ends two years after the TOC date of the last Trainset of Option Quantity. During DLP/ DNP, the Contractor shall be responsible for including but not limited to the following scope of activities: a) Corrective Maintenance b) Asset and Maintenance Management System (AMMS) c) Coordination with OCC/ BCC/ DCC/ PPIO d) Spares management <u>11.1.2 DLP/DNP- Depot M&P:</u>

1

PCC to GCC Clause No.	Description
	DLP / DNP shall start on the TOC date of the respective equipment item and will ends two years after the TOC date of the last equipment. During DLP/ DNP, Contractor shall be responsible for including but not limited to the following scope of activities: a) Corrective Maintenance b) Asset and Maintenance Management System (AMMS) c) Coordination with OCC/ BCC/ DCC/ PPIO d) Spares management If the works or sections not available for usage by the Employer for more than 48 hrs, then a penalty as below shall be paid by the contractor for each day till the works or sections made ready by him. The cumulative amount shall be deducted by the Employer from the subsequent bills submitted by contractor. Rolling Stock: Rs. 25,000 per day / train Depot Machinery & Plant: Rs. 5,000 per day / equipment A penalty of Rs.2,00,000 for each case shall be levied for the failure or malfunction in the works or sections during passenger operation which interrupt metro operations for more than 10 mins.
11.3 Extension of Defects Notification Period	
11.3	<u>Replace sub-clause 11.3 with the following:</u> The Employer shall be entitled subject to Sub-Clause 2.5 [Employer's Claims] to an extension of the DNP for the Works or a Section if and to the extent that the Works, Section or a major item of Plant (as the case may be, and after taking over) (a) does not meet the reliability targets set in Part 2, Section VI A, ERTS-RS clause 18.6. Train / System / Sub-system level extension of DNP will be applicable in the case where the reliability targets defined in ERTS 18.6 are not met. In case of any retrofits or modifications done by the Contractor or their sub-supplier in any specific system / sub- system / function / component / software of any train or spares, these specific system / sub-system / function / component / software shall be subjected to 24 months warranty from the date of completion of retrofit / modification in that train or spares. This is in order to mitigate any issues that would arise due to the retrofit / modification. This specific 24 months warranty is irrespective of the train DNP / warranty.
11.9 Performance Certificate	
11.9	<u>Replace the following at the end of Sub-clause 11.9</u> The Engineer shall issue the Performance Certificate within 28 days after the latest of the expiry dates of the Defect Notification Periods (or extensions thereof (as per PCC SP 11.3)), or as soon thereafter as the Contractor has supplied all the Contractor's Documents and completed and tested all the Works, including remedying any defects. A copy of the Performance Certificate shall be issued to the Employer.
12 Test after Completion	
12.1 Procedure for Tests after Completion	

PCC to GCC Clause No.	Description
12.1	<u>Replace Sub-clause 12.1 with the following:</u> The contractor is responsible for test after completion such as Performance and RAMS demonstration etc., and shall arrange all equipment, fuel, instruments, labour, materials, required testing and measuring equipment's and suitably qualified and experienced staff, as are necessary to carry out the test after completion efficiently and shall carryout the tests in accordance with the approved Performance and RAMS demonstration plan and in the presence of the Engineer / the Employer. The Employer will provide only traction power. The contractor is responsible for all post completion tests at his cost and responsibility. The Tests after Completion shall be carried out as soon as is reasonably practicable after the Works or Section have been taken over by the Employer. The Employer shall give to the Contractor 21 days' notice of the date after which the Tests after Completion will be carried out. Unless otherwise agreed, these Tests shall be carried out within 14 days after this date, on the day or days determined by the Employer. The results of the Tests after Completion shall be compiled and evaluated by both Parties.
12.2 Delayed tests	
12.2	<u>Replace Sub-clause 12.2 with the following:</u> If the Contractor incurs Cost as a result of any delay by the Employer to the Tests after Completion, the Contractor shall (i) give 28 days' notice to the Engineer and (ii) be entitled subject to Sub-Clause 20.1 [Contractor's claims] to payment of any such Cost of manpower, equipment and any other costs which can be directly attributed to the delay in conducting the above tests, subject to substantiation of such cost with profit, if delayed beyond the 28 day-notice period. After receiving this notice, the Engineer shall proceed in accordance with Sub-Clause 3.5 [Determinations] to agree or determine this Cost and Profit.
12.4 Failure to pass tests on completion	
12.4	<u>Add the following at the end of sub-clause 12.4 (b):</u> The Engineer / the Employer will assess the non-performance damages for this failure based on the loss / reduction of performance incurred by the employer on case-to-case basis and this cost shall be levied to the Contractor. Maximum value of this non-performance damages shall be limited up to the value of Performance Security + Retention amount.
13 Variations and Adjustments	
13.1 Right to vary	
13.1	<u>The following sentence in the 1st Paragraph of GC 13.1,</u> <i>"Variations may be initiated by the Engineer at any time prior to issuing the Taking-Over Certificate for the Works, either by an instruction or by a request for the Contractor to</i>

PCC to GCC Clause No.	Description
	<i>submit a proposal.”</i> is replaced with “Variations may be initiated by the Engineer at any time during the performance of the Contract, either by an instruction or by a request for the Contractor to submit a proposal”. Reference shall be made to Part 1 - Section IV – Bidding Forms – ‘Instructions for completing the Pricing document’ – Cl. 3.3 for Quantity variation conditions.
13.5 Provisional Sums	
13.5	<u>Add the following to the end of subclause:</u> As an exception to the above, the Provisional Sum for the cost of the DAB shall be used for payments to the Contractor of the Employer’s share (one-half) of the invoices of the DAB for its fees and expenses, in accordance with GC 20.2. No prior instruction of the Engineer shall be required with respect to the work of the DAB. The Contractor shall produce the DAB invoices and satisfactory evidence of having paid 100% of such invoices as part of the substantiation of those Statements submitted under Sub-Clause 14.3, which contain requests for payment under the Provisional Sum toward the cost of the DAB. The Engineer’s certification of such Statements shall be based upon such invoices and such evidence of payment by the Contractor. Contractor’s overhead, profit, etc., shall not be included in the provisional sums for the cost of the DAB.
13.6 Adjustments for Changes in Laws	
13.6	<u>Add the following to the end of subclause:</u> Notwithstanding the foregoing, the Contractor shall not be entitled to an extension of time if the relevant delay has already been taken into account in the determination of a previous extension of time and such Cost shall not be separately paid if the same shall already have been taken into account in the indexing of any inputs to the table of adjustment data in accordance with the provisions of Sub-Clause 13.8 [<i>Adjustments for Changes in Cost</i>]. If extension of the contract period is on account of contractor’s fault, no compensation shall be made towards upward revision towards “Change in Taxes and Duties”. Any benefit on account of downward revision towards “Change in Taxes and Duties”, during the original contract period or extended contract period shall be on Employer’s account.
13.7 Adjustments for Changes in Legislation	
13.7	<u>Add the following to the end of subclause:</u> Notwithstanding the foregoing, the Contractor shall not be entitled to an extension of time if the relevant delay has already been taken into account in the determination of a previous extension of time and such Cost shall not be separately paid if the same shall already have been taken into account in the indexing of any inputs to the table of adjustment data in accordance with the provisions of Sub-Clause 13.8 [<i>Adjustments for Changes in Cost</i>].

PCC to GCC Clause No.	Description
13.8 Adjustment for Changes in Cost	
13.8	Reference shall be made to Cl. 3.2 of Part 1 - Section IV - Bidding Forms - 'Instructions for Completing the Pricing document'.
14 Contract Price and Payment	
14.1 The Contract Price	
14.1	Add the following to the end of Sub-Clause 14.1(a). Contract Price means the price excluding Provisional Sum. Delete last paragraph of GCC Sub-Clause 14.1 Reference shall be made to Part 1 - Section IV – Bidding Forms – ‘Instructions for completing the Pricing document’ – Cl. 3.1 for General Requirements
14.2 Advance Payment	
14.2	<u>Replace first paragraph of Sub-Clause 14.2 with the following:</u> The Employer shall make an interest free advance payment for mobilization when the Contractor submits a guarantee in accordance with this sub-clause. This guarantee shall be in the form of BG for 100% of the advance amount requested plus GST (in parlance with CVC guidelines) as per format given in the Annex to PC from a Public sector bank (PSB) of India or Scheduled Commercial Banks in India or as listed under Schedule of Commercial Banks by The Reserve Bank of India (RBI). GST on the mobilization advance is not reimbursable. The total advance payment and the applicable currencies and proportions shall be as stated in Contract Data. Mobilization advance shall be paid in two equal instalments as mentioned below: The First instalment of the Advance Payment may be paid after: (i) the Contract Agreement is signed; and (ii) the required Bank Guarantee in the specified format from banks as mentioned above is submitted. The Second & final instalment of the Advance Payment may be paid after: (i) the required Bank Guarantee in the specified format from banks as mentioned above is submitted (ii) the evidence for satisfactory utilization of the First instalment of mobilization is submitted; and (iii) provision of 3D virtual models. Within 90 days of release of the second and final Instalment of the Advance Payment, the Contractor shall submit the evidence for satisfactory utilization of the second instalment of mobilization.
14.5 Plant and Materials intended for work	
14.5	Delete “Schedules” in the second paragraph, in the sub-paragraph (b) (i) and in the sub-paragraph (c) and substitute “Contract Data” respectively.

2

PCC to GCC Clause No.	Description
14.7 Payment	
14.7	Replace the paragraph 14.7 (b) with the following: After preliminary scrutiny and certification by the Engineer, payment of 80% of the certified interim amount shall be made by the Employer within 28 days of receiving the IPC from the Engineer. The amount certified shall account for all deductions, including statutory deductions, recoveries for Advances and any amounts due from the Contractor. The balance 20% shall be paid within 56 days, after the Employer receives the IPC from the Engineer. If during the pendency of the Contract, the above facility shall be withdrawn in case the interim payment certification by the Engineer falls below 80% of the payment application by the Contractor in a maximum two applications. On withdrawal of such facility, the amount certified in each Interim payment Certificate shall be paid within 56 days after the Engineer receives the statement and supporting documents.
14.7	Delete last paragraph of this Sub-Clause and substitute the following: “Payment of the amount due in: (A) local currency, payable from the proceeds of the Loan, shall be made through as stated in the Contract Data; and (B) foreign currency, payable from the proceeds of the Loan, shall be made through as stated in the Contract Data. Payment of the amount due in each currency, payable from any source of finance other than the Loan Agreement such as the Employer's funds, shall be made directly into the bank account, nominated by the Contractor, in the payment country (for this currency) specified in the contract. Any charges or fees associated with or incidental to remittance of funds from Employer to the Contractor's account including but not limited to those for opening and amendment commissions of the Letter of Credit shall solely be borne by the Employer.”
14.7	Notwithstanding anything mentioned above under Sub-Clause 14.7, CMRL may allow payments to be made to the Contractor directly from the Funding Agency in the following case: In the case of lease funding model, the Contractor shall raise invoice/IPA in the name of Funding Agency and submit to Engineer copy to Employer. IPA/Invoices shall be certified by the Engineer/Employer and then be submitted to Funding Agency for processing and payment. The Funding Agency shall pay to the Contractor within 56 days after the Engineer receives the Statement and supporting documents. Any such direct payment by the Funding Agency to the Contractor shall be deemed to be a payment made by the Employer to the Contractor under the Contract. The Employer's obligation to make payment shall be discharged to the extent of such payment made by the Funding Agency.
14.9 Payment of Retention Money	
14.9	<u>Replace Clause 14.9 with the following</u> Retention money shall be deducted at the rate of 5% on each Interim payment certificate

PCC to GCC Clause No.	Description
	(IPC), excluding taxes & duties, in respective currencies and up to the cumulative value equal to 5% of the Accepted Contract Amount (excluding Provisional sum), excluding taxes & duties. Upon the request of the Contractor, the Employer after issuance of Taking-Over certificate of each trainset / each Depot Machinery & Plant may release the withheld retention money specific to that trainset / Depot Machinery & Plant, on submission of Bank Guarantee for an equivalent amount in respective currencies from a Public sector bank (PSB) of India or Scheduled Commercial Banks in India as listed under Schedule of Commercial Banks by The Reserve Bank of India (RBI), in the format annexed to the Particular Conditions. Upon completion of DNP of Rolling Stock and Depot Machinery & Plant, the Retention money amount or the Retention money Bank Guarantees (less the value of claims made by the Employer for uncompleted warranty work) for Rolling Stock and Depot Machinery & Plant shall be certified by the Engineer / Employer for releasing to the Contractor. The Employer may, at its sole discretion, release the accumulated retention money on yearly basis against the Contractor's request. In such cases, the Contractor shall submit an irrevocable and unconditional e-BG for 100% of the requested amount, valid up to the end of the Defects Liability Period (DLP).
17. Risk and Responsibility	
17.1 Indemnities	
17.1	<u>The second paragraph of GC 17.1,</u> “The Employer shall indemnify and hold harmless the Contractor, the Contractor's Personnel, and their respective agents, against and from all claims, damages, losses and expenses (including legal fees and expenses) in respect of (1) bodily injury, sickness, disease or death, which is attributable to any negligence, willful act or breach of the Contract by the Employer, the Employer's Personnel, or any of their respective agents, and (2) the matters for which liability may be excluded from insurance cover, as described in subparagraphs (d)(i), (ii) and (iii) of Sub- Clause 18.3 [Insurance Against Injury to Persons and Damage to Property].” are Deleted
17.1	<u>Add the following at the end of sub-clause 17.1</u> The Contractor shall, at all times indemnify the CMRL against all claims and penalties which may be suffered by the CMRL or its employees by reason of any default on the part of the Contractor or its staff in due observance and performance of provision of: - Prevention of Child Labour (No child labour shall be employed by the Contractor) - Prevention of Bonded Labour System (abolition of bonded labour system) - any other Acts, Rules, Regulations and Statutes in force or to be passed by Union Government of India or State Government of Tamil Nadu. The Contractor shall, at all times indemnify the CMRL against all claims and penalties which may be suffered by the CMRL or its employees by reason of any default on the part of the Contractor or its staff in due observance and performance of provision of:

PCC to GCC Clause No.	Description
	a. The Contract Labour Act (1970) b. Minimum Wages Act 1948 c. Weekly Holidays Act 1942 d. Prevention of Child Labour (No child labour shall be employed by the Contractor) e. Prevention of Bonded Labour System (abolition of bonded labour system) f. The Payment of Wages Act, 1936 g. Hours of employment Regulations h. The Workmen's Compensation Act, 1923 i. The EPF Act j. The Bonus Act k. The ESI Act l. The Inter-State Migrant Workmen (Regulation of Employment and Conditions of Service) Act, 1979.
17.2 Contractor's Care of the Works	
17.2	<u>Add the following at the end of sub-clause 17.2</u> The Contractor shall also be liable for any loss or damage which occurs until issuance of Performance Certificate, and which arose from a previous event for which the Contractor was liable.
17.3 Employer's Risks	
17.3	<u>Replace GC 17.3 with the following:</u> The risks referred to in Sub-Clause 17.4 [Consequences of Employer's Risks] below, insofar as they directly affect the execution of the Works in India, are: (a) deleted (b) deleted (c) deleted (d) deleted (e) deleted (f) use or occupation by the Employer of any part of the Permanent Works, except as may be specified in the Contract, (g) design of any part of the Works by the Employer's Personnel or by others for whom the Employer is responsible, if any (h) deleted.
18. Insurance	
18.1	<u>Add the following at the end of sub-clause 18.1</u> Insurance cover for the Contractor's All Risk and other requirements as specified in

PCC to GCC Clause No.	Description
	GCC shall cover 100 % of the Total Contract price (including taxes and duties) and also cover the variation price. This insurance shall cover the total contract period including the DNP period.
18.5	<u>Add New sub-clause 18.5:</u> In the case of a lease funding model, the Funding Agency shall also be named as the principal insured under the said insurance policy. The insurance policies shall remain valid and in full force until the issuance of the Performance Certificate as per the Contract.
19. Force Majeure	
19.4 Consequences of Force Majeure	
19.4	<u>The clause 19.4 is deleted in its entirety and replaced with the following:</u> If the Contractor is prevented from performing substantial obligations under the Contract by Force Majeure of which notice has been given under Sub-Clause 19.2 [Notice of Force Majeure], and suffers delay by reason of such Force Majeure, the Contractor shall be entitled subject to Sub-Clause 20.1 [Contractor's Claims] to an extension of time for any such delay, if completion is or will be delayed, under Sub-Clause 8.4 [Extension of Time for Completion] The Costs incurred by both the parties due to this event shall be borne by the respective parties without raising any claim to the other party."
19.6 Optional Termination, payment and Release	
19.6	<u>Replace 19.6 with the following:</u> Either party shall not terminate the Contract without the consent of the other party during Force Majeure. If both the parties agree for a termination of the Contract, then the Engineer shall determine the value of the work done and issue a Payment Certificate which shall include the amounts payable for any work carried out for which a price is stated in the Contract.
19.8 Resumption of work after Force Majeure	
19.8	<u>Add a new Sub-Clause 19.8:</u> The obligations under the Contract shall be resumed as soon as practicable after the event has come to an end or ceased to exist. In case of doubt or dispute, whether a particular occurrence should be considered an "event" as defined under this Clause, the Engineer shall first try to resolve the issue and give his decision. If the Engineer's decision is not acceptable to any party, the aggrieved party may refer the matter for resolution under Clause 20 [Claims, Disputes and Arbitration]. However, the execution of the work shall continue and shall not be stopped or slowed down on that account.
20 Claims, Disputes and Arbitration	

PCC to GCC Clause No.	Description
20.1 Contractor's Claims	
20.1	In 20.1 of GCC, 9th Para 2nd line delete "the Dispute Board in accordance with Sub-Clause 20.4 [Obtaining Dispute Board's Decision]" and replace with "Standing Grievance Redressal Committee (SGRC) in accordance with Sub-Clause 20.1 (A)" Add Clause no. 20.1 A after GCC 20.1 <u>20.1 A Standing Grievance Redressal Committee (SGRC)</u> i) If a dispute (of any kind whatsoever) arises between the Parties in connection with or arising out of the contract or the execution of the works, including any dispute as to any opinion, instruction, determination, certification or valuation of the Engineer, either party shall initially refer the same in writing to Standing Grievance Redressal Committee (here in after termed as SGRC). ii) 'Three numbers of Standing Grievance Redress Committees' have been formed by the Employer to address such disputes raised by either Party. iii) The Employer shall communicate one SGRC to resolve the dispute within 28 days from the date of commencement. The SGRC members shall comprise three members not below the rank of Additional General Manager, CMRL, but those who have not dealt with the subject contract or disputed matter. iv) If any dispute is referred to the SGRC, it will within a week of receipt of such request acknowledge and convene a meeting with both the parties. The committee will go through the submitted documents, hear the parties and attempt at finding an amicable solution within 28 days of receipt of such reference by the SGRC. If any settlement is arrived at the Standing Grievance Redressal Committee the same shall be recorded in writing as a settlement agreement and be signed by the Contractor, Engineer, Employer and all committee members. Such settlement shall be final and binding on the parties with regards to the disputes so resolved. v) If the Standing Grievance Redressal committee fails to settle all or part of the dispute within 28 days, the same shall be notified to the parties. Thereafter, it is left to the parties to refer the unresolved disputes to DB. In such case, either Party may give notice in writing, with copies to the other party and the Employer's Representatives of its intention to refer such dispute to Dispute Board, within 28 days of such notice by SGRC.
20.2 Appointment of Dispute Board	
20.2	<u>Delete Sub-Clause 20.2 of GCC in its entirety and replace with the following Sub-Clauses:</u> 20.2 Appointment of Dispute Board Dispute Board (DB): (i) The DB shall comprise three members. The Employer shall, within fifteen (15) days from the date of receipt of notice under sub-clause 20.1 A (v), send a panel of ten (10) independent and neutral members who shall be professionals, experienced in the relevant field. The members shall not be ex-employees or directly or indirectly associated with CMRL. Each party shall choose any one member from the panel provided by the Employer. The first two members shall recommend a third member

PCC to GCC Clause No.	Description
	from the panel and the Parties shall agree upon the same, who shall then act as Chairman of the DB. (ii) The remuneration payable to the DB members shall be mutually agreed to by the Parties and shall be shared by both Parties equally. (iii) Neither Party shall consult the DB members on any matter without the agreement of the other Party. (iv) If any member of the DB declines to act or is unable to act as a result of death, disability, resignation or termination of appointment, a replacement shall be made in the same manner as the replaced person was appointed. (v) The appointment of any member may be terminated by mutual agreement of both Parties, but not by the Employer or the Contractor acting alone. (vi) The DB shall be appointed as and when a request is raised. (vii) The Contractor has to pay the entire amount (100%) of the DB and raise an invoice of 50% of such cost (Employer Share) which will be reimbursed. (viii) If either party is dissatisfied with the DB's decision, then the party, on or before 28 days on receipt of such decision, shall notify the other party of its dissatisfaction, and its intention to refer the dispute for Conciliation, to the Conciliator, failing which the decision of the DB shall be final and binding.
20.3 Failure to Agree on the Composition of the Dispute Board	
20.3	Delete Sub-Clause 20.3 of Part 3 General Conditions in its entirety
20.4 Obtaining Dispute Board's Decision	
20.4	Delete entire first paragraph, In Para 4, line 4, replace "an amicable settlement" with "Conciliation". In Para 5, line 3, replace "arbitration" with "Conciliation". In Para 6, line 4, replace "arbitration" with "Conciliation" of Sub-Clause 20.4 of Part 3 General Conditions.
20.5 Amicable Settlement	
20.5	Replace entire sub-clause of 20.5 amicable Settlement by following: 20.5 Conciliation There shall be a Conciliator well experienced in required field who will carry out the conciliation process under part III of the Indian Arbitration and Conciliation Act, 1996 as amended by the Arbitration and Conciliation (Amendment) Act 2015. (i) If the dispute is not resolved through DB and notice of dissatisfaction has been given by either party, the parties shall attempt to settle such dispute through Conciliation. (ii) Both parties will agree for nominating sole Conciliator from the list provided by the Employer, Such Conciliator shall be nominated from the List maintained by the

PCC to GCC Clause No.	Description
	Employer. The Employer shall, within 15 (fifteen) days from the date of receipt of such dissatisfaction notice, send a panel of 5 (Five) independent and neutral members who shall be professionals, experienced in the relevant field. The Contractor shall nominate sole Conciliator from the said Panel within 15 (Fifteen) days from the date of receipt of such Panel from the Employer. (iii) Conciliation proceedings shall commence when the party submit a brief statement of the claims/disputes to the conciliator. (iv) The Conciliator shall be paid a fee of Rs. 50,000/- per sitting plus Rs. 5,000/- towards local transport charges for each day of proceedings. An outstation member shall be reimbursed the air fare by economy class and hotel accommodation additionally. Applicable taxes, if any, shall be reimbursed as per actuals. The expenditure shall be shared equally by both the parties. (v) The Conciliator shall hold its sitting at a designated place in Chennai and complete the proceedings within 10 sittings in a period of 6 months. In case more sittings are required by the Conciliator, the same may be held at the discretion of the Conciliator with the consent of the parties. (vi) The procedures and methodologies of the Conciliation proceedings shall be evolved by the Conciliator in its first meeting. The Forum of Conciliator is a settlement forum, where mutual give and take constitutes the essence, rather than strict legal positions of the parties. The parties are expected to be brief and to the point before the committee with regards to their respective stand and views to exercise the spirit of settlement. (vii) The Parties before the Conciliator shall be represented by a senior Executive and regular employee of the company, supported by an Authorization letter to enter into a Settlement Agreement. The representing parties appearing before the Conciliator shall be capable of taking decision immediately and settle the dispute. (viii) The Conciliator shall be guided by principles of objectivity, fairness and justice, giving consideration to other things, the rights and obligations of the parties and usage of the trade practice and circumstances surrounding the dispute and suggest the proposal for a settlement of the dispute. If a settlement is arrived at, the same shall be recorded as a settlement agreement and signed by the Contractor, Employer and the Conciliator. The settlement agreement shall be final and binding on the parties in terms of section 73 of the Arbitration and Conciliation Act 1996 as amended. (ix) In case of failure of the conciliation process, the Conciliator shall write a declaration after consultation with the parties to the effect that further efforts at conciliation are no longer justified on the date of declaration. (x) If any dispute between the parties is not resolved through Conciliation, either party on or before 30 days from the date of declaration of Conciliator, shall give notice in writing to the other party of its intention to refer such dispute to Arbitration.
20.6 Arbitration	
20.6	Delete sub-clause 20.6 of Part 3 GCC in its entirety and replace with the following sub-clauses. 20.6 Arbitration:

PCC to GCC Clause No.	Description
	1. Any dispute between the Parties arising out of or in connection with the Contract, not settled under Conciliation in accordance with Sub-Clause 20.5 above, shall be finally settled by arbitration. The rules governing arbitration shall be as under. (i) The dispute shall be referred to an Arbitral Tribunal comprising three members. Either Party may propose to the other Party for referring the dispute to Arbitration. If the proposal is initiated by the Contractor, such proposal shall be addressed to the Employer and the Employer shall, within fifteen days from the date of receipt of such proposal, send a Panel of Arbitrators maintained by the Employer to the Contractor. The Panel of Arbitrators, maintained by the Employer, consisting of independent persons, shall meet with the requirement relating to the independence or impartiality of arbitrators referred to in the Fifth and Seventh schedules, read with Section 12, sub-sections (1) (a), (b) and (5) of the Indian Arbitration and Conciliation Act, 1996 as amended by the Arbitration and Conciliation (Amendment) Act 2015. (ii) The Contractor shall nominate an arbitrator from the said Panel within fifteen days from the date of receipt of the Panel from the Employer. The Employer shall nominate its Arbitrator from the said Panel within 15 days thereafter. (iii) If the proposal for referring the dispute to Arbitration is made by the Employer to the Contractor, it shall forward such proposal to the Contractor along with the nomination of its Arbitrator from the said Panel. The Contractor shall, within fifteen days of receipt of the Panel from the Employer, nominate its arbitrator from the same Panel. (iv) If either party fails to nominate its Arbitrator within the prescribed time limit as mentioned above, after the nomination by the other party, then such other party, after the expiry of the prescribed time limit, has the right to nominate the arbitrator from the said Panel, on behalf of the party failing to nominate. The two arbitrators nominated by the Contractor and the Employer as above, shall appoint the Presiding Arbitrator from the Panel referred above, by mutual consultation among themselves, within 15 days of the appointment of the second Arbitrator. (v) If no consensus is reached within 15 days regarding the appointment of the Presiding Arbitrator, either party may apply to the Designated Court referred to in the Arbitration and Conciliation Act, 1996 as amended by the Arbitration and Conciliation (Amendment) Act 2015 for the appointment of the Presiding Arbitrator. (vi) In the event of an arbitrator dying, neglecting or refusing to act or resigning or being unable to act for any reason, it shall be lawful to appoint another arbitrator in place of the outgoing arbitrator in the manner aforesaid. (vii) Subject to aforesaid, the Arbitration and Conciliation Act, 1996 as amended from time to time, and the rules thereunder and any statutory modifications thereof for the time being in force shall be deemed to apply to the arbitration proceedings under this clause. The Arbitration fees shall be payable in terms of Schedule Fourth of the Arbitration and Conciliation Act, 1996 as amended from time to time. (viii) The seat and venue of the arbitration shall be Chennai. The cost of Arbitration including the fees of the Arbitrators shall be borne equally by both the parties.

PCC to GCC Clause No.	Description
	2. The arbitrators shall have full power to open up, review and revise any certificate, determination, instruction, opinion or valuation of the Engineer, and any decision of the DB relevant to the dispute. Nothing shall disqualify representatives of the Parties and the Engineer from being called as a witness and giving evidence before the arbitrators in any matter whatsoever relevant to the dispute. 3. Neither Party shall be limited in the proceedings before the arbitrators to the evidence or arguments previously put before the DB to obtain its decision, or to the reasons for dissatisfaction given in its Notice of Dissatisfaction. Any decision of the DB shall be admissible in the arbitration. 4. Arbitration may be commenced prior to or after completion of the Works. The obligations of the Parties, the Engineer and the DB shall not be altered by reason of any arbitration being conducted during the progress of the Works.
20.7 Failure to Comply with Dispute Board's Decision:	
20.7	<u>Delete Sub-Clause 20.7 of GCC in its entirety and replace with the following Sub-Clauses:</u> In the event that a Party fails to comply with a final and binding DB decision, then the other Party may, without prejudice to any other rights it may have, refer the failure itself to Conciliation under Sub-Clause 20.5.
20.8 Expiry of Dispute Board's Appointment:	
20.8	<u>Delete Sub-Clause 20.8 of GCC in its entirety and replace with the following Sub-Clauses:</u> 20.8 Expiry of Dispute Board's Appointment: If a dispute arises between the Parties in connection with, or arising out of, the Contract or the execution of the Works and there is no DB in place, whether by reason of the expiry of the DB's appointment or otherwise: (a) Sub-Clause 20.4 [Obtaining Dispute Board's Decision] shall not apply, and the dispute may be referred directly to Conciliation under Sub-Clause 20.5 Conciliation.



CHENNAI METRO RAIL LIMITED

CHENNAI METRO RAIL PROJECT PHASE 1

TENDER NO. ARE05

**DESIGN, MANUFACTURE, SUPPLY, TESTING,
COMMISSIONING OF STANDARD GAUGE
METRO ROLLING STOCK (ELECTRICAL
MULTIPLE UNITS) AND DEPOT MACHINERY &
PLANT AND TRAINING OF PERSONNEL.**

**PART 3: CONDITIONS OF CONTRACT AND
CONTRACT FORMS**

**SECTION – IX : ANNEX TO PARTICULAR
CONDITIONS - CONTRACT FORMS**

~~NOV 2025~~ APR 2026 JUN 2026

1. Letter of Acceptance

[insert letterhead paper of the Employer]

[insert date]

To: *[insert name and address of the Contractor]*

Kind Attention: *[Contractor's Representative Name and Designation]*

Dear Sir/ Madam,

Subject: Tender No. CMRL / SYS / PHASE 1 / SYS / ARE05 / 2025: "DESIGN, MANUFACTURE, SUPPLY, TESTING, COMMISSIONING OF STANDARD GAUGE METRO ROLLING STOCK (ELECTRICAL MULTIPLE UNITS) AND DEPOT MACHINERY & PLANT AND TRAINING OF PERSONNEL' – LETTER OF ACCEPTANCE.

Reference: *[insert reference]*

1. With reference to the above, we are pleased to inform you that the tender for works of "DESIGN, MANUFACTURE, SUPPLY, TESTING, COMMISSIONING OF STANDARD GAUGE METRO ROLLING STOCK (ELECTRICAL MULTIPLE UNITS) AND DEPOT MACHINERY & PLANT AND TRAINING OF PERSONNEL (28 TRAINSETS OF 6-CAR EACH) AND DEPOT MACHINERY & PLANT INCLUDING SUPPLY OF SPARE PARTS AND DEFECT LIABILITY" has been evaluated and your offer has been accepted by Chennai Metro Rail Limited for a price of INR *[insert INR in numbers]* (*[insert Indian Rupees in words]*) and FC1 *[insert FC1 in numbers]* (*[insert Foreign currency 1 in words]*) and FC2 *[insert FC2 in numbers]* (*[insert Foreign currency 2 in words]*) which is inclusive of all taxes, duties, levies etc. for a fully compliant tender as per tender document.
2. The taxes and duties will be reimbursed by the Employer (CMRL) on production of proof of payment/liability as per the conditions mentioned under Part 1, Section IV - Para 4.3 of the Tender document.
3. You shall ensure full compliance with the relevant tax laws with regard to this contract and shall be solely responsible for the same. You shall keep the Employer fully indemnified against your liability of tax, duties, levies, interest, and penalty etc. whichever may arise.
4. The Contractor is reminded that the submitted 'Certificate confirming no deviation from tender conditions' supersedes the bid; to the extent that all tender conditions (throughout Parts 1, 2 & 3 of the bidding documents as well as all Addendums and/or Corrigendum) shall prevail.
5. Any conditions, assumptions, exclusion, suggestion of alternatives clauses, request of amendment in conditions & specifications of work submitted by you along with technical or financial bid and any other information which is different from the tender documents, corrigendum, addendum, reply to pre-bid queries uploaded by CMRL on the E-procurement portal, shall not be treated as a part of the Contract Agreement & shall not be binding upon CMRL in anyway whatsoever at any stage of work during execution or thereafter, unless specifically agreed to by CMRL in writing.
6. You are required to furnish the Performance Security @ 10% of the Accepted Contract Amount, i.e., INR *[insert INR in numbers]* (*[insert Indian Rupees in words]*) and FC1 *[insert FC1 in numbers]* (*[insert Foreign currency 1 in words]*) and FC2 *[insert FC2 in numbers]* (*[insert Foreign currency 2 in words]*) within twenty-eight (28) days after receiving this Letter of Acceptance in accordance with the Conditions of Contract (General Condition Clause 4.2 and Particular Condition Contract Data Sl. No. 13 and Specific Provisions Clause 4.2), using for that purpose one of the Performance Security Forms included in Section IX- Annex to Particular Conditions – Contract Forms, of the Bidding Documents. The Performance Security shall be valid as specified in General Condition of

Contract-Clause 4.2.

7. Please note that until a formal Contract Agreement is executed, this “**Letter of Acceptance**” along with the tender document and the accepted offer shall constitute a binding contract between *[insert name of the bidder]* and Chennai Metro Rail Limited (CMRL).
8. You are also informed that you have to sign the Contract Agreement within twenty-eight (28) days from the receipt of the Letter of Acceptance and return it to the Employer as per clause 43.2 of ITB of the Tender document.
9. Chief General Manager (RS, S&T), Chennai Metro Rail Limited will be the overall Engineer-In-Charge for the subject works. The Chief General Manager (RS, S&T) will be the Employer’s Representative for the subject works. You shall be suitably intimated, in case of any changes.
10. In accordance with the Clause PC SP Clause 8.1 (Commencement of Works) the date of commencement shall be 35 days from the date of this LoA. The time of completion shall be as specified in the tender document.
11. This “**Letter of Acceptance**” is sent in duplicate. You are requested to return one copy to the Employer duly acknowledged and signed by authorized signatory on all pages indicating ‘**Unconditional Acceptance**’ thereof, within one week of receipt of this letter.
12. Annexure to LOA : Post bid Clarifications (if applicable) sought from the successful Bidder.

Yours sincerely,

For, Chennai Metro Rail Limited

Authorized Signature

Name and Title of Signatory

Chennai Metro Rail Limited

Encl: This letter in duplicate

We, the undersigned hereby accept the Letter of Acceptance unconditionally,

Authorized Signature with date and stamp: _____

Name and Title of Signatory: _____

Name of the Bidder: *[insert name of the bidder]*

[Note: The above format is indicative only. CMRL reserves the right to modify.]

2. Contract Agreement

THIS AGREEMENT is made at Chennai on the *[insert day]* day of *[insert month]*, *[Insert year]*,
between

Chennai Metro Rail Limited, a company incorporated under the laws of India and having its registered office at CMRL METROS, No. 327, Anna Salai, Nandanam, Chennai – 600 035, Tamil Nadu, India (hereinafter “the Employer”), of the one part,

and

[insert name and registered address of the Contractor] (hereinafter “the Contractor”), of the other part:

WHEREAS the Employer desires that the Works known as Contract No. ARE-05 (e-Tender ID: *[Insert ID]*): **DESIGN, MANUFACTURE, SUPPLY, TESTING, COMMISSIONING OF STANDARD GAUGE METRO ROLLING STOCK (ELECTRICAL MULTIPLE UNITS) AND DEPOT MACHINERY & PLANT AND TRAINING OF PERSONNEL** under **Chennai Metro Rail Project Phase 1** should be executed by the Contractor, and has accepted a Bid by the Contractor for the execution and completion of these Works and the remedying of any defects therein,

The Employer and the Contractor agree as follows:

1. In this Agreement words and expressions shall have the same meanings as are respectively assigned to them in the Contract documents referred to.
2. The following documents shall be deemed to form and be read and construed as part of this Agreement. This Agreement along with Schedules shall prevail over all other Contract documents.
 - a) The Letter of Acceptance (LoA) vide CMRL letter No. *[insert Letter No.]* dated *[insert letter date]*.
 - b) Post bid clarification and responses.
 - c) Addendum / Corrigendum to Tender
 - d) Reply to Bidder Queries issued by the Employer / Engineer
 - e) the Particular Conditions – Part A (Contract Data)
 - f) the Particular Conditions – Part B (Specific Provisions)
 - g) the General Conditions
 - h) Not Used.
 - i) Employer’s Requirements – Technical Specifications
 - j) Pricing Document & Financial Bid
 - k) Letter of Technical Bid and Letter of Price Bid
 - l) Part 1: Bidding Procedures
 - m) The Contractor’s proposal and any other documents forming part of the Contract
3. In consideration of the payments to be made by the Employer to the Contractor as specified in this Agreement, the Contractor hereby covenants with the Employer to execute the Works and to remedy defects therein in conformity in all respects with the provisions of the Contract.
4. The Employer hereby covenants to pay the Contractor in consideration of the execution and completion of the Works and the remedying of defects therein, the Accepted Contract Amount of INR *[insert INR in numbers]* (*[insert Indian Rupees in words]*) and FC1 *[insert FC1 in numbers]*

([insert Foreign currency 1 in words]) and FC2 [insert FC2 in numbers] ([insert Foreign currency 2 in words]), being the sum stated in Letter of Acceptance vide CMRL letter No. [insert letter number] dated [insert letter date] or such other sum as may become payable under the provisions of the Contract at the times and in the manner prescribed by the Contract..

5. The Employer has received Performance Security in the form of BG vide BG.No. *[insert BG number]* dated *[insert BG dated]* for and amount of INR *[insert INR in numbers]* (*[insert Indian Rupees in words]*) and FC1 *[insert FC1 in numbers]* (*[insert Foreign currency 1 in words]*) and FC2 *[insert FC2 in numbers]* (*[insert Foreign currency 2 in words]*) valid up to *[insert validity date]* issued by *[insert bank name]* and duly confirmed by Bank.

IN WITNESS whereof the parties hereto have caused this Agreement to be executed in accordance with the laws of India on the day, month and year specified above.

Signed by

On behalf of the Employer

<Designation>

<Address>

Signed by

On behalf of the Contractor

<Designation>

<Address>

Stamp/seal of the Employer

for and on behalf of the Employer
in the presence of:

Stamp/seal of the Contractor

for and on behalf the Contractor in the
presence of:

____ <Name> ____
____ <Designation> ____
____ <Address> ____

____ <Name> ____
____ <Designation> ____
____ <Address> ____

[Note: The above format is indicative only. CMRL reserves the right to modify.]

3. Performance Security

Option 1: Demand Guarantee

[insert Guarantor letterhead or SWIFT identifier code]

Beneficiary: [insert name and Address of the Employer]

Date: [insert date of issue]

PERFORMANCE GUARANTEE No.: [insert guarantee reference number]

Guarantor: [insert name and address of place of issue, unless indicated in the letterhead]

We have been informed that [insert name of Contractor, which in the case of a joint venture shall be the name of the joint venture] (hereinafter called "the Applicant") has entered into Contract No. [insert reference number of the contract] dated [insert date] with the Beneficiary, for the execution of [insert name of the contract and brief description of the Works] (hereinafter called "the Contract").

Furthermore, we understand that, according to the conditions of the Contract, a performance guarantee is required.

At the request of the Applicant, we as Guarantor, hereby irrevocably undertake to pay the Beneficiary any sum or sums not exceeding in total an amount of [insert amount in figures]([insert amount in words]),¹ such sum being payable in the types and proportions of currencies in which the Contract Price is payable, upon receipt by us of the Beneficiary's complying demand supported by the Beneficiary's statement, whether in the demand itself or in a separate signed document accompanying or identifying the demand, stating that the Applicant is in breach of its obligation(s) under the Contract, without the Beneficiary needing to prove or to show grounds for its demand or the sum specified therein.

This guarantee shall expire and be returned to us, no later than the [insert the day] day of [insert month], [insert year]², and any demand for payment under it must be received by us at this office indicated above on or before that date.

This guarantee is subject to the Uniform Rules for Demand Guarantees (URDG) 2010 Revision, ICC Publication No. 758, except that the supporting statement under Article 15(a) is hereby excluded.

[signature(s)]

Note:

1. All italicized text (including footnotes) is for use in preparing this form and shall be deleted from the final product.

¹ The Guarantor shall insert an amount representing the percentage of the Accepted Contract Amount specified in the Letter of Acceptance and denominated either in the currency(cies) of the Contract or a freely convertible currency acceptable to the Beneficiary.

² Insert the date twenty-eight days after the expected completion date as described in GC Clause 11.9.

4. Advance Payment Security

Demand Guarantee

[insert Guarantor letterhead or SWIFT identifier code]

Beneficiary: *[insert name and address of the Employer]*

Date: *[insert date of issue]*

ADVANCE PAYMENT GUARANTEE No.: *[insert guarantee reference number]*

Guarantor: *[insert name and address of place of issue, unless indicated in the letterhead]*

We have been informed that *[insert name of Contractor, which in the case of a joint venture shall be the name of the joint venture]* (hereinafter called "the Applicant") has entered into Contract No. *[insert reference number of the contract]* dated *[insert date of the contract]* with the Beneficiary, for the execution of *[insert name of contract and brief description of Works]* (hereinafter called "the Contract").

Furthermore, we understand that, according to the conditions of the Contract, an advance payment in the sum *[insert amount in figures]* (*[insert amount in words]*) is to be made against an advance payment guarantee.

At the request of the Applicant, we as Guarantor, hereby irrevocably undertake to pay the Beneficiary any sum or sums not exceeding in total an amount of *[insert amount in figures]* (*[insert amount in words]*)¹ upon receipt by us of the Beneficiary's complying demand supported by the Beneficiary's statement, whether in the demand itself or in a separate signed document accompanying or identifying the demand, stating either that the Applicant:

- (a) has used the advance payment for purposes other than the costs of mobilization in respect of the Works; or
- (b) has failed to repay the advance payment in accordance with the Contract conditions, specifying the amount which the Applicant has failed to repay.

A demand under this guarantee may be presented as from the presentation to the Guarantor of a certificate from the Beneficiary's bank stating that the advance payment referred to above has been credited to the Applicant on its account number *[insert number]* at *[insert name and address of Applicant's bank]*.

The maximum amount of this guarantee shall be progressively reduced by the amount of the advance payment repaid by the Applicant as specified in copies of interim statements or payment certificates which shall be presented to us. This guarantee shall expire and be returned to us, at the latest, upon our receipt of a copy of the interim payment certificate indicating that ninety (90) percent of the Accepted Contract Amount, less provisional sums, has been certified for payment, or on the *[insert day]* day of *[insert month]*, *[insert year]*,² whichever is earlier. Consequently, any demand for payment under this guarantee must be received by us at this office on or before that date.

This guarantee is subject to the Uniform Rules for Demand Guarantees (URDG) 2010 Revision, ICC Publication No. 758, except that the supporting statement under Article 15(a) is hereby excluded.

[signature(s)]

[Note: All italicized text (including footnotes) is for use in preparing this form and shall be deleted from the final product.]

¹ The Guarantor shall insert an amount representing the amount of the advance payment and denominated either in the currency(ies) of the advance payment as specified in the Contract, or in a freely convertible currency acceptable to the Employer.

² Insert the expected expiration date of the Time for Completion.

5. Retention Money Security

Demand Guarantee

[insert Guarantor letterhead or SWIFT identifier code]

Beneficiary: [insert name and Address of Employer]

Date: [insert date of issue]

RETENTION MONEY GUARANTEE No.: [insert guarantee reference number]

Guarantor: [insert name and address of place of issue, unless indicated in the letterhead]

We have been informed that [insert name of Contractor, which in the case of a joint venture shall be the name of the joint venture] (hereinafter called "the Applicant") has entered into Contract No. [insert reference number of the contract] dated [insert date] with the Beneficiary, for the execution of [insert name of contract and brief description of Works] (hereinafter called "the Contract").

Furthermore, we understand that, according to Part 3 – Section VIII, Clause 44, SP 14.9 of Particular conditions of the Contract, the Beneficiary retains moneys up to the limit set forth in the Contract ("the Retention Money"), upon completion of Defect Notification Period of last train of base order or options vehicle, whichever is later, the Retention money amount or the Retention money Bank Guarantees shall be certified by the Engineer for releasing to the Contractor.

At the request of the Applicant, we, as Guarantor, hereby irrevocably undertake to pay the Beneficiary any sum or sums not exceeding in total an amount of [insert amount in figures] ([insert amount in words])¹ upon receipt by us of the Beneficiary's complying demand supported by the Beneficiary's statement, whether in the demand itself or in a separate signed document accompanying or identifying the demand, stating that the Applicant is in breach of its obligation(s) under the Contract, without the Beneficiary needing to prove or show grounds for its demand or the sum specified therein.

A demand under this guarantee may be presented as from the presentation to the Guarantor of a certificate from the Beneficiary's bank stating that the second half of the Retention Money as referred to above has been credited to the Applicant on its account number [insert account's number] at [insert name and address of Applicant's bank].

This guarantee shall expire and be returned to us no later than the [insert day] day of [insert month], [insert year]², and any demand for payment under it must be received by us at the office indicated above on or before that date.

This guarantee is subject to the Uniform Rules for Demand Guarantees (URDG) 2010 Revision, ICC Publication No. 758, except that the supporting statement under Article 15(a) is hereby excluded.

[signature(s)]

Note:

1. All italicized text (including footnotes) is for use in preparing this form and shall be deleted from the final product.

¹ The Guarantor shall insert an amount representing the amount of the second half of the Retention Money or if the amount guaranteed under the Performance Guarantee when the Taking-Over Certificate is issued is less than half of the Retention Money, the difference between half of the Retention Money and the amount guaranteed under the Performance Security and denominated either in the currency(ies) of the second half of the Retention Money as specified in the Contract, or in a freely convertible currency acceptable to the Beneficiary.

² Insert the same expiry date as set forth in the Performance Security, representing the date twenty-eight days after the completion date described in GC Clause 11.9.

6. Schedules

SCH 1 : Schedule of Prices

Note: Insert Schedule of Prices submitted with the Letter of (Price) Bid or uploaded in e-procurement portal and finalized, at signing of the Contract

SCH 2: Schedule of Payment

Note: Insert Schedule of payment included in Bidding Documents and finalized at signing of the Contract (if any).

SCH3: Schedule of Adjustment

Note: Insert Schedule of Adjustment data provided in “Part 1 – Section IV – Bidding Forms”.

SCH 4: Schedule of Guarantee

Not used.