

CP26 / ARE02A Contract (Addendum 02)					
S. No.	Part	Section	Clause No.	Original Bid Condition	Revised Bid Condition
1	Part 1	Section - IV (Bidding Forms)	4.3	All of Section 4.3	All of Section 4.3 is replaced by:- <u>Annexure (01) to ARE02A Addendum (02).</u> [Note: This also supersedes Annexure_01 to Addendum_01]
2	Part 1	Section - IV (Bidding Forms)	4.4.5 (Note iv)		<u>New foot note added (Note number iv):</u> Bidder is free to mention any number of trains under this category (subject to a maximum of 25% of the Order Quantity). In such scenario the Bidder shall not alter the number sequence or the Lot size of train delivery key dates.
3	Part 1	Section - IV (Bidding Forms)	4.4.12 4.4.17		Table in section 4.4.12 & 4.4.17 is replaced by:- <u>Annexure (03) to ARE02A Addendum (02).</u> <u>Note:</u> Revised eBOQ is uploaded in CPP portal
4	Part 1	Section - IV (Bidding Forms)	4.4.13	DM&P-Q15: Bogie Turn Table (Dia 3500mm); Qty : 5 Nos	DM&P-Q15: Bogie Turn Table (Dia 3500mm) ; Qty : 6 Nos
5	Part 1	Section - IV (Bidding Forms)	Form 5.16		Form 5.16 Form MAN: Manufacturers Authorization is replaced by:- <u>Annexure (04) to ARE02A Addendum (02).</u>
6	Part 1	Section - IV (Bidding Forms)	6.14 (New Form)	During the complete fleet operation conditions of this project, the trains may travel an average of 1,50,000 km per year at a minimum average operating speed of 32 kmph.	A new mandatory bidding form 6.14 Form – Subsidiary Company(s) has been added. Refer to:- <u>Annexure (02) to ARE02A Addendum 02.</u>
7	Part 2	Section - VI A (ERTS - RS)	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. a) Operating Schedule Speed : The minimum average Round-trip Operating Schedule Speed shall be 32 kmph. b) 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 32 kmph and shall meet the requirements defined in Clause 2.14.1.
8	Part 2	Section - VI A (ERTS - RS)	1.4.7 (New)		<u>New Clause 1.4.7 is added after 1.4.6:</u> 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. When the train is in UTO / ATO mode, the train will get appropriate commands from Signalling system.
9	Part 2	Section - VI A (ERTS - RS)	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 IP 65 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.	When fully mated, the connectors for internal use (i.e., fitted within the car body) shall achieve a seal rated to at least IP 53 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.

CP26 / ARE02A Contract (Addendum 02)					
S. No.	Part	Section	Clause No.	Original Bid Condition	Revised Bid Condition
10	Part 2	Section - VI A (ERTS - RS)	2.14.2.2	<p>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) with its parking brakes applied. 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.</p> <p>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 disembark. The healthy train shall thereafter be able to push the defective train (with its load now reduced to AW0, but with parking brakes still applied) as far as necessary to reach the Depot.</p> <p>The wheels of the train with parking brakes applied shall rotate without sliding under all operating conditions. The Contractor shall demonstrate that this requirement is met during main line type testing. Wheel temperatures shall be monitored during testing using thermocouples that are mounted on every wheel with parking brakes applied during the entire push-out operation.</p>	<p>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.</p> <p>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 disembark. 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.</p> <p>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-II network to the maintenance depot. The Contractor shall demonstrate that this can be accomplished this without exceeding any thermal limits.</p>
11	Part 2	Section - VI A (ERTS - RS)	2.14.3.7	<p>The parking brakes shall also be capable of holding a stationary rake in the Tare Loading Condition AW0 on the worst gradient of the Depot track (4%) in the worst wind conditions stated in Table 2-6. Under rescue conditions 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. The rake shall not move during the transition from emergency brake to parking brake or vice versa, when positioned on the worst track gradient.</p>	<p>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.</p>
12	Part 2	Section - VI A (ERTS - RS)	2.15.9.7	<p>The correction of slide shall act independently on each axle basis. The system shall be fully adaptive to varying adhesion conditions to maximize the use of the available adhesion level at every individual axle.</p>	<p>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. The overall blended brakes system shall be fully adaptive to optimise braking in varying adhesion conditions.</p>
13	Part 2	Section - VI A (ERTS - RS)	2.15.9.8	<p>If wheel spin is detected in any individual axle basis, the traction equipment shall reduce power to the concerned specific motor of the axle. When wheel spin is corrected in the individual axle, traction power shall be gradually increased to meet performance requirements per axle basis.</p>	<p>Wheel spin on any individual axle must always be detected. However, correction of wheel spin need only be applied at a whole bogie level. When wheel spin is corrected, traction power shall be gradually increased to meet performance requirements.</p>
14	Part 2	Section - VI A (ERTS - RS)	2.15.10.13	<p>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 a Normal Loading Condition (AW3) on that car.</p>	<p>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.</p>
15	Part 2	Section - VI A (ERTS - RS)	2.25.1	<p>The Contractor shall note that 'SPECIFIC ENERGY CONSUMPTION (SEC)' shall be verified in any one corridor of Phase 2 as agreed with CMRL under conditions detailed hereafter in this clause shall not exceed 48 Wh/GTKM (watt hours per gross tonne kilometre), referred to as SECs. The Contractor shall submit detailed simulation results for all corridors of Phase 2 in Pre-Final Design stage.</p>	<p>The Contractor shall note that 'SPECIFIC ENERGY CONSUMPTION (SEC)' shall be verified in any one corridor of Phase 2 (which can be selected by the Contractor) under the conditions detailed hereafter in this clause and 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 2 during the Pre-Final Design stage.</p>
16	Part 2	Section - VI A (ERTS - RS)	2.25.2	<p>This Specific Energy Consumption shall be total of two components viz. SEC for 3 car train (with VAC switched off) i.e. 'SECP' value and SEC of VAC for 3 car train i.e. 'SECH' value. These two values shall be declared by the Contractor (SECP-declared + SECH-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. SECdeclared for 3 car train as declared by the Contractor i.e. SECP-declared + SECH-declared shall not exceed the SECS i.e. 48 Wh/GTKM as mentioned above.</p>	<p>This Specific Energy Consumption shall be total of two components viz. SEC for 3 car train (with VAC switched off) i.e. 'SECP' value and SEC of VAC for 3 car train i.e. 'SECH' value. These two values shall be declared by the Contractor (SECP-declared + SECH-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. SECdeclared for 3 car train as declared by the Contractor i.e. SECP-declared + SECH-declared shall not exceed the SECS i.e. 50 Wh/GTKM as mentioned above.</p>
17	Part 2	Section - VI A (ERTS - RS)	2.25.4	<p>In the event of measured SEC exceeding 48 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 48 Wh/GTKM. In case the Contractor fails to achieve 48 Wh/GTKM, the Bank Guarantee related to Project Performance Security will be held.</p>	<p>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.</p>

CP26 / ARE02A Contract (Addendum 02)					
S. No.	Part	Section	Clause No.	Original Bid Condition	Revised Bid Condition
18	Part 2	Section - VI A (ERTS - RS)	2.25.10 a)	v) The train operation in Normal mode shall be in maximum acceleration and deceleration with no coasting till maximum speed is achieved and thereafter speed is maintained within 5 kmph below than the maximum speed. During braking, maximum regenerative braking shall be utilized to achieve the specified retardation rate from top speed till train stops and the Jerk rate shall be limited within the specified limit.	v) The Train operation under Normal mode as per the Guaranteed "Declared Schedule Speed (DSSP)" in Kmph for a round trip in Corridor 3, Corridor 4 & Corridor 5.
19	Part 2	Section - VI A (ERTS - RS)	3.2.4	Roof shrouding shall be designed in a manner that does not impede equipment function, drainage, or duty cycle, or cause premature degradation.	Deleted
20	Part 2	Section - VI A (ERTS - RS)	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 sealants life shall match with the 35-years of design life of the car body and 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.	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. <u>The life of the sealant shall be at least 12 years.</u> 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.
21	Part 2	Section - VI A (ERTS - RS)	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 15 years under the loading and environmental conditions identified in these Technical Provisions. Joints formed primarily with caulking or sealant shall not be used.	If a "plug-in" cab enclosure is used, the watertight seal between the main carbody and cab shell shall last for a minimum of <u>12 years</u> under the loading and environmental conditions identified in these Technical Provisions. Joints formed primarily with caulking or sealant shall not be used.
22	Part 2	Section - VI A (ERTS - RS)	3.9.6	All roof-mounted equipment shall be masked or covered by a continuous shroud that is consistent with the exterior colours and styling of the car. Shrouds shall be easily removable to enable access to roof-mounted equipment.	Deleted
23	Part 2	Section - VI A (ERTS - RS)	3.14.1.2	The Car structure shall be designed and constructed to withstand an extra crush load of standing passengers at 10 persons per m2 (650 kg/m2) / AW5 conditions.	The Car structure shall be designed and constructed to withstand AW5 conditions.
24	Part 2	Section - VI A (ERTS - RS)	5.2.16	The train operator's seat shall be cushioned, non-slippery, ergonomically designed using non-flammable materials and filling, and fully adjustable in the longitudinal and vertical directions. The seat shall be foldable and adequate measures shall be taken to ensure that it is opened only by the train operator.	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.
25	Part 2	Section - VI A (ERTS - RS)	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 tare to crush loadings.	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.
26	Part 2	Section - VI A (ERTS - RS)	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 a Crush Loading condition of Rake.	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.
27	Part 2	Section - VI A (ERTS - RS)	6.3.4	Seals shall be effective under all operating conditions from Tare Loading to Crush 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.	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.
28	Part 2	Section - VI A (ERTS - RS)	6.9.2	Each Detrainment Door shall offer the possibility of two (2) operating modes, either through a single hybrid design; or shall otherwise be reconfigurable by the installation and removal of door subsystem equipment at a maintenance depot.	Each Detrainment Door shall be a hybrid design, which offers the possibility of two (2) operating modes.

CP26 / ARE02A Contract (Addendum 02)					
S. No.	Part	Section	Clause No.	Original Bid Condition	Revised Bid Condition
29	Part 2	Section - VI A (ERTS - RS)	6.9.4	If the Contractor chooses to propose a non-hybrid design; thus requiring conversion of the operating mode to be performed by staff at a maintenance depot, then the design of the detrainment door must ensure that the conversion process requires minimal effort and can easily be accomplished by no greater than two (2) maintenance staff, in less than 6 hours. The conversion process shall be a simple to follow maintenance work instruction which does not call for the use of an overhead crane or other specialist lifting equipment.	<p>The hybrid design concept shall ensure that the same door is able to serve both operating modes; without the entire door assembly needing to be interchanged to convert the door between modes. However, a conversion process which involves interchange of the ramp (used for train-to-track evacuation mode) with a bridging plate (used for train-train evacuation mode) is acceptable.</p> <p>Such conversion process shall be undertaken at depot under the guidance of an easy to follow maintenance work instruction. It must be easy to accomplish by no greater than two (2) maintenance staff, in less than four (4) hours.</p>
30	Part 2	Section - VI A (ERTS - RS)	6.9.10	The Contractor shall ensure that the detrainment door should not jam in the event of a train collision.	Deleted
31	Part 2	Section - VI A (ERTS - RS)	6.9.12	The detrainment ramp shall have full length longitudinal handrail and fluorescent material marking on both sides of passenger egress direction. The ramp shall be designed for load of 500 kg/m2 or more and it shall not sag during the evacuation process. The ramp angle shall not be more than 16.5 degrees. The ramp shall also be suitably supported to ensure there is no tilting on straight or curved sections of track.	The detrainment ramp shall have full length longitudinal handrail / guiding straps as well as fluorescent or photo luminescent material marking on both sides of passenger egress direction. The ramp shall be designed for load of 500 kg/m2 or more and it shall not excessively sag or have permanent deformation >1mm after loading . The ramp angle shall not be more than 17.5 degrees. The ramp shall also be suitably supported to ensure there is no tilting on straight or curved sections of track.
32	Part 2	Section - VI A (ERTS - RS)	6.9.17	The complete opening of the 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.	<p>The complete opening of the detrainment door (including deployment of ramps and/or bridging plates in each respective mode) shall be possible by an untrained passenger in under one (1) minute.</p> <p>The Contractor shall propose a suitable type test procedure to demonstrate compliance with all requirements.</p> <p>Separately, an endurance test shall also be performed to demonstrate 200 open/close cycles of operation.</p>
33	Part 2	Section - VI A (ERTS - RS)	6.9.18	During Train-to-Train mode of operation, the Detrainment Doors shall deploy a bridging plate to provide a safe walkway to the coupled train consist. It shall also be possible to deploy the door of the coupled train from its exterior so that passengers are able to safely evacuate to the coupled train, without requiring assistance from other persons inside of the coupled trainset.	<p>During Train-to-Train mode of operation, the bridging footplate and physical side barriers / straps (if required to mitigate risk of falls) shall deploy by a simple / mechanised action to avoid risk of passenger confusion.</p> <p>It shall also be possible to open the detrainment door of the coupled train from its exterior so that passengers are able to safely evacuate to the coupled train, without requiring assistance from other persons located inside of the coupled train consist.</p>
34	Part 2	Section - VI A (ERTS - RS)	6.9.27	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.	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 or EN 14752 .
35	Part 2	Section - VI A (ERTS - RS)	7.3.16	Temperature Distribution: Temperature difference among all points in the same horizontal and vertical planes spread over full car length shall be minimal. It shall conform to EN 14750 or any other equivalent standard. The Contractor shall submit a proposal for review by CMRL.	<p>Temperature Distribution: Temperature difference in horizontal and vertical planes spread over full car length shall be minimal.</p> <p>The instantaneous saloon interior temperature at 1.1m above car floor level shall be 25°C ± 2°C at any given time.</p> <p>The mean saloon interior temperature at 1.1m over (taken over a round-trip period) shall not exceed 25°C.</p> <p>The saloon interior area includes Gangway and Emergency Driver desk areas. The Contractor shall submit details during PFDR.</p>
36	Part 2	Section - VI A (ERTS - RS)	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 5 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.	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.
37	Part 2	Section - VI A (ERTS - RS)	7.6.4	Each VAC unit shall be sized for an additional 10% over the required capacity calculated for the design of the VAC System.	Deleted
38	Part 2	Section - VI A (ERTS - RS)	10.8.1	The main transformer shall have a service life of at least 35 years, demonstrable through design calculations to CMRL for approval.	<p>The Contractor shall (no later than Preliminary Design Stage) propose a suitable main transformer with a service life of at least 35 years.</p> <p>The submitted proposal shall be supported by calculations which demonstrate compliance with all applicable ERTS requirements for CMRL's review.</p>

CP26 / ARE02A Contract (Addendum 02)					
S. No.	Part	Section	Clause No.	Original Bid Condition	Revised Bid Condition
39	Part 2	Section - VI A (ERTS - RS)	10.8.2	The overall harmonic current levels viewed at the pantograph shall be according to clause 10.3.1. The KVA rating of the transformers shall be specified at a line voltage of 22.50 KV and shall be designed to deliver the power corresponding to the continuously rated traction motor currents, after accounting for the efficiency and the power factor of the traction motor, converter, inverter and auxiliary inverter.	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; without exceeding any thermal limits.
40	Part 2	Section - VI A (ERTS - RS)	10.8.8	The KVA rating of the main transformer shall be designed to meet the continuous power load as well as the additional power required for emergency operational condition(s). The additional load capacity shall not be less than 10% and the main transformer shall be rated to tolerate the full load for at least 30 minutes without exceeding any thermal limits.	Deleted
41	Part 2	Section - VI A (ERTS - RS)	10.16.8	The HV and Propulsion system of the 3-car train shall be able to rescue another 6-car AW4 passenger loaded train in the CMRL Phase 2 alignment including gradients and curves. Refer Appendix D for alignment data.	Deleted
42	Part 2	Section - VI A (ERTS - RS)	11.4.2	Elastomeric springs are preferred by CMRL and shall have a minimum creep. 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.	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.
43	Part 2	Section - VI A (ERTS - RS)	11.4.10 (a)	The primary suspension shall consist of elastomeric elements, such as chevrons or conical rubber springs.	The primary suspension shall consist of Helical springs or Elastomeric springs.
44	Part 2	Section - VI A (ERTS - RS)	11.4.10 (b)	Elastomeric primary suspension system designs shall include creep adjustment provisions that require minimal bogie disassembly and can be accomplished with standard rail car maintenance equipment.	Primary suspension system designs shall include creep adjustment provisions that require minimal bogie disassembly and can be accomplished with standard rail car maintenance equipment.
45	Part 2	Section - VI A (ERTS - RS)	11.4.10 (e)	The service life of rubber bonded metal components / rubber of spring type primary suspension shall be not less than 12 years and shall be warranted for the same.	The Helical springs shall be designed for the lifetime of train / carbody. Helical springs shall be designed and tested as per EN 13298 and EN 13906. The service life of rubber bonded metal components / rubber of spring type primary suspension shall be not less than 12 years. The Contractor shall ensure that the chosen supplier provides a warranty for the same.
46	Part 2	Section - VI A (ERTS - RS)	11.4.10 (f) (New)		<u>New Clause (f) is added after 11.4.10(e):</u> 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.
47	Part 2	Section - VI A (ERTS - RS)	11.4.11 (e)	Quality of dampers used shall be very high and guaranteed against any oil leakage / oozing	Deleted
48	Part 2	Section - VI A (ERTS - RS)	11.4.15	Motion Damping Vertical and horizontal non-adjustable damping devices, including the orifice of the air spring, shall be provided on each bogie. The characteristics of the dampers shall be optimized to function with the primary and secondary suspension such that the ride quality specified in clause .2.13.4 is achieved throughout the life of the damper. Dampers shall be readily accessible for replacement.	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.

CP26 / ARE02A Contract (Addendum 02)					
S. No.	Part	Section	Clause No.	Original Bid Condition	Revised Bid Condition
49	Part 2	Section - VI A (ERTS - RS)	11.12.1	At both the outer ends of the Driving Motor Car, an obstruction deflection & detection device shall be installed to detect the obstacles and push away obstacles on track to avoid derailment. At the front of the cab car at both ends of the train, an obstacle detection device shall be installed. The obstacle detection device shall detect obstacles in front of the train at the earliest point practicable within emergency braking distance. The detection of obstacle shall initiate the emergency brake. Detection of an obstacle shall be reported to the OCC as an emergency message and shall be recorded by the TCMS.	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.
50	Part 2	Section - VI A (ERTS - RS)	11.12.2	All wheels of bogies shall have derailment detection device	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.
51	Part 2	Section - VI A (ERTS - RS)	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 the Crush Loading condition. The rake shall be deemed to then accelerate at its maximum rate up to maximum speed after each stop.	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.
52	Part 2	Section - VI A (ERTS - RS)	13.7.1.14.2	Each DRMD unit shall be a single display screen with a stretched aspect ratio. The minimum dimensions shall be 965mm x 183mm. The use of multiple screens joined together shall not be accepted.	Each DRMD unit shall be a single display screen with a stretched aspect ratio. The minimum screen size shall be at least 48" corner to corner. The use of multiple screens joined together shall not be accepted.
53	Part 2	Section - VI A (ERTS - RS)	13.7.1.14.11	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 destination in Tamil & English language along with other graphic. The display location and specification shall be submitted for CMRL approval.	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 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.
54	Part 2	Section - VI A (ERTS - RS)	13.7.1.16.1	6 no's of LCD with LED backlit displays or any latest better technology displays of size not less than 65 cm x 40 cm shall be provided inside each coach at an appropriate location. The display location and specification shall be submitted for CMRL approval.	6 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.
55	Part 2	Section - VI A (ERTS - RS)	13.10.12	Each PEI device shall be equipped with one miniature temper proof camera including microphones, loud-speakers and alarm button. Additionally, the CCTV's of the car shall also focus the specific PEI area shall be automatically selected and displayed in OCC, BCC, DCC and in TCMS.	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 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 in OCC, BCC, DCC and on TCMS screens.
56	Part 2	Section - VI A (ERTS - RS)	15.12.6	b. Source code of the software being used in CMRL trains.	Deleted
57	Part 2	Section - VI A (ERTS - RS)	15.16.5 (f)	Modification in the software to extend or modify the control and monitoring functions.	Deleted
58	Part 2	Section - VI A (ERTS - RS)	16.13.12.2 (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; the second level of software documentation is one level above source code.	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.
59	Part 2	Section - VI A (ERTS - RS)	17.1.10 (New)		<u>New Clause 17.1.10 to be added after 17.1.9:</u> In case of any change in the place of manufacture (either trainsets or major subsystems) then related type tests shall be repeated.
60	Part 2	Section - VI A (ERTS - RS)	17.9.12 (New)		<u>New Clause 17.9.12 to be added after 17.9.11 :</u> Any Integrated Testing related to Multi-consist (regardless of whether it is a Type or Routine Systems Integration Test) that is required to be undertaken (or existing test cases need to be retested) in order to verify the safe running of trainsets in 6-car Multi-Consist Mode shall be performed by the Contractor upon request by CMRL. Tests may be conducted at anytime within the Project Period (as decided by CMRL); at no additional cost to CMRL.
61	Part 2	Section - VI A (ERTS - RS)	18.6.6	All of section 18.6.6	All of Section 18.6.6 is replaced by:- <u>Annexure (05) to ARE02A Addendum (02).</u>

CP26 / ARE02A Contract (Addendum 02)					
S. No.	Part	Section	Clause No.	Original Bid Condition	Revised Bid Condition
62	Part 2	Section - VI A (ERTS - RS)	20.6.5.1 (ii)	The software design shall allow for further input/output dialogues, peripheral equipment and controlling equipment to be added. This shall be provided by mechanisms that ensure that the source code and internal data structure do not need modifying.	The software design shall allow for further input/output dialogues, peripheral equipment and controlling equipment to be added.
63	Part 2	Section - VI A (ERTS - RS)	20.6.5.4 (v)	b) Deliver all source code and supporting 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. Alternatively, the Contractor shall deposit the Source codes with any agent as may be nominated by the Contractor and CMRL mutually. The rights, obligations and liabilities etc of CMRL, Contractor and Agency, manner for addressing and communicating with Agency shall be mutually agreed by the Contractor and CMRL on or before the contract execution.	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.
64	Part 2	Section - VI A (ERTS - RS)	20.6.5.4 (vi)	f) All software source code shall be delivered along with its Supporting Documentation.	Deleted
65	Part 2	Section - VI A (ERTS - RS)	20.7 (xv)	Software Source Code and Supporting Documentation	Supporting Documentation
66	Part 2	Section - VI A (ERTS - RS)	Appendix C - Interfaces 2.5.15 (New)		<p><u>New Clause 2.5.15 to be added after 2.5.14 :</u></p> <p>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.</p>
67	Part 2	Section - VI A (ERTS - RS)	Appendix D D1 & D1.1		<p>All of Section Appendix D (D1 & D1.1) is replaced by:-</p> <p><u>Annexure (07) to ARE02A Addendum (02).</u></p>
68	Part 2	Section - VI A (ERTS - RS)	Appendix H Chapter 20 Sl. No. 10	FDR-20-4 : Software Source Code (For All Subsystems from OEM)	FDR-20-4 : Final Approved Software (For All Subsystems from OEM)
69	Part 2	Section - VI B (ERTS - DM&P)	Chapter 1 : Table 1-1	DM&P-Q15: Bogie Turn Table ; Qty : 5 Nos	DM&P-Q15: Bogie Turn Table ; Qty : 6 Nos
70	Part 2	Section - VI B (ERTS - DM&P)	Whole of Chapter-2		<p>The whole of Part-2 Section VIB ERTS DM&P Chapter-2 is replaced by Annexure-8.</p> <p>This change is to rectify clause numbering which should have been preceded by 2. to reflect the chapter number.</p> <p>Other changes to the same Chapter which are applied through Addendum 01 and Addendum 02 are also included and are marked accordingly.</p>
71	Not Used				
72	Not Used				
73	Not Used				
74	Not Used				
75	Not Used				
76	Not Used				
77	Part 2	Section - VI B (ERTS - DM&P)	Chapter 3 : Clause 3.30.19 (New)		<p><u>New Clause 3.30.19 is added to the Section on CMV :</u></p> <p>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 CMV Contractor for installation, testing and commissioning.</p> <p>Refer the Annexure 6 to ARE02A Addendum (02) for the Interface specification between DM&P (CMV) Contractor and Telecom & Radio (RAD) Contractor.</p>

CP26 / ARE02A Contract (Addendum 02)					
S. No.	Part	Section	Clause No.	Original Bid Condition	Revised Bid Condition
78	Part 2	Section - VI C (ERTS - CMC)	1.1.19 (New)		<p><u>New Clause 1.1.19 is added after 1.1.18 :</u></p> <p>Where it is the case that a DLP / DNP extension had arisen on account of non-fulfilment of the Reliability Demonstration Targets for Rolling Stock (as defined in Part 2, Section VI A, ERTS-RS clause 18.6) then the penalty regime detailed in Clause numbers 1.16 & 3.3 shall not come in to force until DLP / DNP period of extension ends. This provision is made to ensure that the Contractor is not exposed to double penalties.</p>
79	Part 2	Section - VI C (ERTS - CMC)	2.4.1 iii) c)	A Minimum of 25% maintenance staff and supervisor of the Contractor shall be transferred to CMRL payroll after expiry of Comprehensive maintenance contract to ensure continuity and quality of maintenance of the train till alternative arrangements are made by CMRL. The selection procedure shall be finalized jointly by CMRL and Rolling stock Contractor.	To safeguard its succession plan for maintenance; CMRL reserves the right to offer of employment to any of the Contractor's maintenance workforce (regardless of their level of seniority) prior to cessation of the CMC Period. The Contractor shall not impede CMRL's selection process or object to the transfer of any staff willing to join CMRL and/or Subcontracted organisation.
80	Part 3	Section VIII PCC (Part B)	Sl. No. 7	<p><u>Add a new Sub-Clause 1.1.3.13:</u></p> <p>"Comprehensive Maintenance Contract (CMC) Period" or "CMC Period" defines the period during which the Contractor shall be responsible for undertaking comprehensive maintenance of Rolling Stock and Depot Machinery & Plant. The requirements are described in Part 2 – VI C ERTS - CMC.</p> <p>It is clarified that DLP / DNP extensions arising only at a System / Sub-system level (as mentioned in PCC No. 42 and defined by ERTS-RS Clause 18.6) shall not delay commencement of the CMC Period.</p>	<p><u>Add a new Sub-Clause 1.1.3.13:</u></p> <p>"Comprehensive Maintenance Contract (CMC) Period" or "CMC Period" defines the period during which the Contractor shall be responsible for undertaking comprehensive maintenance of Rolling Stock and Depot Machinery & Plant.</p> <p>Commencement of the CMC Period is defined in Part-3 Section VIII PCC (Part B) SI No. 26.</p> <p>Requirements during the CMC Period are described in Part 2 – VI C ERTS - CMC.</p> <p>Any extension of DLP / DNP beyond the start of the CMC Period will result in the following consequences:-</p> <p><u>Only For Rolling Stock:-</u></p> <p>There shall be no delay in the start of the CMC Period, however, if the DLP / DNP extension arose on account of non-fulfilment of the Reliability Demonstration targets for Rolling Stock (as defined in Part 2, Section VI A, ERTS-RS clause 18.6) then payments made against RS-CMC Price Centres shall be reduced by 65%.</p> <p>This notional price reduction is to offset costs for the portion of CMC Works that are Corrective Maintenance in nature and would otherwise have been undertaken by the Contractor through an extension of the Warranty Period. The price reduction shall prevail until such time that the DLP / DNP extension for Rolling Stock ends.</p>
81	Part 3	Section VIII PCC (Part B)	Sl. No. 26	<p><u>4.25.1 CMC - Rolling Stock:</u></p> <p>The Contractor is required to carry out 15 years Comprehensive Maintenance Contract (CMC) for Rolling Stock which shall commence after the DLP/ DNP or extended DLP/ DNP is completed for all the trainsets (Base order) and shall end after 15 years from start. The Contractor shall provide key maintenance staff as per qualification and experience detailed under Part 2, Section VI C ERTS (CMC). Upon expiry of CMC, the Contractor shall handover all equipment under this Contract in a working condition to the Employer. The procedures for handing over shall be as stated in Part 2, Section VI C ERTS (CMC).</p>	<p><u>4.25.1 CMC - Rolling Stock:</u></p> <p>The Contractor is required to carry out 15 years Comprehensive Maintenance Contract (CMC) for Rolling Stock which shall commence <u>2 years after the TOC date of 70th Trainset</u> and shall end after 15 years from start. The Contractor shall provide key maintenance staff as per qualification and experience detailed under Part 2, Section VI C ERTS (CMC). Upon expiry of CMC, the Contractor shall handover all equipment under this Contract in a working condition to the Employer. The procedures for handing over shall be as stated in Part 2, Section VI C ERTS (CMC).</p>
82	Part 3	Section VIII PCC (Part B)	Sl. No. 42	RS-CMC' shall be reckoned from the date of completion of DLP/ DNP of Rolling Stock (Train level). 'DM&P-CMC' shall be reckoned from the date of completion of DLP / DNP of last Depot Machinery & Plant.	DM&P-CMC' shall be reckoned from the date of completion of DLP / DNP of last Depot Machinery & Plant.
83	Part 1	Section - IV (Bidding Forms)	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.	<p>Whenever the Bidder comprises of a Single Entity / JV Bidder, Payment will be made only to the Bank Account of the Single Entity / JV.</p> <p>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.</p> <p>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.</p>

CP26 / ARE02A Contract (Addendum 02)					
S. No.	Part	Section	Clause No.	Original Bid Condition	Revised Bid Condition
84	Part 2	Section - VI A (ERTS - RS)	2.25.10 (b) (vi)	Loading Condition: Heat load of AW3 numbers of persons as per EN 14750-1, throughout the round trip including the terminal turnaround time.	Loading Condition: Heat load of AW4 numbers of persons as per EN 14750-1, throughout the round trip including the terminal turnaround time.
85	Part 2	Section - VI A (ERTS - RS)	2.25.11 (b) (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.	Doors shall be opened and closed as detailed for a round trip and passenger load throughout the Round Trip (including terminal detention) shall be AW4 .
86	Part 2	Section - VI A (ERTS - RS)	9.6.4	The Contractor shall propose battery of NiCad, Lithium Based, SCiB 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 equivalent.	The Contractor shall propose battery of NiCad, Lithium Based, SCiB 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.
87	Part 2	Section - VI A (ERTS - RS)	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 – Clause 20.	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.
88	Part 2	Section - VI A (ERTS - RS)	16.4.11 (New)		<p><u>New Clause 16.4.11 is added after Clause 16.4.10 :-</u></p> <p>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.</p>
89	Part 2	Section - VI A (ERTS - RS)	2.29 (New)		<p><u>New Clause 2.29 is added after Clause 2.28 :-</u></p> <p>2.29 FLEET DESIGN FAMILIARITY AND CONSISTENCY 2.29.1 The Contractor shall ensure that interior aesthetics, configuration and colour schemes (including PIS Displays and Media) shall as far as reasonably practicable follow similar concepts to those that have already been adopted on earlier introduced Chennai Phase-II 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-II fleets.</p>
90	Part 2	Section - VI A (ERTS - RS)	10.11.21	<p>The Contractor shall hire reputed Power system analysis Design Consultant with the approval of CMRL and provision shall be made for arranging minimum three presentations by design Consultant to CMRL. The Role of the Power System analysis Design consultant is as below but not limited to,</p> <p><input type="checkbox"/> Power system Design Analysis shall be performed for all Corridors of Phase 2 considering (ARE02A contract 70 trains, ARE03A contract 26 trains & ARE04A contract 42 trains) 138 trains of 3 car configuration.</p> <p><input type="checkbox"/> Power system Design Analysis consultant along with Rolling Stock Contractor shall Interface with Railway Electrification, Power Supply Contractor to comply the Design requirements of CMRL Phase 2 project.</p> <p><input type="checkbox"/> The proposed consultant shall be an ISO certified having proven previous experience in Power System Analysis.</p>	<p>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.</p> <p>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.</p>

Annexure (1) to Addendum (02):

4.3 DETAILS OF TAXES / DUTIES / LEVIES ETC. INCLUDED IN THE LUMP SUM PRICE (PRICE CENTRE WISE)

DETAILS ARE TO BE FILLED AND UPLOADED THROUGH THE E-PROCUREMENT PORTAL AS PART OF THE PRICE BID DOCUMENT. PRICING INFORMATION MUST NOT BE SUBMITTED WITHIN THE TECHNICAL BID.

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 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
RS-A	NOT APPLICABLE														
RS-CST															
RS-FAI															
RS-CPT															
RS-B															
RS-C															
RS-D	NOT APPLICABLE														
RS-E															
RS-F															
RS-H															
RS-CMC															
DM&P-Q															
DM&P-R															
DM&P-S															
DM&P-T															
DM&P-CMC															
Total															

Note : Bidder Shall Specify the values in the above table (Details of taxes/duties/levies etc.,) in INR only.

Table 4.3.2: Overview of Contract Price

DETAILS ARE TO BE FILLED AND UPLOADED THROUGH THE E-PROCUREMENT PORTAL AS PART OF THE PRICE BID DOCUMENT. PRICING INFORMATION MUST NOT BE SUBMITTED WITHIN THE TECHNICAL BID.

Price Centre	Contract Price without taxes & duties			Customs duty	GST	Any other taxes/duties	Contract Price with taxes & duties		
	INR	JPY	FC	INR	INR	INR	INR	JPY	FC
RS-A				NOT APPLICABLE					
RS-CST									
RS-FAI									
RS-CPT									
RS-B									
RS-C									
RS-D				NOT APPLICABLE					
RS-E									
RS-F									
RS-H									
RS-CMC									
DM&P-Q									
DM&P-R									
DM&P-S									
DM&P-T									
DM&P-CMC									
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 and for CMC Price Centres.
- Customs Duty** is only applicable for Price Centres RS-B, RS-C, RS-CMC, DM&P-Q, DM&P-R, DM&P-S, DM&P-T and DM&P-CMC.
 - 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.
 - 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. Increases in Taxes / Duties / Levies incurred by the Contractor due to currency fluctuations (or for any currency hedging) are deemed to have been included in the Lumpsum Price. Ceiling limits shall not be adjusted on this account.
7. 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.
8. 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.
9. 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.

Annexure – 2 to Addendum (02)

6.14 Form SC – Subsidiary Company(s)

Bidders' seeking to qualify a Subsidiary Company as eligible to bid (as part of a **Joint Venture / Consortium** in accordance with Part-1, Section – V -Eligible Source Countries) shall fill out the following form:-

Contract No	CP26 / ARE02A
Name of the Bidder	
Name of Subsidiary Company *	
Name of Subsidiary's Parent Company	
% of ownership held by the Parent Company	
Nation where Subsidiary Company is incorporated	
Nationality of ESC Qualifying Parent Company (E.g, Japan / OECD member nation)	
<u>Evidence list for Subsidiary company:</u> <ul style="list-style-type: none">• Annual Report (last Financial 5 years)• Share Holding Pattern• Board of Directors (certified by Company Secretary)• RBI Approved document copy of FCGPR / FIPB.• Any other documents	<u>List of Documents enclosed:</u>

* In case of more than one (1) Subsidiary Company, a separate form shall be filled for each member

Annexure (3) to Addendum (02):

4.4.12 PRICE CENTRE 'RS-CMC' – Comprehensive Maintenance Contract of Rolling Stock for 15 years

This Price Centre comprises of all requirements / activities associated with ERTS – CMC

DETAILS ARE TO BE FILLED AND UPLOADED THROUGH THE E-PROCUREMENT PORTAL AS PART OF THE PRICE BID DOCUMENT. PRICING INFORMATION MUST NOT BE SUBMITTED WITHIN THE TECHNICAL BID.

MILESTONE NUMBER	WORK DESCRIPTION	APPORTIONED AMOUNT		AppORTIONED AMOUNT
	MILESTONE ACTIVITY	INR COLUMN A	JPY COLUMN B	
Obtain the “No Objection With Comments (NOWC) or Notice of No Objection (NONO)” from the Employer / Engineer for CMC Works:				
RS-CMC1-1	AppORTIONED amount for 70 trainset : 1 st Year (Quarter 1)			0.30%
RS-CMC1-2	AppORTIONED amount for 70 trainset : 1 st Year (Quarter 2)			0.30%
RS-CMC1-3	AppORTIONED amount for 70 trainset : 1 st Year (Quarter 3)			0.30%
RS-CMC1-4	AppORTIONED amount for 70 trainset : 1 st Year (Quarter 4)			0.30%
RS-CMC2-1	AppORTIONED amount for 70 trainset : 2 nd Year (Quarter 1)			0.30%
RS-CMC2-2	AppORTIONED amount for 70 trainset : 2 nd Year (Quarter 2)			0.30%
RS-CMC2-3	AppORTIONED amount for 70 trainset : 2 nd Year (Quarter 3)			0.30%
RS-CMC2-4	AppORTIONED amount for 70 trainset : 2 nd Year (Quarter 4)			0.30%
RS-CMC3-1	AppORTIONED amount for 70 trainset : 3 rd Year (Quarter 1)			0.30%
RS-CMC3-2	AppORTIONED amount for 70 trainset : 3 rd Year (Quarter 2)			0.30%
RS-CMC3-3	AppORTIONED amount for 70 trainset : 3 rd Year (Quarter 3)			0.30%
RS-CMC3-4	AppORTIONED amount for 70 trainset : 3 rd Year (Quarter 4)			0.30%
RS-CMC4-1	AppORTIONED amount for 70 trainset : 4 th Year (Quarter 1)			0.30%
RS-CMC4-2	AppORTIONED amount for 70 trainset : 4 th Year (Quarter 2)			0.38%
RS-CMC4-3	AppORTIONED amount for 70 trainset : 4 th Year (Quarter 3)			0.38%
RS-CMC4-4	AppORTIONED amount for 70 trainset : 4 th Year (Quarter 4)			0.38%
RS-CMC5-1	AppORTIONED amount for 70 trainset : 5 th Year (Quarter 1)			0.38%
RS-CMC5-2	AppORTIONED amount for 70 trainset : 5 th Year (Quarter 2)			0.38%
RS-CMC5-3	AppORTIONED amount for 70 trainset : 5 th Year (Quarter 3)			0.38%
RS-CMC5-4	AppORTIONED amount for 70 trainset : 5 th Year (Quarter 4)			0.38%
RS-CMC6-1	AppORTIONED amount for 70 trainset : 6 th Year (Quarter 1)			0.38%
RS-CMC6-2	AppORTIONED amount for 70 trainset : 6 th Year (Quarter 2)			0.38%

MILESTONE NUMBER	WORK DESCRIPTION	APPORTIONED AMOUNT		AppORTIONED AMOUNT
	MILESTONE ACTIVITY	INR COLUMN A	JPY COLUMN B	
Obtain the “No Objection With Comments (NOWC) or Notice of No Objection (NONO)” from the Employer / Engineer for CMC Works:				
RS-CMC6-3	AppORTIONED amount for 70 trainset : 6 th Year (Quarter 3)			0.38%
RS-CMC6-4	AppORTIONED amount for 70 trainset : 6 th Year (Quarter 4)			0.38%
RS-CMC7-1	AppORTIONED amount for 70 trainset : 7 th Year (Quarter 1)			0.38%
RS-CMC7-2	AppORTIONED amount for 70 trainset : 7 th Year (Quarter 2)			0.38%
RS-CMC7-3	AppORTIONED amount for 70 trainset : 7 th Year (Quarter 3)			0.38%
RS-CMC7-4	AppORTIONED amount for 70 trainset : 7 th Year (Quarter 4)			0.38%
RS-CMC8-1	AppORTIONED amount for 70 trainset : 8 th Year (Quarter 1)			0.45%
RS-CMC8-2	AppORTIONED amount for 70 trainset : 8 th Year (Quarter 2)			0.45%
RS-CMC8-3	AppORTIONED amount for 70 trainset : 8 th Year (Quarter 3)			0.45%
RS-CMC8-4	AppORTIONED amount for 70 trainset : 8 th Year (Quarter 4)			0.45%
RS-CMC9-1	AppORTIONED amount for 70 trainset : 9 th Year (Quarter 1)			0.45%
RS-CMC9-2	AppORTIONED amount for 70 trainset : 9 th Year (Quarter 2)			0.45%
RS-CMC9-3	AppORTIONED amount for 70 trainset : 9 th Year (Quarter 3)			0.45%
RS-CMC9-4	AppORTIONED amount for 70 trainset : 9 th Year (Quarter 4)			0.45%
RS-CMC10-1	AppORTIONED amount for 70 trainset : 10 th Year (Quarter 1)			0.60%
RS-CMC10-2	AppORTIONED amount for 70 trainset : 10 th Year (Quarter 2)			0.60%
RS-CMC10-3	AppORTIONED amount for 70 trainset : 10 th Year (Quarter 3)			0.60%
RS-CMC10-4	AppORTIONED amount for 70 trainset : 10 th Year (Quarter 4)			0.60%
RS-CMC11-1	AppORTIONED amount for 70 trainset : 11 th Year (Quarter 1)			0.60%
RS-CMC11-2	AppORTIONED amount for 70 trainset : 11 th Year (Quarter 2)			0.60%
RS-CMC11-3	AppORTIONED amount for 70 trainset : 11 th Year (Quarter 3)			0.60%
RS-CMC11-4	AppORTIONED amount for 70 trainset : 11 th Year (Quarter 4)			0.60%
RS-CMC12-1	AppORTIONED amount for 70 trainset : 12 th Year (Quarter 1)			0.60%
RS-CMC12-2	AppORTIONED amount for 70 trainset : 12 th Year (Quarter 2)			0.60%
RS-CMC12-3	AppORTIONED amount for 70 trainset : 12 th Year (Quarter 3)			0.60%
RS-CMC12-4	AppORTIONED amount for 70 trainset : 12 th Year (Quarter 4)			0.60%
RS-CMC13-1	AppORTIONED amount for 70 trainset : 13 th Year (Quarter 1)			0.75%
RS-CMC13-2	AppORTIONED amount for 70 trainset : 13 th Year (Quarter 2)			0.75%
RS-CMC13-3	AppORTIONED amount for 70 trainset : 13 th Year (Quarter 3)			0.75%

MILESTONE NUMBER	WORK DESCRIPTION	APPORTIONED AMOUNT		AppORTIONED AMOUNT
	MILESTONE ACTIVITY	INR COLUMN A	JPY COLUMN B	
Obtain the “No Objection With Comments (NOWC) or Notice of No Objection (NONO)” from the Employer / Engineer for CMC Works:				
RS-CMC13-4	AppORTIONED amount for 70 trainset : 13 th Year (Quarter 4)			0.75%
RS-CMC14-1	AppORTIONED amount for 70 trainset : 14 th Year (Quarter 1)			0.75%
RS-CMC14-2	AppORTIONED amount for 70 trainset : 14 th Year (Quarter 2)			0.75%
RS-CMC14-3	AppORTIONED amount for 70 trainset : 14 th Year (Quarter 3)			0.75%
RS-CMC14-4	AppORTIONED amount for 70 trainset : 14 th Year (Quarter 4)			0.75%
RS-CMC15-1	AppORTIONED amount for 70 trainset : 15 th Year (Quarter 1)			0.90%
RS-CMC15-2	AppORTIONED amount for 70 trainset : 15 th Year (Quarter 2)			0.90%
RS-CMC15-3	AppORTIONED amount for 70 trainset : 15 th Year (Quarter 3)			0.90%
RS-CMC15-4	AppORTIONED amount for 70 trainset : 15 th Year (Quarter 4)			0.90%
RS-CMC : Price Centre Total				30%
15 years CMC cost for 70 Trainsets of 3 Car configuration				

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

4.4.17 PRICE CENTRE ‘DM&P-CMC’ – Comprehensive Maintenance of Depot Machinery & Plant for 15 years

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

DETAILS ARE TO BE FILLED AND UPLOADED THROUGH THE E-PROCUREMENT PORTAL AS PART OF THE PRICE BID DOCUMENT. PRICING INFORMATION MUST NOT BE SUBMITTED WITHIN THE TECHNICAL BID.

	WORK DESCRIPTION	AppORTIONED AMOUNT		AppORTIONED AMOUNT
MILESTONE NUMBER	MILESTONE ACTIVITY	INR COLUMN A	JPY COLUMN B	
Obtain the “No Objection With Comments (NOWC) or Notice of No Objection (NONO)” from the Employer / Engineer for CMC Works:				
DM&P-CMC1-1	AppORTIONED amount for complete Depot Machinery & Plant : 1 st Year (Quarter 1)			1%
DM&P-CMC1-2	AppORTIONED amount for complete Depot Machinery & Plant : 1 st Year (Quarter 2)			1%
DM&P-CMC1-3	AppORTIONED amount for complete Depot Machinery & Plant : 1 st Year (Quarter 3)			1%
DM&P-CMC1-4	AppORTIONED amount for complete Depot Machinery & Plant : 1 st Year (Quarter 4)			1%
DM&P-CMC 2-1	AppORTIONED amount for complete Depot Machinery & Plant : 2 nd Year (Quarter 1)			1%
DM&P-CMC 2-2	AppORTIONED amount for complete Depot Machinery & Plant : 2 nd Year (Quarter 2)			1%

MILESTONE NUMBER	WORK DESCRIPTION MILESTONE ACTIVITY	Apportioned AMOUNT		Apportioned AMOUNT
		INR COLUMN A	JPY COLUMN B	
DM&P-CMC 2-3	Apportioned amount for complete Depot Machinery & Plant : 2 nd Year (Quarter 3)			1%
DM&P-CMC 2-4	Apportioned amount for complete Depot Machinery & Plant : 2 nd Year (Quarter 4)			1%
DM&P-CMC 3-1	Apportioned amount for complete Depot Machinery & Plant : 3 rd Year (Quarter 1)			1%
DM&P-CMC 3-2	Apportioned amount for complete Depot Machinery & Plant : 3 rd Year (Quarter 2)			1%
DM&P-CMC 3-3	Apportioned amount for complete Depot Machinery & Plant : 3 rd Year (Quarter 3)			1%
DM&P-CMC 3-4	Apportioned amount for complete Depot Machinery & Plant : 3 rd Year (Quarter 4)			1%
DM&P-CMC 4-1	Apportioned amount for complete Depot Machinery & Plant : 4 th Year (Quarter 1)			1.25%
DM&P-CMC 4-2	Apportioned amount for complete Depot Machinery & Plant : 4 th Year (Quarter 2)			1.25%
DM&P-CMC 4-3	Apportioned amount for complete Depot Machinery & Plant : 4 th Year (Quarter 3)			1.25%
DM&P-CMC 4-4	Apportioned amount for complete Depot Machinery & Plant : 4 th Year (Quarter 4)			1.25%
DM&P-CMC 5-1	Apportioned amount for complete Depot Machinery & Plant : 5 th Year (Quarter 1)			1.25%
DM&P-CMC 5-2	Apportioned amount for complete Depot Machinery & Plant : 5 th Year (Quarter 2)			1.25%
DM&P-CMC 5-3	Apportioned amount for complete Depot Machinery & Plant : 5 th Year (Quarter 3)			1.25%
DM&P-CMC 5-4	Apportioned amount for complete Depot Machinery & Plant : 5 th Year (Quarter 4)			1.25%
DM&P-CMC 6-1	Apportioned amount for complete Depot Machinery & Plant : 6 th Year (Quarter 1)			1.25%
DM&P-CMC 6-2	Apportioned amount for complete Depot Machinery & Plant : 6 th Year (Quarter 2)			1.25%
DM&P-CMC 6-3	Apportioned amount for complete Depot Machinery & Plant : 6 th Year (Quarter 3)			1.25%
DM&P-CMC 6-4	Apportioned amount for complete Depot Machinery & Plant : 6 th Year (Quarter 4)			1.25%
DM&P-CMC 7-1	Apportioned amount for complete Depot Machinery & Plant : 7 th Year (Quarter 1)			1.25%
DM&P-CMC 7-2	Apportioned amount for complete Depot Machinery & Plant : 7 th Year (Quarter 2)			1.25%
DM&P-CMC 7-3	Apportioned amount for complete Depot Machinery & Plant : 7 th Year (Quarter 3)			1.25%
DM&P-CMC 7-4	Apportioned amount for complete Depot Machinery & Plant : 7 th Year (Quarter 4)			1.25%
DM&P-CMC 8-1	Apportioned amount for complete Depot Machinery & Plant : 8 th Year (Quarter 1)			1.5%

MILESTONE NUMBER	WORK DESCRIPTION MILESTONE ACTIVITY	Apportioned AMOUNT		Apportioned AMOUNT
		INR COLUMN A	JPY COLUMN B	
DM&P-CMC 8-2	Apportioned amount for complete Depot Machinery & Plant : 8 th Year (Quarter 2)			1.5%
DM&P-CMC 8-3	Apportioned amount for complete Depot Machinery & Plant : 8 th Year (Quarter 3)			1.5%
DM&P-CMC 8-4	Apportioned amount for complete Depot Machinery & Plant : 8 th Year (Quarter 4)			1.5%
DM&P-CMC 9-1	Apportioned amount for complete Depot Machinery & Plant : 9 th Year (Quarter 1)			1.5%
DM&P-CMC 9-2	Apportioned amount for complete Depot Machinery & Plant : 9 th Year (Quarter 2)			1.5%
DM&P-CMC 9-3	Apportioned amount for complete Depot Machinery & Plant : 9 th Year (Quarter 3)			1.5%
DM&P-CMC 9-4	Apportioned amount for complete Depot Machinery & Plant : 9 th Year (Quarter 4)			1.5%
DM&P-CMC 10-1	Apportioned amount for complete Depot Machinery & Plant : 10 th Year (Quarter 1)			2%
DM&P-CMC 10-2	Apportioned amount for complete Depot Machinery & Plant : 10 th Year (Quarter 2)			2%
DM&P-CMC 10-3	Apportioned amount for complete Depot Machinery & Plant : 10 th Year (Quarter 3)			2%
DM&P-CMC 10-4	Apportioned amount for complete Depot Machinery & Plant : 10 th Year (Quarter 4)			2%
DM&P-CMC 11-1	Apportioned amount for complete Depot Machinery & Plant : 11 th Year (Quarter 1)			2%
DM&P-CMC 11-2	Apportioned amount for complete Depot Machinery & Plant : 11 th Year (Quarter 2)			2%
DM&P-CMC 11-3	Apportioned amount for complete Depot Machinery & Plant : 11 th Year (Quarter 3)			2%
DM&P-CMC 11-4	Apportioned amount for complete Depot Machinery & Plant : 11 th Year (Quarter 4)			2%
DM&P-CMC 12-1	Apportioned amount for complete Depot Machinery & Plant : 12 th Year (Quarter 1)			2%
DM&P-CMC 12-2	Apportioned amount for complete Depot Machinery & Plant : 12 th Year (Quarter 2)			2%
DM&P-CMC 12-3	Apportioned amount for complete Depot Machinery & Plant : 12 th Year (Quarter 3)			2%
DM&P-CMC 12-4	Apportioned amount for complete Depot Machinery & Plant : 12 th Year (Quarter 4)			2%
DM&P-CMC 13-1	Apportioned amount for complete Depot Machinery & Plant : 13 th Year (Quarter 1)			2.5%
DM&P-CMC 13-2	Apportioned amount for complete Depot Machinery & Plant : 13 th Year (Quarter 2)			2.5%
DM&P-CMC 13-3	Apportioned amount for complete Depot Machinery & Plant : 13 th Year (Quarter 3)			2.5%
DM&P-CMC 13-4	Apportioned amount for complete Depot Machinery & Plant : 13 th Year (Quarter 4)			2.5%

MILESTONE NUMBER	WORK DESCRIPTION MILESTONE ACTIVITY	Apportioned AMOUNT		Apportioned AMOUNT
		INR COLUMN A	JPY COLUMN B	
DM&P-CMC 14-1	Apportioned amount for complete Depot Machinery & Plant : 14 th Year (Quarter 1)			2.5%
DM&P-CMC 14-2	Apportioned amount for complete Depot Machinery & Plant : 14 th Year (Quarter 2)			2.5%
DM&P-CMC 14-3	Apportioned amount for complete Depot Machinery & Plant : 14 th Year (Quarter 3)			2.5%
DM&P-CMC 14-4	Apportioned amount for complete Depot Machinery & Plant : 14 th Year (Quarter 4)			2.5%
DM&P-CMC 15-1	Apportioned amount for complete Depot Machinery & Plant : 15 th Year (Quarter 1)			3%
DM&P-CMC 15-2	Apportioned amount for complete Depot Machinery & Plant : 15 th Year (Quarter 2)			3%
DM&P-CMC 15-3	Apportioned amount for complete Depot Machinery & Plant : 15 th Year (Quarter 3)			3%
DM&P-CMC 15-4	Apportioned amount for complete Depot Machinery & Plant : 15 th Year (Quarter 4)			3%
DM&P-CMC : Price Centre Total (DM&P-CMC 1 - DM&P-CMC 15)				100%

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

Annexure – 04 to Addendum (02)

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..]

Date: *[insert date (as day, month and year) of Bid Submission]*
IFB No.: CP26 / ARE02A

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.

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]*

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:

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	1st Train RID	1st Train RID +1 Month (Informal Reporting Only)	1st Train RID +6 Months	No Target / Reporting Only	1 Month
Level 1	1st Train RID +6 Months	1st Train RID +13 Months	MDBF Target met for 18 Reporting Months (accumulated)	80,000 Km	6 Months
Level 2	1st Train RID +6 Months	1st Train RID +19 Months	MDBF Target met for 12 Reporting Months (accumulated)	1,25,0000 Km	12 Months

Table 18-2: Requirements for Reliability Demonstration (RD)

- a) 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.
- b) 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.
- c) 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).
- d) 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.

Annexure 6 to Addendum (02)

4.7 INTERFACE SPECIFICATION (New Clause):

DEPOT MACHINERY & PLANT (DM&P) CONTRACTOR AND TELECOM & RADIO (RAD) CONTRACTOR

Item	DM&P (RRV&CMV) Contractor Responsibility	Telecom & Radio (RAD) Contractor Responsibility
Diesel operated Relief and Rescue (RRV) with rerailling, rescue device. And Catenary / Overhead Maintenance Vehicle	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, Construction, Testing & Commissioning, Test report formats, Maintenance as applicable

Annexure 7 to Addendum (02)

CHENNAI METRO RAIL LIMITED

SCHEDULE OF DIMENSIONS FOR STANDARD GAUGE

(1435 mm)

CMRL PHASE 2 PROJECT

DRAFT

DOCUMENT VERIFICATION AND REVISION RECORD

PROJECT NAME		Chennai Metro Rail Project Phase – 2			
DOC/ NO.		P2C0000PRW000-0GC1-ENGERT-00001	DATE OF ISSUE		31-10-2023
DOC/ TITLE		Schedule of Dimensions for Standard Gauge (1435 mm)			
REV. No.	DATE OF ISSUE/REV.	DESCRIPTION	PREPARED / DESIGNED	CHECKED	APPROVED
A1	25-04-2021	Submission for review	Dr. Selva	Mahatma	Tony
A2	13-07-2021	Submission for Review	Dr. Selva	Mahatma	Tony
A3	17-07-2021	Submission for Review	Dr. Selva	Mahatma	Tony
A4	14-09-2021	Submission for Review	Dr. Selva	Mahatma	Tony
A5	23-Oct-2021	Submission for Review	Dr. Selva	Mahatma	Tony
A6	14-Sep-2022	Submission for Review	Suresh D/ Selvakumar	Dr. Selva	Ian
A7	29-Nov-2022	Submission for Review	Suresh D/ Selvakumar	Dr. Selva	Ian
A8	13-Dec-2022	Submission for Review	Suresh D/ Selvakumar	Dr. Selva	Ian
A9	16-Feb-2023	Submission for Review	Suresh D/ Selvakumar	Dr. Selva	Ian
A10	08-Sep-2023	Submission for Review	Suresh D/ Selvakumar	Dr. Selva	Ian
A11	31-Oct-2023	Submission for Review	Suresh D/ Selvakumar	Dr. Selva	Ian

Revision History		
REV. No.	Highlight of changes	Revision History
A2	Underline	CMRL/ DDC/GC comments updated
A3	Underline	Internal GC review comments updated
A4	Underline	CMRL Comments/SOD amendments / Highlighted changes from approved SOD
A5	Underline	CMRL comments/update from DMRC SOD
A6	Underline	CMRL/GC comments/update from DMRC SOD
A7	Underline	CMRL/GC comments/update from DMRC SOD
A8	Underline	CMRL/GC comments/update from DMRC SOD
A9	Underline	CMRL/GC comments/update from RDSO Guidelines for framing SOD
A10	Underline	RDSO Comments updated
A11	Underline	RDSO Comments updated

INDEX

PARA NO.	DESCRIPTION	PAGE NO.
	• Preamble	6
	• Introduction	8
	CHAPTER – 1 GENERAL	
1.1	Spacing of Tracks	9
1.2	Curves	9
1.3	Gradients	10
1.4	Buildings and Structures	10
1.5	Kinematic Envelope	11
1.6	Structure Gauge	12
1.7	Extra Clearances on Curves	13
1.8	Minimum Track Spacing on Curves	15
1.9	Derailment Guard	16
	CHAPTER – 2 STATION	
2.1	Spacing of Track at Stations	18
2.2	Platforms	18
2.3	Track Gradient	19
2.4	Interlocking and Signal Gear	20
2.5	Points and Crossings	21
2.6	Super elevation and speed at stations on curves with turnouts of contrary and similar flexure	22
2.7	Additional clearance for platforms on Curves	22
	CHAPTER – 3 ROLLING STOCK	
3.1	Passenger Rolling Stock	23
3.2	Locomotives and Engineering Service Vehicles	24
	CHAPTER – 4 Overhead Electric Traction-25 KV AC 50 Hz cycles per second	
4.1	Electrical Clearances for underground	25
4.2	Electrical Clearances for AT-Grade and Elevated sections	26
4.3	<u>The vertical clearance from Overhead line to power line crossing of Tracks</u>	<u>27</u>
	CHAPTER – 5 PLATFORM SCREEN DOOR(PSD)	
5.1	Setting Out Dimensions	29

APPENDIX

APPENDIX NO.	DESCRIPTION	PAGE NO.
Appendix – 1	Permissible Speed, Cant and Minimum Track Spacing on Curves Underground(Tunnels), Elevated and At-Grade Sections	30
Appendix – 2A	Extra Horizontal Shift on Curves (Curvature effect) Inside of Curve	31
Appendix – 2B	Extra Horizontal Shift on Curves (Curvature effect) Outside of Curve	33
Appendix – 3	Cant Effect on Structure Gauge – Horizontal At Grade and Elevated	35
Appendix – 3 (TNL)	Cant Effect on Structure Gauge – Horizontal Underground sections (Rectangular Box Tunnel)	36
Appendix-3A	Cant Effect on Kinematic Envelope – Horizontal At Grade and Elevated Sections	37
Appendix-3A (TNL)	Cant Effect on Kinematic Envelope – Underground Sections (Rectangular Box/ Tunnel)	38
Appendix – 4	Lateral and Vertical Shift of Centre of Circular Tunnel for Different Cant Values	39
Appendix – 5	Additional Clearance for platforms on curves Underground, Elevated and At Grade Stations	40
Appendix – 6	Sample Egress Calculation for Underground Station	41
Appendix – 6A	Sample Egress Calculation for Elevated Station	42

LIST OF DRAWINGS
25 KV AC OHE TRACTION SYSTEM

SN	Drawing No.	Title	Page No.
1	CMSG-1	Kinematic Envelope for 90kmph – At Grade, Elevated Sections, Through & Semi through Girder Bridges on level (or constant grade) tangent track	43
2	CMSG-1A	Kinematic Envelope for 55 kmph – At Grade and Elevated Sections on level (or constant grade) tangent track at stations	44
3	CMSG-1(TNL)	Kinematic Envelope for 90 kmph–Underground Sections on level (or constant grade) tangent track	45
4	CMSG-1A(TNL)	Kinematic Envelope for 55 kmph – Underground Sections on level (or constant grade) tangent track at stations	46
5	CMSG-2	Structure Gauge – At Grade and Elevated Sections on level or Constant Grade Tangent Track (Outside Station)	47
6	CMSG-2(TNL)	Structure Gauge –Circular Tunnel (5800mm Dia) and Rectangular Box tunnel on tangent track and curve upto R=200M	48
7	CMSG-3	Shift of the Centre of Circular Tunnel due to rotation of Tunnel to provide cant	49
8	CMSG-4	Effect of cant on structure Gauge	50
9	CMSG-4A	Effect of cant on Kinematic envelope	51
10	CMSG-5	Effect of vertical curve on structure gauge	52
11	CMSG-6	Structural Clearance At – Grade and Elevated station with PSD in Side Platforms on level (or constant grade) tangent track	53
12	CMSG-6(TNL)	Structural Clearance at Underground station with PSD in Side Platforms Rectangular Box Tunnel on level or constant grade tangent track	54
13	CMSG-7	Structural Clearance at Elevated/At- Grade station with PSD in Island Platform on level or constant grade tangent track	55
14	CMSG-7(TNL)	Structural Clearance at Underground Station with PSD in Island Platform on level or constant grade tangent track	56
15	CMSG-8	Check for Derailment condition for Elevated & Cut and Cover section with sharpest curve and max. Cant – Normal Condition (R200m, CANT 120mm)	57
16	CMSG-8A	Check for Derailment condition for Elevated & Cut and Cover section with sharpest curve and max. Cant – Derailed Condition (R200m, CANT 120mm) (Inward)	58
17	CMSG-8B	Check for Derailment condition for Elevated & Cut and Cover section with sharpest curve and max. Cant – Derailed Condition (R200m, CANT 120mm) (Outward)	59
18	CMSG-9	Structural Clearance Platform Screen Door for Elevated Stations	60
19	CMSG-9(TNL)	Structural Clearance Platform Screen Door for Underground Stations	61

PREAMBLE

The Schedule of Dimensions (SOD) has been prepared for the Chennai Metro Rail project-Phase 2 having Standard Gauge Track(1435mm), with OHE and Front evacuation.

This SOD has been prepared based on the following guiding factors:

1. The SOD has been developed assuming certain coach dimensions and design characteristics as well as track and coach maintenance tolerance. Whenever, new Rolling Stock is introduced the track and coach tolerance for maintenance should be laid down. The suitability of Rolling Stock for operation with these maintenance tolerances should be established and sanction shall be obtained from the competent authority before operation of the Rolling Stock commences.
2. The Kinematic Envelope has been developed for 2900mm wide and 3900 mm to 4048 mm high Rolling Stock and the max height of Kinematic Envelope is defined as 4200 mm.
3. The clearances are based on the assumption that windows are sealed, and doors are closed during movement/operation of Rolling Stock.
4. Track and Rolling Stock shall be maintained to the tolerances that were considered for the calculation of the kinematic envelope.
5. The Structure Gauge indicated in SOD shall not be violated under any circumstances except for platform coping, platform screen doors/gates, hand railing in back of house of platform edge, track access gates. The Kinematic Envelope of Rolling Stock should not infringe under any circumstance. Any infringement to SOD should be condoned by Railway Board.
6. The vehicle Kinematic Envelope has been calculated assuming a cross wind speed of 70 Kmph for the platform areas of At-Grade and, Elevated stations. At all other At-Grade and Elevated locations (e.g. outside of stations), the Kinematic Envelope was calculated assuming a cross wind speed of 100 Kmph.
7. At all underground sections (including stations) the Kinematic Envelope was calculated assuming a cross wind speed of 0 Kmph.
8. The cross wind speed calculations for the Kinematic Envelope has been developed taking into account all Track defects and Rolling Stock defects.
9. The speed of trains at platform on Elevated or At Grade Station shall be restricted to 40 Kmph when wind speed is more than 70 KMPH but less than 90 KMPH. Metro operations shall cease when the wind speed reaches 90 KMPH or more. Continuous recording of wind speed shall be ensured.
10. The Maximum Design Speed is 90 Kmph, however, the Operating Speed shall be limited to 80 Kmph (Except for stations where the Operating Speed is 55 kmph). The Operating speed in depots shall be 25 Kmph. The maximum speed potential on diverging lines at turnouts having:
 - (i) Weldable CMS crossing (1 in 9) and thick web switch with 300 m radius of lead curve rail shall be 45Kmph.
 - (ii) Weldable CMS crossing (1 in 9) and thick web switch with 190 m radius of lead curve rail shall be 35Kmph.

- (iii) Weldable CMS crossing (1 in 7) and thick web switch with 190 m radius of lead curve rail shall be 35Kmph.
 - (iv) Weldable CMS crossing (1 in 7) and thick web switch with 140 m radius of lead curve rail shall be 25Kmph.
11. No work/workmen/equipment is allowed between vehicle and Structure gauge during operation of trains.
12. The Fitness of OHE Installation must meet the requirements of the Rolling Stock at its Design Speed. Electrical Clearances should be measured from the Kinematic Envelope drawn at Design speed of Rolling Stock.
13. The train operation will be stopped in affected section by Central Control if any one of the Train in UP or DN direction derails. The operation will remain suspended till the clearance given by Accident Site Manager from the site by exchange of private number with Central Control.
14. Note: As per the basic principles of preparation of SOD, the gap between kinematic envelope remains very less of the order of 30 mm only, once any of the train derails
15. The clearance between S&T gear and Structure Gauge should always be kept more than 25 mm.
16. The front end evacuation comprises of an on-train detrainment door which deploys a ramp to the 4 foot zone of the track. The minimum width of the ramp is 700mm and the door has a minimum headroom of 1900mm. The minimum clear width of the pathway (within the 4 foot zone) is 610mm.
17. The Regional wind speed as per IS 875 is 50 m/sec and the same was considered for CMRL Phase 2 Project OHE Design.

CHENNAI METRO RAIL LIMITED

SCHEDULE OF DIMENSIONS

STANDARD GAUGE (1435mm)

(For 2900 wide stock)

INTRODUCTION

The dimension given in this Schedule of Dimensions are to be observed in all works on 1435mm, Standard Gauge, and 2900 mm wide Rolling Stock, unless prior sanction has been obtained from the Railway Board through the Commissioner of Metro Railway safety to execute works which infringe this Schedule of Dimensions.

This Schedule of Dimensions is applicable to Under Ground, Elevated and At-Grade sections of Chennai Metro Rail Limited Project-Phase 2 which shall be with 25 kV AC Traction system and Over Head current collection. The Rolling Stock shall be 2900 mm wide with sealed windows and doors closed while in motion.

The Under Ground system may be with a Circular Tunnel or Rectangular Box or of any other suitable shape while Elevated system may be with suitable Over Ground Structures such as Viaducts. Both, Under Ground and Elevated systems shall have suitably designed Ballastless track. For depot, the track may be ballasted/ ballastless.

The schedule of Dimensions (SOD) has been divided into five chapters as under:

Chapter 1	General
Chapter 2	Station
Chapter 3	Rolling Stock
Chapter 4	Electric Traction
Chapter 5	Platform Screen Doors

CHAPTER – 1

GENERAL

1.1 SPACING OF TRACKS

1.1.1 Minimum distance, centre to centre of tracks without any structure between tracks for tangent (straight) track for:

- | | |
|---------------------------|-----------|
| (a) Under Ground Sections | : 3600 mm |
| (b) Elevated Sections | : 3650 mm |
| (c) At-Grade Sections | : 3650 mm |

(Ref: The dimension of 300 mm is based on maximum lateral shift of 270 mm for wheel after derailment)

Note: See Appendix-1 for minimum track centres on curves.

1.2 CURVES

1.2.1 Minimum radius of curves(horizontal)

- | | |
|---|----------|
| (a) On main running lines | |
| i) Under Ground Sections | : 200 m |
| ii) Elevated and At-Grade Sections | : 120 m |
| (b) Depot and other non-passenger Lines | : 100 m |
| (c) At passenger platforms | : 1000 m |

1.2.2 Minimum Transition length (horizontal)

- | | |
|------------------------------------|--------|
| (a) On main running lines | |
| i) Under Ground Sections | : 15 m |
| ii) Elevated and At-Grade Sections | : 15 m |

1.2.3 Minimum length of alignment elements(horizontal)

The Minimum length of alignment elements (circular curves and straights) between two transition curves should be 20 m.

1.2.4 Check Rail/Restraining Rail:

- (a) Check rail/Restraining Rail shall be provided on curves on main line where radius is 190 m or less. Check rail/Restraining Rail shall not be mandatory for curves in depots, yards and non-passenger lines where speed is less than 25Kmph.
- (b) The clearance between check/restraining rail and running rail shall be suitably decided by metro depending upon study of track vehicle interaction.

Minimum radius of vertical curve: 1500 m

Minimum length of vertical curve: 20 m

(To keep vertical acceleration in range of 0.3 to 0.45 m/s²)

1.2.5 Cant and Cant Deficiency (suggested values)

Criteria	SG (1435 mm)
Maximum Cant Gradient	1 in 440
Maximum Cant on curves	110 mm (Desirable)
Maximum Cant on curves	125 mm (Exceptional)
Maximum Cant Deficiency	85 mm (Desirable)
Maximum Cant Deficiency	100 mm (Exceptional)
Desirable rate of change of Cant	40 mm/ sec
Desirable rate of change of Cant deficiency	40 mm/ sec
Maximum Lateral acceleration	0.55 m/sec ²

Note- The above cant deficiency value is proposed within the limit as mentioned in EN Code 13803:2017(E), table-7 upper limits for cant deficiency and Rolling stock are complying with EN14363, equipped with a cant deficiency compensation system. Refer: Appendix-2A & 2B for Curvature Effect.

1.3 GRADIENTS

1.3.1 The maximum grade (compensated) shall be 4%.

Note- (i) There will be no change of gradient in transition portion of curves.

(ii) The gradient will be compensated for curvature at the rate of 0.04% per degree of curve.

1.4 BUILDINGS AND STRUCTURES

1.4.1 Minimum horizontal distance from centre of track to any structure (except a passenger platform) for heights above rail level on level / constant grade tangent track shall be as under:

(a) Under Ground Sections

(i) Circular tunnels

S.N.	Height from rail level	Horizontal distance from C.L. of track
(i)	Rail level to 65mm	Up to 1465 mm
(ii)	65 mm to 200 mm	1465 mm increasing to 1585 mm
(iii)	200 mm to 305 mm	1585 mm
(iv)	305 mm to 940 mm	1585 mm increasing to 1670 mm
(v)	940 mm to 1095 mm	1670 mm increasing to 1675 mm
(vi)	1095 mm to 3305 mm	1675 mm increasing to 1740 mm
(vii)	3305 mm to 3965 mm	1740 mm decreasing to 1250 mm
(viii)	3965 mm to 4775 mm	1250 mm

(ix)	4775 mm to 4920 mm	1250 mm decreasing to zero along an arc of circle of radius of 2900
------	--------------------	---

Also refer to Drawing No. CMSG-2(TNL)

(ii) Rectangular Box Tunnels

S.N.	Height from rail level	Horizontal distance from C.L. of track
(i)	Rail Level to 65 mm	Up to 1465 mm
(ii)	65 mm to 200 mm	1465 mm increasing to 1585 mm
(iii)	200 mm to 305 mm	1585 mm
(iv)	305 mm to 940 mm	1585 mm increasing to 1670 mm
(v)	940 mm to 1095 mm	1670 mm increasing to 1675 mm
(vi)	1095 mm to 3305 mm	1675 mm increasing to 1740 mm
(vii)	3305 mm to 3965 mm	1740 mm decreasing to 1250 mm
(viii)	3965 mm to 4838 mm	1250 mm

Also refer to Drawing No. CMSG-2(TNL)

(b) Elevated and At-Grade Sections

S.N.	Height from rail level	Horizontal distance from C.L. of track
(i)	Rail Level to 65 mm	Up to 1465 mm
(ii)	65 mm to 200 mm	1465 mm increasing to 1640 mm
(iii)	200 mm to 305 mm	1640 mm
(iv)	305 mm to 930 mm	1640 mm increasing to 1735 mm
(v)	930 mm to 1095 mm	1735 mm increasing to 1740 mm
(vi)	1095 mm to 3310 mm	1740 mm increasing to 1825 mm
(vii)	3310 mm to 3775 mm	1825 mm decreasing to 1546 mm
(viii)	3775 mm to 6250 mm	1546 mm

Also refer to Drawing No. CMSG-2

Notes for (a) and (b) above:

- i) Extra allowance shall be provided for curves as laid down at para 1.7
- ii) The term 'structure' covers any item including light ones like ladders, isolated posts, cable etc., erected alongside the track.
- iii) Minimum lateral clearance for OHE masts for tangent track at-grade and elevated station shall be 2150mm from centre line of nearest track.
- iv) Minimum lateral clearance for OHE masts for tangent track at depot shall be 1950mm from centre line of nearest track.
- v) For passenger platform refer to para 2.2.1 to 2.2.3 of chapter 2.

1.5 KINEMATIC ENVELOPE

The maximum limit of Kinematic Envelope allowed for Rolling Stock (for level or constant grade tangent track is defined in the following drawings:

- a) Drawing No. CMSG-1 for - Kinematic Envelope for 90kmph – At Grade, Elevated Sections, Through & Semi through Girder Bridges on level (or constant grade) tangent track
- b) Drawing No. CMSG-1(TNL) for - Kinematic Envelope for 90 kmph–Underground Sections on level (or constant grade) tangent track
- c) Drawing No CMSG-1A for-Kinematic Envelope for 55 kmph – At Grade and Elevated Sections on level (or constant grade) tangent track at stations
- d) Drawing No. CMSG-1A(TNL) for - Kinematic Envelope for 55 kmph – Underground Sections on level (or constant grade) tangent track at stations

1.6 STRUCTURE GAUGE

1.6.1 Under Ground Sections

The Indicative Structure Gauge (Fixed Structure Line) has been arrived at by allowing a minimum clearance of 100 mm to the derived Kinematic Envelope and minimum electrical clearance of 270mm from 25 kV live parts conforming to the stipulation in chapter – 4 of this SOD.

Refer to Drawing No. CMSG-2(TNL) for Structure Gauge for Outside station on level or constant grade tangent track.

Note:

Extra allowance shall be provided for curves as laid down at para 1.7.

1.6.2 Elevated Sections

The Structure Gauge (Fixed Structure Line) has been arrived at by allowing minimum clearance of 150 mm to the derived Kinematic Envelope and minimum electrical clearance of 320 mm from 25 kV live parts conforming to the stipulations in chapter – 4 of this SOD.

Refer to Drawing No. CMSG-2, for Structure Gauge for outside stations on level or constant grade tangent track.

Note:

Extra allowance shall be provided for curves as laid down at para 1.7

1.6.3 At-Grade Sections

The Structure Gauge (Fixed Structure Line) has been arrived at by allowing minimum clearance of 150 mm to the derived Kinematic Envelope and minimum electrical clearance of 320mm from 25kV live parts, conforming to stipulations in chapter 4 of this SOD.

Refer to Drawing No. CMSG-2 for Structure Gauge for outside stations on level or constant grade tangent track.

Note:

Extra allowance shall be provided for curves as laid down in para 1.7

1.7 EXTRA CLEARANCE ON CURVES

Following are the extra allowances considered for curves.

Abbreviations used in para 1.7

C is the distance between centres of bogies in metres

C1 is the car (Vehicle) length in metres

R is the radius of curve in metres

Ca is the Cant applied in mm

h is the height from rail level in mm and

g is the distance between centres of rails in mm

1.7.1 Inside of Curve

(A) Curvature effect

(a) Mid throw at the centre of the vehicle = V (in mm) = $125 \times C^2 / R$

(b) Allowance due to gauge widening on curves

For values of items (i) and (ii) above, refer to Appendix-2A

Note:

Lateral shift of 26mm due to nosing is included in Kinematic Envelope for tangent track (and as a result, included in Structure Gauge also) shall be subtracted from the total extra allowance worked out as at para 1.7.1(A)-i and ii above for inside of a curve in case the value of mid throw (V) is equal to or greater than 26mm. In case the value of mid throw (V) is less than 26mm, the curvature effect shall be due to widening of the gauge only. (The Mid throw minus 26mm shall be taken as zero). Refer to Appendix-2.

(B) Allowance for super elevation

(a) Under Ground (Box Structures), Elevated and At-Grade Sections

The lean 'L' due to Cant at any point at height 'h' above rail level is given by:

$$L = Ca \times h/g (\text{all in mm})$$

For values of Structure Gauge (E1) for inside of a curve with cant effect only, (as shown in Drawing No. CMSG-4) refer to:

- (i) Appendix -3 (TNL) for Under Ground Sections
- (ii) Appendix-3 for At-Grade and Elevated Sections

(b) Circular Tunnels

In the case of Circular Tunnel, the cant is provided by raising the outer rail and suitably shifting the centre of the Circular Tunnel towards inside of curve and upwards. This has same effect as assuming rotation of the Circular Tunnel about mid point of top of inner rail resulting in shift of Tunnel centre laterally towards inside of curve and also vertically upwards.

The Rigid OCS (if applicable) shall also be rotated with the tunnel so as to be along the centre line of canted track.

For values of horizontal and vertical shifts of centre of Circular Tunnel for different values of cant, refer to Appendix-4 and Drawing No. CMSG-3.

(C) Allowance for vertical curve (vertical throw)

Vertical throw V1 and V2 (in mm) for vertical curve shall be calculated as under:

$$V1 \text{ (with vertical centre in sag or vehicle end on summit)} = 125 \times C^2/R$$

$$V2 \text{ (with vehicle centre on summit or vehicle end in sag)} = 125 \times C1^2/R - (125 \times C^2/R)$$

Values of vertical throw due to vertical curves of different radii are given in Drawing No. CMSG-5.

1.7.2 OUTSIDE OF CURVE

(A) Curvature effect

i) End throw at the end of vehicle = V_o (in mm)
$$= (125 \times C1^2/R) - (125 \times C^2/R)$$

ii) Allowance due to gauge widening on curves

iii) Additional nosing due to gauge widening on curves.

The values of items (i) and (iii) are shown in Appendix -2B.

(B) Allowance for super elevation

(a) Under Ground (Box Structures), Elevated and At-Grade Sections

The lean 'L' due to Cant at any point at height 'h' above rail level is given by:

$$L = (-) Ca \times h/g \text{ (all in mm)}$$

-ve sign indicates relief due to cant or reduction in clearance required.

Note:

Full relief for lean due to cant (Ca) is to be taken into account only for calculation of track spacing without any structure between tracks. In case there is a structure adjacent to track, relief for lean is to be taken into account only if the cant provided is greater than 50mm and shall be limited to a value = $(Ca-50) \times h/g$.

Values of Structure Gauge (F1) on outside of curve with cant effect only (as shown in Drawing No. CMSG-4), refer to:

- Appendix 3 (TNL) for Under Ground Sections (Rectangular Box)
- Appendix 3 for Elevated and At-Grade Sections

(b) Circular Tunnels

In the case of Circular Tunnel, the cant is provided by raising the outer rail and suitably shifting the centre of the Circular Tunnel towards inside of curve and upwards. This has same effect as

assuming rotation of the Circular Tunnel about mid point of top of inner rail resulting in shift of Tunnel centre laterally towards inside of curve and also vertically upwards.

The Rigid OCS (if applicable) shall also be rotated with the tunnel so as to be along the centre line of canted track.

For the values of horizontal and vertical shifts of centre of Circular Tunnel for different values of cant, refer to Appendix-4 and Drawing No. CMSG-3 .

(C) Allowance for vertical curve (vertical throw)

The provision at para 1.7.1 (C) above shall be applicable in this case also.

1.8 MINIMUM TRACK SPACING ON CURVES

Under Ground, Elevated and At-Grade Sections

The worst case will be when the end of a bogie carriage on the inner track is opposite to the centre of a similar carriage on the outer track.

1.8.1 Without any structure between tracks

The minimum track spacing on curves without any structure between tracks shall be the sum of the following:

- a) (E +F),
- b) T_1 (Extra lateral clearance due to curvature on inside of curve),
- c) T_2 (Extra lateral clearance due to curvature on outside of curve),
- d) Minimum clearance between adjacent Kinematic Envelope stipulated is as under:
 - i) 300 mm for Under-Ground Sections
 - ii) 300 mm for Elevated and At-Grade Sections.

Where,

'E' is the distance from vertical axis of centre line of canted track to canted Kinematic Envelope on inside of curve at a height 'h' (from rail level) for a given cant (Drawing No. CMSG-4A) and,

'F' is the distance from vertical axis of centre line of canted track to canted Kinematic Envelope on outside of curve at a height 'h' (from rail level) for a given cant (Drawing No. CMSG-4A).

Notes:

- i) The value of 'F', calculated from the formula at Drawing No. CMSG-4A includes full relief due to cant.
- ii) The sum of 'E' and 'F' for same height (which are with cant effect only), shall be the maximum of values calculated for various heights from rail level.

For values of E, F, T_1 and T_2 , refer to the Appendices as shown below:

<u>SECTIONS</u>	<u>For E & F</u>	<u>For T₁&T₂</u>
i) Under Ground	3A (TNL)	2A & 2B
ii) Elevated and At-Grade	3A	2A & 2B

1.8.2 With a structure between adjacent tracks

The minimum track spacing on curves with a structure between tracks shall be the sum of the following:

- ($E_1 + T_1$) Minimum clearance to the structure from centre line of track on inside of curve (for outer track),
- ($F_1 + T_2$) Minimum clearance to the structure from centre line of track on outside of curve (for inner track),
- Width of structure between adjacent tracks (measured across the tracks).

Where,

E_1 is the horizontal distance from vertical axis of centre line of track to canted Structure Gauge on inside of curve for a given cant (Drawing No. CMSG-4),

F_1 is the horizontal distance from vertical axis of centre line of track to canted Structure Gauge on outside of curve for a given cant (Drawing No. CMSG-4),

T_1 is extra lateral clearance due to curvature on inside of curve and

T_2 is extra lateral clearance due to curvature on outside of curve

Notes:

- The values of ' E_1 ' and ' F_1 ' for a given cant C_a , shall each be the maximum of values at different heights of structure from rail level. In case the cant provided is greater than 50 mm on inner track, the value of F_1 shall be for the cant of $(C_a - 50)$ mm. In case the cant provided is 50 mm or less on inner track, the value of F_1 shall be for ZERO cant.
- Minimum track spacing, so worked out with a structure between the adjacent tracks shall not be less than that calculated as per para 1.8.1 for tracks without any structure between adjacent tracks.

For values of E_1 , F_1 , T_1 and T_2 , refer to the Appendices as shown below:

<u>SECTIONS</u>	<u>For E₁ & F₁</u>	<u>For T₁&T₂</u>
i) Under Ground	3 (TNL)	2A & 2B
ii) Elevated and At-Grade	3	2A & 2B

1.9 DERAILMENT GUARD

- Derailment Guard should be provided on inside/outside of running rail on viaduct as well as in tunnel and at grade section at locations specified by the Metro Railway. In tunnel, the derailment

guard should preferably be provided inside the track so that it permits less sway of coach towards tunnel wall in case of derailment.

Note:

Location for providing Derailment Guard in single track tunnel:

1. Entry of tunnel 200 m from tunnel portal outside the tunnel to 50 m inside the tunnel.
2. Exit of tunnel 50 m from inside of tunnel portal to 200 m outside of tunnel
3. In curved track having radius 500m or less including transition portion but excluding location where check rail is provided.
4. Location of all-important installations e.g. Location of any substation or hazardous structure inside the tunnel, etc. damage to which in the assessment of the metro rail administration can result into serious loss of life or / and infrastructure as a result of relevant in tunnel.

The above is subject to the condition that metro railway shall carry out of the risk assessment analysis for derailment in the tunnel and ensure that the maintenance practices in the maintenance manual as per the risk assessment mitigation plan. (For Risk Analysis kindly refer Drawing No: CMSG-8, CMSG-8A, CMSG-8B).

- (b) Lateral Clearance between the running rail and the derailment Guard should be 210 ± 30 mm. It shall not be lower than 25 mm below the top of running rail and should be clear of the rail fastenings to permit installation, replacement and maintenance.

Note:

In case of Double Resilient Base Plate Assembly Fastening System as approved by MOR, the lateral clearance between running rail and the derailment guard shall be 250 ± 20 mm. This fastening system, if used in tunnels having multiple tracks, Metro Administration should ensure that KE for adjacent track is not infringed so long as the wheels of any derailed vehicle are within the main rail and derailment guard and also the KE of derailed rolling stock shall not have any infringement with the structure gauge.

CHAPTER – 2

STATION

2.1 SPACING OF TRACKS AT STATIONS

Minimum spacing of tracks at station on straight and on curve of radius of 1000m and flatter, without any structure between tracks At-Grade, Elevated and Under- Ground Stations-3900 mm.

2.2 PLATFORMS

2.2.1 Horizontal distance from Centre of track to face of passenger platform coping/PSD threshold shall be

Condition	Value
For Elevated, At Grade section,	Minimum value: 1515 Mm Maximum value: 1520 mm
For Underground section	Minimum value: 1510 Mm Maximum value: 1515mm

Notes:

- Passenger platforms have PSD's therefore, the closest dimension to the centreline of the track is always the PSD threshold/Platform Coping.
- Platform coping faces shall be flared away smoothly (wherever there is no PSD) from the centre line of the track at either end for a distance of 1500 mm beyond passenger area/at Platform end so as to give from centre of track a minimum dimension:

Condition	Value
Elevated, At Grade section,	1590±5
Underground section	1575±5

- For additional clearance for platforms on curves, refer to para 2.7

2.2.2 Height above rail level for passenger platform:

	Maximum	Minimum
(a) At-Grade Ballasted.....	1085 mm	1075 mm
(b) Elevated/Under Ground.....	1095 mm	1085 mm

2.2.3

(i)	Minimum horizontal distance of any isolated structure on a passenger platform from the edge of coping, if platform screen door is provided	2000 mm
(ii)	Minimum horizontal distance of any continuous structure on a passenger platform from the edge of coping, if Platform Screen Door is provided	2450 mm

(Refer Appendix – 6 & 6A - Sample egress calculation report for Underground station & Elevated Station)

Notes:

- a) The Platform Gates (PG) may be installed at platform as per design of Original Equipment Manufacturer (OEM) of PG but shall have a minimum clearance of 10 mm from Kinematic Envelope.
- b) The structure on the platform is treated as isolated if the length along the platform length is 2000 mm or less. Any structure having a length exceeding 2000 mm is treated as continuous structure.
- c) The clocks/mirrors/CCTV/LED/LCD Screens/PIDS (passenger Information Display System)/ Signages etc. shall not be considered structures and shall be located at a minimum height of 2300 mm from top of platform.

Note: Anything like above, hung from the Roof of Station shall be adequately secured and a safety loop is to be provided for taking care of incidences of failure of hanging arrangement.

- d) For platform structure setting-out dimensions at stations, refer to Drawing No. CMSG-6 and CMSG-7 for Elevated/at grade station and Drawing No. CMSG-6(TNL) and CMSG-7(TNL) for underground station. No fixed structures should infringe the Structure Gauge except for designated railway operational platform gates, hand railing in back-of-house platform edge, Track Access Gates. Such designated railway operational structures should not infringe the Kinematic Envelope under any circumstances.

2.2.4 For Structure Gauge at station platform, refer to following drawings:

- a) For under Ground Station CMSG-6(TNL) & CMSG-7(TNL)
- b) For At-Grade and Elevated Stations CMSG-6 & CMSG-7

2.3 TRACK GRADIENT

2.3.1 TRACK GRADIENTS IN PLATFORM

- | | |
|----------------------------------|-------------|
| 1. Desirable Grade (Recommended) | : Level |
| 2. Maximum Grade | : 1 in 1200 |
| 3. Exceptional Grade | : 1 in 400 |

Note:

1. There shall be no change of grade within station platform track.
2. Any gradient steeper than 1 in 1200 and up to Exceptional gradient of 1 in 400 shall be proposed by Civil Engineering Head and approved by Managing Director in consultation with Head of Safety nominated by Metro Authority.

2.3.2 GRADIENT ON TURNOUTS

Maximum permissible gradient on turnouts

On Ballasted Track	0.25%
On Ballastless Track	3.00%

Notes:

- (i) There shall be no change of gradient (i.e., vertical curve) on and within 15.0 m (desirable)/3.0m (minimum) length from any turnout on Ballastless track. In case of Ballasted track, there shall be no change of gradient on and within 30 meters of any turnout.
- (ii) There shall be no horizontal curve within 15.0 m length (desirable)/3.0m (minimum) from any turnout on Ballastless track and 30 meters from any turnout on Ballasted Track.
- (iii) Turnout shall normally be installed on straight track. In exceptional situations, turnout may take off from curve provided that the radius of lead curve (main line as well as diverging line) is not less than 190 m. The negotiability of rolling stock on such turnout must be certified by rolling stock supplier and confirmed through oscillation trial and a suitable speed restriction should be imposed on main and/or diverging line based on track geometry and other considerations, if required. In case of turnout installed on curved track, the minimum distance for commencement of vertical curve or another horizontal curve shall be 15m for Ballastless track. Turnout shall not be laid on transition curve.
- (iv) The limit of turnout for above purposes shall be taken from Stock Rail Joint (SRJ) to end (i.e. heel) of crossing for Ballastless track. For Ballasted track, it shall be from SRJ to last common sleeper behind end of crossing.
- (v) The maximum permissible gradient on turnout and the location of turnout with respect to vertical/horizontal curves in vicinity shall be ensured by metro that the Rolling Stock is fit to negotiate these gradients.
- (vi) The above stipulations shall also be applicable for turnout to be laid outside station limit, if any.

2.4 INTERLOCKING AND SIGNAL GEAR

Maximum height above rail level or any part of interlocking or signal gear on either side of centre of track subject to the restrictions embodied in Note below shall be as under:

(a) For Under Ground Stations

- | | |
|-------------------------------|------------------------|
| • From CL of track to 1330 mm | 25 mm |
| • From 1330 mm to 1465 mm | 25 mm rising to 65 mm |
| • From 1465 mm to 1585 mm | 65 mm rising to 200 mm |

(b) For Surface and Elevated Stations

- | | |
|-------------------------------|------------------------|
| • From CL of track to 1330 mm | 25 mm |
| • From 1330 mm to 1465 mm | 25 mm rising to 65 mm |
| • From 1465 mm to 1640 mm | 65 mm rising to 200 mm |

Note: Except for check rails of ordinary and diamond crossings, or wing rails and point rails of crossings leading to snag dead ends, or such parts of signalling gear as are required to be actuated by the wheels, no gear or track fittings shall project above rail level for a distance of 229 mm outside and 140 mm inside the gauge face of the rails.

2.5 Points and Crossings:

Para	Description	SG (1435mm)
2.5.1	Maximum clearance of check rail opposite nose of crossing	44* mm
2.5.2	Minimum clearance of check rail opposite nose of crossings	41* mm
2.5.3	Minimum clearance between switch rail and stock rail at heel of Switch Rail	52 mm
2.5.4	Maximum clearance of wing rail at nose of crossing	44 mm
2.5.5	Minimum clearance of wing rail at nose of crossings	41 mm
2.5.6	Minimum clearance between toe of open switch and stock rail (depend upon type of point machine)	160 mm
2.5.7	Minimum radius of curvatures for slip points, turnouts and crossover	190 m

Note: *Minimum & Maximum clearance value of checkrails opposite to nose of crossing shall be as per the design of Turnout

2.5.8 On main lines, the turnouts and diamond crossings shall be of the following types or flatter: -

- a) 1 in 9 type turnout 300m/190m radius
- b) 1 in 7 type turnout 190m radius
- c) Scissors cross-over of 1 in 9 type consisting of 4 turnouts of 300m/190m radius and 1 diamond crossing
- d) Scissors cross-over of 1 in 7 type consisting of 4 turnouts of 190m radius and 1 diamond crossing

2.5.9 On depot lines, the turnouts and diamond crossings shall be of the following types or flatter:

- a) 1 in 7 type turnout 190m radius
- b) 1 in 7 type turnout 140m radius
- c) Scissors cross-over of 1 in 7 type consisting of 4 turnouts of 190m/140m radius and 1 diamond crossing
- d) 1 in 7 derailing switches/ 1 in 7 type symmetrical split turnout

2.5.10 Diamond crossings not to be flatter than 1 in 4.5

Note:

- a) The above restrictions shall not apply to moveable diamond crossings.
- b) There must be no change of super elevation (of outer rail over inner rail) between points 18 meters outside toe of switch rail and nose of crossings respectively, except in the case

of special crossing leading to snag dead – ends or under circumstances as provided for in item 2.6 below.

2.5.11 Minimum length of tongue rail: 9000 *mm for Standard Gauge.

Note : *As per the turnout manufacturer design value.

2.6 Superelevation and speed at stations on curves with turnouts of contrary and similar flexure.

2.6.1 Main Line:

Subject to the permissible run through speed based on the standard of interlocking the equilibrium super elevation calculated for the speed of the fastest train may be reduced by a maximum amount of Cant deficiency without reducing speed on the main line.

2.6.2 Turnouts:

i) Curves of contrary flexure

The equilibrium super elevation (s) in mm should be $= (G/127)(V^2/R)$

Where G = Dynamic gauge in mm, R = radius of turnout in metres and V is speed on turnout in kmph.

The permissible negative super elevation on the turnout (which is also the actual super elevation of the main line) may then be = (Cant deficiency-s) mm.

ii) Curves of Similar Flexure

The question of reduction or otherwise of super elevation on the main line must necessarily be determined by the administration concerned. In the case of a reverse curve close behind the crossing of a turnout, the super elevation may be run out at the maximum of 1 mm in 440 mm.

iii) There must be no change of superelevation (of outer rail over inner rail) between points 18 metres outside toe of switch rail and nose of crossings respectively, except in the case of special crossing leading to snag dead – ends

2.7 ADDITIONAL CLEARANCE FOR PLATFORMS ON CURVES

The additional clearance for platforms on curves is to be provided as shown at appendix-5.

Note:

- i) As the minimum radius of horizontal curve for station platform line is 1000 metres, there will be no super elevation and gauge widening at stations on passenger platform lines.
- ii) Platforms located in curve shall be fitted with gap filler/ or suitable arrangement wherever necessary to maintain the Maximum stepping distance (between platform and car body floor) at platform as 75 mm in Horizontal direction and 45 mm in Vertical direction. The gap filler shall be of elastic nature and flexible to allow train contact without any adverse effect on passenger safety and stability of train.

CHAPTER – 3

ROLLING STOCK

3.1 Passenger Rolling Stock

Note: all dimensions are in mm

S.No.	Description	Specified Value
1	Gauge	1435 (SG)
2	a) Maximum Length of the coach body (including end fairings)	22150
	b) Length of coach over couplers	22600
	c) Width of the Coach Body	2900
	d) Height of the coach body (maximum with pantograph in locked down condition)	4048
3	a) Distance between bogie centres*	14850±250
	b) Length of rigid wheel base for single bogie*	2400±200
	c) Maximum Distance between any two adjacent axles	12900
Note: * The above dimensions a), b) should commensurate to each other as per the design selected by Metro considering the manoeuvrability of the coach and the entire train on sharper curves and maximum gradient to avoid any infringement to the structure gauge.		
4	Kinematic Envelope for level tangent track	Drawing No:
	a) Kinematic Envelope for 90kmph – At Grade, Elevated Sections, Through & Semi through Girder Bridges on level (or constant grade) tangent track	CMSG-1
	b) Kinematic Envelope for 55 kmph – At Grade and Elevated Sections on level (or constant grade) tangent track at stations	CMSG-1A
	c) Kinematic Envelope for 90 kmph–Underground Sections on level (or constant grade) tangent track	CMSG-1(TNL)
	d) Kinematic Envelope for 55 kmph – Underground Sections on level (or constant grade) tangent track at stations	CMSG-1A(TNL)
5	a) Minimum clearance from rail level under fully loaded condition for bogie mounted equipment in worst condition* (<i>*The worst condition means wheels with maximum tread wear and primary springs with maximum deflection</i>) in static condition.	75
	b) Minimum clearance from rail level under fully loaded condition for body mounted equipment in worst condition* (<i>*The worst condition means deflated secondary air spring, wheels with maximum tread wear and primary springs with maximum deflection</i>) in static condition.	102
	c) Minimum clearance from rail level, under dynamic condition of fully loaded vehicle, with maximum tread wear and primary springs with maximum deflection, with the exception of wheels & attachments there to (vide note below #).	50
	Note: # A tyre or an attachment to a wheel or sand pipes or wheel / Track Lubrication Nozzle in line with the wheel may project below the minimum height of 50mm from a distance of 51mm inside to 216mm outside of the gauge face of wheel.	
6	Wheel Profile <i>Note: The "Incline of tread" for S1002 has a varying gradient and must therefore be inferred from the coordinates shown in Table C.1 of EN 13715. Alternative profiles [V135 or EPS 32.5] may be adopted, if the RS Contractor's wheel-rail interface study demonstrates significantly better overall wear characteristics.</i>	<u>S1002/h28/e32.5</u> <u>Reverse slope between 6.7 and 15%</u>

7	Wheel a) Maximum wheel gauge back-to-back distance	1360
	b) Minimum wheel gauge back-to-back distance	1358
8	a) Maximum wheel diameter on the tread <i>(Wheel Profile dimensions as per EN 13715 / EN15313. Wheel Diameter value "D" is measured from point D0 on the wheel tread; 70mm from wheel gauge face)</i>	860
	b) Minimum wheel diameter on the tread <i>(Wheel Profile dimensions as per EN 13715 / EN15313. Wheel Diameter value "D" is measured from point D0 on the wheel tread; 70mm from wheel gauge face)</i>	780
9	a) Maximum projection for flange of new wheel <i>(Wheel Profile dimensions as per EN 13715 / EN15313. Flange Height value "h" is measured from point D0 on the wheel tread; 70mm from wheel gauge face)</i>	36
	b) Minimum projection for flange of new wheel <i>(Wheel Profile dimensions as per EN 13715 / EN15313. Flange Height value "h" is measured from point D0 on the wheel tread; 70mm from wheel gauge face)</i>	28
10	a) Maximum thickness of flange of wheel <i>(Wheel Profile dimensions as per EN 13715 / EN15313. Flange Thickness values "e1, e2" are measured 10mm below wheel tread point D0)</i>	32.5
	b) Minimum thickness of flange of wheel. <i>(Wheel Profile dimensions as per EN 13715 / EN15313. Flange Thickness values "e1, e2" are measured 10mm below wheel tread point D0)</i>	22
11	Minimum width of Wheel as per respective wheel profile	135±1
12	a) Maximum height above rail level for floor of any unloaded vehicle	1130
	b) Minimum height above rail level for floor of fully loaded normal vehicle	1100
13	a) Maximum height of centre coupler above rail level for unloaded vehicle	815
	b) Minimum height of centre coupler above rail level for fully loaded vehicle	740

3.2 LOCOMOTIVE AND ENGINEERING SERVICE VEHICLES

Other items of Rolling Stock viz. shunting locomotives, OHE maintenance and inspection cars, emergency re-railing van, track machines etc., used on Chennai Metro System (where these cars should be plying) will conform with the kinematic envelope of the Passenger Electric Multiple Units as detailed in the annexure of KE drawings.

CHAPTER – 4

OVERHEAD ELECTRIC TRACTION 25 KV/AC 50 CYCLES PER SECOND

Note:

- (i) Electrical Clearances are compiled as per Table 2 of Electrical Clearances under 'Para 5.1.3 – Clearances between live parts of contact lines and earth' of BS EN 50119:2009. However, These Electrical clearances are minimum and may be increased depending on various parameters e.g. Absolute humidity, the Ambient Temperature range, Air Pressure, Pollution, Relative Air Density, Shape and material for both energised and earth Structures. Metro may consider each case individually as suggested in BS EN 50119:2009.
- (ii) Wherever electric traction is in use, special precautions must be taken to maintain following clearances:

4.1 Electrical Clearances for under ground

Minimum height from rail level to the underside of the Wearing Copper / Metal Conductor of Rigid OCS (Overhead Contact System) in Tunnel would be - 4318 mm.

Note:

- a) Location of level crossing from the exit point of the tunnel will take into consideration the OHE height of 4318 mm at the tunnel exit and the permissible contact wire gradient.
- b) In the Depot deck portion, where Rigid OCS is provided and the track is Ballastless, the Electrical clearances laid down at paras 4.1.1 to 4.1.4 shall be applicable.
- c) For location of rigid OCS in circular tunnel with canted track, refer to para 1.7.1(B)-b and 1.7.2(B)-b.
- d) It shall be ensured that environment level inside the tunnel is controlled suitably so that no extra air clearance, over and above the minimum separation prescribed in para 4.1.3 and 4.1.4 on account of pollution, fog etc. is required.

4.1.1 Stagger of Rigid OCS Conductor in Tunnels shall not be more than (IRS Code)

- | | |
|-----------------------|------------------------|
| (a) On Straight | ± 200 mm (from IR SOD) |
| (b) On Curves..... | ± 300 mm (from IR SOD) |

4.1.2 Prescribed minimum clearance between live parts of contact lines and bodies of structures.

Air clearance between bodies of structures and live un-insulated parts of contact lines, feeders and current collectors for 25 KV shall be as per IEC 60913 as under:

	Condition	Minimum clearance between live parts and structures	Absolute minimum dynamic clearance between live parts and structure
a)	Long duration (Static)	270 mm	-
b)	Short Duration (Dynamic)	170 mm	150 mm*

*In exceptional cases and considering operating in climatic conditions (Ref: IEC 60913)

4.1.3 Prescribed minimum clearance between live parts of contact lines and bodies of vehicles

	Condition	Clearance (mm)
a)	Long duration (Static)	290 mm
b)	Short Duration (Dynamic)	190 mm

4.1.4 Maximum width of pantograph – under dynamic condition: (indicative)

The Kinematic Envelope for the underground system with Ballast less track is shown in Drawing No. CMSG-1(TNL). The pantograph adopted should be such that its actual half KE width does not exceed 820 mm and 980 mm at the top and bottom respectively in pantograph raised condition for a contact wire height of 4318 mm to fulfil electrical clearances as per item 4.1.3.

4.2 ELECTRICAL CLEARANCES FOR AT-GRADE AND ELEVATED SECTIONS

4.2.1 Minimum vertical distance between any live bare conductor (overhead equipment) and any earthed structure or other bodies (over bridges, signal gantries etc.)

	Condition	For Flexible OHE
a)	Long duration (Static)	320 mm
b)	Short Duration (Dynamic)	270 mm

Note: A minimum vertical distance of 340 mm shall normally be provided between rolling stock and contact wire to allow for a 20 mm temporary raising of the tracks during maintenance. Wherever the allowance required for track maintenance exceeds 20 mm, the vertical distance between rolling stock and contact wire shall correspondingly be increased.

4.2.2 Minimum lateral distance between bare live conductor (overhead equipment) or any earthed structure or other bodies (over bridges, signal gantries etc.)

	Condition	For Flexible OHE
a)	Long duration (Static)	320 mm
b)	Short Duration (Dynamic)	220 mm

4.2.3 Height of contact wire: (indicative)

Minimum height from rail level to the underside of live Conductor wire.

a)	Under bridges and in ramp area	4800 mm
b)	In the open	5000 mm
c)	<u>Minimum Height at Depot</u>	<u>5500 mm</u>
d)	In running and carriage sheds wherever staff are expected to work on the roof of rolling stock	5200 mm

Note: On curves, all vertical distances specified in items 4.2.3 above, shall be measured above level of the inner rail, increased by half the super elevation.

4.2.4 Maximum variation of the live conductor wire on either side of the centre line of the track under static conditions:

- i) On Straight ± 200 mm
- ii) On Curves..... ± 300 mm

4.2.5 Maximum width of pantograph collector:

The Kinematic Envelope with the size of Pantograph adopted shall be within the Kinematic Envelope shown at Drawing No: CMSG-1.

4.3 The vertical clearance from Overhead line to power line crossing of Tracks:

<u>Sl. No</u>	<u>Overhead Crossing Voltage</u>	<u>Minimum clearance from Rail level</u>		<u>Minimum Clearance between Highest Traction Conductor and lowest Transmission Line Crossing Conductor</u>
		<u>Existing Power Line Crossing For Non-Electrified Territory</u>	<u>New Power Line Crossing or Crossing Planned For Alteration</u>	
<u>(1)</u>	<u>(2)</u>	<u>(3)</u>	<u>(4)</u>	<u>(5)</u>
<u>(a)</u>	<u>Upto and including 11kV</u>	<u>Normally by Underground Cable</u>		
<u>(b)</u>	<u>Above 11kV & upto 33kV</u>	<u>10860mm</u>	<u>16660mm</u>	<u>2440mm</u>
<u>(c)</u>	<u>Above 33kV & upto 66kV</u>	<u>11160mm</u>	<u>16960mm</u>	<u>2440mm</u>
<u>(d)</u>	<u>Above 66kV & upto 132kV</u>	<u>11760mm</u>	<u>17560mm</u>	<u>3050mm</u>
<u>(e)</u>	<u>Above 132kV & upto 220kV</u>	<u>12660mm</u>	<u>18460mm</u>	<u>4580mm</u>
<u>(f)</u>	<u>Above 220kV & upto 400kV</u>	<u>14460mm</u>	<u>20260mm</u>	<u>5490mm</u>

(g)	<u>Above 400kV & upto 500kV</u>	<u>15360mm</u>	<u>21160mm</u>	<u>7940mm</u>
(h)	<u>Above 500kV & upto 800kV</u>	<u>18060mm</u>	<u>23860mm</u>	<u>7940mm</u>

Note:

- (i) All height/clearances are in mm and under maximum sag conditions.
- (ii) If the crossing is provided with a guarding, a minimum clearance of 2000mm shall be maintained between bottom of the guard wire and highest traction conductor.
- (iii) Power line crossing in yards & stations area shall be avoided.
- (iv) For any electrification work of existing line; doubling/gauge conversion along with electrification, existing crossings can continue, if dimensions are as per Column (5) above, even if dimensions of Col (3) are not satisfied i.e., for electrification works Col (3) is not applicable.

DRAFT

CHAPTER – 5

PLATFORM SCREEN DOOR (PSD)

(As per MoHUA guidelines issued in 2013, planning of Metro system with PSD is mandatory.)

5.1 Setting out Dimensions

S.N.	Particular	2900 mm wide RS
i.	Minimum Platform Screen Door Width (clear opening)	2000 mm
ii.	Minimum Platform Screen Door Height from PF level (Full hight)	2100 mm
iii.	Minimum Platform Screen Gate Height from PF level (Half hight)	1500 mm
iv.	Minimum Platform Screen Door threshold offset from track centreline – straight track (Underground)	1510 mm
v.	Minimum Platform Screen Door panel offset from track centreline – straight track (underground)	1535 mm Excluding the deflector plate
vi.	Minimum Platform Screen Door threshold offset from track centreline – straight track (Elevated/At Grade)	1515 mm
vii.	Minimum Platform screen door panel offset from Track – centre line – straight track (Elevated/At- Grade)	1540 mm Excluding the deflector plate, drive assembly
viii.	The minimum size of object which can be sensed for retraction of doors (the dimensions given are only indicative, Metro may adopt more sensitive screen door which can sense lesser size as indicated).	19mm dia Rod or 5mmx40mm plate

RS door width of 1400mm, stopping accuracy of +/-300mm of signalling considered for PSD door width
Note

- Stopping Accuracy of Metro Train is (+/-) 300 mm or less.
- For curved platforms, additional clearance as per appendix-5 to be considered.
- Platform Gates are considered as designated railway operational structure. Therefore, platform gates may infringe the structure gauge, but does not infringe the kinematic envelope of train in station.
- The deflector (if provided) attached to the bottom of the sliding door shall be designed in order not to protrude beyond the door threshold.

APPENDIX-1

PERMISSIBLE SPEED, CANT AND MINIMUM TRACK SPACING ON CURVES UNDERGROUND (TUNNELS), ELEVATED AND AT-GRADE SECTIONS

Reference Para 1.1

RADIUS OF CURVE	CANT	MAXIMUM DESIGN SPEED	MINIMUM DISTANCE BETWEEN ADJACENT TRACKS	
			BALLASTLESS	
			UNDERGROUND	ELEVATED & AT-GRADE
metres	mm	kmph	mm	mm
>3000	-	90	3600	3650
3000	15	90	3600	3650
2800	15	90	3600	3650
2400	20	90	3600	3650
2000	20	90	3600	3650
1600	25	90	3600	3650
1500	30	90	3600	3650
1200	35	90	3600	3670
1000	45	90	3650	3700
800	55	90	3600	3750
600	70	90	3650	3750
500	95	90	3750	3800
450	115	90	3800	3850
400	120	85	3850	3900
350	120	80	3850	3900
300	125	75	3900	3950
200	120	60	4000	4050
150	110	50	4100	4150
150*	0	35	4000	4050
120	110	45	4200	4250
120*	0	30	4100	4150

Notes:

- The Track spacing shown in the table above is without any column / structure between two tracks and is with equal cant for both outer and inner tracks..
- Track spacing shown in Table above is not applicable to station which should be calculated depending on specific requirement but the spacing should not be less than the spacing stipulated in para 2.1.
- Cant provided is limited to desirable value of 125mm

- d) Maximum cant deficiency is 100mm
- e) *The curve with radius 120 and 150 without cant are used in depot/depot connections.
- f) For in between radius more sharper radius to be adopted to arrive track spacing

APPENDIX-2A

EXTRA HORIZONTAL SHIFT ON CURVES (CURVATURE EFFECT)

INSIDE OF CURVE

RADIUS	MID THROW (28500/R)	EXTRA GAUGE TOLERANCE ON CURVES	EXTRA NOSING DUE TO EXTRA GAUGE TOLERANCE	EXTRA HORIZONTAL SHIFT ON CURVE	REMARKS
R	(V)	(N)	(G)	(T1)	
100	285.0	26	9.0	268	
120	237.5	26	9.0	221	
150	190.0	26	9.0	173	
175	162.9	26	9.0	146	
190	150.0	26	9.0	133	
200	142.5	26	9.0	126	
250	114.0	26	9.0	97	
300	95.0	26	9.0	78	
350	81.4	26	9.0	64	
400	71.3	26	9.0	54	
450	63.3	26	9.0	46	
500	57.0	26	5.0	36	
550	51.8	26	5.0	31	
600	47.5	26	5.0	27	
650	43.8	26	5.0	23	
700	40.7	26	5.0	20	
750	38.0	26	5.0	17	
800	35.6	26	5.0	15	
850	33.5	26	5.0	13	
900	31.7	26	5.0	11	
950	30.0	26	0.0	4	
1000	28.5	26	0.0	3	
1100	25.9	26	0.0	0	
1200	23.8	26	0.0	0	
1300	21.9	26	0.0	0	
1400	20.4	26	0.0	0	
1500	19.0	26	0.0	0	
1600	17.8	26	0.0	0	
1700	16.8	26	0.0	0	
1800	15.8	26	0.0	0	
1900	15.0	26	0.0	0	
2000	14.3	26	0.0	0	
2200	13.0	26	0.0	0	

(G) Extra Gauge Tolerance on Curves sharper than 1000m Radius : 9mm for curves with Radius sharper than 500 m radius and 5 mm for curves of with Radius of 500 m to less than 1000m

T1 = V-N+G for V equal to or Greater than (N) and T1 = G for V <(N)

2400	11.9	26	0.0	0
2600	11.0	26	0.0	0
2800	10.2	26	0.0	0
3000 OR More	9.50	26	0.0	0

Mid Throw (in mm) $V = (125XC^2)/R = 28500/R$

Where C is the distance between bogie centres = $14.850 + 0.250 = 15.100\text{m}$ OR

$$14.850 - 0.250 = 14.600\text{m}$$

The worst case will be with $C = 15.100\text{ m}$

R is the Radius of curve in mtrs

Mid Throw (in MM) $V = (125xC^2) / R = 28500/R$

For in Between radius more sharper radius to be adopted

DRAFT

APPENDIX-2B

EXTRA HORIZONTAL SHIFT ON CURVES (CURVATURE EFFECT)

OUTSIDE OF CURVE

RADIUS	END THROW (34683/R)	EXTRA GAUGE TOLERANCE ON CURVES	EXTRA NOSING DUE TO EXTRA GAUGE TOLERANCE	EXTRA HORIZONTAL SHIFT ON CURVE	REMARKS
R	(Vo)	(G)	(EN)	(T2)	
100	346.8	9	2.3	358	
120	289.0	9	2.3	300	
150	231.2	9	2.3	242	
175	198.2	9	2.3	209	
190	182.5	9	2.3	194	
200	173.4	9	2.3	185	
250	138.7	9	2.3	150	
300	115.6	9	2.3	127	
350	99.1	9	2.3	110	
400	86.7	9	2.3	98	(G) Extra Gauge Tolerance on Curves sharper than 1000m Radius : 9mm for curves with Radius sharper than 500 m radius and 5 mm for curves of with Radius of 500 m to less than 1000m
450	77.1	9	2.3	88	
500	69.4	5	1.3	76	
550	63.1	5	1.3	69	
600	57.8	5	1.3	64	
650	53.4	5	1.3	60	
700	49.5	5	1.3	56	
750	46.2	5	1.3	53	
800	43.4	5	1.3	50	
850	40.8	5	1.3	47	
900	38.5	5	1.3	45	T2 = V0+G+EN EN=G x 0.251986301
950	36.5	5	1.3	43	
1000	34.7	0	0.0	35	
1100	31.5	0	0.0	32	
1200	28.9	0	0.0	29	
1300	26.7	0	0.0	27	
1400	24.8	0	0.0	25	
1500	23.1	0	0.0	23	
1600	21.7	0	0.0	22	
1700	20.4	0	0.0	20	
1800	19.3	0	0.0	19	
1900	18.3	0	0.0	18	
2000	17.3	0	0.0	17	

2200	15.8	0	0.0	16
2400	14.5	0	0.0	14
2600	13.3	0	0.0	13
2800	12.4	0	0.0	12
3000 OR More	11.6	0	0.0	12

End Throw (in mm) $V = (125XC^3)/R - (125 XC^2)/R = 34683/R$

Where C is the distance between bogie centres = $14.850 + 0.250 = 15.100\text{m}$ OR

$14.850 - 0.250 = 14.600\text{m}$

The worst case will be with $C = 14.6000\text{m}$

C1 is the length of coach in meters = 22.150 and

R is the radius of curve in meters

For in between radius more sharper radius to be adopted.

DRAFT

APPENDIX-3
CANT EFFECT ON STRUCTURE GAUGE - HORIZONTAL AT-GRADE AND ELEVATED
REFERENCE: PARA 1.7.2

ALL FIGURES ARE IN MM

Height above rail level measured perpendicular to plane of track Distance from centre line of track to Structure Gauge for tangent track					h = 305 ab = 1640				h = 930 ab = 1735				h = 3310 ab = 1825				h = 3775 ab = 1546				h = 6250 ab = 1546			
Cant	Angle a Degrees	Sin a	cos a	tan a	E ₁	F ₁	H ₁	H ₂	E ₁	F ₁	H ₁	H ₂	E ₁	F ₁	H ₁	H ₂	E ₁	F ₁	H ₁	H ₂	E ₁	F ₁	H ₁	H ₂
125	4.748	0.083	0.997	0.083	1660	1609	502	231	1806	1652	1133	846	2093	1545	3512	3210	1853	1228	3953	3697	2058	1023	6419	6163
120	4.558	0.079	0.997	0.080	1659	1611	494	234	1803	1656	1125	849	2082	1556	3505	3214	1841	1241	3946	3700	2038	1044	6413	6167
115	4.368	0.076	0.997	0.076	1658	1612	487	237	1801	1659	1117	853	2072	1568	3497	3219	1829	1254	3939	3704	2018	1066	6407	6172
110	4.178	0.073	0.997	0.073	1658	1613	479	240	1798	1663	1109	856	2061	1579	3489	3223	1817	1267	3933	3707	1997	1087	6401	6176
105	3.987	0.070	0.998	0.070	1657	1615	471	243	1795	1666	1101	860	2051	1590	3481	3228	1805	1280	3926	3711	1977	1108	6395	6180
100	3.797	0.066	0.998	0.066	1657	1616	463	246	1793	1670	1093	863	2040	1602	3474	3232	1793	1293	3919	3714	1957	1129	6389	6184
95	3.607	0.063	0.998	0.063	1656	1618	455	249	1790	1673	1085	867	2030	1613	3466	3236	1780	1305	3912	3718	1936	1150	6382	6188
90	3.417	0.060	0.998	0.060	1655	1619	447	252	1787	1676	1077	870	2019	1624	3458	3240	1768	1318	3905	3721	1916	1171	6376	6192
85	3.227	0.056	0.998	0.056	1655	1620	439	255	1785	1680	1069	873	2008	1636	3450	3245	1756	1331	3899	3724	1895	1192	6370	6196
80	3.037	0.053	0.999	0.053	1654	1622	431	258	1782	1683	1061	877	1998	1647	3442	3249	1744	1344	3892	3728	1875	1213	6363	6199
75	2.847	0.050	0.999	0.050	1653	1623	424	261	1779	1687	1053	880	1987	1658	3434	3253	1732	1357	3885	3731	1855	1234	6357	6203
70	2.657	0.046	0.999	0.046	1652	1624	416	264	1776	1690	1044	884	1976	1670	3426	3257	1719	1369	3878	3734	1834	1255	6350	6207
65	2.467	0.043	0.999	0.043	1652	1625	408	267	1773	1693	1036	887	1966	1681	3418	3261	1707	1382	3871	3737	1814	1276	6343	6210
60	2.277	0.040	0.999	0.040	1651	1627	400	270	1771	1697	1028	890	1955	1692	3410	3265	1695	1395	3863	3741	1793	1296	6336	6214
55	2.087	0.036	0.999	0.036	1650	1628	392	273	1768	1700	1020	894	1944	1703	3402	3269	1682	1407	3856	3744	1773	1317	6330	6217
50	1.898	0.033	0.999	0.033	1649	1629	384	276	1765	1703	1012	897	1934	1714	3394	3273	1670	1420	3849	3747	1752	1338	6323	6220
45	1.708	0.030	1.000	0.030	1648	1630	376	278	1762	1707	1004	900	1923	1726	3385	3277	1658	1433	3842	3750	1732	1359	6316	6224
40	1.518	0.026	1.000	0.026	1648	1631	368	281	1759	1710	996	904	1912	1737	3377	3280	1645	1445	3835	3753	1711	1380	6309	6227
35	1.328	0.023	1.000	0.023	1647	1632	360	284	1756	1713	987	907	1901	1748	3369	3284	1633	1458	3827	3756	1690	1401	6302	6230
30	1.138	0.020	1.000	0.020	1646	1634	353	287	1753	1716	979	910	1890	1759	3361	3288	1621	1471	3820	3759	1670	1422	6294	6233
25	0.949	0.017	1.000	0.017	1645	1635	345	290	1750	1719	971	914	1880	1770	3352	3292	1608	1483	3813	3761	1649	1442	6287	6236
20	0.759	0.013	1.000	0.013	1644	1636	337	293	1747	1723	963	917	1869	1781	3344	3296	1596	1496	3805	3764	1629	1463	6280	6239
15	0.569	0.010	1.000	0.010	1643	1637	329	296	1744	1726	955	920	1858	1792	3335	3299	1583	1508	3798	3767	1608	1484	6273	6242
10	0.379	0.007	1.000	0.007	1642	1638	321	299	1741	1729	946	923	1847	1803	3327	3303	1571	1521	3790	3770	1587	1505	6265	6245
5	0.190	0.003	1.000	0.003	1641	1639	313	302	1738	1732	938	927	1836	1814	3319	3306	1558	1533	3783	3772	1567	1525	6258	6247
0	0.000	0.000	1.000	0.000	1640	1640	305	305	1735	1735	930	930	1825	1825	3310	3310	1546	1546	3775	3775	1546	1546	6250	6250

REFER TO FIGURE: CMSG-4

$$E_1 = [ab + (h \times \tan \alpha)] \times \cos \alpha; \quad F_1 = [ab - (h \times \tan \alpha)] \times \cos \alpha$$

$$H_1 = (Ca/2) + (h/\cos \alpha) + (Ab - h \times \tan \alpha) \times \sin \alpha$$

$$H_2 = (Ca/2) + (h/\cos \alpha) - (ab + h \times \tan \alpha) \times \sin \alpha$$

ab = Ab = Distance from centre line of vehicle to Structure gauge for Tangent Track at height 'h' from rail level

ac = Distance from centre line of canted track to Structure Gauge for Tangent track at height 'h' from rail level.

bc = $h \times \tan \alpha$ = Lateral increment due to cant (measured along the line parallel to line joining top of rails).

APPENDIX - 3 (TNL)

CANT EFFECT ON STRUCTURE GAUGE-HORIZONTAL UNDER GROUND SECTIONS (RECTANGULAR BOX TUNNELS)

REFERENCE: PARA 1.7.2

ALL FIGURES IN MM

Height above rail level measured perpendicular to plane of track Distance from centre line of track to Structure Gauge for tangent track					h = 305 ab = 1585				h = 940 ab = 1670				h = 3305 ab = 1740				h = 3965 ab = 1250				h = 4838 ab = 1250			
Cant	Angle a Degrees	Sin a	cos a	tan a	E ₁	F ₁	H ₁	H ₂	E ₁	F ₁	H ₁	H ₂	E ₁	F ₁	H ₁	H ₂	E ₁	F ₁	H ₁	H ₂	E ₁	F ₁	H ₁	H ₂
125	4.748	0.083	0.997	0.083	1605	1554	498	235	1742	1586	1138	861	2008	1460	3500	3212	1574	917	4117	3910	1646	845	4987	4780
120	4.558	0.079	0.997	0.080	1604	1556	490	238	1739	1590	1130	864	1997	1472	3493	3216	1561	931	4112	3913	1631	862	4982	4783
115	4.368	0.076	0.997	0.076	1604	1557	482	241	1737	1594	1122	868	1987	1483	3485	3220	1548	944	4106	3916	1615	878	4977	4786
110	4.178	0.073	0.997	0.073	1603	1559	475	244	1734	1597	1114	871	1976	1495	3478	3224	1536	958	4101	3918	1599	894	4971	4789
105	3.987	0.070	0.998	0.070	1602	1560	467	247	1731	1601	1106	874	1966	1506	3470	3229	1523	971	4095	3921	1583	911	4966	4792
100	3.797	0.066	0.998	0.066	1602	1561	459	249	1729	1604	1099	877	1955	1517	3463	3233	1510	985	4089	3924	1568	927	4960	4795
95	3.607	0.063	0.998	0.063	1601	1563	452	252	1726	1608	1091	881	1944	1529	3455	3236	1497	998	4083	3926	1552	943	4955	4797
90	3.417	0.060	0.998	0.060	1600	1564	444	255	1723	1611	1083	884	1934	1540	3448	3240	1484	1011	4077	3928	1536	959	4949	4800
85	3.227	0.056	0.998	0.056	1600	1565	436	258	1720	1614	1075	887	1923	1551	3440	3244	1471	1025	4072	3931	1520	976	4943	4802
80	3.037	0.053	0.999	0.053	1599	1567	429	261	1717	1618	1067	890	1913	1562	3433	3248	1458	1038	4066	3933	1505	992	4937	4805
75	2.847	0.050	0.999	0.050	1598	1568	421	263	1715	1621	1059	893	1902	1574	3425	3252	1445	1052	4060	3936	1489	1008	4932	4807
70	2.657	0.046	0.999	0.046	1597	1569	413	266	1712	1625	1051	897	1891	1585	3417	3256	1432	1065	4054	3938	1473	1024	4926	4810
65	2.467	0.043	0.999	0.043	1597	1570	405	269	1709	1628	1044	900	1881	1596	3409	3260	1420	1078	4048	3940	1457	1041	4920	4812
60	2.277	0.040	0.999	0.040	1596	1572	398	272	1706	1631	1036	903	1870	1607	3402	3263	1407	1091	4042	3942	1441	1057	4914	4815
55	2.087	0.036	0.999	0.036	1595	1573	390	275	1703	1635	1028	906	1859	1618	3394	3267	1394	1105	4035	3944	1425	1073	4908	4817
50	1.898	0.033	0.999	0.033	1594	1574	382	277	1700	1638	1020	909	1848	1630	3386	3271	1381	1118	4029	3946	1410	1089	4902	4819
45	1.708	0.030	1.000	0.030	1593	1575	375	280	1697	1641	1012	912	1838	1641	3378	3274	1368	1131	4023	3948	1394	1105	4896	4821
40	1.518	0.026	1.000	0.026	1593	1576	367	283	1694	1645	1004	915	1827	1652	3370	3278	1355	1145	4017	3950	1378	1121	4889	4823
35	1.328	0.023	1.000	0.023	1592	1578	359	286	1691	1648	996	919	1816	1663	3362	3281	1342	1158	4010	3952	1362	1138	4883	4825
30	1.138	0.020	1.000	0.020	1591	1579	351	288	1688	1651	988	922	1805	1674	3354	3285	1329	1171	4004	3954	1346	1154	4877	4827
25	0.949	0.017	1.000	0.017	1590	1580	344	291	1685	1654	980	925	1794	1685	3346	3288	1315	1184	3998	3956	1330	1170	4871	4829
20	0.759	0.013	1.000	0.013	1589	1581	336	294	1682	1657	972	928	1784	1696	3338	3292	1302	1197	3991	3958	1314	1186	4864	4831
15	0.569	0.010	1.000	0.010	1588	1582	328	297	1679	1661	964	931	1773	1707	3330	3295	1289	1211	3985	3960	1298	1202	4858	4833
10	0.379	0.007	1.000	0.007	1587	1583	320	299	1676	1664	956	934	1762	1718	3321	3298	1276	1224	3978	3962	1282	1218	4851	4835
5	0.190	0.003	1.000	0.003	1586	1584	313	302	1673	1667	948	937	1751	1729	3313	3302	1263	1237	3972	3963	1266	1234	4845	4836
0	0.000	0.000	1.000	0.000	1585	1585	305	305	1670	1670	940	940	1740	1740	3305	3305	1250	1250	3965	3965	1250	1250	4838	4838

REFER TO FIGURE: MSG-4A

$E_1 = [ab + (h \times \tan \alpha)] \times \cos \alpha$

$F_1 = [ab - (h \times \tan \alpha)] \times \cos \alpha$

$H_1 = (Ca/2) + (h/\cos \alpha) + (Ab - h \times \tan \alpha) \times \sin \alpha$ & $H_2 = (Ca/2) + (h/\cos \alpha) - (ab + h \times \tan \alpha) \times \sin \alpha$

ab = Ab = Distance from centre line of vehicle to Structure gauge for Tangent Track at height 'h' from rail level

ac = Distance from centre line of canted track to Structure Gauge for Tangent track at height 'h' from rail level.

bc = $h \times \tan \alpha$ = Lateral increment due to cant (measured along the line parallel to line joining top of rails).

APPENDIX - 3A

CANT EFFECT ON KINEMATIC ENVELOPE-HORIZONTAL AT-GRADE AND ELEVATED SECTIONS

REF: PARA 1.7.1

Height above rail level measured → Perpendicular to plane of track					h = 938				h = 997				h = 1130				h = 2878				h = 3296				h = 4014				h = 4866				h = 5018			
Distance from centre line of track to K.E. for tangent track →					ab = 1582				ab = 1584				ab = 1590				ab = 1658				ab = 1658				ab = 1225				ab = 1220				ab = 880			
Cant	Angle a	Sin a	cos a	tan a	E	F	H ₁	H ₂	E	F	H ₁	H ₂	E	F	H ₁	H ₂	E	F	H ₁	H ₂	E	F	H ₁	H ₂	E	F	H ₁	H ₂	E	F	H ₁	H ₂	E	F	H ₁	H ₂
125	4.748	0.083	0.997	0.083	1654	1499	1128	866	1661	1496	1187	925	1678	1491	1320	1057	1891	1414	3068	2793	1925	1379	3484	3210	1553	889	4164	3961	1619	813	5013	4811	1292	462	5136	4990
120	4.558	0.079	0.997	0.080	1652	1502	1121	869	1658	1500	1180	928	1675	1495	1313	1060	1881	1424	3061	2797	1915	1391	3477	3214	1540	902	4159	3964	1603	829	5008	4814	1276	478	5132	4992
115	4.368	0.076	0.997	0.076	1649	1506	1113	872	1655	1503	1172	931	1671	1499	1305	1063	1872	1434	3053	2801	1904	1402	3470	3218	1527	916	4153	3967	1587	846	5002	4816	1260	495	5128	4994
110	4.178	0.073	0.997	0.073	1646	1509	1106	875	1652	1507	1165	934	1668	1503	1298	1066	1863	1444	3046	2805	1894	1413	3463	3221	1514	929	4148	3969	1571	862	4997	4819	1243	512	5124	4996
105	3.987	0.070	0.998	0.070	1643	1513	1098	878	1649	1511	1157	937	1665	1508	1290	1069	1854	1454	3039	2808	1883	1425	3456	3225	1501	943	4142	3972	1555	879	4992	4822	1227	529	5120	4997
100	3.797	0.066	0.998	0.066	1641	1516	1091	881	1647	1514	1150	940	1661	1512	1283	1072	1845	1464	3031	2812	1873	1436	3449	3229	1488	956	4136	3974	1540	895	4986	4825	1210	546	5115	4999
95	3.607	0.063	0.998	0.063	1638	1520	1083	884	1644	1518	1142	943	1658	1516	1275	1075	1836	1474	3024	2815	1862	1447	3441	3233	1475	970	4131	3976	1524	911	4981	4827	1194	563	5111	5000
90	3.417	0.060	0.998	0.060	1635	1523	1076	887	1641	1522	1135	946	1655	1520	1268	1078	1827	1484	3017	2819	1852	1459	3434	3236	1462	984	4125	3979	1508	928	4975	4830	1178	579	5107	5002
85	3.227	0.056	0.998	0.056	1632	1527	1068	890	1638	1525	1127	949	1651	1524	1260	1081	1817	1493	3009	2823	1841	1470	3427	3240	1449	997	4119	3981	1492	944	4969	4832	1161	596	5102	5003
80	3.037	0.053	0.999	0.053	1629	1530	1060	893	1635	1529	1120	952	1648	1528	1253	1084	1808	1503	3002	2826	1830	1481	3419	3244	1436	1011	4113	3983	1476	960	4964	4835	1145	613	5098	5004
75	2.847	0.050	0.999	0.050	1627	1533	1053	896	1632	1533	1112	955	1644	1532	1245	1087	1799	1513	2994	2830	1820	1492	3412	3247	1423	1024	4107	3986	1460	977	4958	4837	1128	630	5093	5006
70	2.657	0.046	0.999	0.046	1624	1537	1045	899	1629	1536	1104	957	1641	1536	1237	1090	1790	1523	2987	2833	1809	1503	3404	3251	1410	1038	4101	3988	1444	993	4952	4839	1112	646	5088	5007
65	2.467	0.043	0.999	0.043	1621	1540	1038	902	1625	1540	1097	960	1637	1540	1230	1093	1780	1533	2979	2836	1798	1515	3397	3254	1397	1051	4096	3990	1428	1009	4947	4841	1095	663	5084	5008
60	2.277	0.040	0.999	0.040	1618	1543	1030	904	1622	1543	1089	963	1634	1544	1222	1096	1771	1542	2972	2840	1788	1526	3389	3258	1384	1065	4090	3992	1412	1026	4941	4844	1079	680	5079	5009
55	2.087	0.036	0.999	0.036	1615	1547	1023	907	1619	1547	1082	966	1630	1548	1215	1099	1762	1552	2964	2843	1777	1537	3382	3261	1370	1078	4083	3994	1396	1042	4935	4846	1062	697	5074	5010
50	1.898	0.033	0.999	0.033	1612	1550	1015	910	1616	1550	1074	969	1627	1552	1207	1102	1752	1562	2956	2847	1766	1548	3374	3264	1357	1091	4077	3996	1380	1058	4929	4848	1046	713	5069	5011
45	1.708	0.030	1.000	0.030	1609	1553	1007	913	1613	1554	1066	972	1623	1556	1199	1105	1743	1571	2949	2850	1755	1559	3366	3268	1344	1105	4071	3998	1364	1074	4923	4850	1029	730	5064	5012
40	1.518	0.026	1.000	0.026	1606	1557	1000	916	1610	1557	1059	975	1619	1560	1192	1107	1734	1581	2941	2853	1745	1570	3359	3271	1331	1118	4065	4000	1348	1091	4917	4852	1013	747	5060	5013
35	1.328	0.023	1.000	0.023	1603	1560	992	919	1607	1560	1051	978	1616	1563	1184	1110	1724	1591	2933	2856	1734	1581	3351	3274	1318	1132	4059	4002	1332	1107	4910	4854	996	763	5055	5014
30	1.138	0.020	1.000	0.020	1600	1563	984	921	1603	1564	1043	980	1612	1567	1176	1113	1715	1600	2925	2859	1723	1592	3343	3277	1305	1145	4053	4004	1316	1123	4904	4856	980	780	5049	5015
25	0.949	0.017	1.000	0.017	1597	1566	977	924	1600	1567	1036	983	1608	1571	1169	1116	1705	1610	2918	2863	1712	1603	3335	3281	1291	1158	4046	4006	1300	1139	4898	4858	963	797	5044	5015
20	0.759	0.013	1.000	0.013	1594	1569	969	927	1597	1571	1028	986	1605	1575	1161	1119	1696	1620	2910	2866	1702	1614	3328	3284	1278	1172	4040	4007	1284	1155	4892	4859	946	813	5039	5016
15	0.569	0.010	1.000	0.010	1591	1573	961	930	1594	1574	1020	989	1601	1579	1153	1122	1687	1629	2902	2869	1691	1625	3320	3287	1265	1185	4033	4009	1268	1172	4885	4861	930	830	5034	5017
10	0.379	0.007	1.000	0.007	1588	1576	953	933	1591	1577	1012	991	1597	1582	1146	1124	1677	1639	2894	2872	1680	1636	3312	3290	1252	1198	4027	4011	1252	1188	4879	4863	913	847	5029	5017
5	0.190	0.003	1.000	0.003	1585	1579	946	935	1587	1581	1005	994	1594	1586	1138	1127	1668	1648	2886	2875	1669	1647	3304	3293	1238	1212	4021	4012	1236	1204	4873	4864	897	863	5023	5018
0	0.000	0.000	1.000	0.000	1582	1582	938	938	1584	1584	997	997	1590	1590	1130	1130	1658	1658	2878	2878	1658	1658	3296	3296	1225	1225	4014	4014	1220	1220	4866	4866	880	880	5018	5018

REFER TO FIGURE: CMSG-4A

$$E = [ab + (h \times \tan \alpha)] \times \cos \alpha$$

$$F = [ab - (h \times \tan \alpha)] \times \cos \alpha$$

$$H_1 = (Ca/2) + (h/\cos \alpha) + (Ab - h \times \tan \alpha) \times \sin \alpha$$

$$H_2 = (Ca/2) + (h/\cos \alpha) - (ab + h \times \tan \alpha) \times \sin \alpha$$

ab = Ab = Distance from centre line of vehicle to K.E. for Tangent Track at height 'h' from rail level

ac = Distance from centre line of canted track to K.E. for Tangent track at height 'h' from rail level.

bc = $h \tan \alpha$ = Lateral increment due to cant (measured along the line parallel to line joining top of rails).

APPENDIX - 3A (TNL)

CANT EFFECT ON KINEMATIC ENVELOPE UNDER GROUND SECTIONS (RECTANGULAR BOX/ TUNNELS)

REF: PARA 1.7.2

Height above rail level measured perpendicular to plane of track →					h = 947				h = 1130				h = 2885				h = 3287				h = 4005				h = 4158				h = 4318			
Distance from centre line of track to K.E. for tangent track →					ab = 1570				ab = 1576				ab = 1629				ab = 1629				ab = 1089				ab = 980				ab = 820			
Cant	Angle a	Sin a	cos a	tan a	E	F	H ₁	H ₂	E	F	H ₁	H ₂	E	F	H ₁	H ₂	E	F	H ₁	H ₂	E	F	H ₁	H ₂	E	F	H ₁	H ₂	E	F	H ₁	H ₂
125	4.748	0.083	0.997	0.083	1643	1486	1136	876	1664	1477	1319	1058	1862	1385	3072	2803	1896	1351	3473	3203	1417	754	4144	3964	1321	632	4287	4125	1175	460	4434	4298
120	4.558	0.079	0.997	0.080	1640	1490	1129	879	1661	1481	1312	1061	1853	1395	3065	2806	1885	1363	3466	3207	1404	767	4139	3966	1307	646	4283	4127	1161	474	4430	4299
115	4.368	0.076	0.997	0.076	1638	1493	1121	882	1657	1485	1304	1064	1844	1405	3058	2810	1875	1374	3459	3211	1391	781	4134	3968	1294	660	4278	4129	1146	489	4425	4301
110	4.178	0.073	0.997	0.073	1635	1497	1114	885	1654	1489	1297	1067	1835	1415	3051	2814	1864	1385	3452	3215	1378	794	4129	3970	1280	674	4273	4131	1132	503	4421	4302
105	3.987	0.070	0.998	0.070	1632	1500	1106	888	1651	1494	1289	1070	1826	1424	3044	2817	1854	1396	3445	3218	1365	808	4124	3972	1267	688	4269	4132	1118	518	4417	4303
100	3.797	0.066	0.998	0.066	1629	1504	1099	891	1647	1498	1282	1073	1816	1434	3037	2821	1843	1408	3438	3222	1352	821	4118	3974	1253	702	4264	4134	1104	532	4413	4304
95	3.607	0.063	0.998	0.063	1626	1507	1091	894	1644	1502	1274	1076	1807	1444	3029	2824	1833	1419	3430	3226	1339	835	4113	3976	1240	716	4259	4136	1090	547	4409	4305
90	3.417	0.060	0.998	0.060	1624	1511	1084	897	1641	1506	1267	1079	1798	1454	3022	2828	1822	1430	3423	3229	1326	848	4108	3978	1226	730	4254	4137	1076	561	4404	4306
85	3.227	0.056	0.998	0.056	1621	1514	1076	900	1637	1510	1259	1082	1789	1464	3015	2831	1811	1441	3416	3233	1313	862	4102	3980	1213	744	4249	4139	1062	576	4400	4307
80	3.037	0.053	0.999	0.053	1618	1518	1069	902	1634	1514	1252	1085	1780	1474	3007	2835	1801	1453	3409	3236	1300	875	4097	3982	1199	758	4244	4140	1048	590	4395	4308
75	2.847	0.050	0.999	0.050	1615	1521	1061	905	1630	1518	1244	1088	1770	1484	3000	2838	1790	1464	3401	3240	1287	889	4092	3983	1185	772	4239	4142	1033	605	4391	4309
70	2.657	0.046	0.999	0.046	1612	1524	1054	908	1627	1522	1237	1091	1761	1494	2992	2841	1780	1475	3394	3243	1273	902	4086	3985	1172	786	4234	4143	1019	619	4386	4310
65	2.467	0.043	0.999	0.043	1609	1528	1046	911	1623	1526	1229	1094	1752	1503	2985	2845	1769	1486	3387	3246	1260	916	4081	3987	1158	800	4229	4144	1005	633	4382	4311
60	2.277	0.040	0.999	0.040	1606	1531	1039	914	1620	1530	1222	1096	1742	1513	2977	2848	1758	1497	3379	3250	1247	929	4075	3989	1144	814	4224	4146	991	648	4377	4312
55	2.087	0.036	0.999	0.036	1603	1534	1031	917	1616	1534	1214	1099	1733	1523	2970	2851	1748	1508	3372	3253	1234	942	4070	3990	1131	828	4218	4147	977	662	4373	4313
50	1.898	0.033	0.999	0.033	1600	1538	1023	919	1613	1538	1207	1102	1724	1533	2962	2854	1737	1519	3364	3256	1221	956	4064	3992	1117	842	4213	4148	963	677	4368	4313
45	1.708	0.030	1.000	0.030	1598	1541	1016	922	1609	1542	1199	1105	1714	1542	2955	2858	1726	1530	3357	3259	1208	969	4058	3993	1103	856	4208	4149	948	691	4363	4314
40	1.518	0.026	1.000	0.026	1595	1544	1008	925	1605	1546	1191	1108	1705	1552	2947	2861	1716	1541	3349	3263	1195	983	4052	3995	1090	870	4203	4151	934	705	4358	4315
35	1.328	0.023	1.000	0.023	1592	1548	1001	928	1602	1549	1184	1111	1695	1562	2939	2864	1705	1552	3341	3266	1182	996	4047	3996	1076	883	4197	4152	920	720	4353	4315
30	1.138	0.020	1.000	0.020	1589	1551	993	931	1598	1553	1176	1113	1686	1571	2932	2867	1694	1563	3334	3269	1168	1009	4041	3998	1062	897	4192	4153	906	734	4348	4316
25	0.949	0.017	1.000	0.017	1585	1554	985	933	1594	1557	1168	1116	1677	1581	2924	2870	1683	1574	3326	3272	1155	1023	4035	3999	1049	911	4186	4154	891	748	4343	4316
20	0.759	0.013	1.000	0.013	1582	1557	978	936	1591	1561	1161	1119	1667	1591	2916	2873	1672	1585	3318	3275	1142	1036	4029	4000	1035	925	4181	4155	877	763	4338	4317
15	0.569	0.010	1.000	0.010	1579	1561	970	939	1587	1565	1153	1122	1658	1600	2909	2876	1662	1596	3311	3278	1129	1049	4023	4001	1021	939	4175	4156	863	777	4333	4317
10	0.379	0.007	1.000	0.007	1576	1564	962	942	1583	1568	1145	1125	1648	1610	2901	2879	1651	1607	3303	3281	1115	1062	4017	4003	1008	952	4169	4156	849	791	4328	4317
5	0.190	0.003	1.000	0.003	1573	1567	955	944	1580	1572	1138	1127	1639	1619	2893	2882	1640	1618	3295	3284	1102	1076	4011	4004	994	966	4164	4157	834	806	4323	4318
0	0.000	0.000	1.000	0.000	1570	1570	947	947	1576	1576	1130	1130	1629	1629	2885	2885	1629	1629	3287	3287	1089	1089	4005	4005	980	980	4158	4158	820	820	4318	4318

REFER TO FIGURE: CMSG-4A

$$E = [ab + (h \times \tan \alpha)] \times \cos \alpha;$$

$$F = [ab - (h \times \tan \alpha)] \times \cos \alpha$$

$$H_1 = (Ca/2) + (h / \cos \alpha) + (Ab - h \times \tan \alpha) \times \sin \alpha;$$

$$H_2 = (Ca/2) + (h / \cos \alpha) - (ab + h \times \tan \alpha) \times \sin \alpha$$

ab=Ab=Distance from centre line of vehicle to K.E. for Tangent Track at height 'h' from rail level & ac = Distance from centre line of canted track to K.E. for Tangent track at height 'h' from rail level.

bc = hxtanα =Lateral increment due to cant (measured along the line parallel to line joining top of rails).

APPENDIX – 4

LATERAL AND VERTICAL SHIFT OF CENTRE OF CIRCULAR TUNNEL FOR DIFFERENT CANT VALUES

(With $D_1 = 880$ mm & Radius $r=2900$ mm)

REFER TO FIGURE: CMSG-3 AND PARA Nos. 1.7.1 (B)-b & 1.7.2 (B)-b

All figures are in mm

CANT	$\sin \alpha = \text{Cant} / 1510$	Angle α	Angle θ	Lateral Shift of Tunnel centre - X	Vertical Shift of Tunnel centre = Y	Remark
Min		Degrees	Degrees	mm	mm	
125	0.08278	4.7485	69.5061	170	56	
120	0.07947	4.5581	69.5061	163	54	
115	0.07616	4.3678	69.5061	156	52	
110	0.07285	4.1776	69.5061	149	50	
105	0.06954	3.9874	69.5061	142	48	
100	0.06623	3.7972	69.5061	135	46	(a) The cant is provided by raising the outer rail which will mean, rotating the tunnel about the mid point of top of inner rail.
95	0.06291	3.6071	69.5061	129	43	
90	0.05960	3.4170	69.5061	122	41	
85	0.05629	3.2270	69.5061	115	39	
80	0.05298	3.0370	69.5061	108	37	(b) 'X' is lateral shift of the centre of the tunnel towards inside of the curve
75	0.04967	2.8470	69.5061	101	35	$X = \{ [2 \times (r-D_1) / \sin \theta] \times \{ \sin \alpha / 2 \} \} \times \cos (90-\theta - \alpha/2)$
70	0.04636	2.6570	69.5061	94	33	
65	0.04305	2.4671	69.5061	88	31	
60	0.03974	2.2773	69.5061	81	28	(c) 'Y' is the vertical shift of the centre of the tunnel (upwards)
55	0.03642	2.0874	69.5061	74	26	$Y = \{ [2 \times (r-D_1) / \sin \theta] \times \{ \sin \alpha / 2 \} \} \times \sin (90-\theta - \alpha/2)$ where,
50	0.03311	1.8976	69.5061	67	24	
45	0.02980	1.7077	69.5061	61	22	'r' is internal radius of the circular tunnel=2900 mm
40	0.02649	1.5179	69.5061	54	19	D_1 = depth from rail level to invert of circular tunnel=880 mm
35	0.02318	1.3282	69.5061	47	17	α = angle of rotation= $\sin^{-1} (\text{Cant}/g)$ and
30	0.01987	1.1384	69.5061	40	15	θ = angle subtended by line joining top of two rails and the line joining mid point of top of inner rail and the centre of circular Tunnel
25	0.01656	0.9486	69.5061	34	12	= $\tan^{-1} [(r-D_1) / (g/2)]$ in degrees=69.5061
20	0.01325	0.7589	69.5061	27	10	
15	0.00993	0.5692	69.5061	20	7	
10	0.00662	0.3794	69.5061	13	5	
5	0.00331	0.1897	69.5061	7	2	g = Centre to centre of rails = 1510 mm
0	0	0	69.5061	0	0	

APPENDIX – 5

ADDITIONAL CLERANCE FOR PLATFORMS ON CURVES UNDER GROUND, ELEVATED AND AT GRADE STATIONS

Refer Para 2.7

EXTRA CLEARANCE														
RADIUS	INSIDE OF CURVE								OUTSIDE OF CURVE					
	At centre line between Bogies				At Edge of Open Door, Nearest to the centre line between Bogies				At End of Coach	At Edge of Open Door, Farthest from the centre line between Bogies				
	Mid throw =28500/R	Nosing	Additional Clearance	Additional Clearance (rounded up)	Throw =27720/R	Nosing= 13*1.25/11.075	Additional Clearance	Additional Clearance (rounded up)	End throw =34683/R	Throw =23856/R	Nosing =13*10.05 /11.075	Diff bet N & N2	Additional Clearance	Additional Clearance (rounded up)
R	V	N	V-N	V-N	V ₃	N ₁	V ₃ -(N-N ₁)	V ₃ -(N-N ₁)	V ₀	V ₄	N ₂	N-N ₂	V ₄ -(N-N ₂)	V ₄ -(N-N ₂)
Metres	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
1	2	3	4a	4	5	6	7a	7	8	9	10	11	12a	12
3000	10	13	-3.5	0	9.2	1.5	-2.3	0	12	8.0	11.8	1.2	6.7	5
2800	10	13	-2.8	0	9.9	1.5	-1.6	0	12	8.5	11.8	1.2	7.3	10
2600	11	13	-2.0	0	10.7	1.5	-0.9	0	13	9.2	11.8	1.2	8.0	10
2400	12	13	-1.1	0	11.6	1.5	0.0	0	14	9.9	11.8	1.2	8.7	10
2200	13	13	0.0	0	12.6	1.5	1.1	5	16	10.8	11.8	1.2	9.6	10
2000	14	13	1.3	5	13.9	1.5	2.3	5	17	11.9	11.8	1.2	10.7	10
1800	16	13	2.8	5	15.4	1.5	3.9	5	19	13.3	11.8	1.2	12.1	10
1700	17	13	3.8	5	16.3	1.5	4.8	5	20	14.0	11.8	1.2	12.8	15
1600	18	13	4.8	5	17.3	1.5	5.8	10	22	14.9	11.8	1.2	13.7	15
1500	19	13	6.0	10	18.5	1.5	6.9	10	23	15.9	11.8	1.2	14.7	15
1400	20	13	7.4	10	19.8	1.5	8.3	10	25	17.0	11.8	1.2	15.8	20
1300	22	13	8.9	10	21.3	1.5	9.8	10	27	18.4	11.8	1.2	17.1	20
1200	24	13	10.8	15	23.1	1.5	11.6	15	29	19.9	11.8	1.2	18.7	20
1100	26	13	12.9	15	25.2	1.5	13.7	15	32	21.7	11.8	1.2	20.5	25
1000	29	13	15.5	20	27.7	1.5	16.2	20	35	23.9	11.8	1.2	22.7	25

NOTES:

- For outside of curve, the difference between clearance required at coach end and that the farthest door edge is less than 25mm. As half width of coach at ends is at least 25mm less than that at doors locations, additional clearance to be provided is additional clearance required at the farthest door edge (column 12).
- Values of additional clearances (Column 4, 7 and 12) rounded UP to the nearest value that is divisible by 5mm.
- Negative values of additional clearance are taken as zero in the columns 4 & 7 with rounded off figures.
- Extra clearance for curve:
 - Inside of curve:**
 $V = (125C^2 / R) = 28500/R$ when $C=15.10m$ (worst case/ max bogie pitch)
 $V_3 = [(125) \times (15.1^2 - 4 \times 1.25^2) / R] = 27720 / R$
 $N_1 = N \times (X) / (C_1/2) = 13 \times 1.25 / 11.075 = 1.467 \text{ mm}$
 The 1.25m value (X) above is the distance between the centre line between the Bogies and the edge of the nearest door leaf (0.875m wide) in its open position.
 The higher of (i) column 4 and (ii) column 7 shall be adopted.
 - Outside of curve**
 $V_0 = (125 C_1^2 / R) - (125c^2 / R) = 34683 / R$ for coach end when $c=14.6$ meters (worst case/ min bogie pitch) and $C_1 = 2 \times 11.075$ meters.
 $V_4 = 125 \times (20.1^2 - 14.6 \times 14.6) / R = 23856.3 / R$ for furthest edge of end door in open position with
 $C_1 = 2 \times 10.05 = 20.1$ meters and $C = 14.60$ meters for the worst case.
 $N_2 = \text{Nosing at the farthest edge of an open door} = N \times (X) / (C_1/2) = 13 \times 10.05 / 11.075 \text{ mm} = 11.8 \text{ mm}$
 $R = \text{Radius of curve in meters}$
 The 10.05m value (X) above is the distance between the centre line between the Bogies and the edge of the furthest door leaf (0.875m wide) in its open position.
- There will be no super elevation on curves in platform portion.

APPENDIX – 6
Sample Egress calculation report for Underground Station

UNDERGROUND STATION				
Year	Boarding	Alighting		
Dir 1 (Towards CMBT)	57.55	44.67	Per Min	
Dir 2 (Towards MMC)	11.42	28.93	Per Min	
Head way			3.54	mins
Sectional Load Direction 1			5176	Considering 1 missed headway and surge factor
Sectional Load Direction 2			2996	
Dense Crush Load			2004	
Platform Evacuation Time		within	4	mins
Surge Factor			1.3	mins
2 Headway entraining load for Peak Direction			7.1	mins
1 Headway entering entraining load for off-peak Direction			3.54	mins
POL (Emergency Service) Incident Direction 1			2586.2	
POL (Emergency Service) Incident Direction 2			2373.9	
Required Egress Capacity of Platform 1 (PEC)			646.56	
<i>(Evacuation Load / Evacuation Time)</i>				
Staircase Egress Capacity (Per/min)			55.50	
Working Escalator Egress Capacity (Per/min)			120.00	
Stopped Escalator Egress Capacity (Per/min)			55.50	
Elements			Width	Nos
Public Staircase			3.6	1
Fire Escape staircase inside station box			1.5	2
Working Escalator (4 nos; 3 used)			1	3
Stopped Escalator (0 nos; 0 used)			1	0
Proposed Egress Capacity			726.3	
Proposed Time For evacuation of Platform(Fp)			3.56	

APPENDIX – 6A
Sample Egress calculation report for Elevated Station

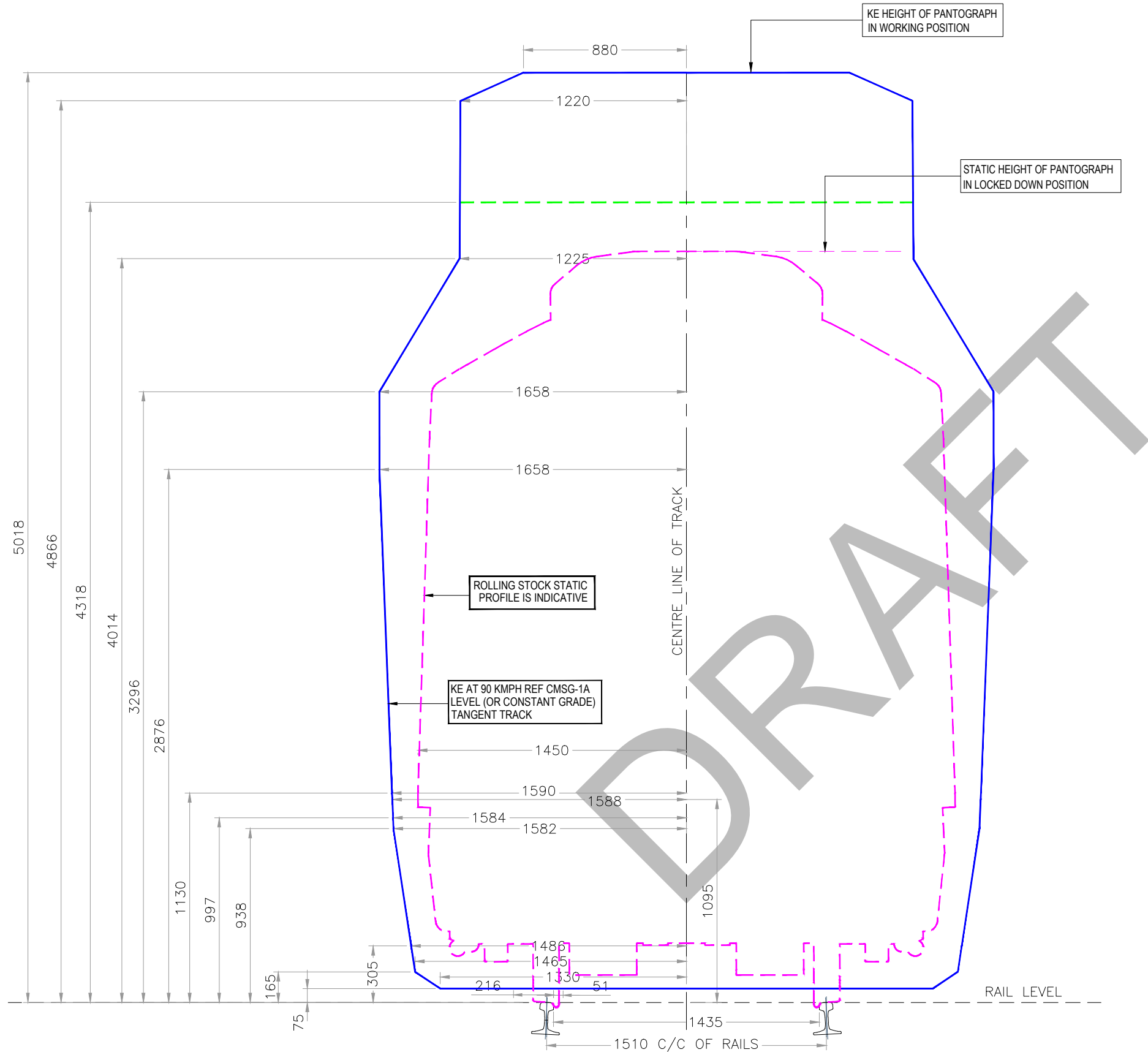
ELEVATED STATION			
Year	Boarding	Alighting	
Dir 1 (Towards CMBT)	34.47	3.80	Per Min
Dir 2 (Towards MMC)	5.27	31.52	Per Min

Head way		8.56	mins
Sectional Load Direction 1		1181	Considering 1 missed headway and surge factor
Sectional Load Direction 2		997	
Dense Crush Load		2004	
Platform Evacuation Time		within 5.5	mins
Surge Factor		1.3	mins
2 Headway entraining load for Peak Direction		17.1	mins
1 Headway entering entraining load for off-peak Direction		8.56	mins

POL (Emergency Service) Direction 1	1947.8
POL (Emergency Service) Direction 2	1114.6

Direction 1		
Elements	Width	Nos
Public Staircase	3.6	1
Fire Escape staircase inside station box	3.6	1
Fire Escape staircase outside station box	0	0
Working Escalator (2 nos; 1 used)	1	1
Stopped Escalator (0 nos; 0 used)	1	0
Proposed Egress Capacity	519.6	
Proposed Time For evacuation of Platform(Fp)	3.75	

Direction 2		
Elements	Width	Nos
Public Staircase	3.6	1
Fire Escape staircase inside station box	3.6	1
Fire Escape staircase outside station box	0	0
Working Escalator (2 nos; 1 used)	1	1
Stopped Escalator (0 nos; 0 used)	1	0
Proposed Egress Capacity	519.6	
Proposed Time For evacuation of Platform(Fp)	2.15	



NOTES:

1. ALL DIMENSIONS ARE IN MM.
2. HORIZONTAL AND VERTICAL SHIFTS DUE TO CURVES, INCLUDING VERTICAL CURVES AND CANT SHALL BE ADDITIONAL.
3. KINEMATIC ENVELOPE IS VALID FOR VEHICLES WITH SEALED WINDOWS AND DOORS CLOSED WHILE IN MOTION.
4. THE CONDUCTOR HEIGHT ABOVE RAIL LEVEL SHALL ALSO TAKE IN TO CONSIDERATION PRESCRIBED ELECTRICAL CLEARANCES BETWEEN ALL LIVE OVERHEAD EQUIPMENT & PANTOGRAPH/VEHICLE AND ALL PARTS THEREOF.
5. A TYRE OR ATTACHMENT OF A WHEEL MAY PROJECT BELOW THE MINIMUM HEIGHT OF KINEMATIC ENVELOPE FOR A DISTANCE OF 51 MM INSIDE AND 216 MM OUTSIDE OF THE GAUGE FACE OF THE WHEEL.
6. KINEMATIC ENVELOPE IS VALID FOR VEHICLE SPEEDS UPTO 90 KMPH
7. ROLLING STOCK STATIC PROFILE IS REPRESENTATIVE. ALL ROLLING STOCK CONTRACTORS WILL COMPLY TO THE KINEMATIC ENVELOPE AS IT HAS BEEN FIXED
8. THE CROSS WIND SPEED FOR CALCULATING THE KINEMATIC ENVELOPE WAS CONSIDERED AS 100 KMPH ON AT-GRADE /ELEVATED SECTION.
9. LEGEND

- KINEMATIC ENVELOPE LEVEL TANGENT TRACK
- ROLLING STOCK STATIC PROFILE
- REDUCED HEIGHT KINEMATIC ENVELOPE LIMIT IS APPLICABLE FOR THROUGH & SEMI THROUGH GIRDER BRIDGES.

CHENNAI METRO RAIL LIMITED



Phase-2 Project
METROS, No:327, Anna Salai, Nandanam,
Chennai-600035.
Ph: 044-23792000 , Fax: 044-23792200.
Email- chennai-metro-rail@gmail.com

STANDARD GAUGE
(1435mm)
25KV 50Hz A.C. TRACTION

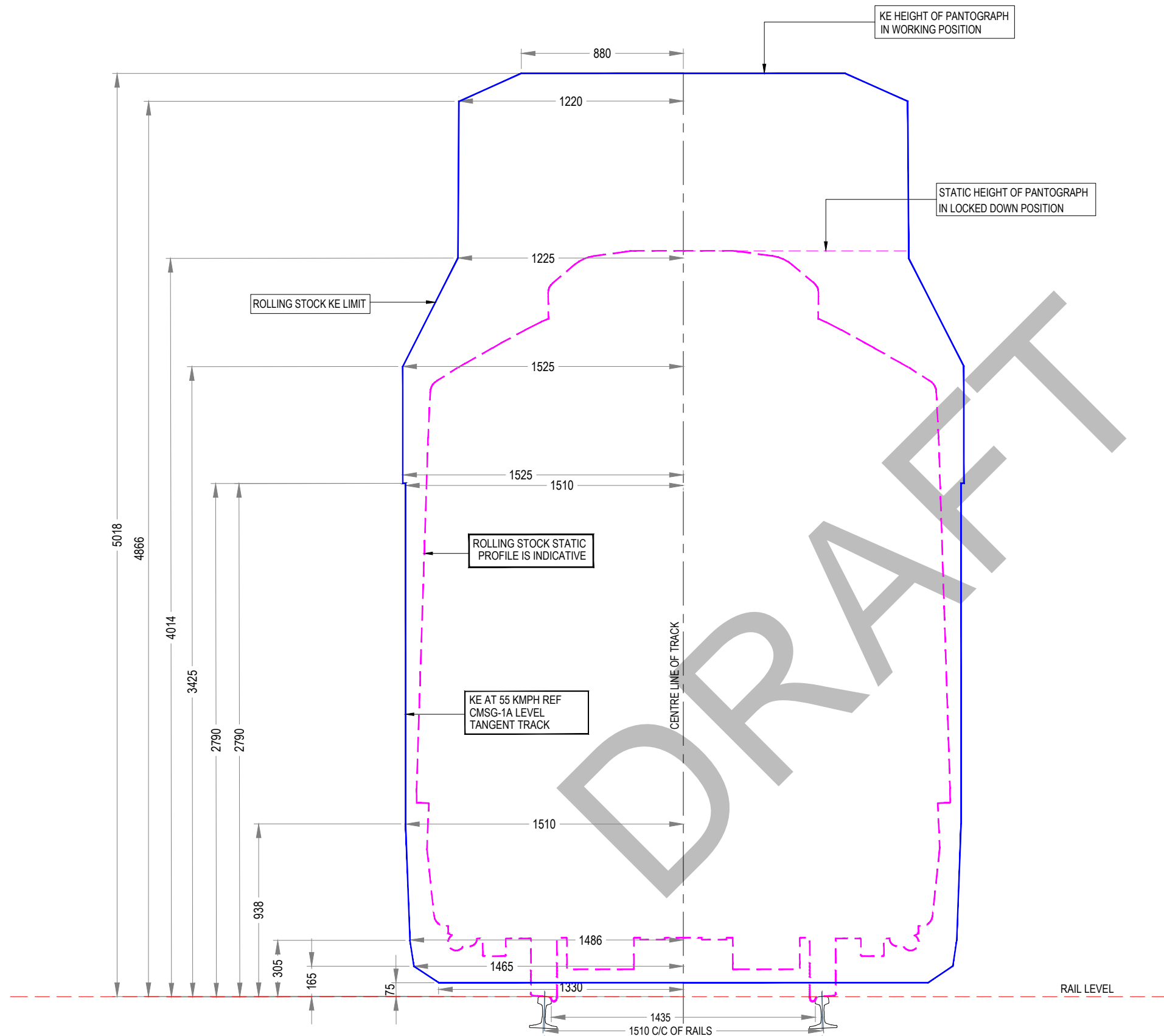
GENERAL NOTES :

REV.	DATE	DESCRIPTION	APPROVED

APPROVED:	
CHECKED:	
DRAWN:	
DATE:	

DRAWING NAME:	KINEMATIC ENVELOPE FOR 90 KMPH – AT GRADE, ELEVATED SECTIONS, THROUGH & SEMI THROUGH GIRDER BRIDGES ON LEVEL (OR CONSTANT GRADE) TANGENT TRACK
DRAWING NUMBER:	CMSG-1 REF-PARA 1.5

SHEET NO	SHEET SIZE
1 of 1	A3
SCALE:	1:1
REV:	1



NOTES:

1. ALL DIMENSIONS ARE IN MM.
2. HORIZONTAL AND VERTICAL SHIFTS DUE TO CURVES, INCLUDING VERTICAL CURVES AND CANT SHALL BE ADDITIONAL.
3. KINEMATIC ENVELOPE IS VALID FOR VEHICLES WITH SEALED WINDOWS AND DOORS CLOSED WHILE IN MOTION. KINEMATIC ENVELOPE IS VALID FOR VEHICLE SPEEDS UPTO 55 KMPH
4. ROLLING STOCK STATIC PROFILE IS REPRESENTATIVE. ALL ROLLING STOCK CONTRACTORS WILL COMPLY TO THE LIMIT FOR KINEMATIC ENVELOPE AS SHOWN.
5. THE CROSS WIND SPEED FOR CALCULATING THE KINEMATIC ENVELOPE WAS CONSIDERED AS 70 KMPH ON AT-GRADE/ ELEVATED STATION.
6. LEGEND
 - KINEMATIC ENVELOPE LEVEL TANGENT TRACK (ELEVATED STATIONS)
 - - - ROLLING STOCK STATIC PROFILE

POINT	X	Y
1	0	5018
2	880	5018
3	1220	4866
4	1225	4014
5	1525	3425
6	1525	2790
7	1510	2790
8	1510	938
9	1486	305
10	1465	165
11	1330	75
12	0	75

CHENNAI METRO RAIL LIMITED



Phase-2 Project
METROS, No:327, Anna Salai, Nandanam,
Chennai-600035.
Ph: 044-23792000 , Fax: 044-23792200.
Email- chennaimetrorail@gmail.com

STANDARD GAUGE
(1435mm)
25KV 50Hz A.C.TRACTION

GENERAL NOTES :

REV.	DATE	DESCRIPTION	APPROVED

APPROVED:

CHECKED:

DRAWN:

DATE:

DRAWING NAME:

KINEMATIC ENVELOPE FOR 55 KMPH
– AT GRADE AND ELEVATED SECTIONS
ON LEVEL (OR CONSTANT GRADE)
TANGENT TRACK AT STATIONS

DRAWING NUMBER: CMSG-1A REF-PARA 1.5

SHEET NO

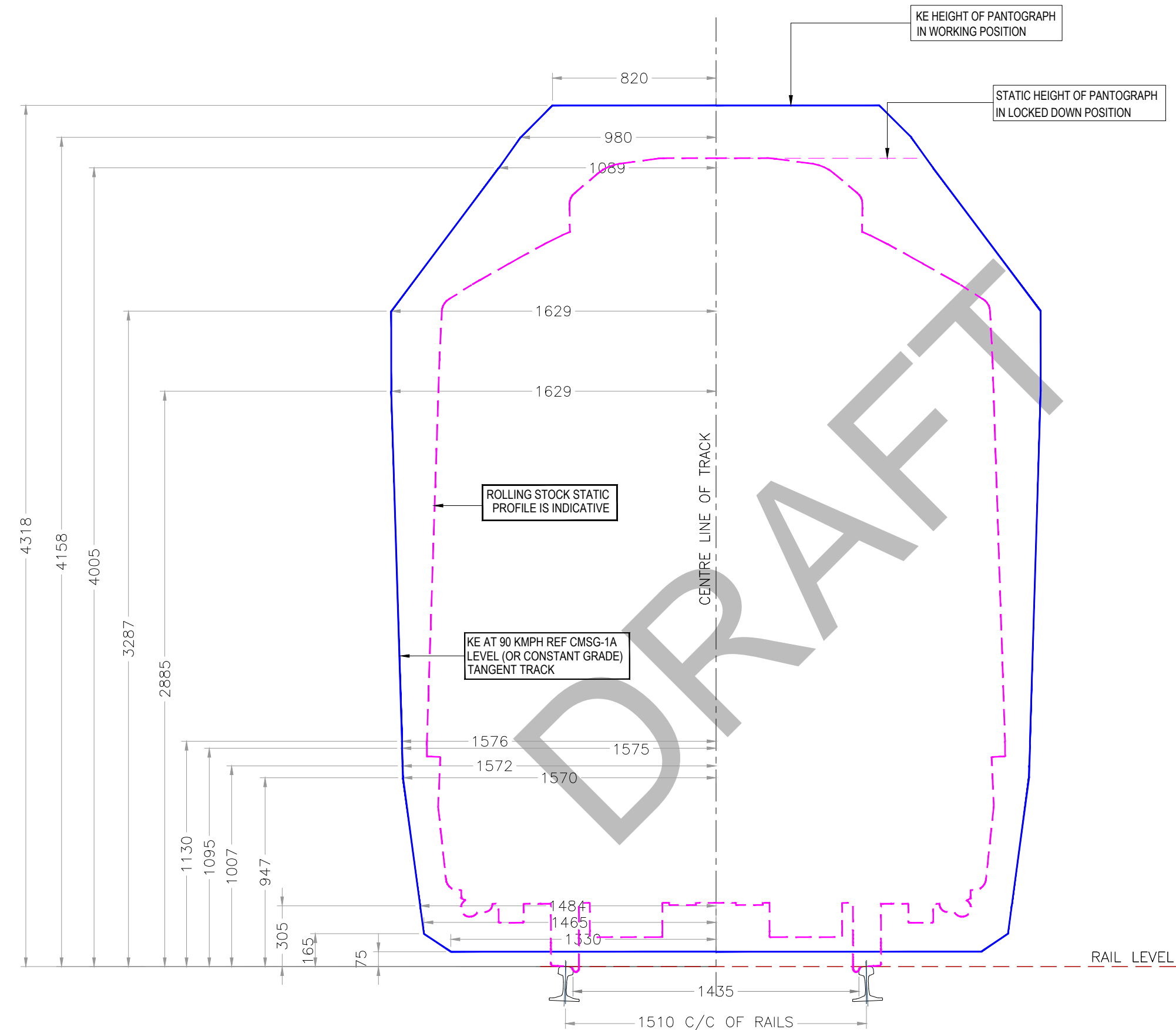
1 of 1

SHEET SIZE

A3

SCALE: 1:1

REV: 1



NOTES:

1. ALL DIMENSIONS ARE IN MM.
2. HORIZONTAL AND VERTICAL SHIFTS DUE TO CURVES, INCLUDING VERTICAL CURVES AND CANT SHALL BE ADDITIONAL.
3. KINEMATIC ENVELOPE IS VALID FOR VEHICLES WITH SEALED WINDOWS AND DOORS CLOSED WHILE IN MOTION.
4. THE CONDUCTOR HEIGHT ABOVE RAIL LEVEL SHALL ALSO TAKE IN TO CONSIDERATION PRESCRIBED ELECTRICAL CLEARANCES BETWEEN ALL LIVE OVERHEAD EQUIPMENT AND PANTOGRAPH/VEHICLE AND ALL PARTS THEREOF.
5. A TYRE OR ATTACHMENT OF A WHEEL MAY PROJECT BELOW THE MINIMUM HEIGHT OF KINEMATIC ENVELOPE FOR A DISTANCE OF 51 MM INSIDE AND 216 MM OUTSIDE OF THE GAUGE FACE OF THE WHEEL.
6. KINEMATIC ENVELOPE IS VALID FOR VEHICLE SPEEDS UPTO 90 KMPH
7. ROLLING STOCK STATIC PROFILE IS REPRESENTATIVE. ALL ROLLING STOCK CONTRACTORS WILL COMPLY TO THE KINEMATIC ENVELOPE LIMIT SHOWN
8. THE CROSS WIND SPEED FOR CALCULATION THE KINEMATIC ENVELOPE WAS CONSIDERED AS ZERO KMPH FOR UNDERGROUND SECTIONS
9. LEGEND

- KINEMATIC ENVELOPE LEVEL TANGENT TRACK
- - - ROLLING STOCK STATIC PROFILE

CHENNAI METRO RAIL LIMITED



Phase-2 Project
METROS, No:327, Anna Salai, Nandanam,
Chennai-600035.
Ph: 044-23792000 , Fax: 044-23792200.
Email- chennai-metrorail@gmail.com

STANDARD GAUGE
(1435mm)
25KV 50 Hz A.C. TRACTION

GENERAL NOTES :

REV.	DATE	DESCRIPTION	APPROVED

APPROVED:

CHECKED:

DRAWN:

DATE:

DRAWING NAME:

KINEMATIC ENVELOPE FOR 90 KMPH
– UNDERGROUND SECTIONS ON LEVEL
(OR CONSTANT GRADE) TANGENT TRACK

DRAWING NUMBER: CMSG-1(TNL)REF-PARA 1.5

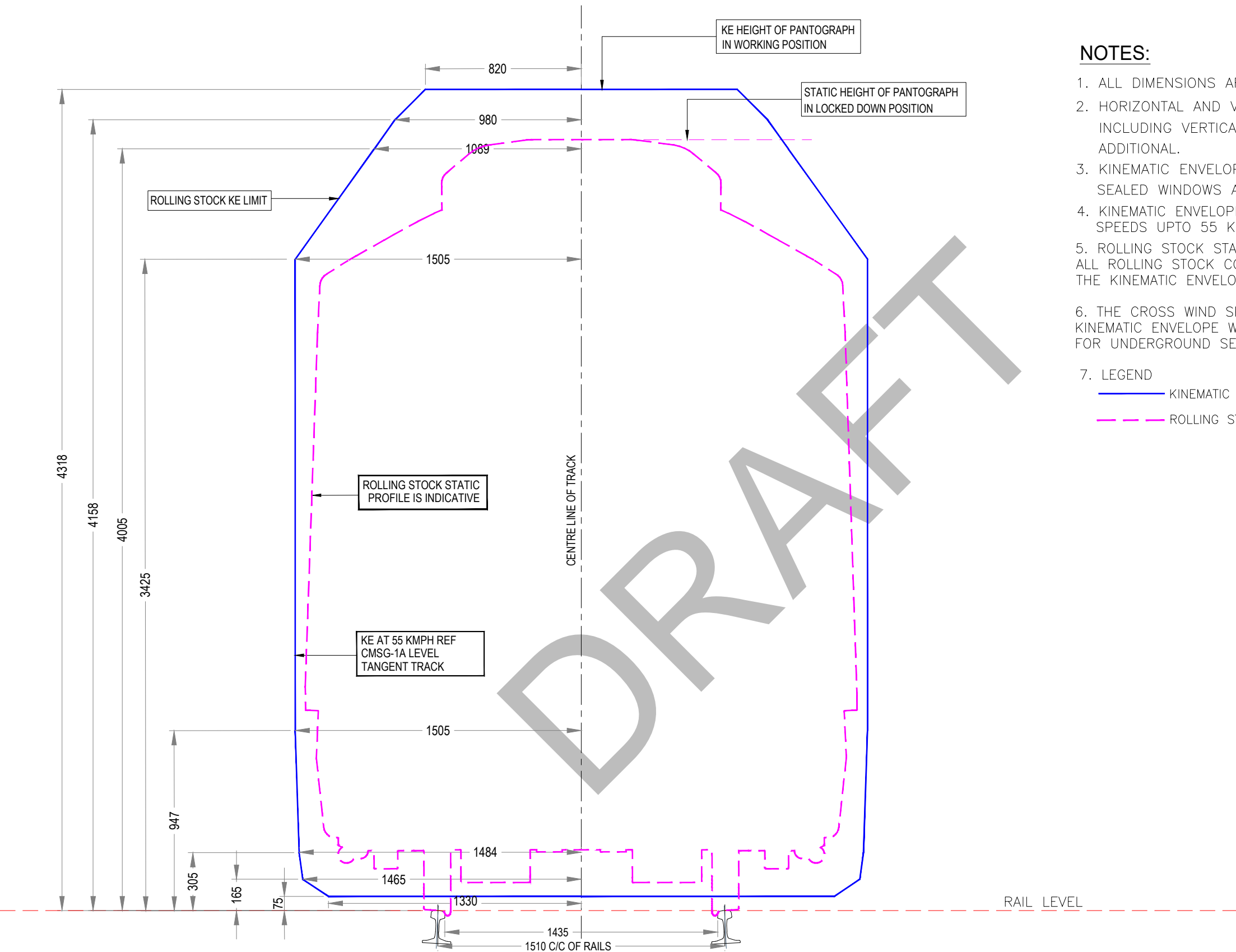
SHEET NO

SHEET SIZE

1 of 1 A3

SCALE: 1:1

REV: 2



NOTES:

1. ALL DIMENSIONS ARE IN MM.
2. HORIZONTAL AND VERTICAL SHIFTS DUE TO CURVES, INCLUDING VERTICAL CURVES AND CANT SHALL BE ADDITIONAL.
3. KINEMATIC ENVELOPE IS VALID FOR VEHICLES WITH SEALED WINDOWS AND DOORS CLOSED WHILE IN MOTION.
4. KINEMATIC ENVELOPE IS VALID FOR VEHICLE SPEEDS UPTO 55 KMPH
5. ROLLING STOCK STATIC PROFILE IS REPRESENTATIVE. ALL ROLLING STOCK CONTRACTORS WILL COMPLY TO THE KINEMATIC ENVELOPE AS IT HAS BEEN FIXED
6. THE CROSS WIND SPEED FOR CALCULATION THE KINEMATIC ENVELOPE WAS CONSIDERED AS ZERO KMPH FOR UNDERGROUND SECTIONS
7. LEGEND
 - KINEMATIC ENVELOPE LEVEL TANGENT TRACK (UNDERGROUND STATIONS)
 - - - ROLLING STOCK STATIC PROFILE

POINT	X	Y
1	0	4318
2	820	4318
3	980	4158
4	1089	4005
5	1505	3425
6	1505	947
7	1484	305
8	1465	165
9	1330	75
10	0	75

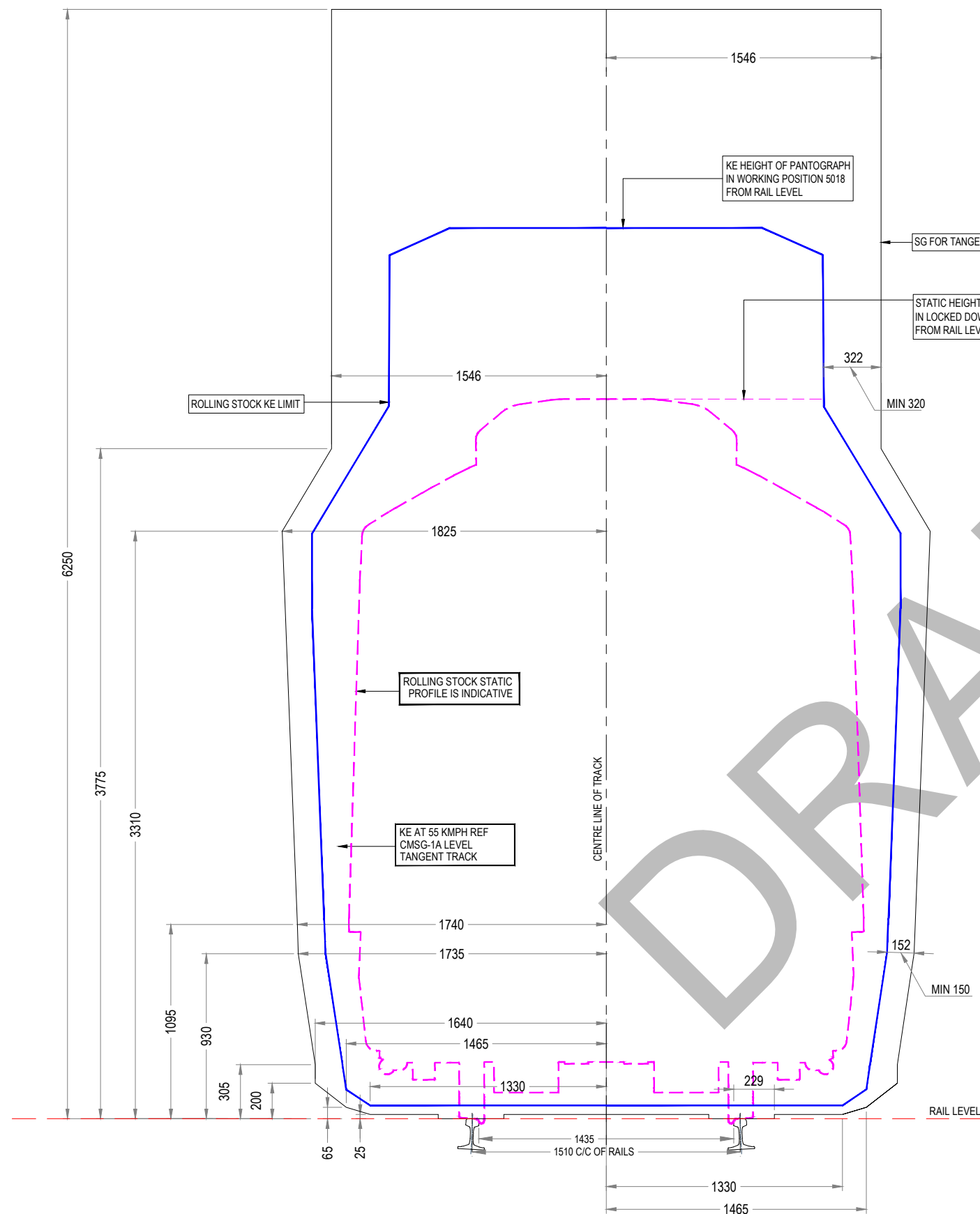
CHENNAI METRO RAIL LIMITED Phase-2 Project METROS, No:327, Anna Salai, Nandanam, Chennai-600035. Ph: 044-23792000 , Fax: 044-23792200. Email- chennai-metro-rail@gmail.com		STANDARD GAUGE (1435mm) 25KV 50 Hz A.C. TRACTION	GENERAL NOTES :	REV.	DATE	DESCRIPTION	APPROVED	APPROVED:	DRAWING NAME: KINEMATIC ENVELOPE FOR 55 KMPH – UNDERGROUND SECTIONS ON LEVEL (OR CONSTANT GRADE) TANGENT TRACK AT STATIONS	SHEET NO	SHEET SIZE
								CHECKED:		1 of 1	A3
								DRAWN:	DRAWING NUMBER: CMSG-1A(TNL)REF-PARA 1.5	SCALE: 1:1	REV: 1
								DATE:			

NOTES:

1. ALL DIMENSIONS ARE IN MM.
2. THIS STRUCTURE GAUGE WILL ALSO BE APPLICABLE FOR ROB/FOBS AT STATIONS WITHOUT THE MAST UNDER THE STRUCTURES.
3. WHERE IT IS NECESSARY TO PROVIDE MAST UNDER THE ROB/FOB, THE HEIGHT SHALL BE INCREASED FROM 6250 mm TO 6290 mm. IN CASE THE CONTACT WIRE IS HIGHER, THE HEIGHT OF THE ROB/FOB SHALL BE INCREASED ACCORDINGLY.
4. MINIMUM CLEARANCE BETWEEN KINEMATIC ENVELOPE AND STRUCTURE GAUGE WILL BE 150 mm.
5. MINIMUM ELECTRICAL CLEARANCE OF 320 mm SHALL BE MAINTAINED BETWEEN 25 KV LIVE PARTS AND THE EARTHED STRUCTURES.
6. MINIMUM CLEARANCE FOR OHE MAST WILL BE 2150 mm FROM THE CENTRE OF TRACK.
7. KINEMATIC ENVELOPE AND STRUCTURE GAUGE ARE VALID FOR ROLLING STOCK WITH SEALED WINDOWS AND DOORS CLOSED WHILE IN MOTION.
8. HORIZONTAL AND VERTICAL SHIFTS DUE TO CURVES, INCLUDING VERTICAL CURVES AND CANT SHALL BE EXTRA.
9. FOR KINEMATIC ENVELOPE, REFER TO DRG.NO:CMSG-1.

LEGEND:

- KINEMATIC GAUGE
- STATIC PROFILE
- STRUCTURE GAUGE



CHENNAI METRO RAIL LIMITED



Phase-2 Project
METROS, No:327, Anna Salai, Nandanam,
Chennai-600035.
Ph: 044-23792000 , Fax: 044-23792200.
Email- chennaietrorail@gmail.com

**STANDARD GAUGE
(1435mm)
25KV 50Hz A.C.TRACTION**

GENERAL NOTES :

REV.	DATE	DESCRIPTION	APPROVED

APPROVED:

CHECKED:

DRAWN:

DATE:

DRAWING NAME:

**STRUCTURE GAUGE - AT GRADE AND
ELEVATED SECTIONS ON LEVEL OR
CONSTANT GRADE TANGENT TRACK
(OUTSIDE STATION)**

DRAWING NUMBER: CMSG-2

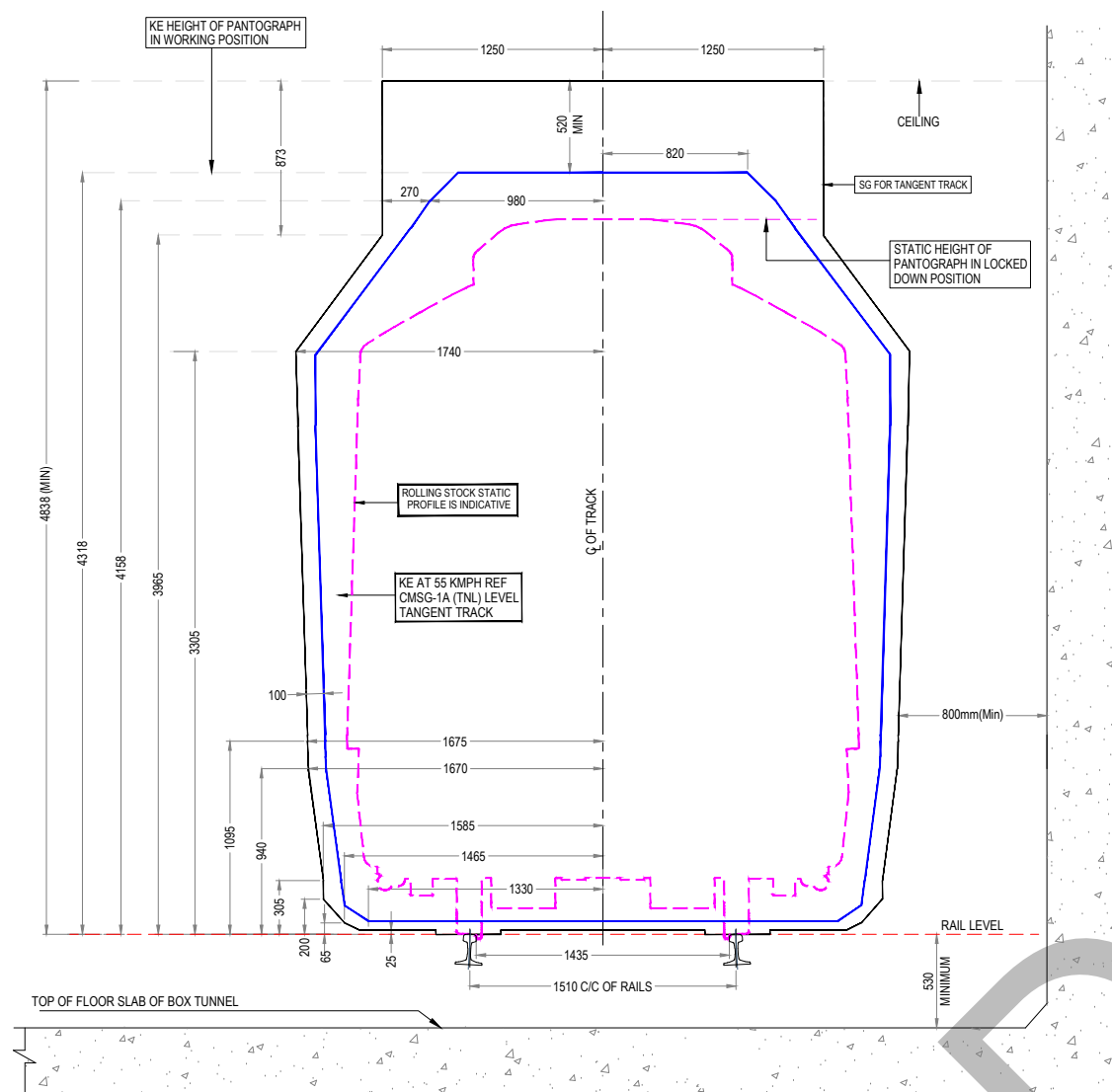
SHEET NO

SHEET SIZE

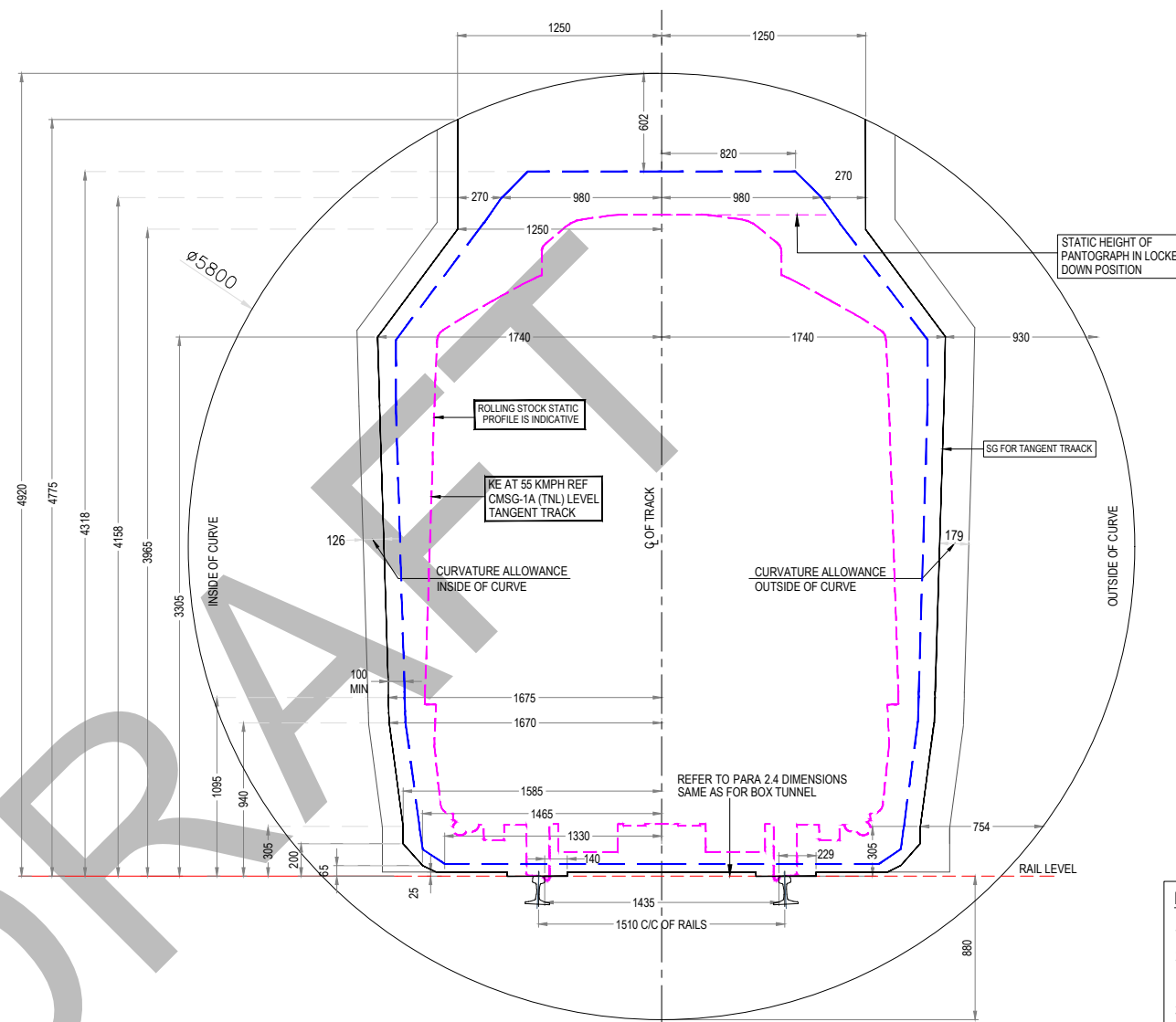
1 of 1 A3

SCALE: NOT TO SCALE

REV: 0



RECTANGULAR BOX TUNNEL



CIRCULAR TUNNEL 5800 mm DIA

NOTES:-

1. ALL DIMENSIONS ARE IN mm.
2. KINEMATIC ENVELOPE AND STRUCTURE GAUGE ARE VALID FOR VEHICLES WITH SEALED WINDOWS AND DOORS CLOSED WHILE IN MOTION.
3. STRUCTURE GAUGE FOR CURVE DOES NOT INCLUDE LATERAL SHIFT (LEAN) DUE TO CANT.
4. HORIZONTAL AND VERTICAL SHIFTS DUE TO CURVES INCLUDING VERTICAL CURVES AND CANT SHALL BE EXTRA.
5. CANT WILL BE PROVIDED BY RAISING OUTER RAIL ONLY AND SHIFTING OF THE CENTRE OF THE CIRCULAR TUNNEL TOWARDS INSIDE OF THE CURVE AND UPWARDS. THIS WILL BE SAME AS ROTATING THE CIRCULAR TUNNEL ABOUT THE MID POINT OF TOP OF INNER RAIL.
6. MINIMUM CLEARANCE BETWEEN KINEMATIC ENVELOPE AND STRUCTURE GAUGE = 100mm.
7. THE ELECTRICAL CLEARANCE FROM 25KV LIVE PARTS AND EARTHED STRUCTURES SHALL BE 270 mm.
8. VERTICAL THROW DUE TO VERTICAL CURVE HAS NOT BEEN SHOWN IN THE FIGURE AND SHALL BE EXTRA.
9. FOR DETAILS OF KINEMATIC ENVELOPE, REFER TO DRAWING No. CMSG-1(TNL).

LEGEND:

- KINEMATIC GAUGE
- STATIC PROFILE
- STRUCTURE GAUGE

CHENNAI METRO RAIL LIMITED,



Phase-2 Project
METROS, No:327, Anna Salai, Nandanam,
Chennai-600035.
Ph: 044-23792000 , Fax: 044-23792200.
Email- chennai-metrorail@gmail.com

STANDARD GAUGE
(1435mm)
25KV 50 Hz A.C. TRACTION

GENERAL NOTES :

REV.	DATE	DESCRIPTION	APPROVED

APPROVED:

CHECKED:

DRAWN:

DATE:

DRAWING NAME: STRUCTURE GAUGE

CIRCULAR TUNNEL (5800MM DIA) AND RECTANGULAR BOX
TUNNEL ON TANGENT TRACK AND CURVE UPTO R=200M .

DRAWING NUMBER: CMSG-2(TNL)

SHEET NO
1 of 1

SHEET SIZE
A3

SCALE: NOT TO SCALE

REV: 0

$$\tan \theta = (r-D_1)/(g/2)$$

$$\theta = \tan^{-1}[(r-D_1)/(g/2)]$$

$$\sin \alpha = \text{cant}/g$$

$$\alpha = \sin^{-1}(\text{cant}/g)$$

$$\text{Chord } C_1C_2 = 2 \times [(r-D_1)/\sin \theta] \times (\sin \alpha/2)$$

$$X = C_1C_2 \times \cos(90-\theta-\alpha/2)$$

$$= 2 \times [(r-D_1)/\sin \theta] \times (\sin \alpha/2) \times \cos(90-\theta-\alpha/2)$$

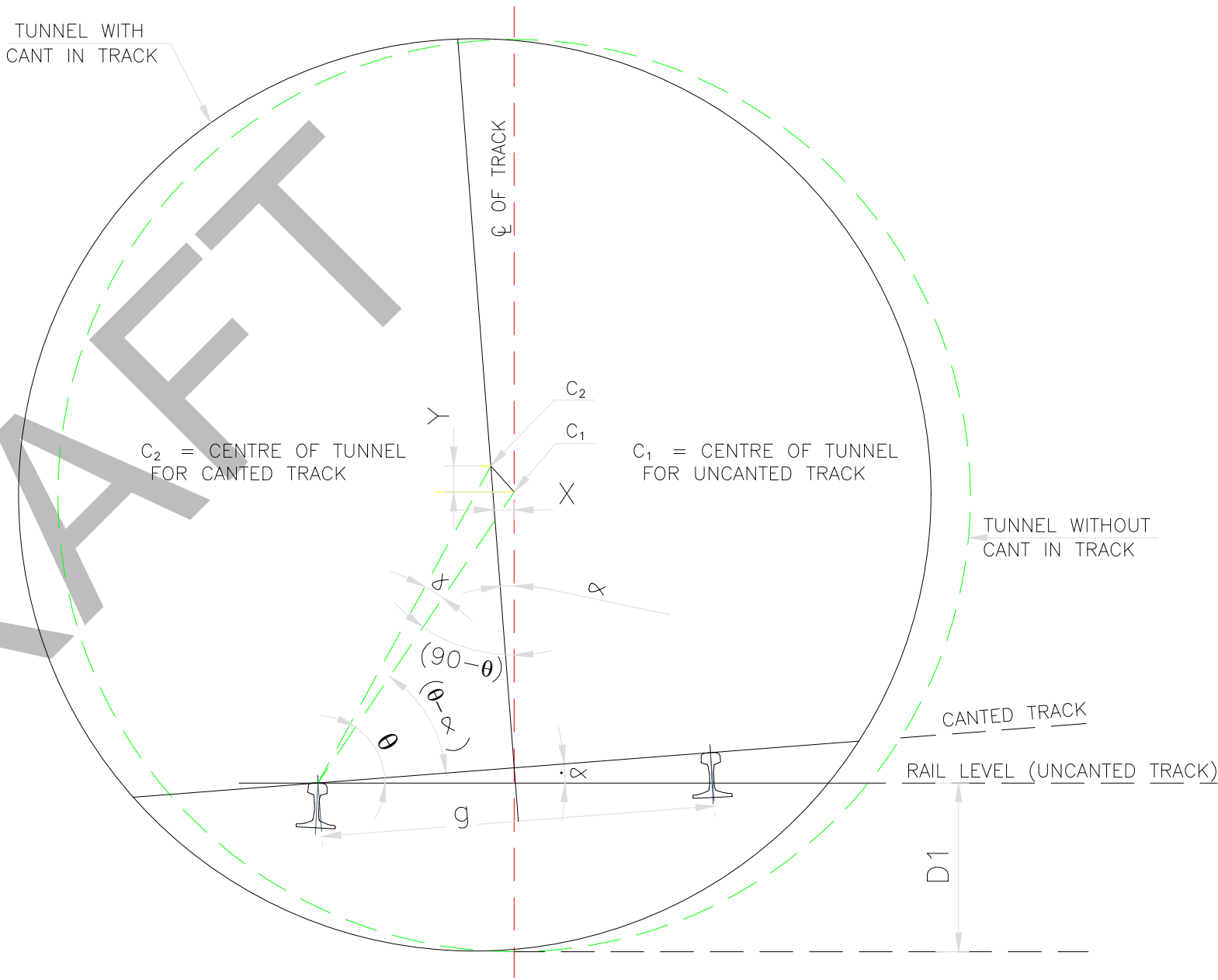
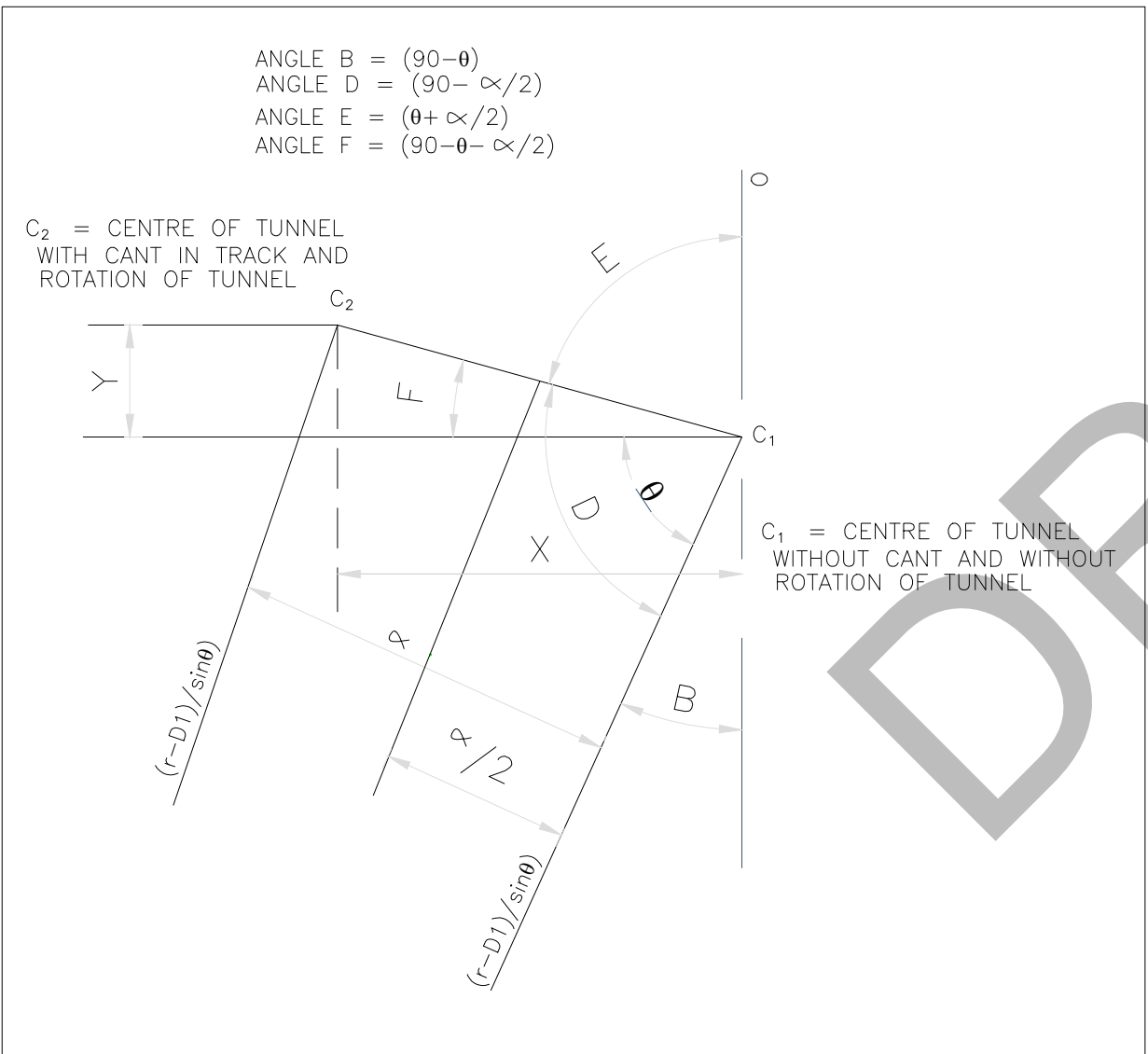
$$Y = 2 \times [(r-D_1)/\sin \theta] \times (\sin \alpha/2) \times \sin(90-\theta-\alpha/2)$$

where 'r' is internal radius of tunnel,
 D_1 = depth from Rail level to invert of tunnel
g = distance between centres of rails = 1510 mm

NOTES:

1. THE CIRCULAR TUNNEL IS ROTATED ABOUT THE MID POINT OF TOP OF INNER RAIL FOR CANT.
2. FOR VALUES OF SHIFT 'X' AND 'Y' FOR VARIOUS VALUES OF CANT,REFER TO APPENDIX-4

DETAIL AT CENTRE OF TUNNEL



CHENNAI METRO RAIL LIMITED

Phase-2 Project
METROS, No.327, Anna Salai, Nandanam,
Chennai-600035.
Ph: 044-23792000 , Fax: 044-23792200.
Email- chennai-metrorail@gmail.com

STANDARD GAUGE
(1435mm)
25KV 50Hz A.C. TRACTION

GENERAL NOTES :

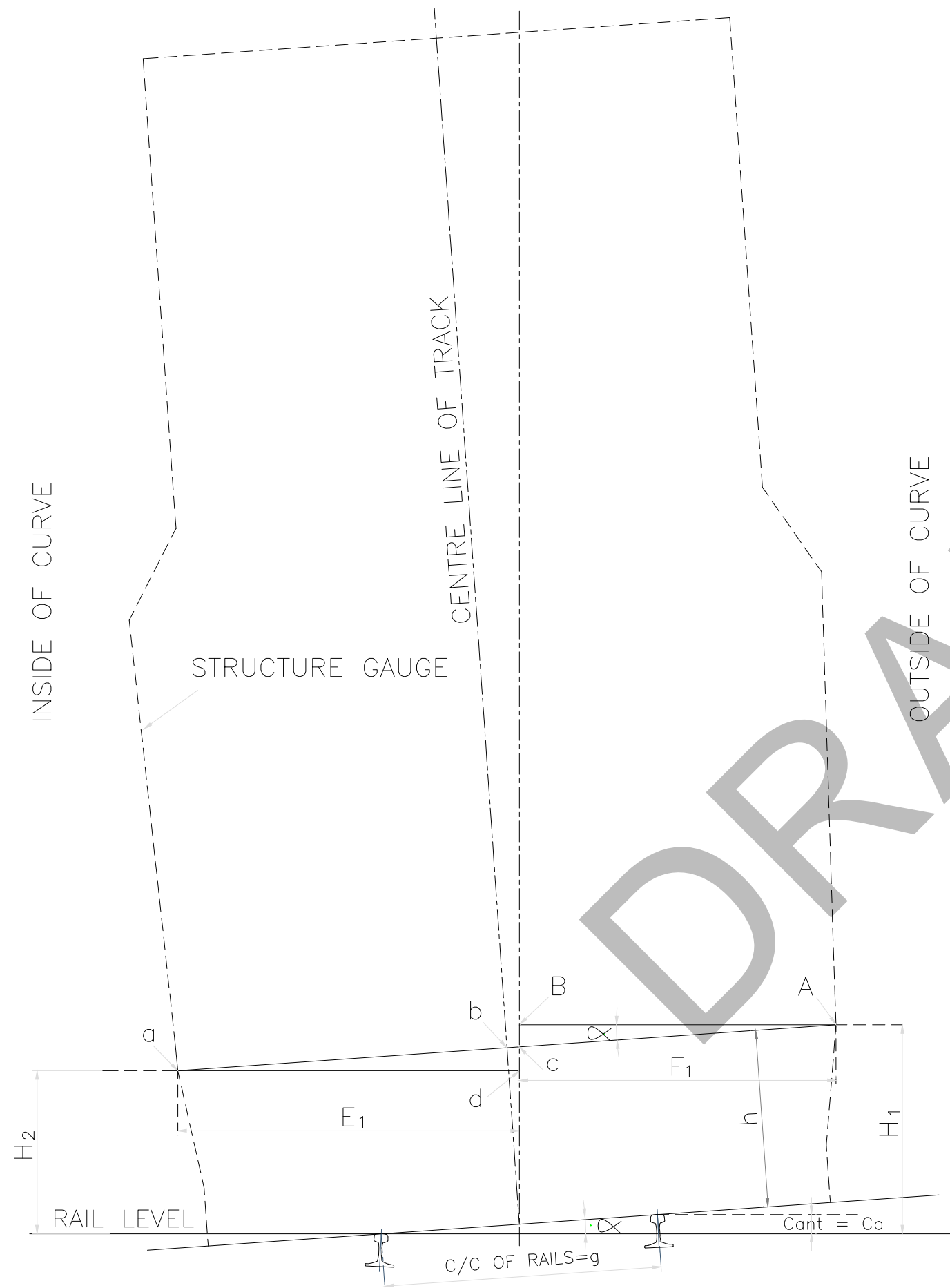
REV.	DATE	DESCRIPTION	APPROVED

APPROVED:
CHECKED:
DRAWN:
DATE:

DRAWING NAME:
SHIFT OF THE CENTRE OF CIRCULAR TUNNEL DUE TO ROTATION OF TUNNEL TO PROVIDE CANT

DRAWING NUMBER: CMSG-3

SHEET NO	SHEET SIZE
1 of 1	A3
SCALE: NOT TO SCALE	
REV: 0	



$ab=Ab$ =Distance from centre line of track to Structure Gauge for Tangent Track at height 'h'
 $\sin \alpha = \text{cant}/g$
 $g = 1510\text{mm}$
 $Ca = \text{Cant applied}$
 $E_1 = [ab+(h \times \tan \alpha)] \times \cos \alpha$
 $F_1 = [Ab-(h \times \tan \alpha)] \times \cos \alpha$
 $H_1 = (Ca/2)+(h/\cos \alpha)+(Ab-h \times \tan \alpha) \times \sin \alpha$
 $H_2 = (Ca/2)+(h/\cos \alpha)-(ab+h \times \tan \alpha) \times \sin \alpha$
 For values of E_1 , F_1 , H_1 AND H_2 refer to Appendix 3 and 3 (TNL)

NOTES:-

1. STRUCTURE GAUGE FOR AT – GRADE/ELEVATED SECTION HAS BEEN SHOWN AS A TYPICAL FIGURE.
2. THE FORMULAE FOR E_1 , F_1 , H_1 AND H_2 SHOWN IN THIS FIGURE WILL ALSO APPLY TO UNDER GROUND BOX TUNNELS.

CHENNAI METRO RAIL LIMITED



Phase-2 Project
 METROS, No:327, Anna Salai, Nandanam,
 Chennai-600035.
 Ph: 044-23792000 , Fax: 044-23792200.
 Email- chennaimetrorail@gmail.com

STANDARD GAUGE
 (1435mm)
 25KV 50 Hz A.C. TRACTION

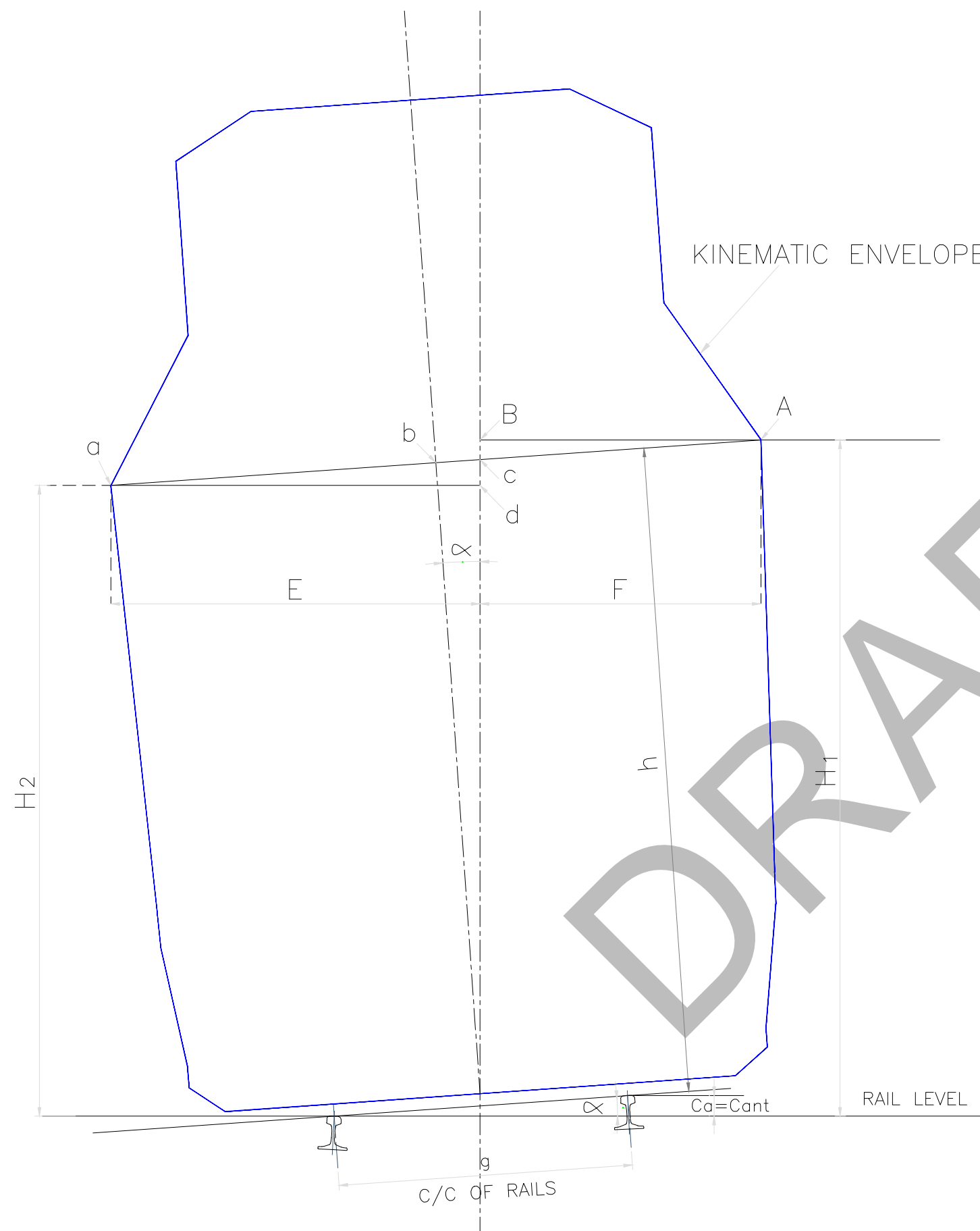
GENERAL NOTES :

REV.	DATE	DESCRIPTION	APPROVED

APPROVED:
CHECKED:
DRAWN:
DATE:

DRAWING NAME:
EFFECT OF CANT ON STRUCTURE GAUGE
DRAWING NUMBER: CMSG-4

SHEET NO	SHEET SIZE
1 of 1	A3
SCALE: NOT TO SCALE	
REV:	0



$ab=Ab$ =Distance from centre line of track to Structure Gauge for Tangent Track at height 'h'

$$\sin \alpha = \frac{\text{cant}}{g}$$

$$g = 1510\text{mm}$$

Ca = Cant applied

$$E = [ab + (h \times \tan \alpha)] \times \cos \alpha$$

$$F = [Ab - (h \times \tan \alpha)] \times \cos \alpha$$

$$H_1 = (Ca/2) + (h/\cos \alpha) + (Ab - h \times \tan \alpha) \times \sin \alpha$$

$$H_2 = (Ca/2) + (h/\cos \alpha) - (ab + h \times \tan \alpha) \times \sin \alpha$$

For values of E , F , H_1 and H_2 refer to Appendix 3A and 3A (TNL)

NOTES:-

1. KINEMATIC ENVELOPE FOR AT-GRADE/ELEVATED SECTIONS HAS BEEN SHOWN AS A TYPICAL FIGURE.
2. THE FORMULAE FOR E , F , H_1 AND H_2 SHOWN IN THIS FIGURE WILL ALSO APPLY TO UNDER GROUND BOX TUNNELS.

CHENNAI METRO RAIL LIMITED



Phase-2 Project
METROS, No:327, Anna Salai, Nandanam,
Chennai-600035.
Ph: 044-23792000, Fax: 044-23792200.
Email- chennai-metro-rail@gmail.com

STANDARD GAUGE
(1435mm)
25KV 50 Hz A.C. TRACTION

GENERAL NOTES :

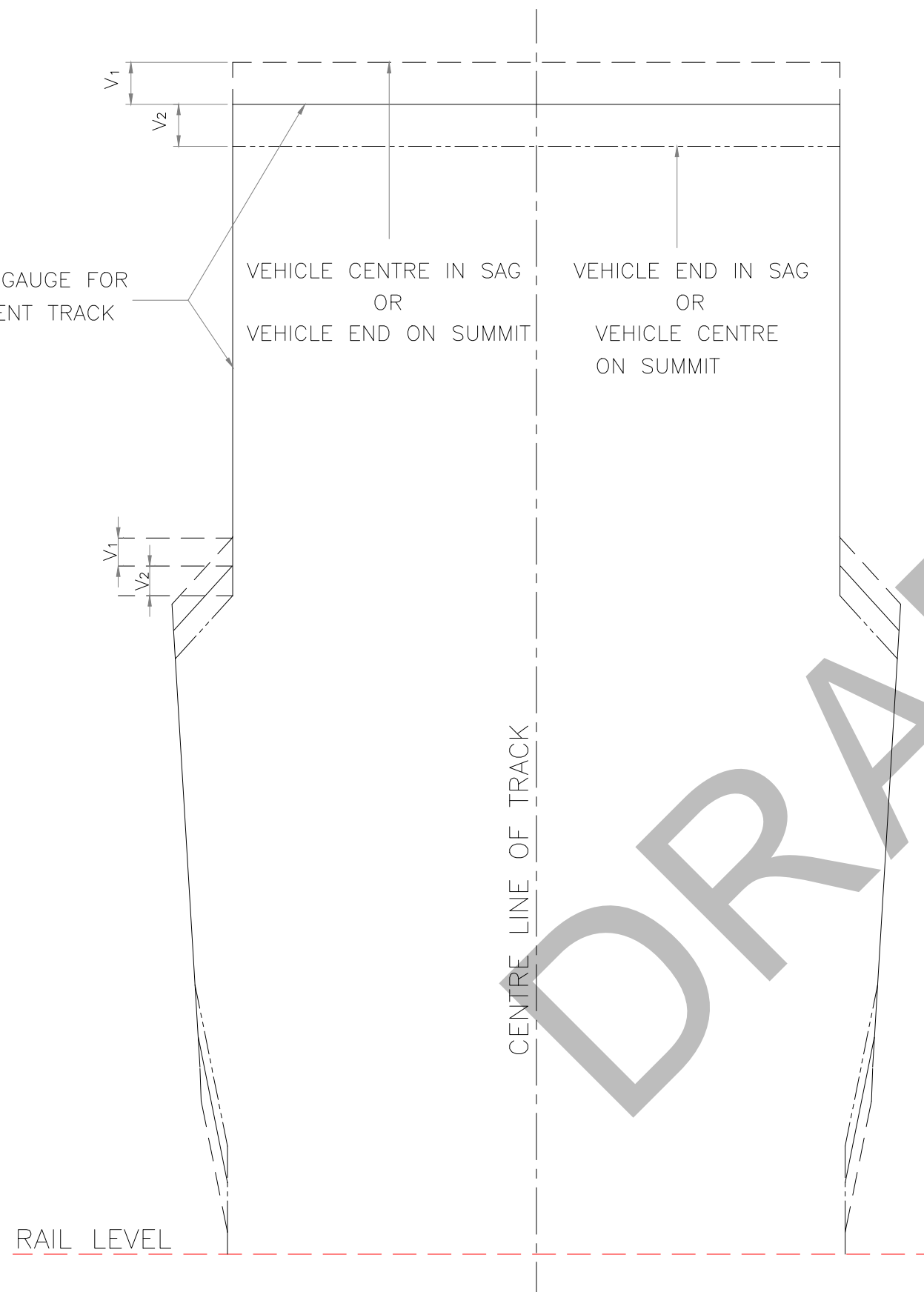
REV.	DATE	DESCRIPTION	APPROVED

APPROVED:
CHECKED:
DRAWN:
DATE:

DRAWING NAME:
EFFECT OF CANT ON KINEMATIC ENVELOPE

DRAWING NUMBER: **CMSG-4A**

SHEET NO	SHEET SIZE
1 of 1	A3
SCALE: NOT TO SCALE	
REV: 0	



VERTICAL THROW

RADIUS OF VERTICAL CURVE metres	V1 mm	V2 mm
1500	19	22
1600	18	21
1700	17	20
1800	16	19
1900	15	18
2000	14	17
2100	14	16
2200	13	15
2300	12	15
2400	12	14
2500	11	14
2600	11	13
2700	11	12
2800	10	12
2900	10	12
3000	10	11

NOTES:-

1. ALL DIMENSIONS ARE IN MM.
2. THE FIGURE IS TYPICAL AND WILL APPLY TO UNDER GROUND, ELEVATED AND AT GRADE SECTIONS.

CHENNAI METRO RAIL LIMITED



Phase-2 Project
METROS, No.327, Anna Salai, Nandanam,
Chennai-600035.
Ph: 044-23792000 , Fax: 044-23792200.
Email- chennai-metro-rail@gmail.com

STANDARD GAUGE
(1435mm)
25KV 50 Hz A.C. TRACTION

GENERAL NOTES :

REV.	DATE	DESCRIPTION	APPROVED

APPROVED:

CHECKED:

DRAWN:

DATE:

DRAWING NAME:

EFFECT OF VERTICAL CURVE ON
STRUCTURE GAUGE

DRAWING NUMBER: CMSG-5

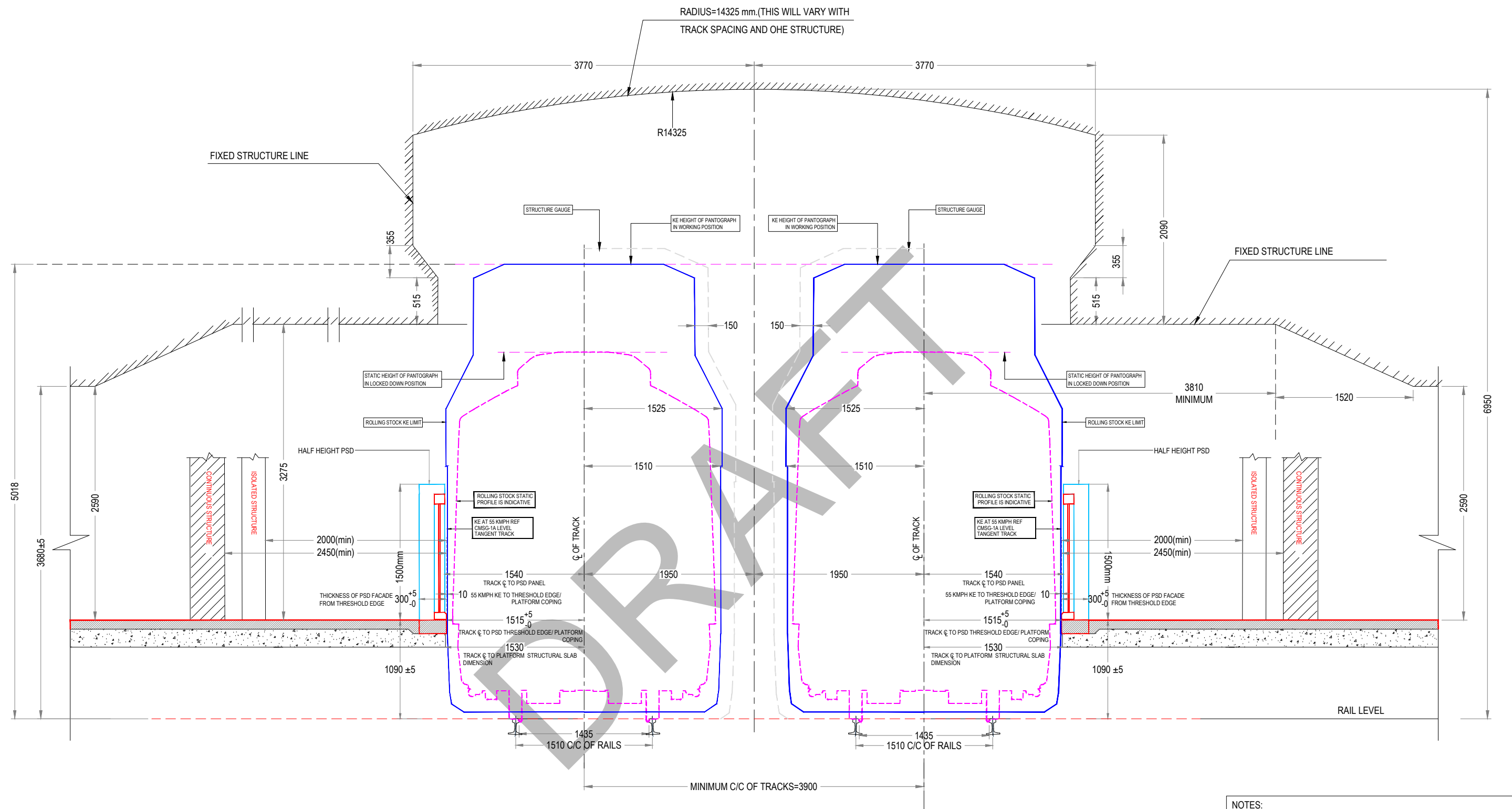
SHEET NO

SHEET SIZE

1 of 1 A3

SCALE: NOT TO SCALE

REV: 0



- NOTES:**
1. ALL DIMENSIONS ARE IN MM.
 2. ADDITIONAL CLEARANCE FOR PLATFORM ON CURVES SHALL BE AS PER APPENDIX-5. HOWEVER THE TRACK CENTRES AT STATION WILL NOT INCREASE WITH CURVES OF RADIUS OF 1000 M AND ABOVE.
 3. STRUCTURE CLEARANCE IS VALID FOR VEHICLES WITH SEALED WINDOWS AND DOORS CLOSED WHILE IN MOTION.
 4. OHE IS SUSPENDED FROM CEILING BY DROP ARM.

CHENNAI METRO RAIL LIMITED



Phase-2 Project
METRO S, No:327, Anna Salai, Nandanam,
Chennai-600035.
Ph: 044-23792000 , Fax: 044-23792200.
Email- chennaimetrorail@gmail.com

STANDARD GAUGE
(1435mm)
25KV 50 Hz A.C. TRACTION

GENERAL NOTES :

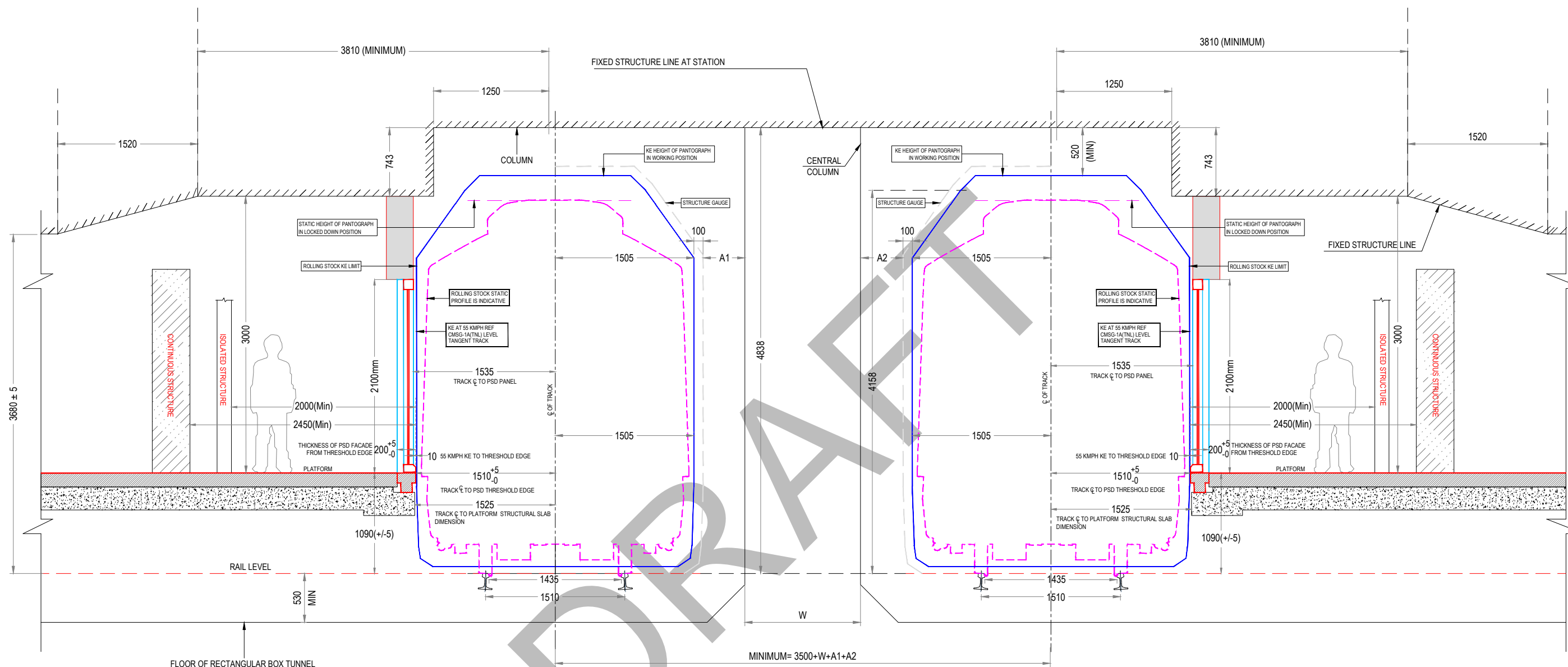
REV.	DATE	DESCRIPTION	APPROVED

APPROVED:
CHECKED:
DRAWN:
DATE:

DRAWING NAME:
STRUCTURAL CLEARANCE AT -GRADE AND
ELEVATED STATION WITH PSD IN SIDE PLATFORMS
ON LEVEL (OR CONSTANT GRADE) TANGENT TRACK

DRAWING NUMBER: CMSG-6

SHEET NO	SHEET SIZE
1 of 1	A3
SCALE: 1:1	
REV: 0	



- NOTES:**
1. ALL DIMENSIONS ARE IN MM.
 2. ADDITIONAL CLEARANCE FOR PLATFORM ON CURVES SHALL BE AS PER APPENDIX-5.
 3. THE STRUCTURE CLEARANCE IS VALID FOR VEHICLES WITH SEALED WINDOWS AND DOORS CLOSED WHILE IN MOTION.
 4. CLEARANCES 'A1' AND 'A2' FOR SERVICES AND PATHWAY SHALL BE AS PER REQUIREMENT AND SHALL BE APPROVED BY THE COMPETENT AUTHORITY.

CHENNAI METRO RAIL LIMITED



Phase-2 Project
METRO S, No:327, Anna Salai, Nandanam,
Chennai-600035.
Ph: 044-23792000, Fax: 044-23792200.
Email- chennai-metro-rail@gmail.com

STANDARD GAUGE
(1435mm)
25KV 50Hz A.C. TRACTION

GENERAL NOTES :

APPROVED:

CHECKED:

DRAWN:

DATE:

DRAWING NAME:

STRUCTURAL CLEARANCE AT UNDERGROUND STATION
WITH PSD IN SIDE PLATFORMS RECTANGULAR BOX
TUNNEL ON LEVEL OR CONSTANT GRADE TANGENT
TRACK

DRAWING NUMBER: CMSG-6(TNL)

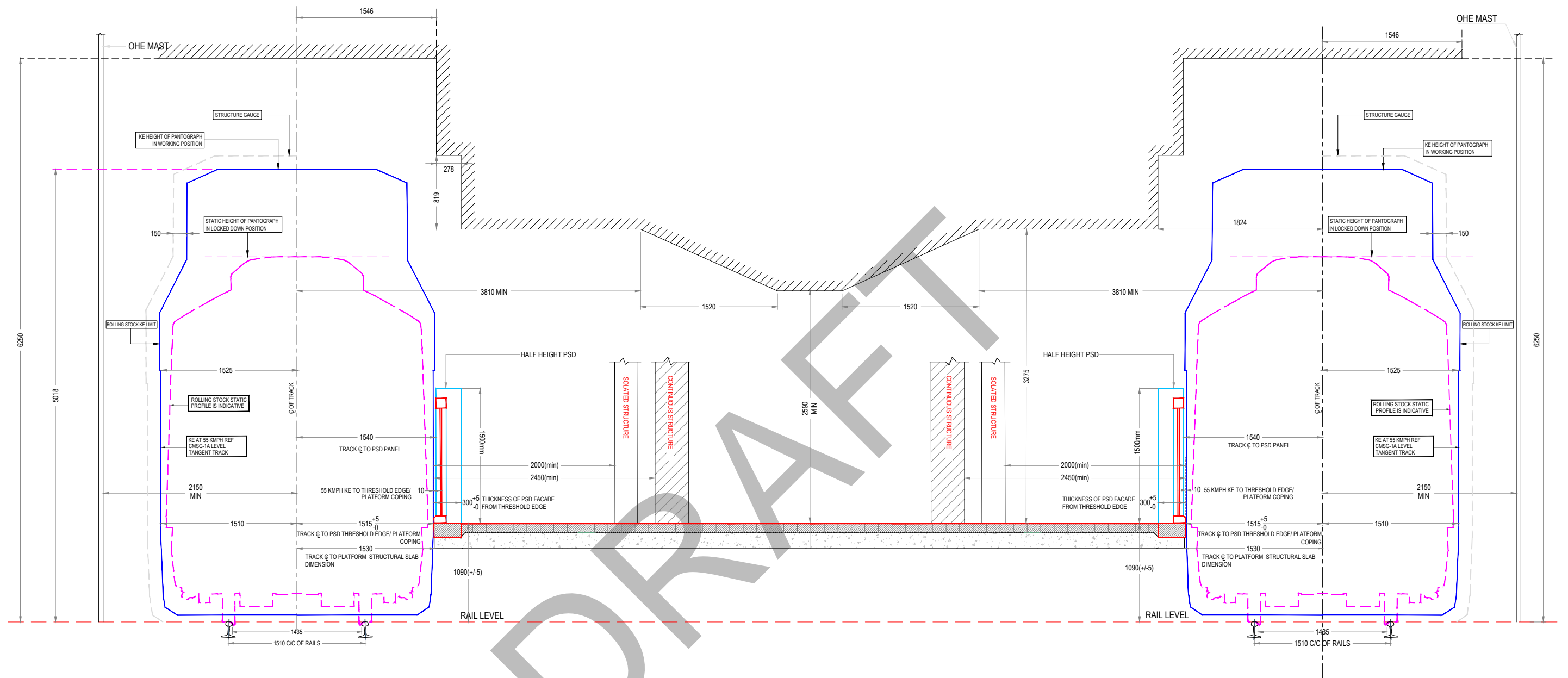
SHEET NO
1 of 1

SHEET SIZE
A3

SCALE: NOT TO SCALE

REV: 0

REV. DATE DESCRIPTION APPROVED



- NOTES:**
1. ALL DIMENSIONS ARE IN MM.
 2. ADDITIONAL CLEARANCE FOR PLATFORM ON CURVES SHALL BE AS PER APPENDIX-5.
 3. STRUCTURE CLEARANCE IS VALID FOR VEHICLES WITH SEALED WINDOWS AND DOORS CLOSED WHILE IN MOTION.

CHENNAI METRO RAIL LIMITED



Phase-2 Project
MetroS, No:327, Anna Salai, Nandanam,
Chennai-600035.
Ph: 044-23792000, Fax: 044-23792200.
Email- chennai-metro-rail@gmail.com

STANDARD GAUGE
(1435mm)
25KV 50Hz A.C. TRACTION

GENERAL NOTES :

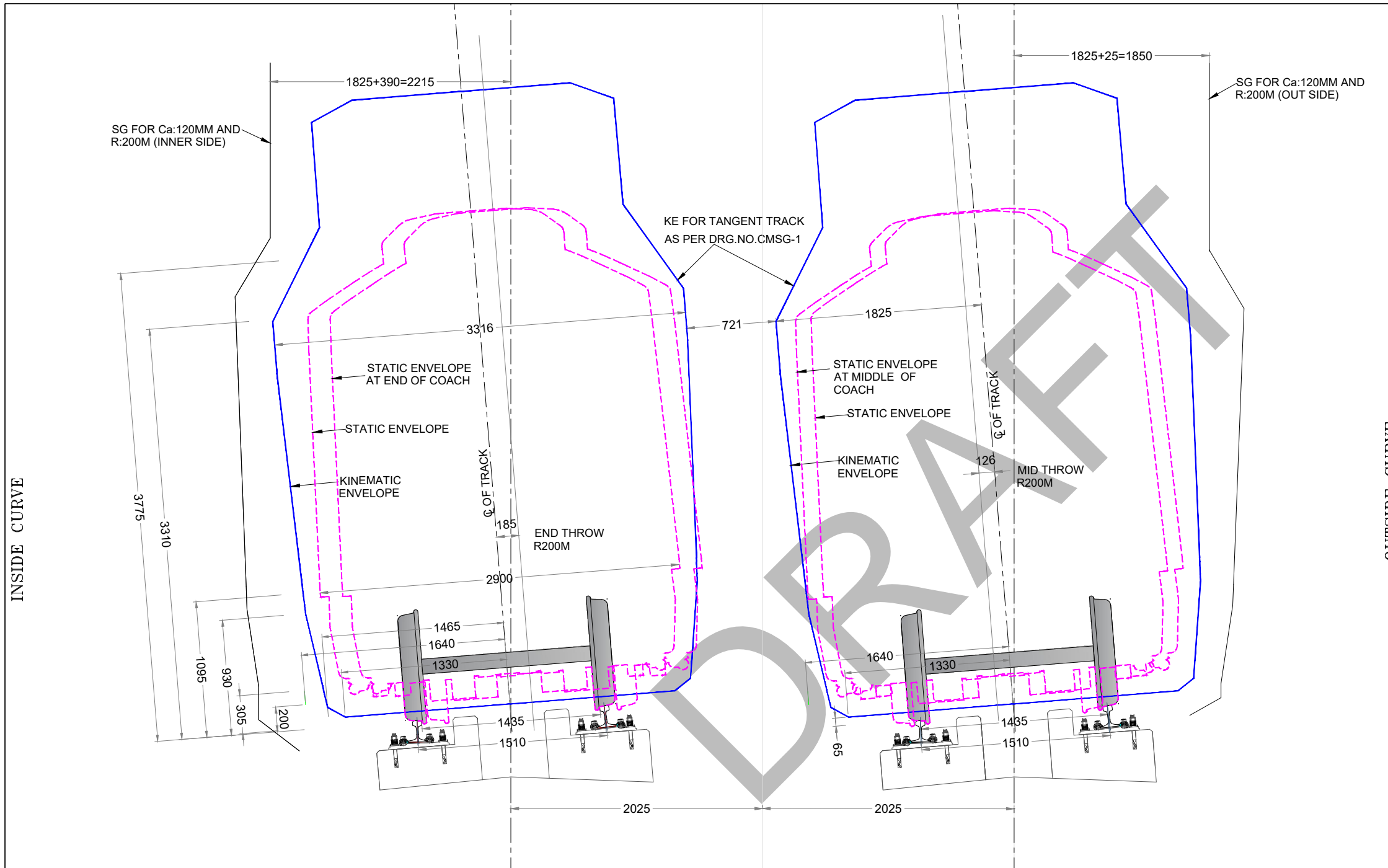
REV.	DATE	DESCRIPTION	APPROVED

APPROVED:
CHECKED:
DRAWN:
DATE:

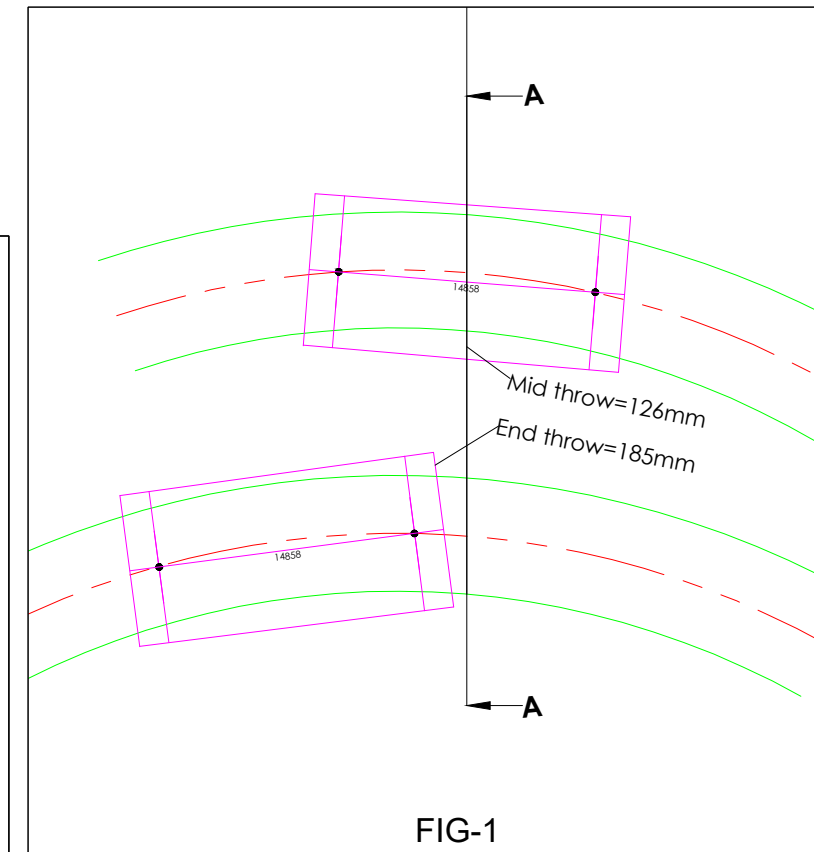
DRAWING NAME:
STRUCTURAL CLEARANCE AT ELEVATED / AT
GRADE STATION WITH PSD IN ISLAND PLATFORM
ON LEVEL OR CONSTANT GRADE TANGENT TRACK

DRAWING NUMBER: CMSG-7

SHEET NO	SHEET SIZE
1 of 1	A3
SCALE: NOT TO SCALE	
REV:	0



COACH POSITION IN NORMAL CONDITION



**FIG-1
SECTION ON A-A**

NOTES:

1. ALL DIMENSIONS ARE IN MM.
2. TRACK CENTRES IS EQUAL TO SUM OF E+F+T1+T2
FOR 200M RADIUS AND CANT OF 120MM, TRACK CENTER IS 4050
(1915+1502+126+185++300) =4028 Say 4050MM
3. STRUCTURE GAUGE HAS BEEN MOVED AWAY FROM CENTRE LINE BY
(264MM FOR 120MM CANT EFFECT +126MM FOR MID THROW) 390MM TOWARDS INSIDE
OF THE CURVE
4. STRUCTURE GAUGE HAS BEEN MOVED AWAY FROM CENTRE LINE BY
(185 MM FOR END THROW, SINCE CANT EFFECT WAS NEGATIVE , IT WAS IGNORED)
50 MM TOWARDS OUTSIDE OF THE CURVE.
5. DERAILMENT GAURD IS PLACED AT 250+/- 20 (WORST CONDITION IS 250+20=270MM)
6. WORST CONDITION OF DERAILMENT IS MENTIONED IN ABOVE FIGURE (FIG-1)

CHENNAI METRO RAIL LIMITED



Phase-2 Project
METROS, No:327, Anna Salai, Nandanam,
Chennai-600035.
Ph: 044-23792000 , Fax: 044-23792200.
Email- chennai-metro-rail@gmail.com

STANDARD GAUGE
(1435mm)
25KV 50Hz A.C. TRACTION

GENERAL NOTES :

REV.	DATE	DESCRIPTION	APPROVED

APPROVED:

CHECKED:

DRAWN:

DATE:

CHECK FOR DERAILMENT CONDITION FOR
ELEVATED & CUT AND COVER SECTION WITH
SHARPEST CURVE AND MAX.CANT-NORMAL
CONDITION (R200m, CANT 120mm)

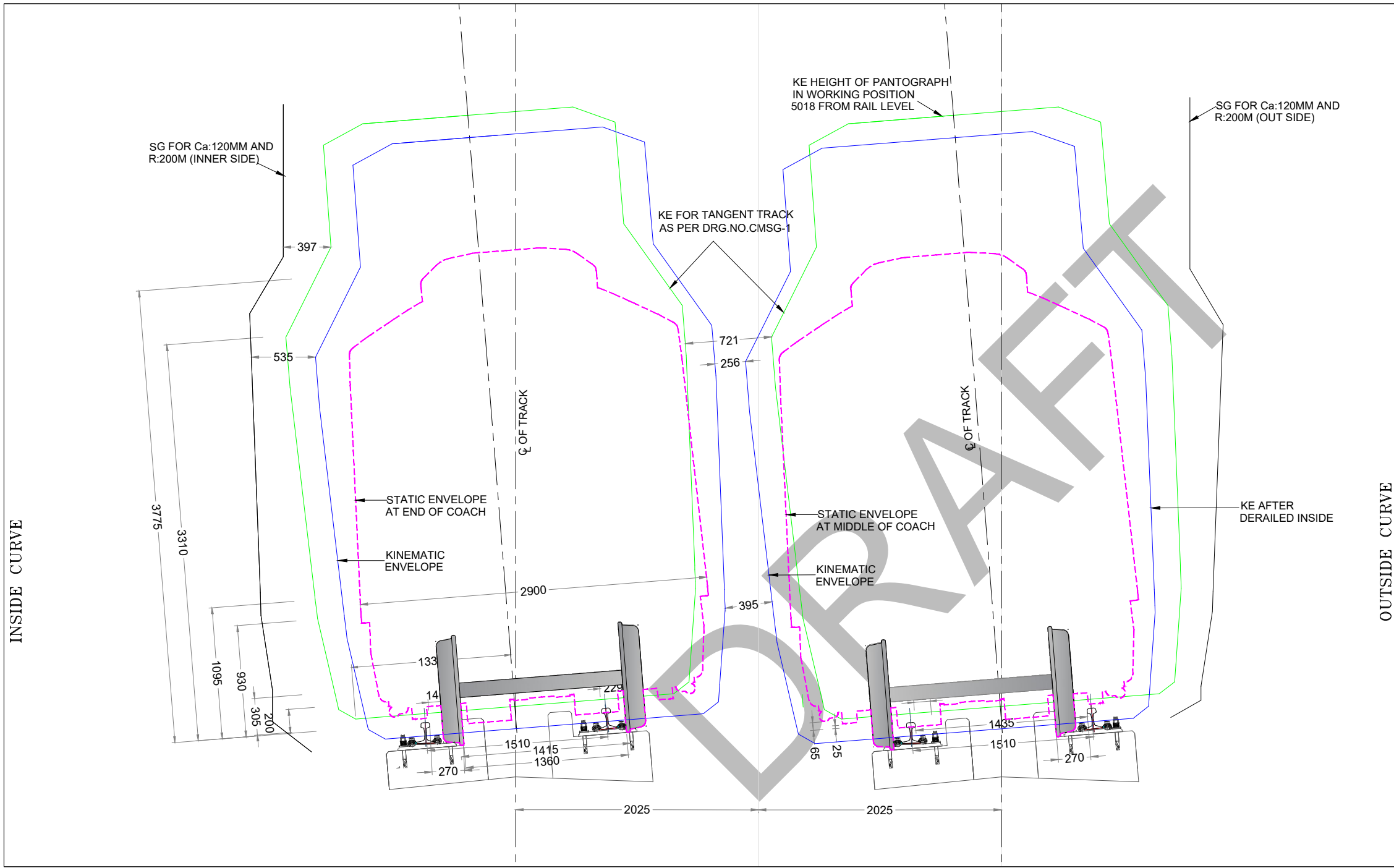
DRAWING NUMBER: CMSG-8

SHEET NO

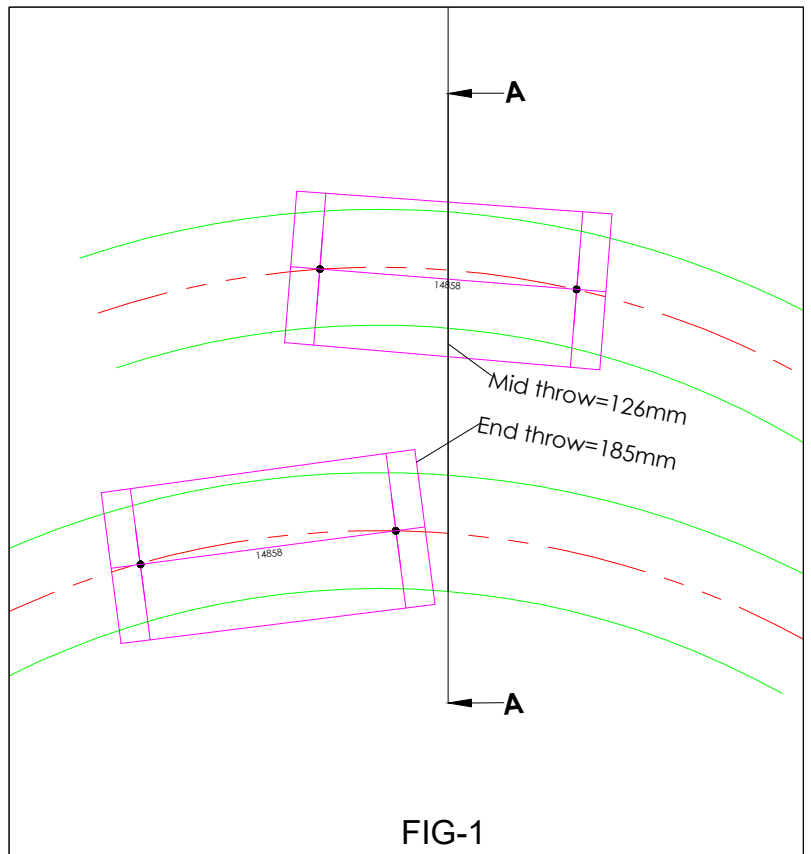
SHEET SIZE

A3

REV: 0



COACH POSITION IN DERAILED CONDITION (BOTH INWARD) SECTION A-A

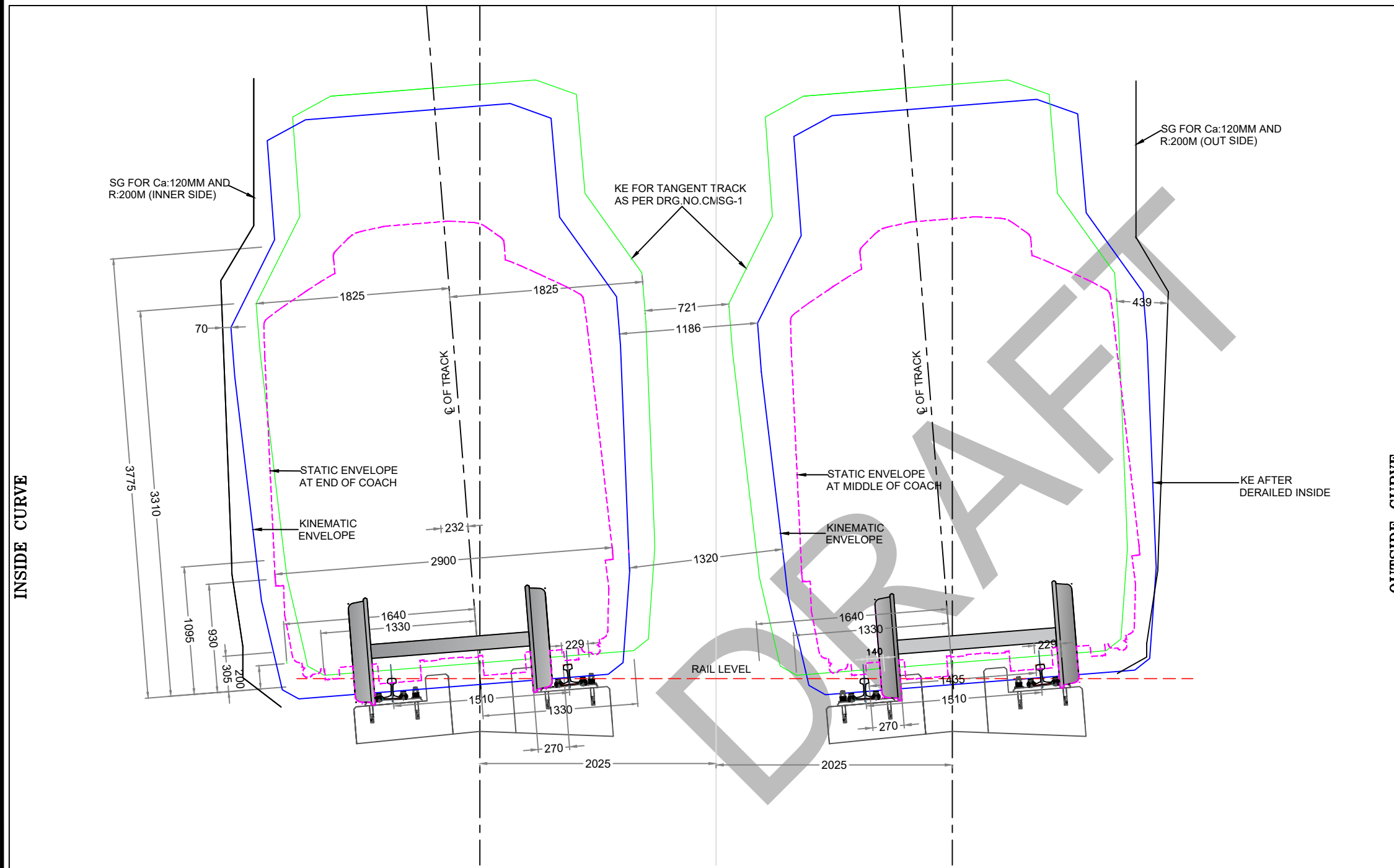


**FIG-1
SECTION ON A-A**

NOTES:

1. ALL DIMENSIONS ARE IN MM.
2. TRACK CENTRES IS EQUAL TO SUM OF E+F+T1+T2
FOR 200M RADIUS AND CANT OF 120MM, TRACK CENTER IS 4050
(1915+1502+126+185++300) =4028 Say 4050MM
3. STRUCTURE GAUGE HAS BEEN MOVED AWAY FROM CENTRE LINE BY
(264MM FOR 120MM CANT EFFECT +126MM FOR MID THROW) 390MM TOWARDS INSIDE
OF THE CURVE
4. STRUCTURE GAUGE HAS BEEN MOVED AWAY FROM CENTRE LINE BY
(185 MM FOR END THROW, SINCE CANT EFFECT WAS NEGATIVE , IT WAS IGNORED)
50 MM TOWARDS OUTSIDE OF THE CURVE.
5. DERAILMENT GAURD IS PLACED AT 250+/- 20 (WORST CONDITION IS 250+20=270MM)
6. WORST CONDITION OF DERAILMENT IS MENTIONED IN ABOVE FIGURE (FIG-1)

<div>CHENNAI METRO RAIL LIMITED</div> <div><div></div><div>Phase-2 Project METRO S, No:327, Anna Salai, Nandanam, Chennai-600035. Ph: 044-23792000 , Fax: 044-23792200. Email- chennai-metrorail@gmail.com</div></div>		STANDARD GAUGE (1435mm) 25KV 50Hz A.C. TRACTION	GENERAL NOTES :					APPROVED:	CHECK FOR DERAILMENT CONDITION FOR ELEVATED & CUT AND COVER SECTION WITH SHARPEST CURVE AND MAX.CANT- DERAILED CONDITION (R200m, CANT 120mm) (INWARD)	SHEET NO	SHEET SIZE
								CHECKED:			A3
								DRAWN:			
								DATE:			
		REV	DATE	DESCRIPTION	APPROVED					DRAWING NUMBER: CMSG – 8A	REV: 0



COACH POSITION IN DERAILED CONDITION (BOTH OUTWARD)SECTION A-A

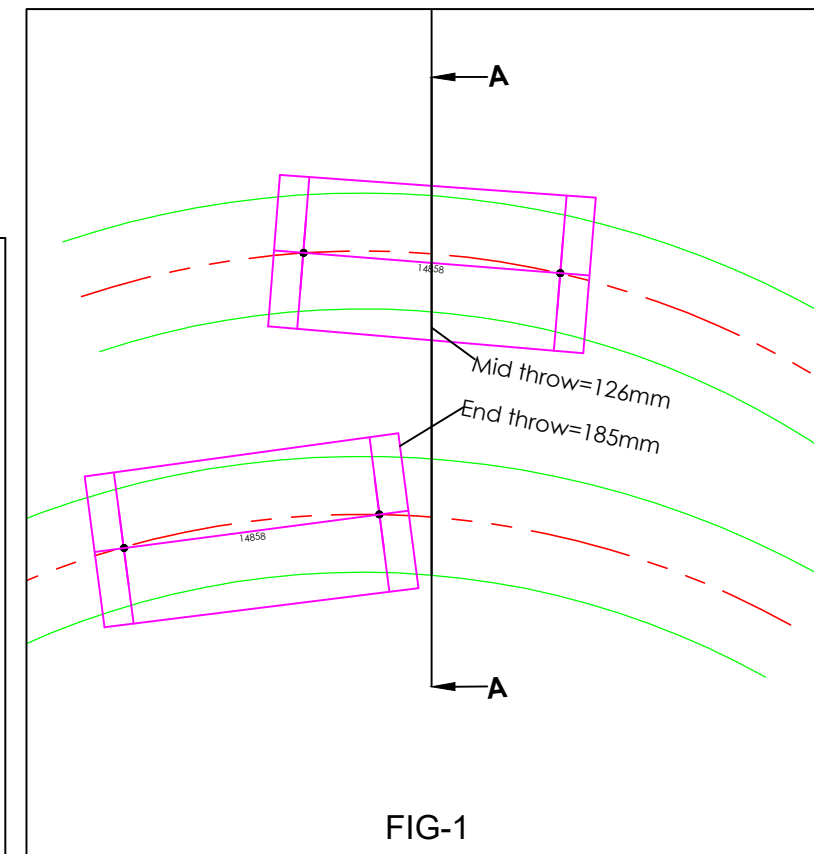


FIG-1
SECTION ON A-A

NOTES:

1. ALL DIMENSIONS ARE IN MM.
2. TRACK CENTRES IS EQUAL TO SUM OF E+F+T1+T2
FOR 200M RADIUS AND CANT OF 120MM, TRACK CENTER IS 4050
(1915+1502+126+185++300) =4028 Say 4050
3. STRUCTURE GAUGE HAS BEEN MOVED AWAY FROM CENTRE LINE BY
(264MM FOR 120MM CANT EFFECT+126MM FOR MID THROW) 390MM TOWARDS
INSIDE OF THE CURVE
4. STRUCTURE GAUGE HAS BEEN MOVED AWAY FROM CENTRE LINE BY
(185 MM FOR END THROW, SINCE CANT EFFECT WAS NEGATIVE , IT WAS IGNORED)
273 MM TOWARDS OUTSIDE OF THE CURVE.
5. DERAILMENT GAURD IS PLACED AT 250+/- 20 (WORST CONDITION IS 250+20=270MM)
6. WORST CONDITION OF DERAILMENT IS MENTIONED IN ABOVE FIGURE (FIG-1)

CHENNAI METRO RAIL LIMITED



Phase-2 Project
METROS, No:327, Anna Salai, Nandanam,
Chennai-600035.
Ph: 044-23792000 , Fax: 044-23792200.
Email- chennai-metro-rail@gmail.com

STANDARD GAUGE
(1435mm)
25KV 50Hz A.C. TRACTION

GENERAL NOTES :

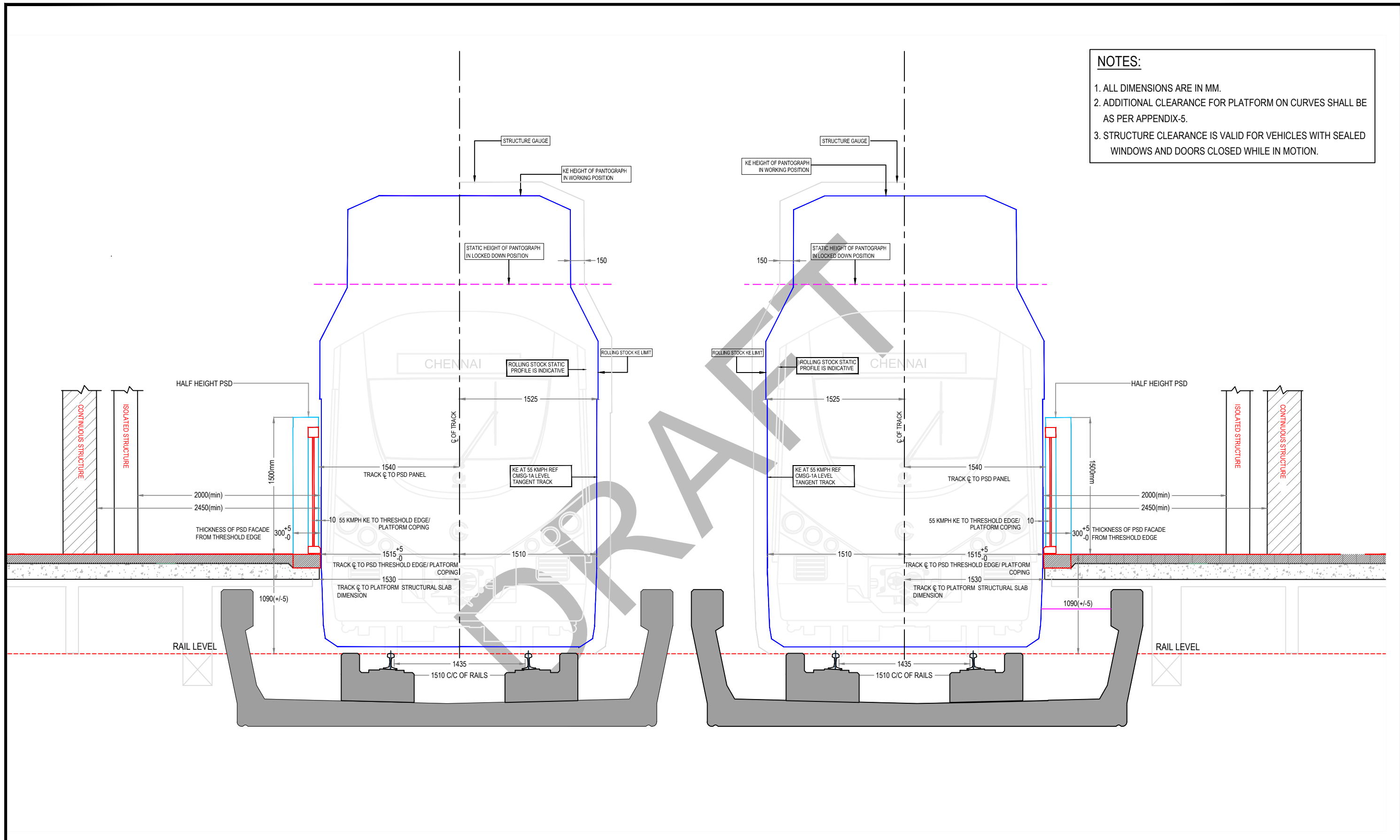
REV	DATE	DESCRIPTION	APPROVED

APPROVED:
CHECKED:
DRAWN:
DATE:

CHECK FOR DERAILMENT CONDITION FOR
ELEVATED & CUT AND COVER SECTION WITH
SHARPEST CURVE AND MAX.CANT-DERAILED
CONDITION (R200m, CANT 120mm)
(OUTWARD)

DRAWING NUMBER: CMSG-8B

SHEET NO	SHEET SIZE
	A3
REV: 0	



NOTES:

1. ALL DIMENSIONS ARE IN MM.
2. ADDITIONAL CLEARANCE FOR PLATFORM ON CURVES SHALL BE AS PER APPENDIX-5.
3. STRUCTURE CLEARANCE IS VALID FOR VEHICLES WITH SEALED WINDOWS AND DOORS CLOSED WHILE IN MOTION.

CHENNAI METRO RAIL LIMITED



Phase-2 Project
METRO S, No:327, Anna Salai, Nandanam,
Chennai-600035.
Ph: 044-23792000 , Fax: 044-23792200.
Email- chennai-metro-rail@gmail.com

STANDARD GAUGE
(1435mm)
25KV 50Hz A.C. TRACTION

GENERAL NOTES :

APPROVED:

CHECKED:

DRAWN:

DATE:

DRAWING NAME:

STRUCTURAL CLEARANCE PLATFORM SCREEN
DOOR FOR ELEVATED STATIONS

DRAWING NUMBER: **CMSG-9**

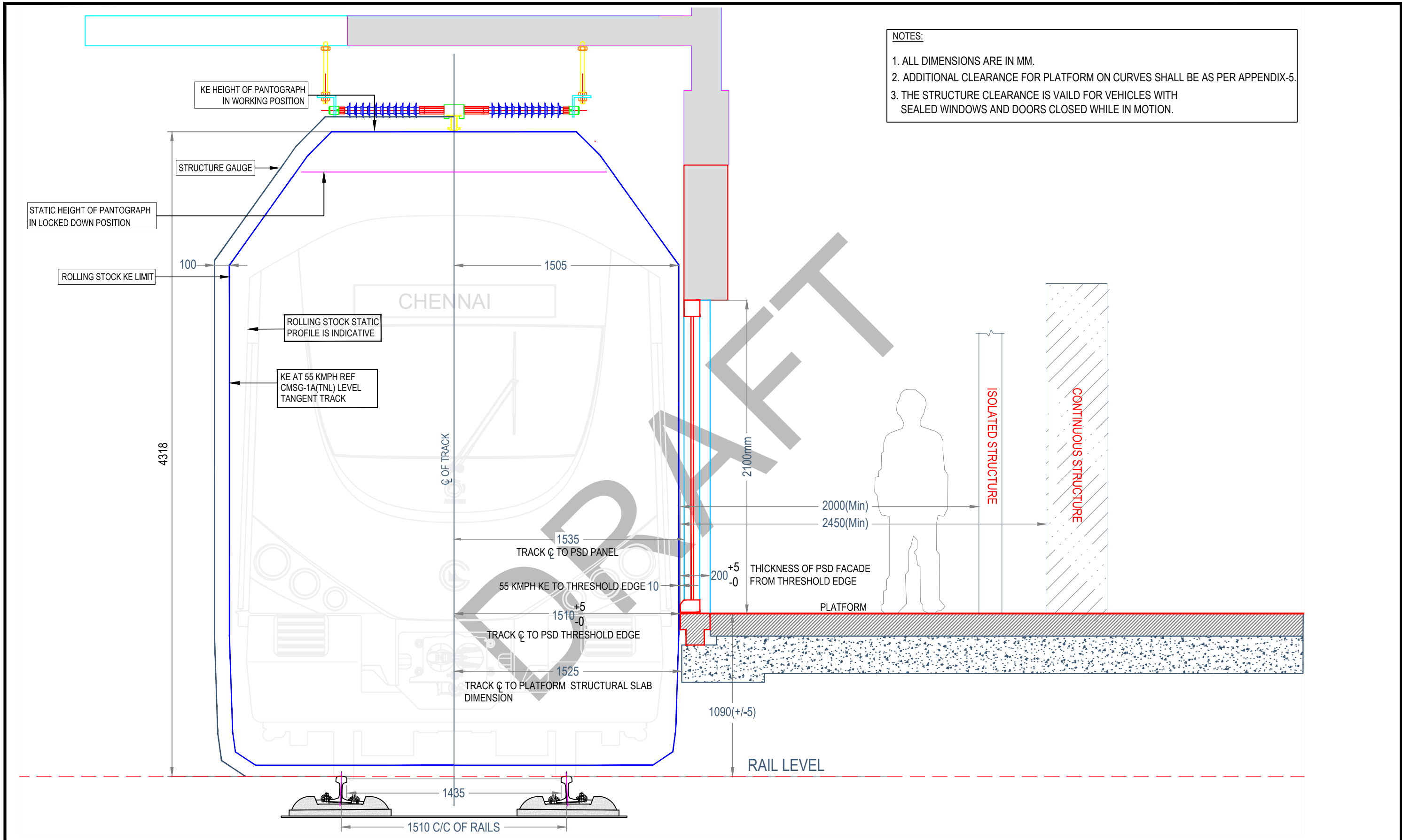
SHEET NO

SHEET SIZE

1 of 1 A3

SCALE: NOT TO SCALE

REV: 0



CHENNAI METRO RAIL LIMITED  Phase-2 Project METROS, No:327, Anna Salai, Nandanam, Chennai-600035. Ph: 044-23792000 , Fax: 044-23792200. Email- chennaimetrorail@gmail.com		STANDARD GAUGE (1435mm) 25KV 50Hz A.C. TRACTION	GENERAL NOTES :	REV.	DATE	DESCRIPTION	APPROVED	APPROVED:	DRAWING NAME: STRUCTURAL CLEARANCE PLATFORM SCREEN DOOR FOR UNDERGROUND STATIONS	SHEET NO	SHEET SIZE
								CHECKED:		1 of 1	A3
								DRAWN:		SCALE: NOT TO SCALE	
								DATE:		DRAWING NUMBER: CMSG-9(TNL)	REV: 0

CHAPTER 2 Annexure - 8 to Addendum 02

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. Wheel sets of multiple types of Rolling stock at CMRL Phase-II Madhavaram 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-

- i. Automatic job setting.
- ii. Pre-measurement of the wheel profile and wheel diameter.
- iii. 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.
- iv. Post measurement of the wheel profile and wheel diameter.
- v. Display of tread diameters of both wheels of an axle before and after turning.
- vi. All the function shall be carried out by the machine automatically without any interference of operator.
- vii. Programming of a new profile should be possible.
- viii. Not Used
- ix. Placement of car bogie on the Wheel Lathe after interlocking of Shunter with Wheel Lathe.

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 Madhavaram Depot of CMRL phase-II. 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) Wheel Profile Measurement device (Hand-Held) – 1 set
 - b) Instrument (Digital) to check Surface Finish(Ra) – 1no

The Contractor shall supply above devices alongwith UFWL. Price of above 2 items shall be deemed included in the UFWL price including DLP and CMC 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 Catenary Maintenance Vehicle, wagons etc. with gross load not more than 64 tons for which detailed parameters can be intimated during design stage if any.
- 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

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 along with 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 $\pm 25\text{ cm}$. 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-
- 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.

2

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 ~~in the bid~~ **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:
- Lift the wheel set from retractable rails.
 - Maintain the axle in the axis of the lathe during turning,
 - Enable movement of the axle to position it in the axis of the lathe,
 - Centre the axles, no matter what might be the spacing between the inner sides, wheels.
 - 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 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 in the bid during the design stage. This shall be integrated with the CNC system.

2 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 ~~in the bid~~ during the design stage.

2

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. A wheeled chip trolley (2 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 in the bid **during the design stage** with a lubrication diagram. Following should also be mentioned:

2

- 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 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
- The sliding rails shall be locked in the extended and retracted positions.
 - A device shall be provided to impede any accidents during sliding rail operation if an obstacle is encountered.
 - The following conditions must be satisfied for vehicle hauling-
 - Continuity of the track provided by the sliding rails.
 - Mobile parts of the machine, viz. roller-holder sliding block, tool-holder sliding block, read head, etc., in retracted position.
 - Safety devices shall be provided to impede any damage to the machine and serious personnel injury in the event of false manoeuvres.
 - Interlocking of Battery Shunter with lathe machine shall ensure that-
 - The shunting will not take place when the lathe is working on Rolling Stock.
 - 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-
- The machining area and workstation shall be appropriately illuminated.
 - Protection against movement of vehicle when retracting rails are not locked.
 - Automatic tool retraction device to withdraw the tool in the event of sudden power failure.
 - 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.
 - Protection against faulty sequence of operation shall be provided.
- 2.1.43.3** Emergency Stop pushbuttons (key lockable) shall be installed on following locations-
- On the control panel
 - At the workplace
 - 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 Standards:

2.1.44.1 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.

2

Note : **The Contractor Bidder** shall submit technical evidence for the compliance against UFWL TS clause no: 1.4.20, 1.6.1, 1.6.3, 1.6.4, 1.6.5, 1.8.3, 1.17.2, 1.21.2, 1.25.1, 1.26, & 1.27.3 ~~with the bid~~ 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 3 and/or 6 car configurations of multiple types of rolling stock including washing of front and rear cabs periodically in UTO (GoA4) and Non UTO modes of train operations in CMRL Phase-II at Madhavaram 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.
- 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.

2.2.2.2 Detergent wash station:

- i. It involves application of liquid detergent by means of rotating scrubbers / brushes on the front and rear faces and lateral surfaces. The brushing pressure shall be wear-adjusted.
- ii. Two retractable counter rotating side brush installed on each side of the train. Wash height adapted to train height.
- iii. Contact pressure between brushes and train is automatically controlled and contact pressure shall be maintained constant.

1

iv. At least ≥ 3 sets of brushes shall be used per side for the detergent application, scrubbing and washing of lateral surfaces of moving trains evenly. 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 CMRL.

- v. Brush rotation with direct drive via gearbox and electric motor. 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. 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.
- ix. 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

2.2.2.3 Front and rear wash station:

- i. It involves the cleaning of the front and rear of rake.
- 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. 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.

2.2.2.4 Post-wash station

1

- 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: ~~Demineralized~~ 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.*

1

2.2.2.5 Drying station : ~~This station shall be capable of completely eliminating water droplets and water streaks from the rake after final rinsing.~~ *pressurized air blowers shall be positioned on both sides of the train to completely eliminating water droplets after the second rinsing.*

2.2.2.6 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.

2.2.2.7 Water softening system: ~~The fresh water shall be demineralized by using any water softening system and demineralized water shall be used in the final rinse of the rake~~ *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.*

1

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 UTO (GoA4) and Non -UTO modes of train operations.

- ii. Semi-Automatic mode - In this mode, the ATWP Operator shall perform the complete cleaning in UTO (GoA4) and Non -UTO modes of train operations.
- iii. 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 Kmph), 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 3 and/or 6 car rakes as it passes through the washing line in UTO (GoA4) and Non –UTO modes 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 Madhavaram 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 (7.15mX 15.3m) 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.

2.2.5 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 in the offer. Detailed design of the splash guard shall be furnished during the detailed design stage of the Automatic train 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:
- i. 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 and piping shall be of stainless steel of suitable grade as per ASTM-AISI standard or equivalent.
 - 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.
 - 1 ix. Material for the detergent tank and RO water storage tanks shall be of SS-316 grade. All other tanks in the plant room shall be of HDPE material.

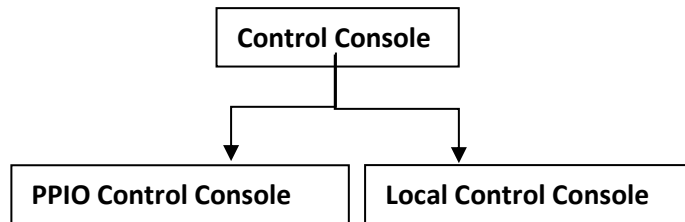
2.2.7 Safety & interlocks

- 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 two consoles. One shall be in the local control room near to wash area and other shall be in PPIO room.
- 2.2.8.2 Both the 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 By default, PPIO control console shall be in active state and wash plant shall respond according to the inputs given through this. Both the consoles 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 The Contractor shall furnish complete details of flow chart sequencing ladder diagram etc. developed for plant operation.
- 2.2.8.6 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.
- 2.2.8.7 The terminal block assembly shall have 20% spare terminal for future usage.
- 2.2.8.8 An appropriate IP Rating protection shall be provided for all the control panels, electrical box and pneumatic distribution box and control system.
- 2.2.8.9 Emergency stop button shall be provided at both control consoles.
- 2.2.8.10 Operation and failure Logs: Number of wash cycles and all wash plant failures shall be logged by the wash plant.

2.2.9 Cameras in Wash Plant:

- 2.2.9.1 Adequate number of cameras with storage devices (atleast 240 hours) 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 both local control Room and PPIO / DCC room always.
- 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 Madhavaram depot.

- i. Space of 8 m x 50 m (approximately) along the track.
- ii. Approximately 7.15 m X 15.3 m covered control room close to the wash area for installation of compressors, water recycling units, demineralized 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:

2.2.12.1 Water Tanks:

- 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.

2.2.12.2 UTO Rolling Stock

- i. Trains shall be operated in GoA4 (UTO) from initial stage of commissioning and revenue operations.
- ii. STC (Signalling and Train controls) Contractor shall be responsible for slow speed and all other train movements required for enabling complete automatic washing of the rake in ATWP. Hence wash plant Contractor shall interface with STC Contractor to obtain all train information and operate the wash plant accordingly.

2

- iii. Interface ~~matrix~~ **specification** under ~~General requirement and scope~~ Chapter- 4 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 5 – 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 -II, Madhavaram 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
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 two (02) sets of Synchronised Pit Jacks for 3 car lifting rolling stock in single and/or group mode at Madhavaram Metro Depot of CMRL Phase-II. System shall comprise of a total of 6 Bogie Hoists/Lifter and 12 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** Out of 2 sets of pit jacks, one set shall be designed as per configuration one type of rolling stock. The second set of pit jacks shall be designed as per configuration of second type of rolling stock. The Contractor shall demonstrate the testing and commissioning for above pits jacks separately. Each set of pit jacks shall be installed on separate workshop lane.
- 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. ~~In case the Pit jack Contractor is unavailable, the Civil Contractor shall initially construct an oversized / generic pit at the likely location of each Bogie Hoist / Lifter. The Pit Jacks Contractor shall submit a pit and foundation design and Depot civil Contractor shall construct (or otherwise modify the oversize pits) as per the requirement of pit jack Contractor including the infilling of the oversize area.~~
- 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 3 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 minimum with:

- 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 pendant 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 5, Part 2, Section VIB – Employer's drawing.

2.3.20 Interface:

2 Interface ~~Specification matrix table~~ under General requirement and scope Chapter- 4 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 WHEEL PROFILE MEASUREMENT SYSTEM- WAY SIDE (WPMS)

2.4.1 Purpose of the machine:

The main purpose of Wheel Profile Measurement System (WPMS) for measurement of wheel profile parameters (of multiple types of Rolling stocks in phase II) automatically while trains / wheels in motion / rolling condition.

2.4.1.1 Basic Parameters / features for the design of Wheel Profile Measurement System (WPMS): The WPMS shall automatically measure the following minimum parameters of wheelsets (but not limited to):

Parameter	Accuracy
Flange height	± 0.5mm
Flange thickness	± 0.5mm
Flange gradient / qR	± 0.5mm
Root wear	± 0.5mm
Wheel tread hollow	± 0.5mm

Parameter	Accuracy
Wheel rim thickness	±1.0mm
Flange rollover and tread rollover	± 0.5mm
Wheel diameter	± 2.5 mm
Wheel width	±1.0mm
Wheel flange back-to-back gauge	±1.0mm

2.4.2 General Description of Scope of Works

- 2.4.2.1 Design, Manufacture, Supply, Installation, Testing & Commissioning, Training, of one number wheel profile measurement system.
- 2.4.2.2 The WPMS shall be installed in Madhavaram depot on ballast-less track outside the workshop shed so that the respective train get examined by WPMS.
- 2.4.2.3 The WPMS shall be supplied including all hardware, software, safety tools / system, electrical, pneumatic, calibration kit and other accessories to enable WPMS fully functional.
- 2.4.2.4 The Contractor shall design and demonstrate compatibility of WPMS during testing commissioning with multiple types rolling stock.

2.4.3 Design requirement of Measurement System

- 2.4.3.1 The WPMS shall be designed for measurement of all parameters mentioned vide clause 2.4.1.1 above for complete range of wheel diameter.
- 2.4.3.2 The Automatic Wheel Profile Measurement System shall be placed on the track. The system shall feature contactless measurement of the wheel profile. The system shall be able to measure wheel profile while the wheelset is in motion.
- 2.4.3.3 Installation of the WPMS shall require no cutting of the tracks or any major civil works on the track. The system shall be installed on the existing Ballast-less track or using a special sleeper by the Contractor without altering the track layout. In case of usage of special sleeper, the Contractor has to prove the strength of the sleeper through test reports.
- 2.4.3.4 System shall not require regular maintenance. The system shall have inbuilt diagnostics to determine any system failure and shall generate requisite alerts regarding the same.
- 2.4.3.5 Calibration Kit shall also be provided as a part of supply. The frequency of calibration shall not be lesser than 6 months.
- 2.4.3.6 The system shall be suitably designed for isolation of dirt, dust, debris, humidity, water etc. with suitable system (which shall be supplied along with the system), so that optical pathways are not obstructed at any point of time in operation. System design shall be suitable to kept clean optical surfaces and physical cleaning of optical surfaces shall not require very frequently.
- 2.4.3.7 The system shall be easily removable / dismantled in case of emergency (bad climate condition, flooding etc). The system design shall be such that the time required for dismantling of track installed camera / laser boxes shall be less than 1 hour. The Contractor shall also submit the detailed instructions for removal and reinstallation of the systems or part thereof.
- 2.4.3.8 Suitable arrangement and care shall be adhered during designing of the Wheel Profile Measurement System such that the measurement system installed on the track shall not infringe with any of the rubber tyres / wheels of maintenance vehicle like CMV, rail cum road shunters / RRV etc. in both static and dynamic condition. It is the responsibility of the Contractor to check the compatibility of the system with vehicles which will be running on the track of Chennai Metro phase-II.

- 2.4.3.9 The WPMS shall be capable of operating up to 55 °C ambient temperature and shall be able to sustain harsh climate of Chennai. All Electronic equipment and sensors shall be able to withstand the temperature rise up to 55 °C. The system shall then shutdown & alert shall be sent before shutdown.
- 2.4.3.10 The on-track sensors shall be housed in IP67 or better rated enclosures for protection against water and dust.
- 2.4.3.11 The System shall automatically identify the Train number and its orientation by means of inputs received from on-board Signalling and rolling stock system. WPMS Contractor shall interface with the Signalling and rolling stock Contractor for all specific requirement to enable data inputs for train number, type of trainset, wheelset number, Bogie number etc.
- 2.4.3.12 The measurement of all parameters shall be mapped automatically to the respective wheels / wheelsets.
- 2.4.3.13 The mapped data shall be transmitted to CMRL depot server.
- 2.4.3.14 The measurement system shall be capable of measuring at speed up to 30kmph.
- 2.4.3.15 The system shall be capable of measurement in the presence of any bogie components.
- 2.4.3.16 It shall measure and evaluate wheel profiles w.r.t. different reference wheel profiles on different trains within the same line / network without any manual intervention during run time. The backend software shall have the capability of correlating the train type with the adopted wheel profile and wheel design and corresponding acceptable wheel parameters to generate the requisite information.
- 2.4.3.17 It shall be capable of detecting, measuring, and reporting the vehicles passing the WPMS.
- 2.4.3.18 The WPMS shall output the results obtained in real time, within couple of minutes after the train unit has passed the WPMS site.

2.4.4 Design requirement of Way Side Control Panel

- 2.4.4.1 The wayside control panel shall be housed in a robust IP 55 or better rated housing which shall contain all the necessary devices, components and computing system required by the system.
- 2.4.4.2 It shall be placed as near to the measurement system as possible but outside the maximum moving dimensions of rolling stock.
- 2.4.4.3 The foundation for placement of any such cabinet(s) to be in scope of WPMS Contractor. It shall be installed at an adequate height for safety of equipment in case of water logging.
- 2.4.4.4 It shall be capable of being networked for data transmission to control room/central server of CMRL.
- 2.4.4.5 Reliable control cabling, power cables and air pipes shall run through suitable protective sheathed hoses and pipes from the control cabinet to the measurement system. The sheathed hoses and pipes shall be of adequate strength and shall be laid suitably so that these are not damaged and do not pose hindrance during routine daily work.
- 2.4.4.6 The Control Cabinet shall be connected to the internet / intranet / wifi through adequate means to transmit the data to depot central server or control room.
- 2.4.4.7 The cabinet shall be compact in size to a maximum extent to be able to be fitted in available space envelope in close vicinity of system on track. It should be able to operate at the ambient temperature with adequate cooling systems provided as part of design.
- 2.4.4.8 The System design shall be such that no wayside bungalow / hut for housing of servers / controls panels etc required.
- 2.4.4.9 It shall not interfere with structure gauge / kinematic envelope of the specified corridor.
- 2.4.4.10 The cabinet shall have a dehumidification membrane or any other proven humidity control mechanisms to protect sensitive electronics against mould growth, corrosion etc. There shall be an arrangement to protect the system when there is an unusual temperature

increase.

2.4.4.11 The computing system in the cabinet shall have CPU / RAM / Storage Drive etc of adequate capacity and size as per the requirement for the system. The system shall have sufficient storage to store measured data for at least 30000 wheelsets.

2.4.4.12 The cabinet shall have equipped with a suitable capacity UPS system to ensure safely shut-down the system in case of any power supply concerns and safely transfer the captured data of relevant train / wheelset etc to central server. The system shall generate an alert prior to shut-down and diagnosis the failure cause.

2.4.5 Design requirement of Application Software

2.4.5.1 The system shall consist with packaged software tool for the end user in order to visualize results and trends in Tabular, Graphical, Statistical and Predictive Formats.

2.4.5.2 The system shall be capable of exporting the data and reports in numerous formats including PDF / XML / DOC / DXF / CSV / RTF. The system shall be capable of exporting the data and reports as per above mentioned formats to CMRL's centralized server.

2.4.5.3 The system shall be able to generate reports based on Date, Time, Train, Car, Bogie, Axle and Wheel side RHS &LHS or A&B etc.

2.4.5.4 The software shall have modules to:

- i. Allow new Wheel profiles for different types of Trains Wheels to be incorporated.
- ii. Configure thresholds for automatic warnings / alarms for each type of Train / wheel.
- iii. Capture the wheel profile data and wheel parameters as reported by the measurement system and store it in a database.
- iv. Analyse the Data in near real-time comparing with the standards / thresholds to generate alerts for each Train / wheel for corrective actions required.
- v. Analyse the trends in the profile and parameters to create alerts for predictive maintenance.
- vi. Analyse and report any accidental maladjustment in the measurement system.
- vii. The software shall be capable of generating alerts in case of faults requiring attention.
- viii. The software shall permit the operator to retrieve the status of any Train / Car / Wheel for maintenance.
- ix. The entire software solution shall be web based and data would be stored in the server within wayside installation and same shall be shared to the Chennai Metro central server with adequate securities and accessible through the internet for analysis and reporting. Since the system shall be web-based, it shall be protected against virus and external intrusions.
- x. The software shall be accessible on PCs, Laptop, Tablets and/or smart phones remotely. One number(1No) of industrial Laptop of latest configuration to be provided by Contractor along with WPMS.
- xi. System shall be delivered with applicable number of end user licenses maximum to 5 numbers.
- xii. The system shall be user and password protected. Only authorised CMRL administrator shall be able to access all information / data.

2.4.6 Site Layout:

2.4.6.1 The location for the installation of WPMS shall be on a straight and at-grade track level.

2.4.7 Software:

2.4.7.1 All the application software shall be provided to CMRL along with valid licences.

2.4.7.2 Debugging and troubleshooting required in the application software during DLP and CMC

period shall be attended by the Contractor without any financial implication including upgradation of Software when required.

2.4.8 System Administration:

2.4.8.1 The system administration shall enable the operator to manage the system architecture, slice and dice data acquired from the system.

2.4.8.2 It shall maintain a software library management tool which will be able to generate version controls of software, upgrade history, list of authorized users with various access controls and privileges.

2.4.8.3 The system shall also be able to generate reports and can be configured time to time based on application needs including Summary of daily, weekly, monthly report based on the data acquisition from the system and processed data from the controller.

2.4.8.4 Customise reports (upto 5 numbers) shall be finalized during design implementation.

2.4.9 Interface:

The Contractor shall interface with other designated Contractors (civil, track, rolling stock and Signalling & Train control Contractor etc) for finalization of design / manufacturing / installation / commissioning and successful execution / performance of the WPMS.

2.4.10 Standards:

Work related to the design and manufacturing of the WPMS shall comply with relevant international standard or equivalent Indian standards, Codes of Practice and the latest statutory requirements of India.

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-II project at Madhavaram 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*	at grade
3	Minimum curve radius*	100 m
BORRS Parameters		
1	Shunter type	Battery powered (Rail cum Road)
2	Tractive effort**	35 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 35kN.*

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 300meters.
- 2.5.4.3** The Shunter shall be capable of generating a continuous draw bar pull of minimum 35 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 Madhavaram Depot of CMRL Phase II. 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:

- 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.
- 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** 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.
- 2.5.5.7** ~~The shunting vehicle shall have high degree of manoeuvrability by means of hydraulic system giving a minimum turning radius of not more than 4500 mm.~~ **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

2.5.6 Mechanical Part

- 2.5.6.1** Coupler:
- i. A suitable coupler adapter, 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.
- 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.

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:

2 Interface ~~specification matrix table~~ under General requirement and scope Chapter-4 Section VIB Part-2 shall be referred for the interface with other system Interfacing Contractors for BORRS.

2.5.14 Standards:

2 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 3 car Rolling stock for replacing the bogies or to do under frame repair works.

2.6.2 Basic Parameters for the design of Synchronized Mobile Lifting Jacks:

Parameter	Dimensions
Required quantity of LiftingJacks	12 nos.
Lifting capacity per Jack	12 t (Minimum)
Lifting capacity per set	12 t X 12 = 144 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:

2.6.5.1 Local Control box shall be designed with the following minimum buttons, controls (but not limited to):

2.6.5.2 Emergency stop button.

2.6.5.3 Push button without self-locking for the individual operation of the lifting jack "LIFTING / LOWERING".

2.6.5.4 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.

2.6.5.5 Indicators as applicable

2.6.5.6 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 movable control console shall be designed for 3 cars operation and shall have a minimum IP 55 protection. The operation of the jacks in a group of four, eight and twelve 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 three)
- 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.

Note : The Mobile Lifting Jacks shall be used at four (4) locations for lifting/lowering 3 car trains in the workshop. The Contractor shall supply and install/lay required cabling in the pre laid concealed galvanised / PVC conduits with socket / plugs in all 4 locations. The underground concealed galvanised / PVC conduits shall be laid by depot contractor in all 4 locations. All pit covers shall be in scope of Jacks Contractor. The covers shall be of GI solid steel plates flush with floor level and design to sustain the rollover load of workshop vehicles.

2.6.8 Synchronization

The complete system (12 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 The operation of lifting jacks shall be restricted in the event of retractable OHE in ON condition. To implement this, Jacks supplier shall interface with retractable OHE Contractor.

2.6.10.2 Interface requirement under Chapter-4 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 (12nos)
Max. Support Height	2000 mm above from the floor level
Min. Support Height	1500 mm above from the floor level

Parameter	Requirements
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-II. 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 3 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-II 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 **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 and CMC 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 preferably 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 inverter 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-II.
- 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

- i. Compartment for Re-railing and Rescue Equipment and tools is to be located directly behind the personnel compartment. This compartment has the following requirements.
- ii. 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).
- iii. 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.
- iv. Buffers with adequate strength at the rear.

- v. Rollers immersed in the body sub frame serving as guide for the re-railing bridge.
- vi. Adequate illumination of the compartment.
- vii. 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.

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-II.
- 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

S. No.	Description of Item	Unit	Qty.
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
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 WASH PLANT (BWP)**2.9.1 Purpose of the machine:**

The Bogie Wash Plant (Automatic) is required for cleaning all types of bogies of multiple rolling stock including frame and other associated accessories / components etc of standard gauge at Madhavaram Depot of Chennai Metro Rail Project phase-II.

2.9.2 Scope of Works (but not limited to)

- 2.9.2.1** Design, Manufacture, Supply, Installation, Testing & Commissioning of automatic Bogie Wash Plant at Madhavaram Depot of CMRL phase-II. The supply shall include all equipment and accessories required to make the machine fully functional when connected to a power source.
- 2.9.2.2** Electrical cables for connecting Power point to Control cabinet of machine shall be supplied by the Contractor as per the requirement.

- 2.9.2.3 Powered loading and unloading for Bogies, trolley etc. The bogie will be automatically drawn inside the wash cabin / chamber and return by an automatic traction system means. The Bogie shall be prepared outside the wash cabin before washing and drawn inside wash cabin automatically with a suitable and proven hauling / traction system. Loading and Unloading shall be bidirectional.
- 2.9.2.4 Water filtering & recycling system – 1 set
- 2.9.2.5 Hand spray gun – 1 no.
- 2.9.2.6 Part Trolley – 1 no.
- 2.9.2.7 Sludge Bins with transport trolley– 2 nos.
- 2.9.2.8 Powered loading & unloading system – 1 set
- 2.9.2.9 Powered loading & unloading Doors – 1 no.
- 2.9.2.10 Servo controlled voltage stabilizer & Ultra isolation transformer (if required), suitable for the electrical requirements viz. control system – 1.
- 2.9.2.11 Waste Oil extractor / separator & sludge removal system – 1 no.
- 2.9.2.12 All types of consumables, including chemicals / detergent for cleaning.
- 2.9.2.13 Any other accessory considered essential for the operation of the plant to meet the purpose and capability.
- 2.9.2.14 The Contractor shall design, demonstrate the testing & commissioning the machine with all types of bogies of multiple rolling stock.

2.9.3 Design Responsibility

The Contractor shall be responsible for the design of the Automatic Bogie Wash Plant, which shall include but not be limited to the following: -

- 2.9.3.1 The Contractor shall obtain design approval from CMRL before starting the manufacturing of the Equipment to be supplied under the Contract.
- 2.9.3.2 The Contractor, co-ordinating with CMRL and Designated Contractors on all matters relating to design and documentation, shall retain full responsibility for managing such design and for the maintenance of all documentation associated with the design process.
- 2.9.3.3 The Contractor shall determine and verify as appropriate the materials, site measurements and installation criteria before adopting in the design of the equipment.
- 2.9.3.4 The Contractor shall ensure that the information contained in the submissions has been co-ordinated with the overall requirements of the Works.
- 2.9.3.5 All steel used by the Contractor shall be established to have adequate corrosion resistance.
- 2.9.3.6 All data in concern with the bogie written in this specification if any, is for information only and there may be slight variations.
- 2.9.3.7 The compatibility of the equipment with the bogie characteristics is the responsibility of the Contractor and he shall obtain the required data / documents from the Rolling Stock Contractors.
- 2.9.3.8 All information or documents related to the bogie deemed necessary are to be taken from the rolling stock supplier by the Wash Plant Contractor.

2.9.4 Specific Requirements and Description of Automatic Bogie Wash Plant.

- 2.9.4.1 The Automatic Bogie Wash Plant shall be designed for quality cleaning of metro bogies for removing paint flakes, oil, dirt and grease from surface of bogies.
- 2.9.4.2 Description of Automatic Bogie Wash Plant
 - i. The plant should be able to clean metro bogie. It shall also be capable to clean loose bogie components placed in baskets or on parts trolley.
 - ii. The plant should be designed for continuous operation for 3 shifts of 8 hours each, per

day.

iii. Deleted.

iv. Cleaning at least one complete bogie per 45 minutes at 85% efficiency.

v. The plant shall not produce any hazardous waste in any form during the cleaning process. If produced, proper treatment plant shall be part of the offer.

2

vi. It shall have provision to use a suitable detergent capable of effectively emulsifying dust, dirt and grime during washing cycle and rust inhibitor during rinse cycle. The detergent and rust inhibitor must be available indigenously. Specification, brands and indigenous sources of supply of the detergent and rust inhibitor shall be indicated in the bid furnished during the design stage.

vii. Contractors shall provide the scheme of their design of the Automatic Bogie Wash Plant in the offer. GA drawing shall be provided supporting the scheme.

viii. All basic elements of Automatic Bogie Wash Plant shall be fully interchangeable.

2.9.5 Operating Parameter*

2.9.5.1 Operating temperature of water / solution in 60 – 80 °C detergent wash and final rinse tanks.

i. Process Cycle time: 45 minutes (max.).

- Loading / Unloading 10 minutes (max.)
- Stage 1 (Washing) (20- 25) minutes
- Stage 2 (Rinsing) (4- 6) minutes
- Steam extraction 4 minutes (max.)

ii. Initial water heating up time (60°C to 75°C) to start operation shall be at faster rate.

**These values are indicative only & it will be confirmed during design stage.*

2.9.6 Process Parameter

2.9.6.1 Wash Cycle: In this recirculating stage, work pieces (bogie ,frame, component etc) are sprayed with a low concentration detergent solution (2-5% detergent in water) at 60°C to 75°C. Sufficient Pressure at nozzle tip shall be produced for proper cleaning of Bogies.

2.9.6.2 Rinse Cycle: After wash cycle, heated water is used to remove detergent residue followed by application of rust inhibitor automatically. This cycle shall make use of fresh water with rust inhibitor additive The used water from this cycle is to be added to wash cycle tank. & drag out. Sufficient Pressure at nozzle tip shall be produced for proper rinsing of Metro Bogies.

2.9.6.3 Exhaust Cycle: This cycle shall involve withdrawal of steam from cabinet after completion of wash & rinse cycle before the opening of door.

2.9.6.4 Productivity: The plant shall be capable of cleaning at least 8 bogies per eight-hour shift at 85% efficiency. Initial start-up time of Cleaning Plant (heating of the solution in tanks) shall not be taken into account while calculating the cycle time. The claimed cycle time shall have to be proved out during commissioning. The elemental break-up of claimed cycle time from entry of bogie into the plant to exit from the plant shall be indicated in the bid furnished during the design stage.

2.9.7 Not Used

2.9.8 Construction Features

2.9.8.1 Cleaning of bogie shall be performed in watertight cabin with pressurized water & detergent solution system. The plant consists of a sealed cleaning cabinet with front lifting doors, an oscillating spray system, a fluid tank system and a powered loading and unloading system.

2.9.8.2 Plant shall be designed to remove grease, oil, dust & loose paint flakes deposited on the surface of bogie. It shall have provision of relative movement of Bogie and Nozzle manifold during cleaning, so that all the surface area of bogie shall be cleaned satisfactorily.

- 2.9.8.3** All the frame structure, plates of tanks & cabinets, pipelines, nozzles etc. shall be made of stainless steel having better corrosion resistance properties. Tanks shall have inbuilt heating system with automatic temperature control. Proper Insulation for tanks shall be provided for minimizing the heat loss. It shall be designed to be user friendly for operation and maintenance. Access platform for filters and electrical cabinet shall be provided.
- 2.9.8.4** The plant shall be equipped with oscillating spray system that moves back and forth along the cleaning cabinet to provide the maximum coverage of the components. The spray bars shall be composed of rings to spray liquid from above, below and sides onto the components.
- 2.9.8.5** The plant shall have a common or two separate manifolds for wash & rinse operation. The manifold spray bars shall have adjustable nozzles and used for cleaning and rinsing. In case of common manifold, after each individual process cycle, the spray system will be purged by compressed air to clear all liquid, before next cycle, to prevent cross contamination of different liquid. It shall have sufficient no. of nozzles at proper locations with suitable designed orifice to increase the impact force of water jet on the bogie surface.
- 2.9.8.6** Bogies will be automatically loaded & unloaded by an electrical-mechanical power mover at beginning (outside wash plant cleaning chamber).
- 2.9.8.7** Once bogie is brought to loading table / position, located & fixed, further process will be button push operation and place the bogie automatically inside the washing chamber. At the end of the wash cycle, bogie will be automatically moved to unloading position (outside wash plant cleaning chamber).
- 2.9.8.8** The Contractor shall provide Industrial safety fencing (min 2 m height) around plant area for safety of personnel, equipment etc. The material of the same shall be decided during design stage.

2.9.9 Wash Cum Rinse Cabinet

- 2.9.9.1** The cabinet provided shall be of adequate size to accommodate Bogies. Adequate number of nozzles shall be suitably positioned in the chamber to enable complete cleaning of Bogies.
- 2.9.9.2** The cabinet shall be enclosed, double-walled chamber type, fabricated from 3mm thick stainless steel (SS 304 / International equivalent) sheets for inner shell and 2mm stainless steel (SS 304 / International equivalent) sheet for outer cladding. The cabins shall have insulation of minimum 50mm or better mineral wool/glass wool / Rockwool or 30mm Polystyrene between the inner and outer walls to prevent heat loss.
- 2.9.9.3** The Cabinet shall be equipped with:
- Lifting Door- for loading & unloading side. Door shall be a proven design in operation, in case of failure of automatic operation. Automatic operation of the door with button push operation of washing cycle. Powered Door shall be fabricated from stainless steel plates and properly insulated. Door shall be maintenance free and capable to trap spray and steam inside the cabinet without any leakage.
 - Oscillating Spray system that moves back & forth along the cleaning cabinet to provide the maximum coverage of the bogie or component for top, bottom and side washing and cleaning.
 - Power Loading & Unloading System .
 - Steam extraction system for the cabinet.
- 2.9.9.4** A steam exhaust blower shall be provided for blowing off outside, the hot steam from inside the chamber. Capacity, type, make, model no. and motor power of the blower shall be indicated in the bid furnished during the design stage.
- 2.9.9.5** Galvanised tramex steel floor over the whole installation shall be supplied and installed by wash plant Contractor.

2.9.10 Power Loading & Unloading System:

- 2.9.10.1** A suitable Power Loading & Unloading system applicable for loading bogie into cleaning

chamber and unloading from the chamber after complete wash automatically shall be provided.

- 2** 2.9.10.2 Details of loading & unloading system including constructional features, length, width, speed range, weight carrying capacity, material specification etc. shall be furnished ~~in the bid~~ **during the design stage.**

2.9.11 Spray Nozzles

- 2** 2.9.11.1 Adequate number of stainless-steel nozzles (SS:316) shall be provided to issue jets in the detergent wash and final rinse cabins. Location of nozzles shall be such so as to ensure proper cleaning of Bogie / components on all sides from inside and outside. Location of nozzles shall be shown in a schematic diagram ~~in the bid~~ **during the design stage.** Number of nozzles provided in each cabin shall be ~~indicated in the bid~~ **furnished during the design stage.**

2.9.11.2 Spraying nozzles shall be designed to operate with hot detergent, hot water and hot water with rust inhibitor.

2.9.11.3 The nozzles shall be arranged to ensure that the jets do not neutralize each other.

2.9.12 Pump Units

- 2** 2.9.12.1 There shall be separate pump for detergent wash and final rinse of Bogies. The pump units shall be of stainless steel and capable of generating adequate pressure and flow volume for the nozzles to issue jets for cleaning of bogie. Working pressure shall be ~~indicated in the bid~~ **furnished during the design stage.**

- 2** 2.9.12.2 The pump unit at each stage shall consist of a motor driven pump to enable continuous operation of the plant at rated output. Type, make, model no. and capacity of each pump and motor shall be ~~indicated in the bid~~ **furnished during the design stage.**

2.9.12.3 The pump shall be connected to hot detergent solution / hot water / hot water with rust inhibitor tank to perform complete washing cycle controlled by PLC.

2.9.12.4 The pump units shall be provided with air breather, pressure gauge, and overflow and drainage connections at each stage.

- 2** 2.9.12.5 All pipelines shall be of stainless steel and solid drawn, cold bent, seamless tubes capable of withstanding specified working pressure. The type of pipes shall be ~~indicated in the bid~~ **furnished during the design stage.**

2.9.13 Fume Extraction System

A fume extraction system for evacuation of steam generated inside the cabinet shall be provided. Evacuation of fumes to the atmosphere outside the shop thru proper ducting shall be at a suitable height from the cabin top. The ducting shall be in scope of Contractor.

2.9.14 Tanks

2.9.14.1 Tank for each stage shall be enclosed, double-walled chamber type, fabricated from 3 mm thick stainless steel (SS304 / International equivalent) sheets for inner shell and 2 mm stainless steel (SS304 / International equivalent) sheet for outer cladding along with removable, hinged type stainless steel (SS 304 / International equivalent) sheet covers.

2.9.14.2 Volumes of individual tanks shall be as given below:

- i. Hot Wash Solution Tank - 6000 Litres (minimum)
- ii. Fresh Water Rinse Tank – 3000 Litres (minimum).

Note: Apart from above If any other tanks required shall be in scope of wash plant Contractor.

2.9.14.3 The tanks shall be insulated with minimum 50 mm or better mineral wool / glass wool / rock wool / Polystyrene between the inner and outer walls to prevent heat loss.

2.9.14.4 The tanks should be equipped with:

- Filter Baskets / stainless steel screen filter with service hatch to protect pump suction.
- Drain valve cleaning hatch

- Automatic water refill and cascade refill.
- Filter protection
- Heating elements
- Automatic out flow valve

2.9.15 Sludge Removal

A mechanism for sludge removal like Fluid – Solids Separator will be provided & it will discharge sludge into sludge container. Suitable sludge bin with trolley shall be provided for transportation of sludge from the site.

2.9.16 Automatic Oil skimmer

2.9.16.1 Oil skimmer shall have stainless steel skimmer disc with stainless steel scraper blades or any other suitable arrangement to carry floating oils / grease from tank and discharge into separate drum for disposal. Oil skimmer operation shall be programmable and automatic.

2 2.9.16.2 Details including type, make, model no. and capacity of Automatic Oil Skimmer arrangement along with schematic diagram shall be furnished in the bid during the design stage.

2.9.17 Not Used

2.9.18 Lubrication

2 A centralized adjustable lubrication system shall be provided for areas needing lubrication. The lubrication system shall be explained with a lubricating circuit diagram in the bid during the design stage.

2.9.19 Controls

2.9.19.1 All functions of the plant shall be controlled from a centralized, ergonomically designed control panel through PLC Control. The control panel shall be located to enable a clear view of the plant to the operator.

2.9.19.2 All the Electrics used in the plant shall be suitably ingress protected and conformed to latest relevant specification. Plant shall have Microprocessor based control panelling system with suitable cooling arrangement for controlling of plant equipment / operation with touch screen.

2.9.19.3 The following functions of the plant shall be PLC controlled (but not limited to):

- Programs activated by pressing start button simultaneously like automatic introducing bogie, component trolley etc from outside to wash chamber inside, closing the doors, starts wash cycle, rinse cycle, exhaust blower to evacuate steam, cycle stop & opening doors
- Process times in min or sec.
- Temperature of the solution in all the tanks (should be displayed and audio / visual alert arrangement provided for in case of low / high temperature. Heating should start / stop automatically in case of low / high temperature)
- Temperature range setting (operator can change the temperature range settings)
- Oil Separation time (waiting + weekly timer controller)
- Cleaning Pressure and high / low pressure alarm
- By-pass filter pressure alarm + running time after cycle and auto stop
- Operation of water recycling system

Any other operation which is required for proper working of the plant (firm should clearly mention in the offer)

2 2.9.19.4 Make of the PLC controls shall be indicated in the bid furnished during the design stage. Controls of PLC should be user friendly and operator should be able to change the set parameters as per requirement. Details of each function, its setting arrangement and procedure shall be furnished in the bid during the design stage.

2.9.19.5 Deleted.

2.9.19.6 Firm should provide software backup with all the software locks and passwords (if any) to the CMRL during commissioning.

2.9.20 Detergent and rust inhibitor

2 2.9.20.1 Detergent and rust inhibitor shall have anti foaming properties and shall be safe for human handling. Chemical composition, pH and equivalent brands of these solutions and their availability in India shall be confirmed in the bid furnished during the design stage.

2 2.9.20.2 Concentration of detergent and rust inhibitor for optimal performance of the plant shall be indicated in the bid furnished during the design stage.

2.9.21 Cleaning quality

2.9.21.1 Grease, oil, dust & loose paint flakes etc. to be cleaned completely to the satisfaction of CMRL visually.

2.9.22 Hand Spray Gun

Atleast one number hand spray gun capable of being connected to the spraying system for cleaning the interior of the cabins or job shall be provided (at door) in order to clean surface of job which are difficult for the normal spray system to reach. The gun shall be capable of working at the operating pressure of the plant. The hand spraying is carried out with door open and the steam extraction running. The gun shall be accompanied by adequate length of flexible hose to enable proper cleaning of all cabin area / jobs.

2.9.23 Power loading & unloading system.

Power loading system intended for transport of Bogies on wheels, Bogie frame and components from the loading position into the washing cabinet and out to the unloading position outside the wash cabin. The loading / unloading system suitably designed able to take load of bogie, trolley with component, frame and to suit bogie size.

2.9.24 Heating system for water / solution

The liquid tanks should be equipped with electric heating elements, which heat up the tank solution / water to the desire temperature in °C for starting up the washing operation.

2.9.25 Bogie Wash Cabinet

2.9.25.1 Bogie wash plant shall be designed to work accordingly to layout i.e. bogie will enter from one side into cabinet for washing and will exit from the same side after washing and rinsing.

2.9.25.2 Automatic liquid chemical dosing system shall be provided for washing and rinsing cycle. Operator will select only percentage dosing and remaining work will be automatically carried out accordingly.

2.9.25.3 The plant shall be equipped with automatic water refill system for wash tank. Fresh water shall be added to the rinse tank only to ensure the water used for the rinsing process is clean. Further, entire process of flow of solutions and water will be automatic with solutions / water level controls and pumps.

2.9.26 Part Trolley

One number Parts trolley with wheels shall be supplied for carrying bogie frames without wheels, other large components, or smaller parts in basket. The minimum carrying capacity of parts trolley shall be 4000 kg.

2.9.27 Effluent Treatment Plant

The ETP, will not be part of this Contract, the effluents to be discharged from the bogie Washing Plants shall be drained to the Effluent Treatment Plant (ETP) of the Depot. The suitable size piping for such drainage will be provided by the bogie wash plant Contractor.

2.9.28 Operation sequence

2.9.28.1 The bogie shall first be placed to loading position on their own wheel or on carriage for entering

into the cabinet / chamber automatically.

- 2.9.28.2** From loading position, the Bogie or trolley (loaded with bogie / parts) shall be automatically fed by powered loading system into the wash cabinet / chamber where they shall be sprayed with wash solution under pressure at 60 to 75 °C in such a manner that the bogie remains stationary and spray manifold which surrounds the work piece on all sides travel back and forth to ensure complete cleaning of all work piece (Bogie, frame, associated accessories etc) surface including bottom.
- 2.9.28.3** After washing stage, hot freshwater rinse stage shall be automatically started where bogie will be rinsed to remove wash solution & residue with pressurized hot fresh water and apply a rust inhibitor at 60 to 75 °C.
- 2.9.28.4** After rinse operation, exhaust blower shall be started automatically to remove water steam from the washing cabinet to dry up bogie. When the cycle is completed a Stack pole light alerts operator to open the doors and transfer the clean bogie to unloading position by automatic powered unloading system. Then cleaned bogie should be taken back for maintenance work.
- 2.9.28.5** System should be PLC controlled and there should be option for operator to adjust process variables as required, including spray manifold reciprocation stroke which can be reduced to increase production rate.

2.9.29 Protection and Safety Control

- 2.9.29.1** Suitable interlock shall be provided to prevent plant operations in the event of:
- Faulty sequence of operation.
 - Fluctuation in supply voltage.
 - Resumption of power supply after power failure.
 - Non-positioning of safety guards.
 - Failure of hydraulic system (where applicable)
 - Failure of lubricating system (In case of automatic including drop in pressure lubrication)
- 2.9.29.2** A fault or damage in the control circuit or interruption re-establishment after an interruption of fluctuation in whatever manner in the power supply to the machinery must not lead to dangerous situations in particular.
- The plant must not start unexpectedly.
 - The machinery must not be prevented from stopping if command has already been given.
 - No moving part of the machinery or piece held by the machinery shall fall or be ejected.
 - The protection devices must remain effective.
- 2.9.29.3** The plant shall be fitted with an emergency stop device to enable actual or impending danger to be averted. This device must be:-
- Conveniently located.
 - Clearly identifiable.
 - Stop the plant as quickly as possible without causing additional hazards.
 - The emergency stop must remain engaged. It should be possible to disengage it only by appropriate operation. Disengaging the control must not restart the machinery but only permit restarting.
- 2.9.29.4** Safety features shall also include.
- Safety device against overload for all mechanical and electric items to the extent possible.
 - Safety stops against over-running of slides.
 - Not be easy to bypass or render non-operational.

2.9.30 Noise Level: -

The noise level of the plant during its operation shall not exceed 78 dBA when measured at a distance of one meter from the machine. Minor variation to above limits is acceptable on discretion of Purchaser.

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 Madhavaram depot of CMRL phase-II 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 Madhavaram Depot of CMRL phase-II. 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** 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.
- 2.10.2.12** 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.
- 2.10.2.13** Any other accessory considered essential for the operation of the plant to meet the purpose and capability.
- 2.10.2.14** 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.
- 2.10.2.15** 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 completed 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 designing 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 in the offer.
- 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. A compressed air supply of 8 bars shall be available at workshop columns. Any other requirement of pneumatic supply like pressure regulation, monitoring, pipeline for tapping from nearest compressed air source, etc., 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 integration and interface of pneumatic connections from shop supply to Bogie Test Stand shall be part of scope of work of this Tender.
- iii. The details of proposed pneumatic system of the Bogie Test Stand shall be explained in the offer.

2.10.15.6 Electrical parts

The power requirement of the Bogie Test Stand shall be furnished in the offer. 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 with 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 in the offer.

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 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

**** All dimensions as mentioned above are referred as Indicative only (on the basis of layout).**

EOT type	Double Girder (10/3t Crane)	Single Girder Crane (5t Capacity)
Gantry Span**	Approximately Category-1 (EOT- 22070 mm) Category-2 (EOT 22320 mm)	Approximately (EOT – 7.8m, ETU shed) (EOT- 13.3m, PWL shed)
Working environment & temperature	In-door & 45° C	In-door & 45° C
Class and Duty	Class II M5	Class II M5
Gantry length	Approx. 167.5 m**	ETU shed EOT (Approx. 52.7 m**) PWL shed EOT (Approx. 37.2 m**)
Location	Madhavaram depot – Chennai	Madhavaram 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. 8.0 – 8.5 m**	Approx. 6.0-7.0m **
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

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)	10 t	3 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 (on the basis of layout) and actual may vary.**

2.11.3.3 Crane travel details for 10t/3t Crane -Double Girder (Category 1 &2)-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 Crane -Single Girder (ETU & PWL shed)

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
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:

- The crane shall be rigid, robust and of sturdy construction.
- 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.
- The crane bridge shall comprise of double girders of box type for category 1 and 2 and single girder of box type for 5t EOT. Camber in the box girder shall be as per the relevant IS code.
- 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 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 panel and the electrical components shall be FLAMEPROOF type and the panel shall be IP55 protection and vermin proof.
- vii. Terminal blocks assembly shall have 20% spare terminals for future usage.
- viii. 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.

2

- 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 Madhavaram 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 supply.

Description	Capacity(t)	Qty(nos.)
Nylon sling	10	4
D shackle / bow shackle suitable for lifting bogie frame.	15	4
Nylon sling	5	4
D shackle / bow shackle	5	4
Nylon sling	1	4

Test certificates for the above-mentioned lifting accessories shall be submitted to CMRL before EOT Testing in CMRL Madhavaram depot.

2.11.5.17 Interfaces:

- The operation of EOT crane (category 1&2) shall be restricted in the event of retractable OHE in ON condition. To implement this EOT crane supplier shall interface with retractable OHE Contractor.
- The retractable OHE Contractor will suggest and supply necessary accessories to implement interlock between EOT and retractable OHE. EOT crane Contractor shall incorporate this in his design.
- In addition Chapter- 4 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 5 – Employer's drawing

2.11.5.19 Standards*:

- 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:
- IS 3177 / FEM 1.001/DIN- Code of Practice for electric overhead traveling cranes and gantry cranes other than steel cranes.
- IS 807 / FEM / ISO - Code of Practice for design, manufacture, erection and testing (structural portion) of cranes and hoists
- IS 2266 / FEM 1.001/ FEM 9.811-Specification for Steel Wire Ropes for General Engineering Purposes and Electric wire rope hoists.
- IS 13834 (Part 1) Cranes-classifications.
- IS 13834 (Part 5) Overhead Travelling and Portal Bridge Cranes
- IS 325 - Specification for Three Phase Induction Motors
- ISO 12488-1, Cranes-Tolerance for wheels and travel and traversing tracks.
- IS 800-2007, General construction in steel – code of practice.
- IS 3443 - specifications for crane rail sections.
- IS 15560:2005 - specification for Point hooks with shank up to 160 tons.
- IS 3813 -Specification for 'C' Hooks for Use with Swivels
- IS 3938 - Specification for Electric Wire Rope Hoists
- IS 3043 – Code of practice for earthing.
- 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).*

2.12 BOGIE TURN TABLES

2.12.1 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 Madhavaram depot. The Bogie Turn tables also referred here as Turn Tables.

2.12.2 Operating Requirement:

- 2.12.2.1** 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.
- 2.12.2.2** The design of each turntable shall have the roll over capacity of 25 t with maximum axle load of 11 t.
- 2.12.2.3** The turntables shall allow bogies with a maximum weight of 10t for turning and rollover.
- 2.12.2.4** 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.
- 2.12.2.5** 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.

2.12.3 Design requirement of Mechanical parts:

2.12.3.1 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.
- iv. The track gauge shall be 1435mm for Standard Gauge as specified.

2.12.3.2 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.
- iii. The Turntable platform shall be designed to sustain the rollover load of Workshop vehicle (forklift truck, scissor lift etc).

2.12.3.3 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.

2.12.3.4 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.

2.12.3.5 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.

2.12.3.6 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.

2.12.3.7 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.

2.12.3.8 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.

2.12.3.9 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.

2.12.3.10 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.

2.12.4 Maintenance Provision

2.12.4.1 Maintenance access shall be provided for inspection and lubrication of center pivot and casters.

2.12.4.2 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.

2.12.4.3 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.

2.12.5 Drawings:

List of civil layout Drawing and details provided in Chapter 5 Part 2 section VIB– Employer's drawing.

2.12.6 Interface:

2 2.12.6.1 In addition, the Contractor shall refer Interface matrix / specification Chapter- 4 Section IVIB Part 2 for the interface with other system Interfacing Contractors for Bogie Turn Tables.

2 2.12.6.2 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 IVIB Part-2 but not limited to.

2.13 BOGIE MANIPULATOR

2.13.1 Purpose of the machine:

2.13.1.1 The main purpose of Bogie Manipulator for the lifting and rotation of all types of bogie / bogie frame of multiple rolling stock (at Madhavaram depot) in order to give improved access for assembly, inspection and maintenance etc activities.

2.13.1.2 One set of Bogie Manipulator shall be installed and commissioned at Madhavaram depot.

2.13.1.3 ~~Additional set of Bogie Manipulator shall be installed and commissioned at CMRL designated depot in Chennai. The Contractor shall be responsible to design the equipment as per bogies and frames design of rolling stocks which shall be provided by CMRL during design phase~~
Deleted.

1

2.13.2 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.

2.13.3 Design Requirement of Bogie Manipulator

2.13.3.1 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.

2.13.3.2 Rotating / Turning

- i. One of the two jacks shall be provided with electrically operated Turning Device to rotate the job through 360 degrees.
- ii. 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.

2.13.3.3 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.

2.13.3.4 Lubrication

Lubrication nipples shall be provided at each jack and other assemblies for lubricating the lifting spindle and moving parts.

2.13.3.5 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

2.13.4 Protection and Safety provision:

2.13.4.1 System shall be capable of taking the full bogie load in case of power failure and any other such abnormal occurrence.

2.13.4.2 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.

2.13.4.3 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.

2.13.4.4 Emergency stop buttons of mushroom type shall be provided on control station including local control pendant.

2.13.5 Interface:

2 In addition, the Contractor shall refer Interface matrix / specification Chapter- 4 Section IVIB Part

2 for the interface with other system Interfacing Contractors for Bogie manipulator.

2.13.6 Standard:

The lifting jacks are designed in compliance with the presently valid European and international regulations for prevention of accidents.

2.14 ULTRASONIC FLAW DETECTOR (UFD)

2.14.1 Purpose of the machine:

The Ultrasonic flaw detector is a portable digital type equipment required for testing of axles of rolling stock based on A- scan pulse echo technique at CMRL depot. The unit shall be supplied with all accessories to make the equipment fully functional.

2.14.2 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.

2.14.3 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

S. No.	Parameters
	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.
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.	<p>Scope covers supply of probes and attachments for operation of equipment (but not limited to)</p> <ul style="list-style-type: none"> 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	<p>Scope covers spares for operation of equipment.</p> <ul style="list-style-type: none"> 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.

2.14.4 Standards:

The equipment shall be designed according to relevant / applicable industry standards.

2.15 BATTERY-OPERATED PLATFORM TRUCK (BOPT)

2.15.1 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 Chennai Metro Depot during maintenance / overhauling of metro trains.

2.15.2 Scope of Supply:

2.15.2.1 Design, Manufacture, Supply, Installation, Testing, Training and Commissioning of BOPTs.

2.15.2.2 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.

2.15.3 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 transmission	Variable speed DC motor. Gear Box transmission with fully integrated helical gear giving low noise, high load bearing capability 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.

Parameter	Required
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.

2.15.4 Standards:

The entire supply shall comply with the requirements of the standards in force.

2.16 BATTERY-OPERATED SELF-PROPELLED SCISSOR LIFT

2.16.1 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 workshop. This equipment shall include a travelling base accommodating the hydraulic system and electric system for lifting the platform and moving the assembly.

2.16.2 Technical Requirements (but not limited to below):

2.16.2.1 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

2.16.2.2 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

2.16.2.3 Load details

Lift capacity	At least 225 Kgs.
Lift capacity - extension deck	At least 110 Kgs.

2.16.2.4 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

2.16.2.5 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.

2.16.2.6 Preferred colour – Blue / Red will be finalised during design stage.

2.16.3 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

2.16.4 Machine Construction:

2.16.4.1 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.

2.16.4.2 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.

2.16.4.3 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.

2.16.4.4 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.

2.16.4.5 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.

2.16.4.6 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.

2.16.4.7 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.

2.16.5 Safety and Protection:

2.16.5.1 Braking shall be provided preferably by 2 circuits actuated simultaneously and automatically as soon as the movement control is stopped.

2.16.5.2 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.

2.16.5.3 The equipment shall be provided with a flashing signalling light.

2.16.5.4 Safety devices shall be provided to impede any damage to the machine and serious personnel injury in the event of false maneuvers.

2.16.5.5 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.

2.16.5.6 No failure of the equipment shall cause or give rise to any damage or catastrophe of any nature whatsoever.

2.16.6 Standards:

The Scissor lift shall be designed to ANSI A92.6, CSA B354.2, AS 1418.10, CE EN-280.

2.17 HIGH-PRESSURE WASH PUMP (TYPE-1)

2.17.1 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.

2.17.2 Accessories per equipment (included with supply):

2.17.2.1 High-pressure & high temperature withstanding hose pipe 10m long with quick screw.

i. couplings of steel, Brass or gunmetal on both ends - 1 no.

2.17.2.2 Water inlet pipe 10m with quick screw couplings of steel, Brass or gunmetal on both ends – 1 no.

2.17.2.3 Detergent / scale inhibitor - first fill quantity

2.17.2.4 Diesel oil - first fill quantity

2.17.2.5 Electrical cable with suitable plug top for connecting the machine to mains supplies socket – minimum 10m.

2.17.2.6 Rubber hand gloves - 2 pair.

2.17.2.7 Any other accessories (if not listed) to make this system fully functional to be provided with supply and included with the equipment.

2.17.3 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

Parameters	Required
Type of protection	IPX5 to IP 47 or latest

2.17.4 Design Features:

2.17.4.1 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).

2.17.4.2 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.

2.17.4.3 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.

2.17.4.4 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.

2.17.4.5 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.

2.17.4.6 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.

2.17.5 Safety and protection

2.17.5.1 The equipment shall incorporate all safety features to provide complete protection to the operator and the equipment against all operational / machine failures.

2.17.5.2 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.

2.17.6 Standards

The equipment shall be designed according to relevant / applicable industry standards.

2.18 HIGH-PRESSURE WASH PUMP (TYPE-2)

2.18.1 Purpose of the machine:

The High-Pressure Wash Pumps are required for cleaning / washing the miscellaneous small parts and other items with a handheld jet of water at CMRL depot. The equipment shall be capable of spraying 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 for smooth movement.

2.18.2 Accessories (included with supply):

2.18.2.1 High-pressure hose pipe 10m long with quick screw couplings of steel, Brass or gunmetal - 1 no.

2.18.2.2 Water inlet pipe 10m with quick screw couplings of steel, Brass or gunmetal– 1 no.

2.18.2.3 Electrical cable with suitable plug top for connecting the machine to mains supplies socket – minimum 10m.

2.18.2.4 Rubber hand gloves - 2 pair.

2.18.2.5 Any other accessories (if not listed) to make this system fully functional to be provided with supply and included with the equipment.

2.18.3 Technical Requirements (but not limited to below):

Parameters	Required
Water Flow rate L/h	500–1000

Parameters	Required
Pressure bar / MPa	30–150 / 3–15 (adjustable from minimum to maximum)
Power rating kW	5.5 kw to 6.5 kw
Three piston axial pump	Ceramic piston
Dry running protection	Yes

2.18.4 Design Features:

2.18.4.1 Rigidity & Control

- The equipment shall be robust and of sturdy construction.
- 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.
- 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.
- 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).

2.18.4.2 Main Body

- 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.
- The equipment should have lightweight hinged hood for protection from dirt and water.
- It shall have supports suitable located for hp-hose, spray gun and power cable for neatly storing and ready to use.
- It shall have special compartments for storage of nozzles and tools.

2.18.4.3 High pressure pump and motor unit

- Motor-Three-phase, 4-pole motor with air / water cooling, long-life drive system with overload protection, rotation control & easy change of direction.
- Pump-Three piston pump (axial / crankshaft) having steel pistons with ceramic sleeves, 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.
- Spray gun
- The spray gun shall be fitted with soft grip and long double lance in stainless steel.
- The spray gun shall be fitted with high pressure steel nozzle and brass nozzle.
- The spray gun shall be fitted with high pressure withstanding hose and quick screw couplings. The hoses shall withstand any permanent damage.

2.18.5 Safety and protection

2.18.5.1 The equipment shall incorporate all safety features to provide complete protection to the operator and the equipment against all operational / machine failures.

2.18.5.2 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. Protection against short circuit.

2.18.6 Standards

The equipment shall be designed according to relevant / applicable industry standards.

2.19 HAND PALLET TRUCK

2.19.1 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-II. 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.

2.19.2 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.

2.19.3 Design Requirement

2.19.3.1 Main features of the equipment shall be,

- i. facilitate the personnel's task for storage operations,
- ii. have an adequate angle of steering lock to offer optimum manoeuvrability,
- iii. be capable of handling loads up to 2500 kg minimum,
- iv. guarantee the stability of loads during handling,

2.19.4 Mechanical part

The frame and forks shall be built-in of heavy-duty steel.

2.19.5 Hydraulic part

The hydraulic block shall be built of graphite cast iron. The hydraulic mechanism shall be air and dust tight.

2.19.6 Standard:

The equipment shall be designed in compliance with the presently valid European / international regulations.

2.20 BATTERY-OPERATED FORKLIFT TRUCK

2.20.1 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.

2.20.2 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 Km/h
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)
----	-------	--

2.20.3 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.

2.20.4 Other technical requirements:

- Lifting of the forks shall be hydraulic operated.
- The sound level in the cabin shall be less than 77dB.
- 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.

2.20.5 Mechanical part and Braking

2.20.5.1 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.

2.20.5.2 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.

2.20.6 Electrical Part (Battery and Charger)

2.20.6.1 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.

2.20.6.2 The specification of the battery charger should be suitable to the supplied battery and capable of charging the battery not exceeding 8 hours.

2.20.7 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.

2.20.8 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.

2.20.9 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

2.21 MOBILE LIFTING TABLES (MLT)

2.21.1 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)

2.21.2 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	2800 x 2400 mm (LxW)	1800 x 1800 mm (LxW)

Parameters	For 5t Required	For 2t Required
Basic chassis dimension overall	2800 x 2400 mm (LxW)	1800 x 1800 mm (LxW)
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)

Note: The above dimensions are indicative only. MLT Contractor shall interface with multiple rolling stock Contractor for the required details of underframe items / assemblies to design and construct equipment accordingly.

2.21.3 Machine configuration:

2.21.3.1 Lifting Table

- 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.
- 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.
- A mechanical stopper up to 1 meter height of movable platform shall be provided.
- The lifting table shall be free of rust, mill scale, dirt, oil etc. and thoroughly cleaned, if needed with chemical solution and rinsed.
- The painted surface of the table / part shall be free from wrinkles, irregular painting, dripping, scratches and irregularities in coloring.
- 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.

2.21.3.2 Chassis and Platform

- 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.
- 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.
- 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.
- Handle shall be made from mild steel tubular pipes confirming to IS: 1239:1990.
- Heavy duty foldable type safety railing shall be provided on the back side of top platform.

2.21.3.3 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.

2.21.3.4 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.

2.21.3.5 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.

2.21.3.6 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.

2.21.4 Safety and protection

2.21.4.1 The equipment shall incorporate all safety devices to provide complete protection to the operator from all possible operational failures.

2.21.4.2 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.

2.21.5 Standards

The equipment shall be designed according to relevant / applicable industry standards.

2.22 KEY MANAGEMENT SYSTEM

2.22.1 Purpose of the machine:

The Key management system require to secure keys to physical assets of Madhavaram 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.

2.22.2 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

Parts / items	Required Details
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

2.22.2.1 Accessories (included with supply):

- i. Biometric (Finger) +RFID card (at least 100Nos) based with cabinet.
- ii. Software for Key Management System
- iii. Key fobs
- iv. Any other accessories (if not listed) to make this system fully functional to be provided with supply and included with the system.

2.22.2.2 Specification for Key Cabinet:

- i. 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.
- ii. The cabinet should identify users, by Fingerprint Scan + ISO14443 standard ID cards.
- iii. Cabinet should be made from proven metal as per applicable industry standard.
- iv. 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.
- v. Each key slot should be able to detect the RFID tag and lock the Key automatically inside.
- vi. 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.
- vii. Dimension of the cabinet shall be compact, to be able to accommodate at CMRL depot desired site / location.

2.22.3 Technical Requirement:

2.22.3.1 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.

2.22.3.2 It should have interface for connecting to PC.

2.22.3.3 It should have Graphic TFT / LCD display for displaying messages and keypad for user interface. Keypad should be rugged for easy cleaning & unobstructed performance.

2.22.3.4 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.

2.22.3.5 The cabinet should have provision to archive minimum 10000 Key transaction history.

2.22.3.6 The cabinet should have provision of backup power supply from battery to operate minimum 2 Hours on mains power failure.

2.22.4 Cabinet Management Software:

2.22.4.1 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.

2.22.4.2 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.

2.22.4.3 It should have provision to upload key Numbers and employee details like Employee no, PIN and other user defined parameters to cabinet.

2.22.4.4 The software should have provision for logging of all transaction events (login /log out data with time stamp) of all users including administrator.

2.22.4.5 The software should have provision to display all alarm events.

2.22.4.6 The Software shall run on Windows.

2.22.5 Standards / Certifications:

The design of the Key management system shall conform to CE, ROHS or equivalent standard / certifications.

2

2.23 VERTICAL STORAGE SYSTEM (AUTOMATIC VSS)

2.23.1 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 Madhavaram depot. The material to be stored might be spares parts (Mechanical / electrical / electronic etc) / consumables of trains / tools and any other critical items.

2.23.2 Basic features for design of Automated Vertical Storage system:

The Automated Vertical Storage system shall have following minimum features (but not limited to):

Description	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 as per 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)

Description	Required
Control	Logi control / microprocessor control / PLC
Overall height	7000 ± 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.

2.23.2.1 Accessories (included with supply):

- i. 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.
- ii. Power cable of suitable length with required rated connector to connect the nearby power supply source.
- iii. Any other accessories (if not listed) to make this system fully functional to be provided with supply and included with the system.
- iv. Suitable rating of Isolated Transformer with Stabilizer having surge arrestor of proven make should be supplied along with unit.

2.23.3 Design requirement of Mechanical parts:

2.23.3.1 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.

2.23.3.2 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.

2.23.3.3 The system shall be suitable for continuous working through at least 12 hours a day, 365 days in a year.

2.23.3.4 The design shall take into consideration of fire prevention, the elimination of dust and dirt traps, and easy access for cleaning and routine maintenance.

2.23.3.5 Automatic front Door should be provided in access opening and lift system should operate only in closed condition.

2.23.3.6 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 **2.23.3.7** ~~All fasteners shall be of stainless steel. All structures and the frame shall be of stainless steel SS304 as per ASTM-AISI standard. All piping work shall be of stainless steel of international or equivalent standard.~~ **All fasteners and piping work shall be of stainless steel.**

2.23.4 Design requirement of Electrical Parts:

2.23.4.1 The control shall incorporate a 'Mains ON-OFF' isolator master switch and a 'Main-ON' indication light

2.23.4.2 A worktop illumination light ON-OFF switch shall be provided.

2.23.4.3 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.

2.23.4.4 The equipment shall be suitable for working on 360- 440V, three phase 4 wire, and frequency

47.5 to 51.5 Hz power supply.

2.23.4.5 The motor control shall be through a variable frequency converter to avoid start or stop with jerks. Motor preferably 100% duty cycle.

2.23.5 Control System (Automatic):

2.23.5.1 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.

2.23.5.2 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.

2.23.5.3 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.

2.23.5.4 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.

2.23.5.5 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 format decided during design phase.
- Software source code shall be provided.

2.23.5.6 The system shall have suitable provision / compatible & interface to connect an external PC, barcode reader, camera, printer etc.

2.23.5.7 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.

2.23.5.8 An electronic height detection system shall measure all items to be stored and automatically place them in the optimum location.

2.23.5.9 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.

2.23.5.10 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.

2.23.5.11 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.

2.23.5.12 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.

2.23.5.13 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.

2.23.5.14 Redundancy system for uninterrupted functioning of the unit shall be provided.

2.23.6 Protection and Safety

2.23.6.1 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.

2.23.6.2 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.

2.23.6.3 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.

2.23.6.4 By passing mode for working in case of emergency shall be provided.

2.23.6.5 Inspection door with safety interlocks shall be provided.

2.23.6.6 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.

2.23.6.7 The system shall be designed rodent protections or equivalent and relevant protections for fire safety.

2.23.6.8 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.

2.23.6.9 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.

2.23.6.10 All the operational overrides shall be facilitated with proper interlock system.

2.23.7 Standards:

The design of the Vertical storage system should conform to EN15095 or equivalent standard as applicable for such automatic Vertical storage and retrieval system.

2.24 STATIONARY AIR COMPRESSOR

2.24.1 Purpose of the machine:

The Stationary Air compressor is required for production of compressed air required for the pit wheel lathe Shed. The compressed air shall be used for blowing of metal chips produced during machining at wheel lathe and cleaning of equipment etc at pit wheel lathe shed in CMRL Madhavaram depot.

2.24.2 Scope of Supply:

2.24.2.1 Design, Manufacture, Supply, Installation, Testing, Training and Commissioning of Stationary 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, steel pipe supply & fitting and all other accessories to make the equipment fully functional.

2.24.2.2 The complete unit of compressor along with other controlling equipment shall be mounted on a base frame and placed directly on the firm floor (needs no foundation) at a designated place in pit wheel lathe shed. Fixing arrangement along with adequate damping arrangement in scope

of compressor Contractor.

2.24.2.3 The supply shall include a flexible pipe 15 meters approximate and an operator gun of high thrust nozzle.

2.24.3 Technical Requirements (but not limited to below):

Compressor Configuration	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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 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	<ul style="list-style-type: none"> 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 in to liquid for efficient cooling.
Electrical	a. Compressor unit shall be driven by V-belts with XPZ profile, coupled with

installation	<p>atleast 5.5 KW motor of Power supply 3 phase AC.</p> <p>b. Motor shall have TEFC square cage, F class insulation with IP 55 standard. Motor bearing shall be greased for life long.</p>
Control Panel	<p>The Control Panel shall comprise of:</p> <ul style="list-style-type: none"> - 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.
Other Requirements	<p>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.</p> <p>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.</p> <p>c. Anti-Vibration Mountings shall be provided with sound proofing treatment</p> <p>d. Steel pipe supply & fitting from compressor location to wheel lathe in scope of compressor Contractor.</p>

2.24.4 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.

2.24.5 Standards:

The entire supply shall comply with the requirements of the standards in force.

2.25 MOBILE AIR COMPRESSOR

2.25.1 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.

2.25.2 Scope of Supply:

2.25.2.1 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.

2.25.2.2 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.

2.25.2.3 The supply shall include a flexible pipe 15 meters approximate and an operator gun of high thrust nozzle.

2.25.3 Technical Requirements (but not limited to below):

Compressor Configuration	<ul style="list-style-type: none"> 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	<ul style="list-style-type: none"> 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	<p>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.</p> <p>b. System shall have provision for Compact air to air and air to refrigerant heat exchangers for maximum heat transfer and minimal pressure drop.</p> <p>c. Integrated water separator (moisture trap) shall be provided with automatic and manual drain options.</p> <p>d. Hot Gas bypass valve shall be provided to keep evaporator pressure above a certain level at part load and unload condition.</p> <p>e. Condenser shall be provided to convert refrigerant gas into liquid for efficient cooling.</p>
Electrical installation	<p>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.</p> <p>b. Motor shall have TEFC square cage, F class insulation with IP 55 standard. Motor bearing shall be greased for life long.</p>
Control Panel	<p>The Control Panel shall comprise of:</p> <p>Suitable proven make DOL starter with Contractor and relays for overload and single-phase protection.</p> <ul style="list-style-type: none"> - 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	<p>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 in the bid document during the design stage.</p>
Other Requirements	<p>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.</p> <p>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.</p> <p>c. Anti-Vibration Mountings shall be provided with sound proofing treatment</p>

2.25.4 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

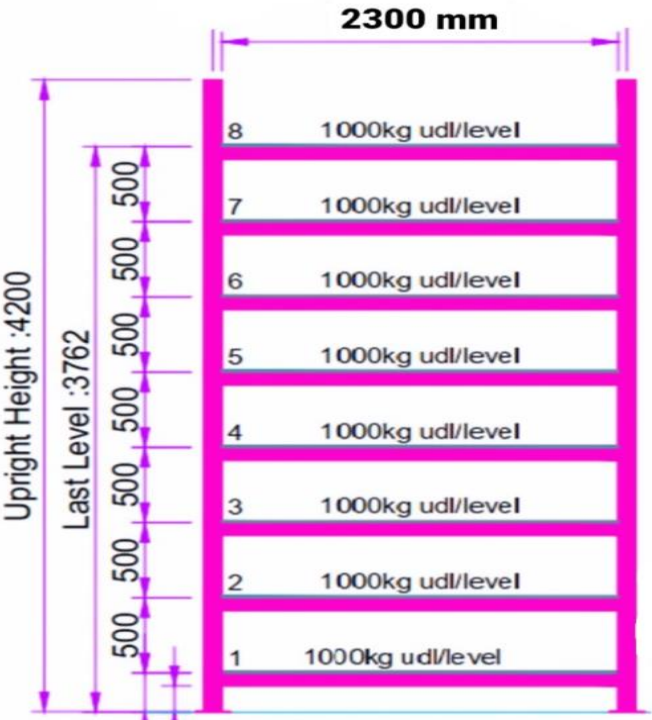
- Oil discharge temperature trip at the outlet.
- Oil level indicator.
- In-built protection against starting on load.
- Pressure transducer mounted at the downstream of moisture trap and upstream of oil separator.

2.25.5 Standards

The entire supply shall comply with the requirements of the standards in force.

2.26 VARIOUS STORAGE ITEMS

2.26.1 Storage Racks

<p>Sample sketch</p> 	<p>Product specification (minimum parameters): :</p> <p>Storage rack; Beam width : 2300 ± 20 mm(min);</p> <p>Load capacity per level : 1000 kg .</p> <p>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)</p> <p>Loading Levels : 8</p> <p>Shelving Depth : 1000 mm</p> <p>Load per level : 1000 kg</p> <p>Other : Panel height shall be adjustable as per requirement</p>
--	--

2.26.2 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

2.26.3 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: <ul style="list-style-type: none"> - 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 	

2.26.4 Pallet (Heavy duty)

Description of Items	Dimension
Pallet (Heavy duty)	(1200 X 1000X 160MM)
Product Specification (minimum parameters):: Above pallets shall be: <ul style="list-style-type: none"> - 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 	

2.26.5 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: <ul style="list-style-type: none"> - 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 	

2.26.6 Personnel Lockers Cabinet

Description of Items	Dimension (in mm)
Personnel Locker cabinet	1800H x 900W x 400D (minimum per set)
Product Specification (minimum parameters):: Above cabinet shall be: <ul style="list-style-type: none"> - One set shall comprise 6 lockers with door (2 lockers vertically) - Door size - 262W x 818H mm (min) - Each Locker with lock with 2 keys - 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 	

2.26.7 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: <ul style="list-style-type: none"> - 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 	

Description of Items	Dimension (mm)
<ul style="list-style-type: none"> - Door Type: Manual - No of Shelves: 2 (Adjustable) - External hazard stickers in accordance with relevant standards. - Color: Yellow 	

2.27 TOOLS AND OTHER MINOR ITEMS

2.27.1 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

2.27.2 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

2.27.3 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

2.27.4 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

2.27.5 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)

2.27.6 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

2.27.7 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.

2.27.8 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

2.27.9 Dewatering Pump Portable

Product specification (minimum parameters)::

- Power source: Fuel powered
- Engine type: Air cooled 4 strokes
- Power: 2.9kw
- Engine Displacement: min 163 cc
- Fuel Tank capacity: min 3 L
- Continue Operation time: min 5 hours
- Pump size: 80mm/ 80mm
- Suction lift: min 6m, Pump lift: 20m (horizontal)
- Discharge capacity: minimum 500l/min
- Frame: Tubular frame for easy handling / lifting
- Contractor shall provide the flexible pipe(suitable length) for suction and discharge port