Corrigendum-2

Part-2 Section VI-C (Particular Specifications)

<table>
<tr><th>Clause no.</th><th>Original Clause</th><th>Modified Clause</th></tr>
<tr><td>3.1.4</td><td>Add new clause</td><td><u>3.1.4 List of stations is tabulated below:</u>
<table>
<tr><th>S. No.</th><th>Station Name</th><th>UG/ Ele</th><th>Stage</th><th>No. of PF</th></tr>
<tr><td>1</td><td>Light House Metro</td><td>UG</td><td>7</td><td>2</td></tr>
<tr><td>2</td><td>Kutchery Road Metro</td><td>UG</td><td>7</td><td>2</td></tr>
<tr><td>3</td><td>Thirumayilai Metro</td><td>UG</td><td>7</td><td>2</td></tr>
<tr><td>4</td><td>Alwarpet Metro</td><td>UG</td><td>7</td><td>2</td></tr>
<tr><td>5</td><td>Bharathidasan Road Metro</td><td>UG</td><td>7</td><td>2</td></tr>
<tr><td>6</td><td>Boatclub Metro</td><td>UG</td><td>4</td><td>2</td></tr>
<tr><td>7</td><td>Nandanam Metro</td><td>UG</td><td>4</td><td>2</td></tr>
<tr><td>8</td><td>Panagal Park Metro</td><td>UG</td><td>4</td><td>2</td></tr>
<tr><td>9</td><td>Kodambakkam Metro</td><td>UG</td><td>4</td><td>2</td></tr>
<tr><td>10</td><td>Kodampakkam Power House</td><td>Ele</td><td>1</td><td>2</td></tr>
<tr><td>11</td><td>Vadapalani Metro</td><td>Ele</td><td>1</td><td>2</td></tr>
<tr><td>12</td><td>Saligramam Metro</td><td>Ele</td><td>1</td><td>2</td></tr>
<tr><td>13</td><td>Avichi School Metro</td><td>Ele</td><td>1</td><td>2</td></tr>
<tr><td>14</td><td>Alwar Thirunagar Metro</td><td>Ele</td><td>1</td><td>2</td></tr>
<tr><td>15</td><td>Valasaravakkam Metro</td><td>Ele</td><td>1</td><td>2</td></tr>
<tr><td>16</td><td>Karambakkam Metro</td><td>Ele</td><td>1</td><td>2</td></tr>
<tr><td>17</td><td>Alappakkam Metro</td><td>Ele</td><td>1</td><td>2</td></tr>
<tr><td>18</td><td>Porur Jn Metro</td><td>Ele</td><td>1</td><td>2</td></tr>
<tr><td>19</td><td>Porur Bypass Crossing Metro</td><td>Ele</td><td>1</td><td>2</td></tr>
<tr><td>20</td><td>Thelliyaragaram Metro</td><td>Ele</td><td>1</td><td>2</td></tr>
<tr><td>21</td><td>Iyyapanthangal Metro</td><td>Ele</td><td>1</td><td>2</td></tr>
<tr><td>22</td><td>Kattupakkam Metro</td><td>Ele</td><td>1</td><td>2</td></tr>
</table></td></tr>
</table>

<table>
<tr><td></td><td></td><td>
<table>
<tr><td>23</td><td>Kumanan Chavadi Metro</td><td>Ele</td><td>1</td><td>2</td></tr>
<tr><td>24</td><td>Karayan Chavadi Metro</td><td>Ele</td><td>1</td><td>2</td></tr>
<tr><td>25</td><td>Mullaithottam Metro</td><td>Ele</td><td>1</td><td>2</td></tr>
<tr><td>26</td><td>Poonamallee Metro</td><td>Ele</td><td>1</td><td>2</td></tr>
<tr><td>27</td><td>Poonamallee Bypass Metro</td><td>Ele</td><td>1</td><td>2</td></tr>
</table>
</td></tr>
<tr><td>3.2.4.2</td><td>The Contractor shall note that there will be phased commissioning of the CMRL Phase 2. All the works related to phased commissioning and changes required for inter phase and final commissioning shall also form part of the work.</td><td>The Contractor shall note that there will be phased commissioning of the CMRL Phase 2. All the works related to phased commissioning and changes required for <u>interface</u> and final commissioning shall also form part of the work.</td></tr>
<tr><td>3.5.1</td><td>The services provided by other contractors and interface scope of work od respective contractors are detailed in Appendix 2P of PS.</td><td>The services provided by other contractors and interface scope of work <u>of</u> respective contractors are detailed in Appendix 2P of PS.</td></tr>
<tr><td>3.5.6</td><td>UPS & Battery Back-up: UPS supply will be provided to S&TC contractor at a shared location in UPS room or suitable location with suitable dual feeder and circuit breaker at Stations, OCC,DCC, BOCC by MEP Contractor.</td><td>UPS & Battery Back-up: UPS supply will be provided to <u>PSD</u> contractor at a shared location in UPS room or suitable location with suitable dual feeder and circuit breaker at <u>Stations, OCC, BOCC</u> by MEP Contractor.</td></tr>
<tr><td>3.7.1</td><td>The facilities shown in the contract drawings shall be provided by the Employer to the Contractor for the on-site work on the dates set out in the Appendix 2A. In the event that the Contractor wishes to use such facilities he shall take into account the dates of availability of such facilities as set out in the appendix in his programming and planning of the Works.</td><td>The facilities shown in the contract drawings shall be provided by the Employer to the Contractor for the on-site work on the dates set out in the <u>Tender document Part 1</u>. In the event that the Contractor wishes to use such facilities he shall take into account the dates of availability of such facilities as set out in the appendix in his programming and planning of the Works.</td></tr>
<tr><td>3.7.3.1</td><td>
<table>
<tr><td>Poonamallee Depot premises
For warehouse, Contractors Office and for Engineer office
(Engineer Office only for Stage 1- From the pre-construction stage till end of DLP of Stage 1)</td><td>1500 sq m vacant land in the Depot premises will be provided by the employer for the said duration.</td></tr>
<tr><td>Near to Nandanam-Engineer office
(Engineer Office only for Stage 2- From the pre-construction stage OR from the end of</td><td>Contractor shall make his own arrangements at his own cost</td></tr>
</table>
</td><td>
<table>
<tr><td>Poonamallee Depot premises
For warehouse, Contractors Office and for Engineer office
(Engineer Office only for Stage 1- From the pre-construction stage till end of DLP of Stage 1)</td><td>1500 sq m vacant land in the Depot premises will be provided by the employer for the said duration <u>(stage 1 to stage 7).</u></td></tr>
<tr><td>Near to Nandanam-Engineer office
(Engineer Office only for <u>Stage 4 & 7</u>- From the pre-construction stage OR <u>from the end of stage 1, till End of Stage 7)</u></td><td>Contractor shall make his own arrangements at his own cost</td></tr>
</table>
</td></tr>
</table>

	DLP of stage 1, till End of DLP of Stage 2)	
4.2.4	For the purposes of Reliability and Availability calculations, the Contractor shall assume that the service operating hours are 19 hours per day (05:00 to 00:00) for 365 days a year. The availability of the PSD System shall be demonstrated by the Contractor in accordance with the processes defined in the Specification. The Reliability and Availability figure as described in Para below shall be reached by the end of the stabilization period from revenue operation. The Reliability and Availability figures shall be calculated monthly after the stabilization period, and the contractor shall demonstrate that the figures are met in 6 consecutive months of observation. If the figure is not met in 6 consecutive months by the end of DLP period then the DLP for that section shall be extended by 1 month each for all PSDs of that stage, every time till the requirement of achieving figures for 6 consecutive months is reached.	For the purposes of Reliability and Availability calculations, the Contractor shall assume that the service operating hours are 19 hours per day (05:00 to 00:00) for 365 days a year. The availability of the PSD System shall be demonstrated by the Contractor in accordance with the processes defined in the Specification. The Reliability and Availability figure as described in Para below shall be reached by the end of the stabilization period from revenue operation. The Reliability and Availability figures **shall be calculated after the stabilization period,** and the contractor shall demonstrate that the figures are met **over** 6 consecutive months of observation. If the figure is not met **over** 6 consecutive months by the end of DLP period then the DLP for that section shall be extended by 1 month each for all PSDs of that stage, every time till the requirement of achieving figures **over** 6 consecutive months is reached.
4.6.8	The DCU system, Open commands shall comply to SIL 3. The All doors closed, and locked signal and Interlock override signals and its associated hardware as a whole shall comply to SIL 4. The Vital Signalling Interface shall be SIL 4.	The DCU system, **Open/close commands** shall comply to SIL 3. The All doors closed, and locked signal and Interlock override signals and its associated hardware as a whole shall comply to SIL 4. The Vital Signalling Interface shall be SIL 4.
4.9.8	The In the event that the ALL DOORS CLOSED AND LOCKED safety signal is not confirmed, the Automatic Re-open function of the BSD shall cause the BSD(s) that have not been proved closed to re-open. The door re-opening width shall be adjustable from 100mm to 500mm and the time delay for re-closing the door shall be adjustable from 0 to 30 seconds.	In the event that the ALL DOORS CLOSED AND LOCKED safety signal is not confirmed, the Automatic Re-open function of the BSD shall cause the BSD(s) that have not been proved closed to re-open. The door re-opening width shall be adjustable **from 100mm to full opening width** and the time delay for re-closing the door shall be adjustable from 0 to 30 seconds.
4.9.9	New clause added	**The BSD shall be capable of operating in maximum loaded condition, including TVS fans operation.**
4.11.2	The noise levels at 1m from the platform edge on any platform resulting from operation of the MSDs shall not exceed 73 dB (A) fast response when all doors are operating on an empty platform with finishes.	The noise levels at 1m from the platform edge on any platform resulting from operation of the **BSDs** shall not exceed 73 dB (A) fast response when all doors are operating on an empty platform with finishes.
4.12.1 (e)	Wind pressure because of a maximum of 200 kmph cyclonic wind in any direction in Elevated platforms (For full Height PSDs)	Wind pressure because of a maximum of 200 kmph cyclonic wind in any direction in Elevated platforms (For **Half Height** PSDs)

4.12.3	The MSDs shall be capable of operating in the above loading conditions except the loading generated by pressure by the train movement. The MSDs shall be capable of operating in the maximum loading with or without a standstill train in the platform.	The **BSDs** shall be capable of operating in the above loading conditions except the loading generated by pressure by the train movement. The **BSDs** shall be capable of operating in the maximum loading with or without a standstill train in the platform.
4.12	Add new sub Clause 4.12.6	**4.12.6 Covering the structural design finite element analysis report shall be submitted to Engineer for NoNO**.
4.13.3 (iii)	It shall be minimized smoke and heat emission and shall be free from toxic gases	It **shall minimise** smoke and heat emission and shall be free from toxic gases
4.13.4 (ii)	The Surface linings will achieve Class 0 (national class) or Class B – S3, d2 (European class) surface spread of flame in accordance with International Building Code (IBRC). Materials will also be compliant with the UK Fire Precautions (Sub-surface Railway Stations) Regulations 2009 and or material/product classified as Class A2-s3, d2 or better in accordance with BS EN 13501-1:2002 Fire classification of construction products and building elements, Part 1 – Classification using data from reaction to fire tests.	The Surface linings will achieve Class 0 (national class) or Class B – S3, d2 (European class) surface spread of flame in accordance with International Building Code (IBRC). Materials **shall** also be compliant with the UK Fire Precautions (Sub-surface Railway Stations) Regulations 2009 and or material/product classified as Class A2-s3, d2 or better in accordance with BS EN 13501-1:2002 Fire classification of construction products and building elements, Part 1 – Classification using data from reaction to fire tests.
4.13.5 (i)	The cables shall be 600/1000V for power cables and 300/500V for control and signal cables.	The cables shall be **rated for** 600/1000V for power cables and 300/500V for control and signal cables.
5.3.3.7	The All Doors Closed and Locked signal shall work, based on the actual Realtime status of the doors of that Platform.	**The PSD system shall provide the following signals as a minimum under fail safe conditions to the Signalling system:** **• All Doors Closed & Locked Signals: Confirms that all door sets are closed and mechanically locked, as determined by the All Doors Closed & Locked Safety Loop going through every door set of the façade.** The All Doors Closed and Locked signal shall work, based on the actual Realtime status of the doors of that Platform.
5.3.4.4	Individual Door Inhibition from the ATS shall NOT be enforced in this mode.	**The inhibition of the Rolling Stock door based on the PSD status shall function normally.**
5.4.1	Any single equipment failure or cable link failure shall not cause any effect on the operation of more than one PSD Bi-parting Sliding Door corresponding to a car of Rolling stock (Rolling stock is having 4 passenger doors per car), except the All doors closed and locked signal.	Any single equipment failure or cable link failure shall not cause any effect on the operation of more than one PSD Bi-parting Sliding Door corresponding to a car of Rolling stock (Rolling stock is having 4 passenger doors per car), except the All doors closed and locked signal **and door close/open commands.**
5.6.1	CBTC system is required to include local and remote maintenance and real time diagnostic capabilities to detect and react to various equipment failure types. The remote diagnostic capabilities shall be available at OCC, BOCC, and to permit authorized personnel to interrogate	**PSD** system is required to include local and remote maintenance and real time diagnostic capabilities to detect and react to various equipment failure types. The remote diagnostic capabilities shall be available at OCC, BOCC, and to permit authorized personnel to interrogate the status of equipments

	the status of equipments and provide active fault diagnosis and isolation. It shall be possible to remotely download the maintenance and diagnostic-related data.	and provide active fault diagnosis and isolation. It shall be possible to remotely download the maintenance and diagnostic-related data.
5.9.7	The MSDs shall have push bar for opening from the track side. From the Platform side, the MSDs shall be opened using the Staff Protection Key (SPK) of the Signalling.	The MSDs shall have push bar for opening from the track side. From the Platform side, the MSDs shall be opened using the Staff Protection Key (SPK) of the Signalling. **The interlock design between the SPK and MSD shall of subjected to NoNO of Engineer.**
5.10.1	The Bi-parting Sliding Doors can be inhibited by Signalling System or from the Station Control Room Workstation.	The Bi-parting Sliding Doors can be inhibited by **Signalling System (ATS Workstation) from the Station Control Room and OCC/BOCC**.
5.14.3	**Isolate:** In this position, the BSD shall be electrically isolated from Opening. The door leaf shall be mechanically locked in Close position and shall not be capable of Operating electrically or using the push bar from the track side. The Door closed and locked signal shall convey the original position of the doors lock and closed condition. **Override:** In this position, the BSD shall be electrically isolated from Opening. The door leaf shall be mechanically locked in Close position and shall not be capable of Operating electrically or using the push bar from the track side. The Door closed and locked signal shall convey the original position of the doors lock and closed condition..	**Isolate:** In this position, the BSD shall be electrically isolated from Opening. The Door closed and locked signal shall convey the original position of the doors lock and closed condition. **Override:** In this position, the BSD shall be electrically isolated from Opening**. The Door closed and locked signal shall be bypassed to bridge the ADCL loop. The override signal to signalling system shall be made available.**
5.15.8	The Summary Lamp for MSD shall be like the EED. Additionally summary lamp shall be provided on the track side for EED providing high visibility from the track side/ tunnels. Platform side light can be like that of EED	The Summary Lamp for MSD **on platform side** shall be like the EED. Additionally summary lamp shall be provided on the track side for **MSD** providing high visibility from the track side/ tunnels.
5.16.4	The MCP shall have specialized key matching the rotary switch to changeover the PSD mode from Auto to Manual.	The MCP shall have specialized key **and matching rotary switch (latching)** to changeover the PSD mode from Auto to Manual.
5.16.5	The MCP shall also be provided with specialized key matching the rotary switch to Override the PSD All Doors Closed and Locked Signal.	The MCP shall also be provided with specialized key **and matching rotary switch (non-latching spring loaded)** to Override the PSD All Doors Closed and Locked Signal.
5.18.6	The minimum reopening distance shall be adjustable from 0.3 m to full width. The time between closing attempts shall be adjustable.	The minimum reopening distance shall be adjustable from **0.1 m** to full width. The time between closing attempts shall be adjustable.
6.4.3.3	All safety critical equipments shall be designed, manufactured and validated to Safety Integrity level 4 as defined in the CENELEC standard	All doors closed and locked **signal (ADCL) and Interlock Override signals and its associated hardware as a whole shall be designed and**

<table>
<tr><td></td><td>EN50126, EN50128, and EN 50129.The Contractor shall submit report that the safety of Door Control Unit meets SIL 3.</td><td><u>validated to Safety Integrity level 4</u> as defined in the CENELEC standard EN50126, EN50128, and EN 50129.The Contractor shall submit report that the safety of Door Control Unit <u>and open/close commands</u> meets SIL 3.</td></tr>
<tr><td>6.14.4
(3rd bullet)</td><td>The All doors close and locked lamp contact for ‘balance 3 car PSD’, which shall be proved in series with the 3-car PSD. Currently these future contacts shall be wired on kept in logically close condition by the existing PSD supplier.</td><td>The All doors close and locked lamp contact for ‘balance 3 car PSD’, which shall be proved in series with the 3-car PSD. Currently these future contacts shall be wired <u>and</u> kept in logically close condition by the existing PSD supplier.</td></tr>
<tr><td>6.15.3</td><td>The Gap filler shall have sufficient rigidity against vertical movement so that deflection under the weight of a passenger does not create additional trip hazard or permit a passenger’s foot to become trapped between the vehicle and barrier threshold. The floor surface at the barrier doorway threshold shall be of slip-resistant material as described and tested in accordance with EN 16584-3. The gap filler shall be able to withstand the impact of likely hits by the rolling stock for a train approaching the station stopping or running through the platform without damaging itself or the rolling stock surface.</td><td>The Gap filler shall have sufficient rigidity against vertical <u>load</u> so that deflection under the weight of a passenger does not create additional trip hazard or permit a passenger’s foot to become trapped between the vehicle and barrier threshold. The floor surface at the barrier doorway threshold shall be of slip-resistant material as described and tested in accordance with EN 16584-3. The gap filler shall be able to withstand the impact of likely hits by the rolling stock for a train approaching the station stopping or running through the platform without damaging itself or the rolling stock surface.</td></tr>
<tr><td>6.15.6</td><td>In exceptional cases, suitable entrapment detection system to be installed by the PSD Contractor, to achieve the above requirements; this system, where installed, apart from triggering a conspicuous alarm in the ATS workstation of Signalling system in OCC/BOCC and SCR, shall also prevent the departure of the train from the platform, if entrapment is detected. The detection system design shall incorporate features to minimize false activation/alarm.</td><td>In exceptional cases, suitable entrapment detection system to be installed by the PSD Contractor, to achieve the above requirements; this system, where installed, apart from triggering a conspicuous alarm in the ATS workstation of Signalling system <u>and PSD workstation</u> in OCC/BOCC and SCR, shall also prevent the departure of the train from the platform, if entrapment is detected. The detection system design shall incorporate features to minimize false activation/alarm.</td></tr>
<tr><td>7.1.1</td><td>The purpose of the Interface Specifications is to provide Other Contractor involved in the interface with a clear overview of the purpose and functionality of each interface. It provides a framework such that Other Contractor can set to work in a co-operative way to produce the interfacing standard. Details of the interfaces with the PSD System are found in the Interface Specifications in Appendix 2P</td><td>The purpose of the Interface Specifications is to provide Other Contractor involved in the interface with a clear overview of the purpose and functionality of each interface. It provides a framework such that Other Contractor can set to work in a co-operative way to produce the interfacing standard. Details of the interfaces with the PSD System are found in the Interface Specifications in Appendix2P. <u>Contractor wise interface Appendices are given in Appendix 2P as tabulated below;</u>
<table>
<tr><td colspan="3">APPENDIX 2P</td></tr>
<tr><td>1</td><td>Appendix 2P-1</td><td>Interface protocol between Rolling stock and Platform Screen Doors (PSD) System</td></tr>
<tr><td>2</td><td>Appendix 2P-2</td><td>Interface protocol between Signalling and Train Control</td></tr>
</table>
</td></tr>
</table>

		system (S&TC) and Platform Screen Doors (PSD) system
3	Appendix 2P-4A	Interface protocol between Civil (UG) and Platform Screen Doors (PSD) system (Full Height)
4	Appendix 2P-4B	Interface protocol between Civil (Elevated) and Platform Screen Doors (PSD) system (Half Height)
5	Appendix 2P-5	Interface protocol between Track and Platform Screen Doors (PSD) system
6	Appendix 2P-6A	Interface protocol between MEP(UG) and Platform Screen Doors (PSD) system (Full Height)
7	Appendix 2P-6B	Interface protocol between MEP (Elevated) and Platform Screen Doors (PSD) system (Half Height)
8	Appendix 2P-7	Interface protocol between VAC and Platform Screen Doors (PSD) system (Full Height)
9	Appendix 2P-78	Interface protocol between TVF and Platform Screen Doors (PSD) system (Full Height)

10.6.5.3

SN	Position/ Category	Total work experience (min number of years)	Experience in similar works (min number of years)
1	Project Manager	22	10
2	Engineering Manager	15	8
3	PSD Design Engineers	10	5
4	Interface Manager	15	8
5	Procurement Engineer	10	5
6	Installation Manager	15	8
7	Installation Engineers	10	5
8	Project Quality Manager	15	8

	Position/Category	Total work experience (min number of years)	Experience in similar works (min number of years)
1	Project Manager	22	**12**
1A	**Deputy Project Manager**	**18**	**10**
2	Engineering Manager	15	8
3	PSD Design Engineers	10	5
4	Interface Manager	15	8
5	Procurement Engineer	10	5
6	Installation Manager	15	8
7	Installation Engineers	10	5
8	Project Quality Manager	15	8

	<table><tr><td>9</td><td>Project Quality Engineers</td><td>10</td><td>5</td></tr><tr><td>10</td><td>OHSE Manager (Accident Prevention Officer)</td><td>15</td><td>8</td></tr><tr><td>11</td><td>OHSE Engineer</td><td>10</td><td>5</td></tr><tr><td>12</td><td>Testing and Commissioning Engineers</td><td>10</td><td>5</td></tr><tr><td>13</td><td>Testing and Commissioning Manager</td><td>15</td><td>8</td></tr><tr><td>14</td><td>DLP manager</td><td>15</td><td>8</td></tr><tr><td>15</td><td>DLP Engineers</td><td>10</td><td>5</td></tr></table>	<table><tr><td>9</td><td>Project Quality Engineers</td><td>10</td><td>5</td></tr><tr><td>10</td><td>OHSE Manager (Accident Prevention Officer)</td><td>15</td><td>8</td></tr><tr><td>11</td><td>OHSE Engineer</td><td>10</td><td>5</td></tr><tr><td>12</td><td>Testing and Commissioning Engineers</td><td>10</td><td>5</td></tr><tr><td>13</td><td>Testing and Commissioning Manager</td><td>15</td><td>8</td></tr><tr><td>14</td><td>DLP manager</td><td>15</td><td>8</td></tr><tr><td>15</td><td>DLP Engineers</td><td>10</td><td>5</td></tr></table>
10.6.7.1.1	All cables shall be installed as per the ducting plans, wherever such ducts are not provided the cables shall be laid & installed in accordance with the standards. Refer Appendix 2J & 2K of this PS.	All cables shall be installed as per the ducting plans, wherever such ducts are not provided the cables shall be laid & installed in accordance with the standards. ~~Refer Appendix 2J & 2K of this PS.~~
10.6.7.2.1	Cables shall be used in accordance with the requirements of Appendix 2K of this PS.	Cables shall be used in accordance with the requirements ~~of Appendix 2K~~ of this PS.
	The mock-up shall be shipped to Chennai in advance after the manufacturing along with the set of PSD used for prototype testing	The **additional set for** mock-up shall be shipped to Chennai in advance. **The set of PSD for prototype testing shall be shifted to the location where the it is to be tested.**
11.11	Equipment field Trial (complete clause)	**Not Used**
11.14.2	All failures and service interruptions shall be logged during the tests on completion and the MTBMA and MTBSAF etc. shall be calculated. The Contractor shall demonstrate that all performance requirements in Chapter 4 of the PS are met.	All failures and service interruptions shall be logged during the tests on completion and the **MCBF, MTBSAF etc.** shall be calculated. The Contractor shall demonstrate that all performance requirements in Chapter 4 of the PS are met.
13.3.5 (b)	Data logging, retrieval and preservation.	**Not Used**
13.3.6	Add New sub clause 13.3.6 (f)	**Add 13.3.6 (f) Data logging, retrieval and preservation.**
14.2.12.3	Disputes between the PSC Contractor and other Project Contractor shall be resolved by the FRB.	Disputes between the **PSD** Contractor and other Project Contractor shall be resolved by the FRB.
14.2.12.5	Upon identification of the failure cause, the contractor shall check for similar potential failures in other installation of the stage and rectify the issue in other locations before the reputation of the failure.	Upon identification of the failure cause, the contractor shall check for similar potential failures in other installation of the stage and rectify the issue in other locations before the **repetition** of the failure.
14.4.1.3	The scope of maintenance activities shall include all scheduled and unscheduled maintenance required including all routine inspections and service overhauls at trackside	The scope of maintenance activities shall include all scheduled and unscheduled maintenance required including all routine inspections and service overhauls **at trackside and in**

	on trains and in workshops/lab/repair center. Maintenance work shall include fault finding following report of incidents and repair of items of equipment changed out in the course of fault rectification and imparting on-job training and guidance for employer's maintenance personnel but excluding any Contractor's liability for work to be carried out under the requirements of the Defects Liability Period.	**workshops/lab/repair center**. Maintenance work shall include fault **identification** following report of incidents and repair of items of equipment changed out in the course of fault rectification and imparting on-job training and guidance for employer's maintenance personnel but excluding any Contractor's liability for work to be carried out under the requirements of the Defects Liability Period.
14.5.1.7	The PSD contractor must ensure that in case Operating System and/or the HW platform/Servers provided by them are compatible to the newer versions/platform of OS and HW. If not, they must make provisions to upgrade their existing SW applications	The PSD contractor must **ensure that Operating System** and/or the HW platform/Servers provided by them are compatible to the newer versions/platform of OS and HW.
14.7.1.1	The Contractor shall provide three kinds of manuals Operation, Maintenance & Training manuals, to the Employer for use by supervisory, Training and technical staff of the Operator. 12 Months prior to completion of Stage 1, the Contractor shall deliver to the Employer the Preliminary Operation and Maintenance manuals in 3 copies. The Final updated manuals shall be delivered to the Employer 06 months before the completion of Stage 1. These manuals shall have been submitted to and reviewed with no objection by the Engineer prior to delivery to the Employer. The number of copies shall be adequate to meet the requirements of copies for maintenance staff and for deployment in all technical rooms for various stages of the project. The exact number will be decided by the Engineer 08 months before the ROD of each stage.	The Contractor shall provide three kinds of manuals Operation, Maintenance & Training manuals, to the Employer for use by supervisory, Training and technical staff of the Operator. 12 Months prior to completion of Stage 1, the Contractor shall deliver to the Employer the Preliminary Operation and Maintenance manuals in 3 copies. The Final updated manuals shall be delivered to the Employer 06 months before the completion of Stage 1. These manuals shall have been submitted to and reviewed with no objection by the Engineer prior to delivery to the Employer. The number of copies shall be adequate to meet the requirements of copies for **operation and** maintenance staff and for deployment in all technical rooms for various stages of the project. The exact number will be decided by the Engineer 08 months before the ROD (**revenue operation date)** of each stage.
Appendices	Complete appendices replaced with new ones.	**The new appendices are attached herewith**

APPENDIX -2N

SCHEDULE OF DIMENSIONS

CMRL

Note: This is Draft document for information. This might undergo changes during the approval process.

CHENNAI METRO RAIL LIMITED

SCHEDULE OF DIMENSIONS
FOR
STANDARD GAUGE

(1435 mm)

CMRL PHASE 2 PROJECT

DOCUMENT VERIFICATION AND REVISION RECORD

PROJECT NAME		**Chennai Metro Rail Project Phase – 1**			
DOC/ NO.		**P2C0000PRW000-0GC1-ENGERT-00001-**		**DATE OF ISSUE**	**17-07-2021**
DOC/ TITLE		**Schedule of Dimensions for Standard Gauge (1435 mm)**			
REV. No.	**DATEOF ISSUE/REV.**	**DESCRIPTION**	**PREPARED / DESIGNED**	**CHECKED**	**APPROVED**
A1	25-04-2021	Phase 1 report submission for review			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

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

TABLE OF CONTENTS

DESCRIPTION **PAGE NO.**

CHAPTER- I GENERAL

1.1 SPACING OF TRACKS 3
1.2 CURVES 3
1.3 BUILDING AND STRUCTURES 4
1.4 KINEMATIC ENVELOPE 6
1.5 STRUCTURE GAUGE 6
1.6 EXTRA CLEARANCES ON CURVES 7
1.7 MINIMUM TRACK SPACING ON CURVES 9
1.8 SPECIAL OPERATING CONDITION 10
1.9 ADDITIONAL OPERATING CONDITION FOR ELEVATED & AT GRADE SECTION 11
1.10 WALKWAY CLAUSE DELETED 11
1.11 GRADIENT 11
1.12 PROVISIONS IN PLATFORM EDGE OTHER THAN PSD LOCATION 11

CHAPTER-2 STATION YARDS

2.1 SPACING OF TRACKS AT STATIONS 13
2.2 PLATFORMS 13
2.3 GRADIENTS 14
2.4 INTERLOCKING AND SIGNAL GEAR 14
2.5 POINTS & CROSSINGS 15
2.6 SUPER ELEVATION AND SPEED AT STATIONS ON CURVES WITH .....TURNOUTS OF CONTRARY AND SIMILAR FLEXURE. 15
2.7 ADDITIONAL CLEARANCE FOR PLATFORMS ON CURVES 16

CHAPTER 3 ROLLING STOCK

3.1 PASSENGER ELECTRIC MULTIPLE UNITS. 17
3.2 LOCOMOTIVES AND ENGINEERING SERVICE VEHICLES 18

CHAPTER 4 OVERHEAD ELECTRIC TRACTION-25 KV AC 50HZ

4.1 ELECTRICAL CLEARANCES FOR UNDER GROUND 19
4.2 ELECTRICAL CLEARANCES FOR AT GRADE AND ELEVATED SECTIONS 20

CHAPTER 5 PLATFORM SCREEN DOORS

5.1 FITMENT 22
5.2 SETTING OUT DIMENSION UNDERGROUND FULL HEIGHT PSD 22
5.3 SETTING OUT DIMENSION ELEVATED HALF HEIGHT PSD 22

APPENDIX NO.	DESCRIPTION	PAGE NO.
Appendix – 1	Permissible Speed, Cant and Minimum Track Spacing on Curves Underground (Tunnels), Elevated and At Grade section	23
Appendix – 2	Extra Horizontal Shift on Curves	24
Appendix – 3	Cant Effect on Structure Gauge – Horizontal At grade and Elevated Reference para 1.7.2	26
Appendix – 3 (TNL)	Cant Effect on Structure Gauge – Horizontal Underground sections (Rectangular Box Tunnel)	27
Appendix – 3A	Cant Effect on Kinematic Envelope – Horizontal At Grade and Elevated Sections	28
Appendix–3A (TNL)	Cant Effect on Kinematic Envelope Underground Sections (Rectangular Box Tunnel)	29
Appendix – 4	Lateral and Vertical Shift of Centre of Circular Tunnel for different Cant values	30
Appendix – 5	Additional clearance for platforms on Curves Underground, elevated and at Grade stations	31

LIST OF FIGURES

1	Figure No. CMSG–1	Kinematic Envelope (At grade and Elevated Sections)	32
2	Figure No. CMSG–1 (TNL)	Kinematic Envelope–Underground Sections (Tunnels, Through & Semi through Girder Bridges)	33
3	Figure No. CMSG–1A	Kinematic Envelope at 55kmph -At grade and Elevated Sections on Tangent track at Stations.	34
4	Figure No. CMSG–2	Structure Gauge – At Grade and Elevated Sections	35
5	Figure No. CMSG–2 (TNL)	Structure Gauge –Circular tunnel (5800mm Dia) Through & Semi through Girder Bridges, and Rectangular box tunnel on tangent track.	36
6	Figure No. CMSG–3	Shift of the Centre of circular tunnel due to rotation of Tunnel to provide cant	37
7	Figure No. CMSG–4	Effect of cant on structure Gauge	38
8	Figure No. CMSG–4A	Effect of cant on Kinematic envelope	39
9	Figure No. CMSG–5	Effect of vertical curve on structure gauge	40
10	Figure No. CMSG-6	Structural clearance at elevated / at grade station with side platforms	41
11	Figure No. CMSG-6 (TNL)	Structural clearance at underground station with side platforms	42
12	Figure No. CMSG-7	Structural clearance at elevated / at grade station with island platforms	43
13	Figure No. CMSG-7 TNL	Structural clearance at underground station with island platforms	44
14	Figure No. CMSG-8	Structural clearance Platform screen door for underground stations	45
15	Figure No. CMSG-9	Structural clearance Platform screen door for Elevated stations	46
16	Figure No. CMSG-10	Provision at platform edge for future developments	47

PREAMBLE

The Schedule of Dimensions for Chennai Metro Standard Gauge has been prepared based on following factors.

1. The Kinematic envelope and other infringements have been calculated for the 2900mm wide and 3900 mm high Rolling Stock, based on the Kinematic envelope calculations. The Track and Car maintenance shall confirm to the clearances indicated therein during the period these stocks are in operation.
2. The clearances are based on the assumption that windows are sealed, and doors are closed during movement/operation.
3. Track shall be maintained to the tolerance taken for calculation of Kinematic envelope.
4. The Structure Gauge indicated in the SOD shall not to be violated under any circumstances except Platform coping and Platform Screen Doors.
5. The Kinematic envelope indicated in the SOD shall not to be violated under any circumstances.
6. The Car Kinematic Envelope for 55 kmph shall be applied only within the confines of stations. At all other locations, the full 80 kmph shall be used for determining the Structure gauge and electrical clearances.
7. Maximum operating Speed at Platform shall be 55 kmph and Kinematic Envelope will not be infringed under any circumstances.
8. No workmen / equipment / structure are allowed between Car and structure gauge during operation of trains.
9. This SOD pertains to ballast less track only.

Kinematic Envelope is abbreviated as KE and Standard Gauge as SG in the document.

CHENNAI METRO RAIL LIMITED

SCHEDULE OF DIMENSIONS

STANDARD GAUGE (1435 MM GAUGE)

INTRODUCTION

The dimensions given in this document are to be observed in all new works on 1435 mm gauge (STANDARD GAUGE), unless prior sanction has been obtained from the Railway Board through the Commissioner of 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 which shall be with 25 kV AC Traction system and Over Head current collection.

The Schedule of Dimensions (SOD) has been divided into four chapters as under

Chapter-1	General
Chapter-2	Station Yards
Chapter-3	Rolling stock
Chapter 4	Electric Traction
Chapter 5	Platform Screen doors

CHAPTER 1 – GENERAL

1.1 SPACING OF TRACKS

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

a)	Under Ground Sections	3500 mm
b)	Elevated & At Grade Sections	3650 mm

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

1.2 CURVES

1.2.1 Horizontal curves

Minimum radius of curves (horizontal)

i)	On main running lines	
	a) Under Ground Sections	200 m (Minimum)
	b) Elevated and At-Grade Sections	120 m (Minimum) & 190m (Desirable)
ii)	Depot and other Lines	100 m (Minimum)
iii)	At passenger stations	1000m
iv)	Length of circular curve	15 m (Minimum) & 20m (Desirable)
v)	Type of Transition Curve	Clothoid
vi)	Length of Transition Curve	15 m (Minimum) 20 m (Desirable)

Note: For curves of radius less than 190 m, check rails to be provided.

1.2.2 Vertical curves

Minimum radius of curves (horizontal)

i)	Minimum radius of curves	1500m
ii)	Minimum length of curve	15 m (Minimum) & 20m (Desirable)
iii)	Type of Curve	Circular
iv)	Minimum distance between two curves	15m

1.2.3 CANT

i)	Maximum cant	110m
ii)	CANT deficiency (Max)	85 mm
iii)	CANT Gradient	1 in 440 (Minimum) 1 in 720 (Desirable)
iv)	Rate of change of CANT	44mm/s (Minimum) 35 mm/s (Desirable)
v)	Rate of change of CANT deficiency	44mm/s (Minimum) 35 mm/s (Desirable)

1.2.4 Tangent lines

i) Minimum length of tangent

length between reverse curves 15 m (Minimum) or Zero m

1.2.5 On Elevated Viaduct & Tunnel suitable derailment up stands will be provided to prevent possibility of capsizement of derailed vehicles.

Lateral clearance between running Rail and Derailment up stand: 250 +/- 40mm. Derailment Guard shall be provided on Inside / Outside of running rail in Viaduct. It shall be Inside in Underground / Tunnel section as it permits less sway of coach towards tunnel wall in case of derailment.

Lateral clearance between the running rail and the derailment guard shall be 250 ± 40 mm. It shall not be lower than 25mm below the top of running rail and shall be clear of the rail fastenings to permit installation, replacement, and maintenance.

1.2.6 Check rail / Restraining Rail It shall be provided on curves on main line where radius is 190m or less. It shall not be mandatory for curves in depots, yards and non-passenger lines, where speed is less than 25 kmph. The clearance between check rail / restraining rail to running rail shall be suitably decided by CMRL.

1.3 BUILDINGS AND STRUCTURES

1.3.1 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 No	Height from rail level	Horizontal distance from C.L. of track
i)	Rail Level to 65mm	Upto 1465 mm
ii)	65mm to 200mm	1465mm increasing to 1585mm
iii)	200 mm to 305 mm	1585mm
iv)	305 mm to 940 mm	1585mm increasing to 1670 mm
v)	940 mm to 1095 mm	1670mm 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	1250mm
ix)	4775 mm to 4920 mm	1250 mm decreasing to zero along an arc of circle of radius of 2900 mm

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

ii) **Rectangular Box Tunnels**

S No	Height from rail level	Horizontal distance from C.L. of track
i)	Rail Level to 65mm	Upto 1465 mm
ii)	65 mm to 200 mm	1465mm increasing to 1585mm
iii)	200 mmm to 305mm	1585mm
iv)	305 mmm to 940 mm	1585mm increasing to 1670 mm
v)	940 mmm to 1095 mm	1670mm increasing to 1675 mm
vi)	1095 mm to 3305 mm	1675 mm increasing to 1740 mm
vii)	3305 mm to 3965 mm	1740mm 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 No	Height from rail level	Horizontal distance from C.L. of track
i)	Rail Level to 65 mm	Upto 1465 mm
ii)	65 mm to 200 mm	1465 mm increasing to 1640mm
iii)	200 mm to 305 mm	1640mm
iv)	305 mm to 930 mm	1640mm increasing too 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 1546mm
viii	3775 mm to 6250mm	1546mm

Also refer to Drawing No.CMSG-2

Notes for (a) and (b) above:

i) Extra clearance shall be provided for curves as laid down at para 1.6.

ii) The term 'structure' covers any item including light ones like ladders, isolated posts, cables etc. erected alongside the track.

iii) Minimum lateral clearance for OHE masts for tangent track shall be 2150 mm from Centre of the nearest track.

1.4 KINEMATIC ENVELOPE

The Kinematic Envelope for level or constant grade tangent track, refer to:

a) Drawing No. CMS G-1 for At-Grade Track and Elevated Sections.
b) Drawing No. CMS G-1(TNL) for Tunnels, Through & Semi through Girder Bridges.
c) Drawing No CMSG-1A For Kinematic Envelope at 55 KMPH speed on Level or Constant Grade Tangent Track at Station Area.

1.5 STRUCTURE GAUGE

1.5.1 Under Ground Sections

The Structure Gauge (Fixed Structure Line) has been arrived at by allowing a minimum mechanical clearance of 100 mm to the derived Kinematic Envelope and minimum electrical clearance of 270 mm from 25 KV live parts conforming to the stipulations in Chapter- 4 of this SOD.

Refer to Drawing No. CMSG-2(TNL) Rev 4 for Structure Gauge for Tunnels, Through & Semi through Girder Bridges for level or constant grade tangent track.

Note: Extra allowance shall be provided for curves as laid down at para 1.6.

1.5.2 Elevated Sections

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

For Structure Gauge on Elevated Sections for level or constant grade tangent track, refer to Drawing No. CMSG-2

Note: Extra allowance shall be provided for curves as laid down at para 1.6

1.5.3 At-Grade Sections

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

For Structure Gauge on At-Grade Sections (outside stations)

for level or constant grade tangent track, refer to Figure No. CMSG-2.

Note: Extra allowance shall be provided for curves as laid down at para 1.6

1.6 EXTRA CLEARANCES ON CURVES

Abbreviations used in para 1.6:

C is the distance between centres of bogies in metres.

C_1 is the coach (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

1.6.1 Inside of curve

(A) Curvature effect

i) Mid throw at the center of the car = V (in mm) = $125xC^2/R$

ii) Allowance due to gauge widening on curves

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

Note:

Lateral shift of 26 mm 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 1.6.1(A)-i &ii above for inside of a curve in case the value of mid throw (V) is equal to or greater than 26 mm. In case the value of mid throw (V) is less than 26 mm, the curvature effect shall be due to widening of the gauge only. (The Mid throw minus 26 mm 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 x h/g (all in mm)

For values of Structure Gauge (E_1) for inside of a curve with cant effect only, as shown in Figure No. CMSG-4, refer to:

i) Appendix -3(TNL) for Box structures of 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 midpoint of top of inner rail resulting in shift of Tunnel centre laterally towards inside of curve and also vertically upwards.

The Rigid OCS 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 Figure No.CMSG-3

(C) Allowance for vertical curve (vertical throw)

Vertical Throw V_1 and V_2 (in mm) for vertical curve shall be calculated as under:

V_1 (with car centre in sag or car end on summit) = $125xC^2/R$

V_2 (with car centre on summit or car end in sag)

= $(125xC_1^2/R)-(125xC^2/R)$

Values of vertical throw due to vertical curves of different radii are given in Figure-CMSG-5

1.6.2 Outside of Curve

A) Curvature effect

i) End throw at the end of vehicle = V_O (in mm)

= $[125xC_1^2/R]-[125xC^2/R]$

ii) Allowance due to gauge widening on curves

iii) Additional nosing due to gauge widening on curves

The values of items (i) to (iii) are shown in Appendix-2

B) Allowance for Superelevation

a) Elevated, At-Grade and box Sections of under ground

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

L = (-) Ca x h/g (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 50 mm and shall be limited to a value =(Ca - 50) x h/g.

Values of Structure Gauge (F_1) on outside of curve with cant effect only (as shown in Figure NoCMSG-4), refer to:

i) Appendix 3(TNL) for Under Ground Sections (Rectangular Box)

ii) 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 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 Figure No. CMSG-3

c) Allowance for vertical curve (vertical throw)

The provisions at para 1.6.1 (C) above shall be applicable in this case also.

1.7 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 the centre of a similar carriage on the outer track.

1.7.1 Without any structure between tracks

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

i) (E + F),

ii) T_1 (Extra lateral allowance due to curvature on inside of curve)

iii) T_2 (Extra lateral allowance due to curvature on outside of curve)

iv) Minimum clearance between adjacent Kinematic Envelopes stipulated is as under:

a) 200 mm for Under-Ground Sections

b) 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 (Figure 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 (Figure No.CMSG-4A).

Notes:

i) The value of 'F', calculated from the formula at Figure 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 value of E,F,T_1 and T_2 Refer Appendix 2,3A,3A (TNL) and drawing No CMSG -4A..

1.7.2 With a structure between adjacent tracks

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

i) (**E_1** + **T_1**) Minimum clearance to the structure from centre line of track on inside of curve (for outer track)

ii) (**F_1** + **T_2**) Minimum clearance to the structure from centre line of track on outside of curve (for inner track)

iii) 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,

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,

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

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

Notes:

a) The values of 'E_1' and 'F_1' for a given cant Ca, 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. (Ca-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.

b) Minimum track spacing, so worked out with a structure between the adjacent tracks shall not be less than that calculated as per para 1.7.1 for tracks without any structure between adjacent tracks.

For values of E_1,F_1,T_1 and T_2, refer to the Appendix 2,3 & 3 (TNL) and Drawing No. CMSG-4

1.8 SPECIAL OPERATING CONDITIONS: (COMMON FOR UNDERGROUND AS WELL AS ELEVATED AND AT GRADE)

1.8.1. Schedule maintenance of permanent way will be performed outside service hours only.

1.8.2. In view of chance of collision of derailed train with the train coming from other direction, adequate measures shall be taken to restrict lateral movement of derailed vehicles. Proper communication facilities should also be available at the stations.

1.8.3. All the coaches will be provided with sealed windows, to prevent limbs and heads of passengers projecting outside the train. The passengers vehicles will be provided with automatic remote controlled double leaf doors with their control from drivers cab. Until all doors are proved closed, it will not be possible to start the train. Likewise until the train has come to the stop, it will not be possible to energize the door opening circuits.

1.8.4. Since minimum clearance with fully worn wheel and under fully loaded condition from rail level for bogie mounted equipment is 75mm, the vehicles with this minimum clearance only will run on Chennai Metro Rail network.

1.8.5. In the event of trains running through stations without stopping, the train speed shall be limited to 55 km/h

1.8.6. Patrolling of the section to be done during extreme winter and summer to monitor effect of Climate, Temperature variation on Track during outside service hours/ non-operation hours.

1.8.7. The corridor when fully functional will not have way side signalling as train protection will be by ATP. However, in the initial period, till cab signalling system is fully commissioned, there will be way side signalling which should be so located near the masts that proper visibility to the motorman is ensured considering the alignment.

1.8.8. No movement shall be made with springs in deflated conditions except for the emergency movement to Depot at suitable speed to be decided after necessary oscillation trials.

1.8.9. Provision of space shall be provided for the railway authority to access the train car from backside to frontside or vice versa during emergency when train stops midway between stations.

1.9 ADDITIONAL OPERATING CONDITION FOR ELEVATED AND AT GRADE SECTION

1.9.1 In case of elevated corridor, the track is expected to be on the surface and passing through populated areas and there are chances of people passing through the track. Considering this fact, to prevent the access to the track by sections will be robustly fenced.

1.9.2 The speed of train at platforms on elevated or At Grade sections shall be restricted to 40kM/h (Instead of 55kM/h) when the wind speed is more than 70kM/h, but less than 90kM/h. When the wind speed exceeds 90kM/h trains will be brought to a halt at platform until the wind speed is again consistently below 90kM.h, CMRL shall ensure observance of stipulation laid down above in the operation procedure.

1.10 Walkway - Deleted

1.11 GRADIENT

1.11.1 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.

1.11.2 Maximum permissible gradient on turnouts on Ballastless track 2.5%

Note:

(i) There shall be no change of grade on and within 15m of any turnout on ballastless track.

(ii) In case of turnouts on gradient, there shall be no horizontal curve on and within 15m of any turnout on ballastless track.

1.12 PROVISIONS IN PLATFORM EDGE OTHER THAN PSD LOCATION

1.12.1 PSD shall be provided at platform edge for the purpose of passenger safety. it shall be provided only in the train operation location of 3 car platform edge. All other platform edge location shall be protected by means of the following.

a) Half height fixed aluminium panel or Glass fixed to stainless steel balusters or perforated panel fixed to stainless steel balusters shall be for the elevated station refer drawing CMSG-09.

b) 2hrs fire rated full height block work shall be provided for the underground station refer drawing CMSG-10.

CHAPTER 2 - STATION YARDS

2.1 SPACING OF TRACKS AT STATIONS

Minimum spacing of tracks at station on straight and on curve of radius of 1000 M and flatter, without any structure between tracks:

At-Grade, Elevated and Under-Ground Stations 3900 mm

2.2 PLATFORMS IN STRAIGHT ALIGNMENT

2.2.1 Maximum horizontal distance from centre of track to

HH PSD threshold for elevated/At grade section	1520
PSD threshold for Underground section	1515

2.2.2 Minimum horizontal distance from centre of track to

HH PSD threshold for elevated/At grade section	1515
PSD threshold for Underground section	1510

Notes:

a) Platform faces shall be flared away smoothly from the centre line of the track at either end for a distance of 1500 mm so as to give from centre of track a dimension:

- 1575 ± 5 for Under Ground Stations
- 1590 ± 5 for At-Grade and Elevated Stations

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

c) For Platforms provided with Platform screen doors in UG & Elevated stations, flaring of platform faces is not required.

2.2.3 Height above rail level for passenger platform:

Maximum	Minimum
1095 mm	1085 mm

2.2.4 Structure Clearance on Platform:

(i)	Minimum horizontal distance of any isolated structure on a passenger platform from the edge of coping if Platform screen door is not provided.	2500mm
(ii)	Minimum horizontal distance of any continuous structure on a passenger platform from the edge of coping, if platform screen door is not provided.	3000mm
(iii)	Minimum horizontal distance of any isolated structure on a passenger platform from the edge of coping, if Platform Screen Door is provided	2000mm
(iv)	Minimum horizontal distance of any continuous structure on a passenger platform from the edge of coping, if Platform Screen Door is provided	2450mm

Notes:

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.

2.2.5 For Structure Gauge at stations, refer to following figures

a) For Under Ground Station — Figure No.CMSG-6(TNL) & 7 (TNL)

b) For At-Grade and Elevated Stations — Figure No.CMSG-6 & 7

2.2.6 For Kinematic Envelope at Station, refer to Drawing –CMSG-1 A (Ref para 1.4.c Chapter-1)

2.2.7 In the event of Train Running-through stations without stopping, the train speed shall be limited to 55 kmph (Ref para 1.8.5 Chapter-1)

2.3 GRADIENTS

2.3.1 Station Yards

Gradient in station yards, unless special safety devices are adopted and / or special rules enforced to prevent accidents in accordance with approved special instructions shall be as under:

a) Maximum gradient — 1 in 400
b) Desirable — Level

Note:

There shall be no change of gradient in platform track.

2.4 INTERLOCKING AND SIGNAL GEAR

Maximum height above rail level of 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 — 25mm
- 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 At Grade and Elevated Stations

- From C.L. of track to 1330 mm — 25mm
- From 1330 mm to 1465 mm — 25 mm increasing to 65 mm
- From 1465 mm to 1640 mm — 65 mm increasing 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 signaling 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 & CROSSINGS

i) Maximum clearance of check rail opposite nose of crossing — 42mm
ii) Minimum clearance of check rail opposite nose of crossings — 37 mm
iii) Minimum clearance of wing rail at nose of crossings — 41 mm
iv) Minimum clearance between toe of open switch and stock rail. — 160 mm
v) Minimum radius of curvature for slip points, turnouts of crossover roads.
   a) For passenger running lines — 190 m
   b) For Depot lines and other than passenger running lines — 100 m
vi) Minimum angle of crossing (ordinary) — 1 in 9 (Desirable)

1 in 7 (Minimum)

vii) 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 superelevation (of outer over inner rail) between points 18 m 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

2.6 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 85 mm without reducing speed on the main fine.

2.6.2 Turnouts:

i) Curves of contrary flexure

The equilibrium superelevation (s) in mm should be = $(1510/127)(V^2 / R)$; Where, R = radius of turnout in metres and V is speed on turnout in kmph.

The permissible negative superelevation on the turnout (which is also the actual superelevation of the main line) may then be = (85 - s) mm

ii) Curves of Similar flexure

The question of reduction or otherwise of superelevation 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 superelevation may be run out at the maximum of 1 mm in 440 mm

2.7 ADDITIONAL CLEARANCE FOR PLATFORMS ON CURVES

The additional clearance for platforms on curves is shown at Appendix-5

2.7.1 Detail of Stations in Curve

Platforms located in curves shall be fitted with a Gap Filler wherever necessary to maintain the minimum stepping distance of 75 mm without contacting the train in normal condition. The Gap Filler shall be of elastic nature and flexible to allow train contact.

Notes:

There will be no Gauge widening and Super elevation in Platform/Station area.

CHAPTER 3-ROLLING STOCK

3.1 PASSENGER ELECTRIC MULTIPLE UNITS.

1.	a) Maximum length of car body (Length over body)	21638 mm
	b) The length of car body may be increased to (without exceeding the KE given in this SOD)	21840mm
	c) The maximum width of the car body	2900 mm
	d) Height of car body (Excluding Pantograph)	3900mm
2	Minimum pantograph locked down height from Rail level.	4048mm
3.	Distance between bogie centres	14850 ± 250 mm
4.	Kinematic Envelope for level tangent track	
	(i) For Underground Sections	Figure No CMSG-1 (TNL)
	(ii) For At-Grade and *Elevated* Sections	Figure No.CMSG-1
	(iii) For all Stations with normal secondary suspension at 55km/h	Figure No.CMSG-1A
5.	Minimum clearance from rail level with fully worn wheel defected air spacing and under fully loaded condition for bogie mounted equipment	75mm
6	The Minimum clearance from rail level in worst conditions such as fully worn wheel, deflated air spring and under fully loaded condition etc for body mounted equipment.	100mm
7	Wheel	
	a) Maximum wheel gauge back-to-back distance	1360mm
	b) Minimum wheel gauge back-to-back distance	1358 mm
8	a) Maximum diameter on the tread measured at 70 mm from the wheel gauge face	860mm
	b) Minimum diameter on the tread measured at 70·mm from the wheel gauge face	780mm
9	a) Minimum projection for flange of new wheel measured from tread at 70 mm from the wheel gauge face	28 mm*
	b) Maximum projection for flange of worn wheel measured from tread at 70 mm from the wheel gauge face	36mm*
10	a) Maximum thickness of flange of wheel. measured from wheel gauge face at 18 mm from outer edge of flange	32.5 mm*

	b) Minimum thickness of flange of wheel measured from wheel gauge face at 18 mm from outer edge of flange	22mm*
11	Minimum width of wheel	134mm*
12	Incline of tread	1 in 20
13	Floor Height	
	a) Maximum height above rail level for floor of any unloaded Car	1120 mm
	b) Minimum height above rail level for floor of any fully loaded car	1087 mm
14	a) Maximum height of centre coupler above rail level for unloaded car	815mm
	b) Minimum height of centre coupler above rail level for fully loaded car	740mm
15	Maximum length over couplers	22600mm
16	Maximum length of rigid wheelbase for single bogie	2600 mm

3.2 LOCOMOTIVES 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 (Standard Gauge) will conform with the Kinematic Envelope of the Passenger Electric Multiple Units as shown in Figure No CMSG-1(TNL) for Under Ground sections and Figure No. CMSG 1 for Elevated and At-Grade sections.

CHAPTER 4 - OVERHEAD ELECTRIC TRACTION 25 KV/AC 50 CYCLES PER SECOND

Note: Wherever electric traction is in use, special precautions must be taken to maintain following clearances

4.1. ELECTRICAL CLEARANCES FOR UNDER GROUND

4.1.1 Minimum height form rail level to the underside of Wearing Copper / Metal Conductor of Rigid OCS (Overhead Contact system) in Tunnel 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 1.6.1(B)-b and 1.6.2 (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.

4.1.2 Stagger of Rigid OCS Conductor in Tunnels shall not be more than

a) On Straight ± 200mm

b) On Curves ± 300mm

4.1.3 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 structures
a)	Long duration (Static)	270mm	–
b)	Short Duration (Dynamic)	170mm	150 mm*

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

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

Minimum Air clearance between bodies of vehicles and the live un-insulated parts of the contact line or feeders for 25 KV

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

4.1.5 Maximum width of pantograph - Under dynamic condition.

The Kinematic Envelope for the underground system with Ballastless track is shown in Figure 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 clearance as per item 4.1.3

Note:

These limits would not apply to special locations like insulated overlaps and out of run wires.

4.2. ELECTRICAL CLEARANCES FOR AT–GRADE AND LEVATED SECTIONS

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

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

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 20mm, the vertical distance between rolling stock and contact wire shall correspondingly be increased.

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

	Condition	For Flexible OHE
i)	Long duration (Static)	320mm
ii)	Short Duration (Dynamic)	220mm

4.2.3 Height of contact wire:

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

i) Under bridges and in tunnels 4800mm
ii) In the open 5000mm
iii) At level crossings 5500mm
iv) In running and carriage sheds wherever staff are expected to work on the roof of rolling stock 5200mm

Maximum height from rail level to the underside of live Conductor wire (corresponding to the maximum height of the train pantograph collecting range)

In any location 5800+/-30mm

Note:

a) For the movement of over- dimensional consignments if any, the height specified under 4.2.3 (i) above, shall be increased by the difference between the height of the consignment contemplated and 4.41 metres. In case such an over-dimensional consignment is moved at speeds not exceeding 15 kmph and is also specially escorted by authorized CMRL staff, the derived height of contact wire may be reduced by 50 mm.

b) 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	200mm
ii)	On Curves	300mm

Note.

These limits would not apply to special locations like insulated overlaps and out of run wires.

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 Figure No. CMSG-1 & CMSG -2

CHAPTER 5 - PLATFORM SCREEN DOORS

5.1. FITMENT

All underground stations shall be equipped with full height platform screen doors & all the elevated stations shall be equipped with half height PSD and the opening is linked to door operation on the rolling stock.

5.2. SETTING OUT DIMENSIONS- UNDERGROUND FULL HEIGHT PSD

Minimum Platform screen door width	2000 mm*
Minimum Platform screen door height	2150 mm
Minimum Platform screen door threshold offset from track centreline – straight track	1510 mm (see para 2.2.2)
Minimum Platform screen door panel offset from track centre line – straight track	1557 mm
Minimum Platform screen door header offset from track centre line – straight track	1519 mm
Minimum Station platform height –finished architectural level	1090 mm

5.3. SETTING OUT DIMENSIONS- ELEVATED STATION- HALF HEIGHT PSD

Minimum Platform screen door width	2000 mm *
Minimum platform door height	1500 mm
Minimum Platform screen door threshold offset from track centre line- Straight track	1520 mm
Minimum Platform screen door panel offset from track centre line- Straight track	1550 mm
Minimum Platform screen door equipment assembly box offset from track centre line- Straight track	1520 mm
Minimum Station platform height -finished architectural level	1090 mm

Notes

- Assumed stopping accuracy of +/ - 300 mm
- The offset in curve applies to the point of the MSO (Motorized Screen Door) + EED (Emergency Egress Door) set (which is straight) which is nearest to the track centreline.
- The leaning due to cant deficiency in station (no cant) at 55 kmph (outside curve effect) is already included in the KE.
- The deflector attached to the bottom of the sliding door shall be designed in order not to protrude beyond the door threshold.
- Platforms located in curves shall be fitted with gap filler as specified in para.2.7.1 .
- For Curved Platform, additional curve allowance as per Appendix-5 to be considered.

APPENDIX-1

PERMISSIBLE SPEED, CANT AND MINIMUM TRACK SPACING ON CURVES UNDER GROUND (TUNNELS), ELEVATED AND AT-GRADE SECTION

(REFERENCE: PARA 1.1)

RADIUS OF CURVE	CANT	MAXIMUM PERMISSIBLE SPEED	MINIMUM DISTANCE BETWEEN ADJACENT TRACKS See note (a)	
			UNDER GROUND	ELEVATED AND AT-GRADE
metre	mm	Km/h	mm	mm
>3000	-	80	3500	3650
3000	15	80	3500	3670
2800	15	80	3500	3670
2400	20	80	3500	3670
2000	20	80	3500	3670
1600	25	80	3500	3680
1500	30	80	3510	3680
1200	35	80	3510	3680
1000	45	80	3550	3700
800	55	80	3550	3710
600	70	80	3570	3750
500	85	80	3600	3760
450	95	80	3610	3800
400	105	80	3650	3800
350	110	75	3650	3820
300	110	70	3700	3850
200	110	55	3800	3950
150	110	50	4000	4050
150*	0	30	4000	4050
120	110	45	4000	4160
120*	0	30	4000	4160

Notes:

(a) 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.

(b) Track spacing shown in Table above is not applicable to station which should be calculated depending on specific requirement.

(c) Cant provided is limited to desirable value of 110 mm

(d) Maximum cant deficiency is 85 mm

(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-2

EXTRA HORIZONTAL SHIFT ON CURVES (CURVATURE EFFECT)
INSIDE OF CURVE

REFERENCE : PARA 1.6.1

RADIUS (metres)	MID-THROW (28500/R) (mm)	NOSING INCLUDED IN K E/ STRUCTURE GAUGE FOR TANGENT TRACK (mm)	EXTRA GAUGE TOLERANCE ON CURVES (mm)	EXTRA HORIZONTAL SHIFT ON CURVE (mm)	REMARKS
R	(V)	(N)	(G)	(T_1)	
120	237.5	26.0	9.0	221	
150	190.0	26.0	9.0	173	
175	162.9	26.0	9.0	146	
200	142.5	26.0	9.0	126	(G) EXTRA GAUGE TOLERANCE ON CURVES SHARPER THAN 1000 M RADIUS: 9 mm FOR CURVES WITH RADIUS SHARPER THAN 500 M AND 5mm FOR CURVES WITH RADIUS OF 500 M TO LESS THAN 1000M. T_1=V-N+G for V EQUAL TO OR GREATER THAN (N) AND T1 = G for V < (N)
250	114.0	26.0	9.0	97	
300	95.0	26.0	9.0	78	
350	81.4	26.0	9.0	64	
400	71.3	26.0	9.0	54	
450	63.3	26.0	9.0	46	
500	57.0	26.0	5.0	36	
600	47.5	26.0	5.0	27	
700	40.7	26.0	5.0	20	
800	35.6	26.0	5.0	15	
900	31.7	26.0	5.0	11	
1000	28.5	26.0	0.0	3	
1200	23.8	26.0	0.0	0	
1500	19.0	26.0	0.0	0	
1600	17.8	26.0	0.0	0	
2000	14.3	26.0	0.0	0	
2400	11.9	26.0	0.0	0	
2800	10.2	26.0	0.0	0	
3000	9.5	26.0	0.0	0	
>3000	9.5	26.0	0.0	0	

Mid throw (in mm) V = (125 x C^2) /R = 28500/R

Where 'C' is the distance between bogies centers = 14.850+0.250=15.100m OR 14.850 - 0.250=14.600 m.

The worst case will be with C=15.100 m

R is the radius of curve in metres.

Mid throw (in mm) V = (125 x C^2) / R = 28500/R

For in between radius more sharper radius to be adopted

APPENDIX-2

EXTRA HORIZONTAL SHIFT ON CURVES (CURVATURE EFFECT)

OUTSIDE OF CURVE

REFERENCE : PARA 1.6.2

RADIUS (metres)	END-THROW (33525/R) (mm)	EXTRA GAUGE TOLERANCE ON CURVES (mm)	EXTRA NOSING DUE TO EXTRA GAUGE TOLERANCE (mm)	EXTRA HORIZONTAL SHIFT ON CURVE (mm)	REMARKS
R	(Vo)	(G)	(EN)	(T_2)	
120	279.4	9.0	2.3	291	
150	223.5	9.0	2.3	235	
175	191.6	9.0	2.3	203	
200	167.6	9.0	2.3	179	(G) EXTRA GAUGE TOLERANCE ON CURVES SHARPER THAN 1000 M RADIUS: 9 mm FOR CURVES WITH RADIUS SHARPER THAN 500 M AND 5mm FOR CURVES WITH RADIUS OF 500 M TO LESS THAN 1000M. T_2 = Vo + G + EN EN=Gx0.251986301
250	134.1	9.0	2.3	145	
300	111.8	9.0	2.3	123	
350	95.8	9.0	2.3	107	
400	83.8	9.0	2.3	95	
450	74.5	9.0	2.3	86	
500	67.1	5.0	1.3	73	
600	55.9	5.0	1.3	62	
700	47.9	5.0	1.3	54	
800	41.9	5.0	1.3	48	
900	37.3	5.0	1.3	44	
1000	33.5	0.0	0.0	34	
1200	27.9	0.0	0.0	28	
1500	22.4	0.0	0.0	22	
1600	21.0	0.0	0.0	21	
2000	16.8	0.0	0.0	17	
2400	14.0	0.0	0.0	14	
2800	12.0	0.0	0.0	12	
3000	11.2	0.0	0.0	11	
>3000	11.2	0.0	0.0	0	

End throw (in mm) Vo = $(125 \times C_1^2) /R - (125 \times C^2)/R = 33525/R$

Where 'C' is the distance between bogie centers = 14.850+0.250=15.100m OR 14.850-0.250=14.600 m.

The worst case will be with C=14.600

'C_1' is length of coach in meters = 21.940 m and 'R' is radius of curve in meters.

For in between radius more sharper radius to be adopted.

APPENDIX-3

CANT EFFECT ON STRUCTURE GAUGE-HORIZONTAL AT-GRADE AND ELEVATED

REFERENCE: PARA 1.7.2

REFERENCE: PARA 1.7.2
ALL FIQURES ARE IN MM

Height above rail level measured perpendicular to plane of track →					h = 305				h = 930				h = 3310				h = 3775				h= 6250			
Distance from centre line of track to Structure Gauge for tangent track →					ab= 1640				ab = 1735				ab = 1825				ab=1546				ab = 1546			
Cant	Angle α Degrees	Sin α	cos α	tan α	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
110	4.178	0.073	0.997	0.07	1658	1613	479	240	1798	1663	1109	856	2061	1579	3489	3223	1817	1267	3933	3707	1997	1087	6401	6176
105	3.987	0.07	0.998	0.07	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	0.07	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	0.06	1656	1618	455	249	1790	1673	1085	867	2030	1613	3466	3236	1780	1305	3912	3718	1936	1150	6382	6188
90	3.417	0.06	0.998	0.06	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	0.06	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	0.05	1654	1622	431	258	1782	1683	1061	877	1998	1647	3442	3249	1744	1344	3892	3728	1875	1213	6363	6199
75	2.847	0.05	0.999	0.05	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	0.05	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	0.04	1652	1625	408	267	1773	1693	1036	887	1966	1681	3418	3261	1707	1382	3871	3737	1814	1276	6343	6210
60	2.277	0.04	0.999	0.04	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	0.04	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	0.03	1649	1629	384	276	1765	1703	1012	897	1934	1714	3394	3273	1670	1420	3849	3747	1752	1338	6323	6220
45	1.708	0.03	1	0.03	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	0.03	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	0.02	1647	1632	360	284	1756	1713	987	907	1901	1748	3369	3284	1633	1458	3827	3756	1690	1401	6302	6230
30	1.138	0.02	1	0.02	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	0.02	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	0.01	1644	1636	337	293	1747	1723	963	917	1869	1781	3344	3296	1596	1496	3805	3764	1629	1463	6280	6239
15	0.569	0.01	1	0.01	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	0.01	1642	1638	321	299	1741	1729	946	923	1847	1803	3327	3303	1571	1521	3790	3770	1587	1505	6265	6245
5	0.19	0.003	1	0	1641	1639	313	302	1738	1732	938	927	1836	1814	3319	3306	1558	1533	3783	3772	1567	1525	6258	6247
0	0	0	1	0	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 x tan α)] x cos α

F_1=[ab-(h x tan α)] x cos α

H_1 = (Ca/2) + (h/cos α)+(Ab-h x tan α)x sin α

H_2 = (Ca/2) + (h/cos α)-(ab+h x tan α) x sin α

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

ac = Distance from center line of canted track to Structure Gauge 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 - 3 (TNL)

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

REFERENCE: PARA 1.7.2

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 α Degrees	Sin α	cos α	tan α	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
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	0.07	0.998	0.0697	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	0.0664	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	0.06	0.998	0.0597	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	0.0564	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	0.0531	1599	1567	429	261	1717	1618	1067	890	1913	1562	3433	3248	1458	1038	4066	3933	1505	992	4937	4805
75	2.847	0.05	0.999	0.0497	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	0.0464	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	0.0431	1597	1570	405	269	1709	1628	1044	900	1881	1596	3409	3260	1420	1078	4048	3940	1457	1041	4920	4812
60	2.277	0.04	0.999	0.0398	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	0.0364	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	0.0331	1594	1574	382	277	1700	1638	1020	909	1848	1630	3386	3271	1381	1118	4029	3946	1410	1089	4902	4819
45	1.708	0.03	1.000	0.0298	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	0.0265	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	0.0232	1592	1578	359	286	1691	1648	996	919	1816	1663	3362	3281	1342	1158	4010	3952	1362	1138	4883	4825
30	1.138	0.02	1.000	0.0199	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	0.0166	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	0.0132	1589	1581	336	294	1682	1657	972	928	1784	1696	3338	3292	1302	1197	3991	3958	1314	1186	4864	4831
15	0.569	0.01	1.000	0.0099	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	0.0066	1587	1583	320	299	1676	1664	956	934	1762	1718	3321	3298	1276	1224	3978	3962	1282	1218	4851	4835
5	0.19	0.003	1.000	0.0033	1586	1584	313	302	1673	1667	948	937	1751	1729	3313	3302	1263	1237	3972	3963	1266	1234	4845	4836
0	0	0	1.000	0	1585	1585	305	305	1670	1670	940	940	1740	1740	3305	3305	1250	1250	3965	3965	1250	1250	4838	4838

REFER TO FIGURE: CMSG-4

E_1 = [ab+(h x tan α)] x cos α

F_1 = [ab-(h x tan α)] x cos α

H_1 = (Ca/2)+(h/cos α)+(Ab-h x tan α)x sin α & H_2 = (Ca/2)+(h/cos α)-(ab+h x tan α) x sin α

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

ac=Distance from center line of canted track to Structure Gauge 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 - 3A

CANT EFFECT ONN 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 α Degrees	Sin α	cos α	tan α	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
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	0.07	0.998	0.07	1643	1513	1098	878	1649	1511	1157	937	1665	1508	1290	1069	1854	1454	3039	2808	1883	1426	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	0.06	0.998	0.06	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	1628	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	0.05	0.999	0.05	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	0.04	0.999	0.04	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	1812	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	0.03	1.000	0.03	1809	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	1806	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	1803	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	0.02	1.000	0.02	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	6015
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	0.01	1.000	0.01	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	0.19	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	0	1.000	0	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-4

E = [ab+(h x tan α)] x cos α

F = [ab-(h x tan α)] x cos α

H_1 = (Ca/2)+(h/cos α)+(Ab-h x tan α)x sin α

H_2 = (Ca/2)+(h/cos α)-(ab+h x tan α) x sin α

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

ac = Distance from center 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 - 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 α	Sin α	cos α	tan α	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
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	0.07	0.998	0.07	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	0.06	0.998	0.06	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	0.05	0.999	0.05	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	0.04	0.999	0.04	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	0.03	1.000	0.03	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	0.02	1.000	0.02	1589	1551	993	931	1598	1553	1176	1113	1686	1571	2932	2887	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	0.01	1.000	0.01	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	0.19	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	0	1.000	0	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 x tan α)] x cos α

F= [ab-(h x tan α)] x cos α

H_1 = (Ca/2)+(h / cos α)+(Ab-h x tan α)x sin α

H_2=(Ca/2)+(h/cos α)-(ab+h x tan α) x sin α

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

CHENNAI METRO
LATERAL AND VERTICAL SHIFT OF CENTRE OF CIRCULAR TUNNEL
FOR DIFFERENT CANT VALUES
(WITH D_1 = 780 mm)

REFER TO FIGURE: CMSG-3 AND PARA Nos. 1.6.1 (B)-b AND 1.6.2 (B)-b

All figures are in mm

Cant	Sin α = Cant/1510	Angle α	Angle θ	Lateral Shift of tunnel centre=X	Vertical shift of tunnel centre = Y	REMARKS
mm		Degrees	Degrees	mm	Mm	
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	
95	0.06291	3.6071	69.5061	129	43	
90	0.0596	3.417	69.5061	122	41	
85	0.05629	3.227	69.5061	115	39	
80	0.05298	3.037	69.5061	108	37	
75	0.04967	2.847	69.5061	101	35	
70	0.04636	2.657	69.5061	94	33	
65	0.04305	2.4671	69.5061	88	31	
60	0.03974	2.2773	69.5061	81	28	
55	0.03642	2.0874	69.5061	74	26	
50	0.03311	1.8976	69.5061	67	24	
45	0.0298	1.7077	69.5061	61	22	
40	0.02649	1.5179	69.5061	54	19	
35	0.02318	1.3282	69.5061	47	17	
30	0.01987	1.1384	69.5061	40	15	
25	0.01656	0.9486	69.5061	34	12	
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	
	0	0	69.5061	0	0	

(a) The cant is provided by raising the outer rail which will mean, rotating the tunnel about the mind point of top of inner rail.

(b) 'X' is lateral shift of the centre of the tunnel towards inside of the curve
$X=2 \times \{ (r-D_1)/\sin\theta \} \times \{\sin(\alpha/2)\} \times \cos(90-\theta-\alpha/2)$

(c) 'Y' is the vertical shift of the centre of the tunnel (upwards)
$Y=2 \times \{ (r-D_1)/\sin\theta \} \times \{\sin\alpha/2\} \times \sin(90-\theta-\alpha/2)$ where,

'r' is internal radius of the circular tunnel=2800 mm
D_1 = depth from rail level to invert of circular tunnel=780 mm
α = angle of rotation = $\sin^{-1}$ (cant/g) and
θ = angle subtended by line joining top of two rails and the line joining midpoint of top of inner rail and the centre of circular Tunnel.

$=\tan^{-1}[(r-D_1)/(g/2)]$ in degrees= 69.5061

g=Centre to centre of rails = 1510 mm

APPENDIX - 4R

LATERAL AND VERTICAL SHIFT OF CENTRE OF CIRCULAR TUNNEL

FOR DIFFERENT CANT VALUES

(WITH D1=700 mm

REFER TO FIGURE: CMMSG-3 AND PARA Nos.1.6.1(B)-B & 1.6.2 (B0-b)

All figures are in mm

CANT	Sin α = Cant / 1510	Angle α	Angle θ	Lateral Shift of Tunnel centre - X	Vertical Shift of Tunnel centre = Y	Remarks
Min		Degrees	Degrees	mm	mm	
110	0.07285	4.1776	70.225	155	49	
105	0.06954	3.9874	70.225	148	47	
100	0.06623	3.7972	70.225	141	45	(a) The cant is provided by raising the outer rail which will mean, rotating
95	0.06291	3.6071	70.225	134	43	the tunnel about the midpoint of top of inner rail.
90	0.05960	3.4170	70.225	127	41	
85	0.05629	3.2270	70.225	119	39	
80	0.05298	3.0370	70.225	112	37	(b) 'X' is lateral shift of the centre of the tunnel towards inside of the curve
75	0.04967	2.8470	70.225	105	35	
70	0.04636	2.6570	70.225	98	33	X= [[2 x (r-D1)/sin q) x { sin a/2]] x cos (90- q - a/2)
65	0.04305	2.4671	70.225	91	31	
60	0.03974	2.2773	70.225	84	28	(c) 'Y' is the vertical shift of the centre of the tunnel (upwards)
55	0.03642	2.0874	70.225	77	26	Y=[{2 x (r-D1)/sin q) x { sin a/2]] x sin (90-q-a/2} where,
50	0.03311	1.8976	70.225	70	24	
45	0.02980	1.7077	70.225	63	22	'r' is internal radius of the circular tunnel=2800 mm
40	0.02649	1.5179	70.225	56	19	D1 = depth from rail level to invert of circular tunnel=700 mm
35	0.02318	1.3282	70.225	49	17	a = angle of rotation=sin-1 (Cant/g) and
30	0.01987	1.1384	70.225	42	15	q = angle subtended by line joining top of two rails and the line joining
25	0.01656	0.9486	70.225	35	12	midpoint of top of inner rail and the centre of circular Tunnel
20	0.01325	0.7589	70.225	28	10	
15	0.00993	0.5692	70.225	21	7	= tan-1[(r-D1) / (g/2)] in degrees
10	0.00662	0.3794	70.225	14	5	=70.225
5	0.00331	0.1897	70.225	7	2	g= Centre to centre of rails = 1510 mm
0	0	0	70.225	0	0	

Approved on 24/11/2020

Railway Board

APPENDIX – 5

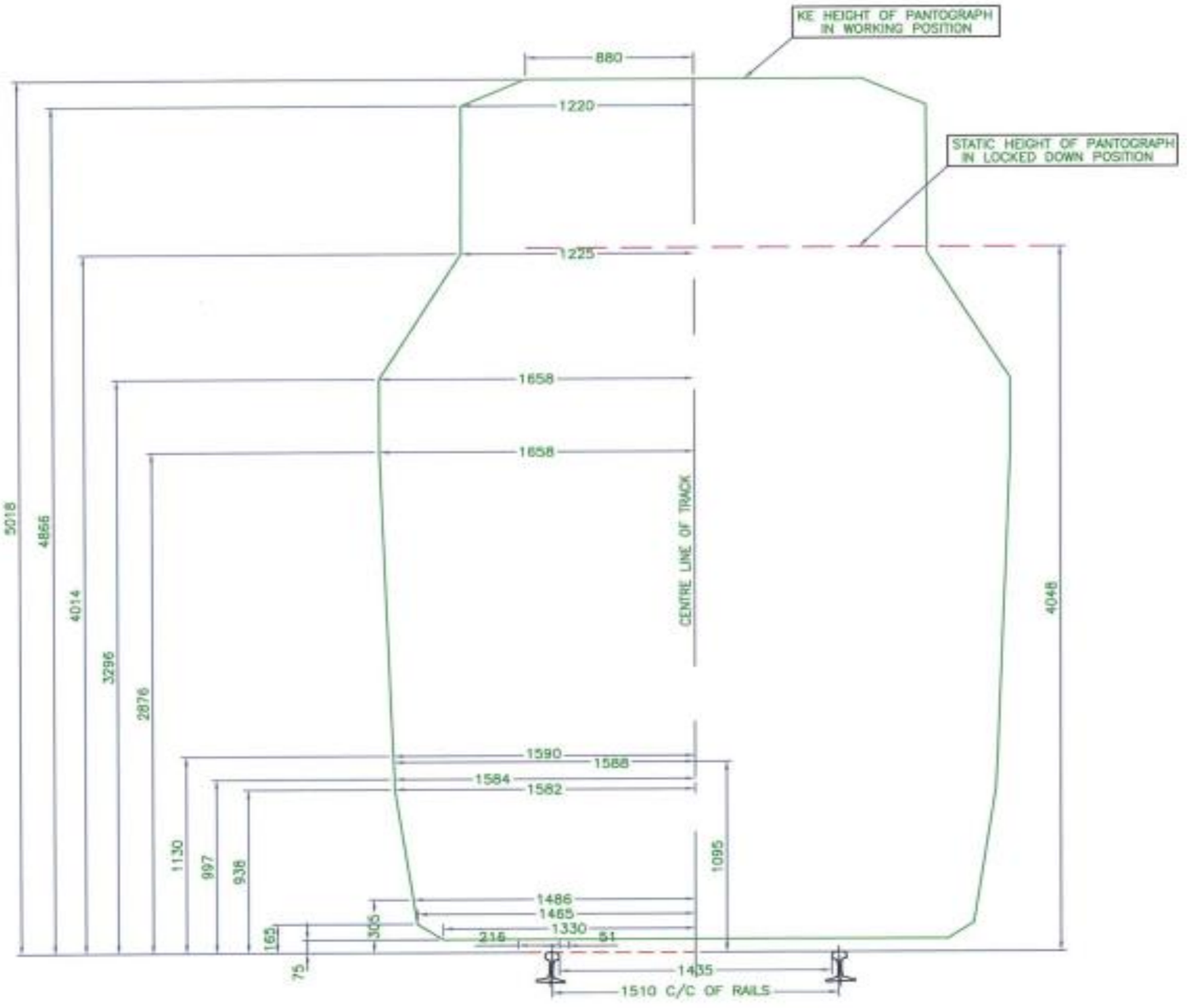
ADDITIONAL CLERANCE FOR PLATFORMS ON CURVES UNDER GROUND, ELEVATED AND AT GRADE STATIONS

REF PARA 2.7

EXTRA CLERANCE														
RADIUS	INSIDE OF CURVE								OUTSIDE OF CURVE					
	AT CENTRE LINE OF BOGIES				AT EDGE OF OPEN DOOR NEAREST TO C.L. OF BOGIES				AT END OF COACH	AT EDGE OF OPEN DOOR, FARTHEST FROM CL OF BOGIES				
	MID THROW =28500/R	NOSING	ADDITIONAL CLERANCE	ADDITIONAL CLEARANCE (ROUNDED OFF TO NEAREST 5 mm) (i)	THROW =28498/R	NOSING = 13x 0.073/10.97	Additional clearance	ADDITIONAL CLEARANCE (ROUNDED OFF TO NEAREST 5 mm) (8)	END THROW =33525/R	THROW =19340/R	NOSING = 13x9.59/10.97	DIFFERENCE BETWEEN N AND N_2	ADDITIONAL CLEARANCE	ADDITIONAL CLEARANCE (ROUNDED OFF TO NEAREST 5 mm) (8)
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)
Metre	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	9.5	13.0	-3.5	0	9.5	1.0	-2.5	0	11	6.4	11.4	1.6	4.8	5
2800	10.2	13.0	-2.8	0	10.2	1.0	-1.8	0	12	6.9	11.4	1.6	5.3	5
2400	11.9	13.0	-1.1	0	11.9	1.0	-0.1	0	14	8.1	11.4	1.6	6.4	5
2000	14.3	13.0	1.3	0	14.2	1.0	2.3	0	17	9.7	11.4	1.6	8.0	10
1800	15.8	13.0	2.8	5	15.8	1.0	3.9	5	19	10.7	11.4	1.6	9.1	10
1600	17.8	13.0	4.8	5	17.8	1.0	5.8	5	21	12.1	11.4	1.6	10.5	15
1500	19.0	13.0	6.0	10	19.0	1.0	7.0	10	22	12.9	11.4	1.6	11.3	15
1200	23.8	13.0	10.8	15	23.7	1.0	11.8	15	28	16.1	11.4	1.6	14.5	15
1000	28.5	13.0	15.5	20	28.5	1.0	16.5	20	34	19.3	11.4	1.6	17.7	20

NOTES:

1. **For outside of curve, the difference between clearance required at coach end that at the farthest door edge is less than 25 mm. As half width of coach at ends is at least 25 mm less than that at door locations, additional clearance to be provided is additional clearance required at the farthest door edge (column 12).**
2. **Values of additional clearances (columns 4, 7 and 12) are rounded off to the nearest 5 mm.**
3. Negative values of additional clearance are taken as Zero in the columns 4 and 7 with rounded off figures.
4. **Extra clearance for curve:**
   - **(a) Inside of curve:**
     $V = (125C^2/R)=28500/R$ with C=15.10 m for the worst case.
     $V_3=[(125)x(15.1^2 – 4x0.873^2)/R]=28498/R$
     $N_1=Nx(X)/(C_1/2)=13 x 0.873/10.97=1.03$ mm
     Minimum distance 'X' for the nearest edge of an open door from centre line of Bogies is 0.873 metre. Higher of (i) column 4 and (ii) column 7 shall be adopted
   - **(b) Outside of curve**
     $V_0=(125C_1^2/R)-(125C^2/R)=3352/R$ for coach end with C=14.6 metres and C_1 =2x10.97 metres.
     $V_4=125x(19.18x19.18-14.6x14.6)/R = 19340/R$ for farthest edge of end door in open position with
     $C_1=2x9.590=19.18$ metres and C=14.60 metres for the worst case.
     N_2=Nosing at the farthest edge of an open door=N x (X)/(C_1/2) = 13x9.59/ 10.97 mm = 11.3 mm
     R = Radius of curve in metres
     Maximum distance (X) for the farthest edge of open door from centre line of two Bogies=9.590 M.
5. **There will be no superelevation on curves In platform Portion**



NOTES:

1. ALL DIMENSIONS ARE IN MM.
2. HORIZONTAL AND VERTICAL SHIFTS DUE TO CURVES, INCLUDING VERTICAL CURVES AND CANT SHALL BE EXTRA.
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 CLEARENCES 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 KINEMETIC ENVELOPE FOR A DISTANCE OF 51 MM INSIDE AND 216 MM OUTSIDE OF THE GAUGE FACE OF THE WHEEL.

CHENNAI METRO RAIL LIMITED,
Metro Towers, No.7, Conran Smith Road,
Gopalapuram, Chennai, Tamil Nadu 600 086.
Ph. +91 - 44 - 2843 0033
Fax. +91 - 44 - 2839 1401
Email- chennaimetrorail@gmail.com

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

GENERAL NOTES :

REV.	DATE	DESCRIPTION	APPROVED

APPROVED:
CHECKED:
DRAWN:
DATE: 27-11-2009

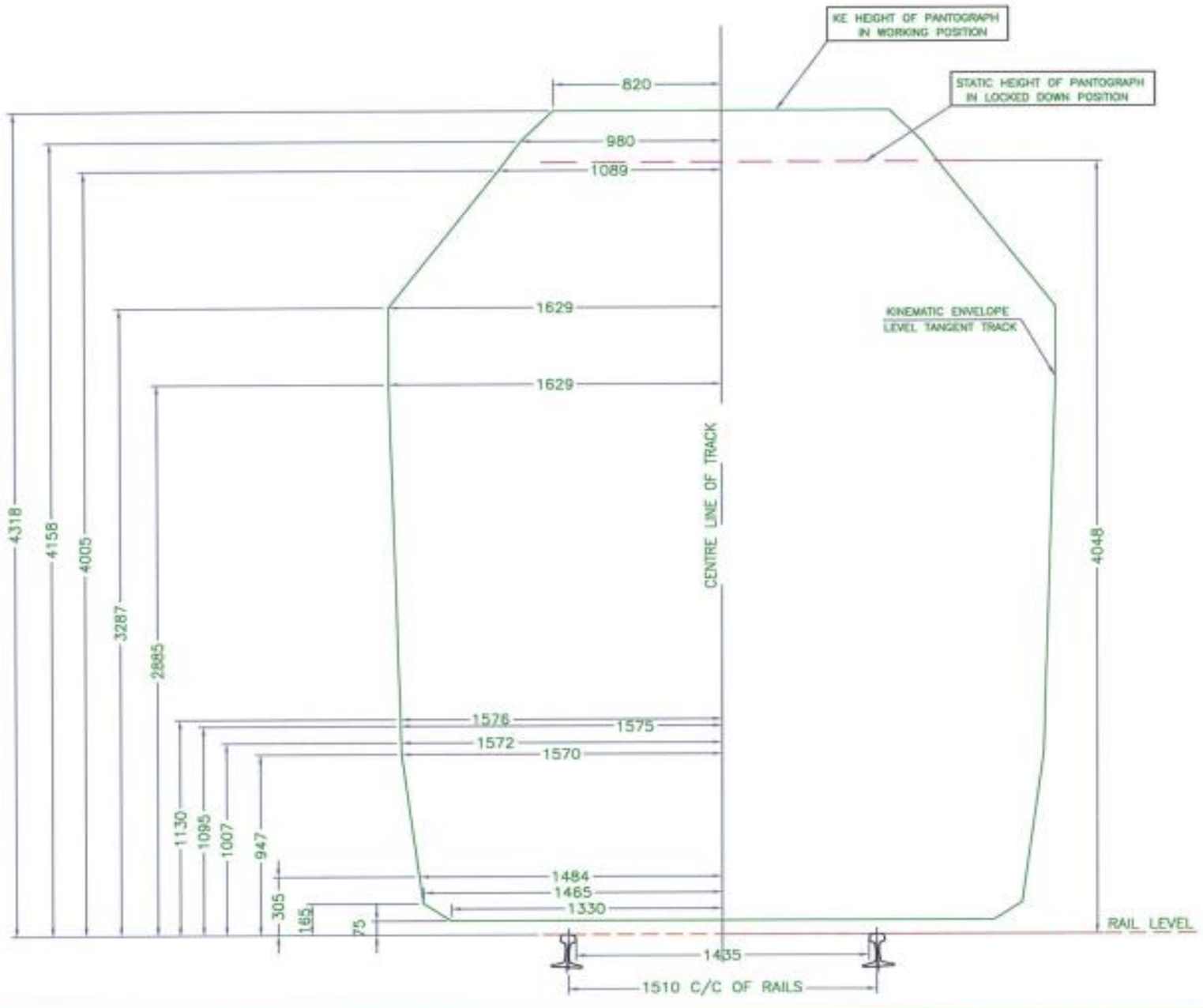
DRAWING NAME:
KINEMATIC ENVELOPE
ON
LEVEL OR CONSTANT GRADE TANGENT TRACK
ELEVATED SECTIONS AND AT-GRADE

DRAWING NUMBER: **CMSG-1 REF:PARA 1.4.a**

SHEET NO	SHEET SIZE
1 of 1	A3

SCALE: NOT TO SCALE

REV: 0



NOTES:

1. ALL DIMENSIONS ARE IN MM.
2. HORIZONTAL AND VERTICAL SHIFTS DUE TO CURVES, INCLUDING VERTICAL CURVES AND CANT SHALL BE EXTRA.
3. KINEMETIC 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 CLEARENCES 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 KINEMETIC ENVELOPE FOR A DISTANCE OF 51 MM INSIDE AND 216 MM OUTSIDE OF THE GAUGE FACE OF THE WHEEL.

CHENNAI METRO RAIL LIMITED,
Halroi Towers, No.7, Conran Smith Road,
Gopalapuram, Chennai, Tamil Nadu-600 086.
Ph: +91 - 44 - 2843020
Fax: +91 - 44 - 2835161
Email: chennaimetrorail@gmail.com

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

GENERAL NOTES :

REV	DATE	DESCRIPTION	APPROVED
1	15.02.10	DRAWING NAME REVISED.	

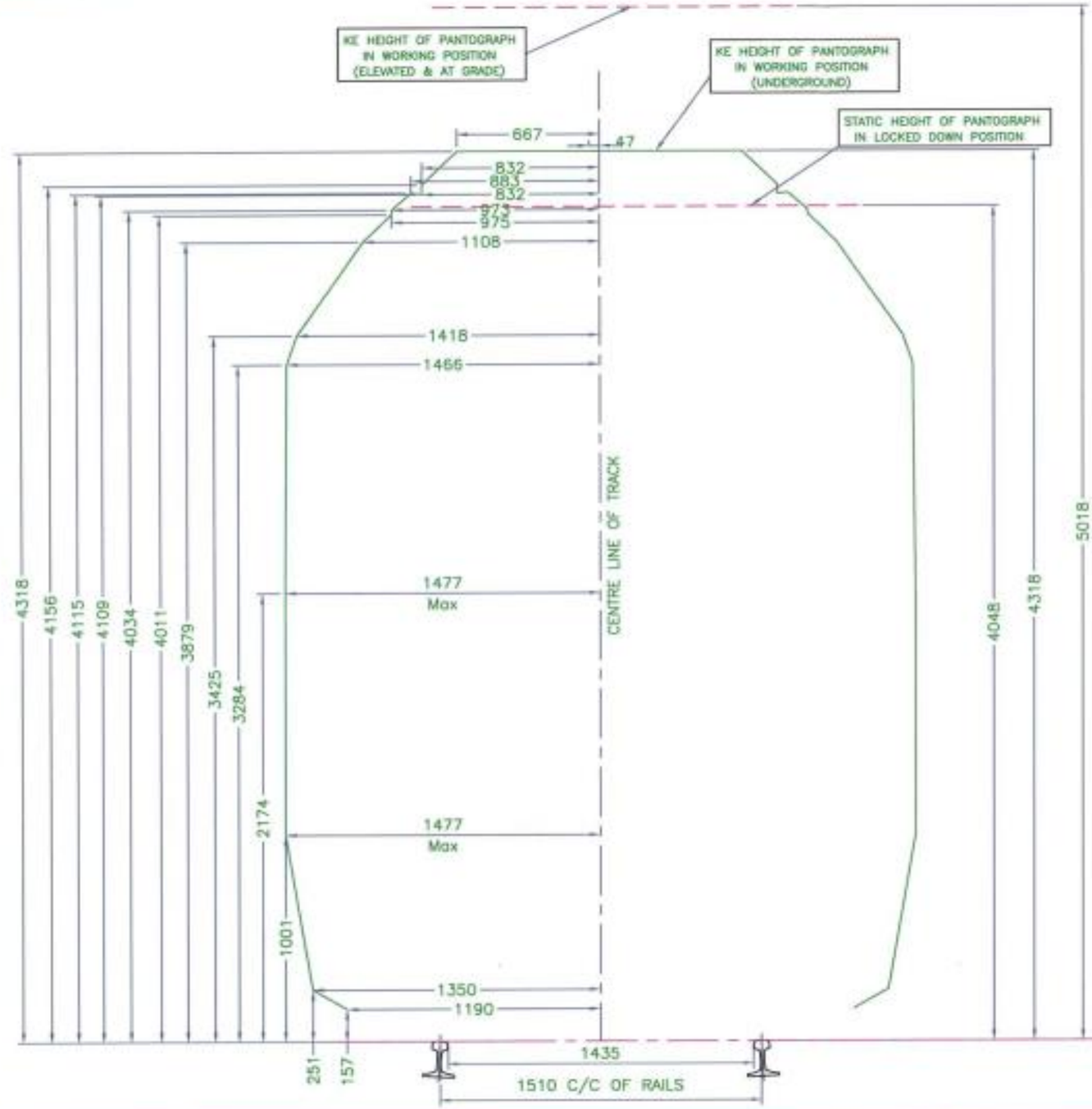
APPROVED:
CHECKED:
DRAWN:
DATE: 27-11-2009

DRAWING NAME:
KINEMATIC ENVELOPE
ON LEVEL OR CONSTANT GRADE
TANGENT TRACK AT UNDER GROUND SECTION (TUNNELS, THROUGH & SEMI THROUGH GIRDER BRIDGES

SHEET NO	SHEET SIZE
1 of 1	A3

SCALE: NOT TO SCALE

DRAWING NUMBER: CMSG-1(TNL) REF:PARA 1.4.b
REV: 1



NOTES:

1. ALL DIMENSIONS ARE IN MM.
2. HORIZONTAL SHIFT DUE TO CURVES SHALL BE EXTRA.
3. KINEMETIC ENVELOPE IS VALID FOR VEHICLES WITH SEALED WINDOWS AND DOORS CLOSED WHILE IN MOTION.
4. THE CONDUCTOR HEIGHT ABOVE RAIL LEVEL SHALL ALSO TAKE INTO CONSIDERATION, PRESCRIBED ELECTRICAL CLEARENCES BETWEEN ALL LIVE OVERHEAD EQUIPMENT AND PANTOGRAPH/VEHICLE AND ALL PARTS THEREOF.

POINT	X	Y
1	47	4318
2	667	4318
3	832	4156
4	832	4109
5	883	4115
6	973	4034
7	975	4011
8	1108	3879
9	1418	3425
10	1466	3284
11	1477	2174
12	1477	1001
13	1350	251
14	1190	157

CHENNAI METRO RAIL LIMITED,
Harini Towers, No.7, Conran Smith Road,
Gopalapuram, Chennai, Tamil Nadu-600 086.
Ph: +91 - 44 - 28430000
Fax: +91 - 44 - 28351461
Email- chennaimetrorail@gmail.com

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

GENERAL NOTES:

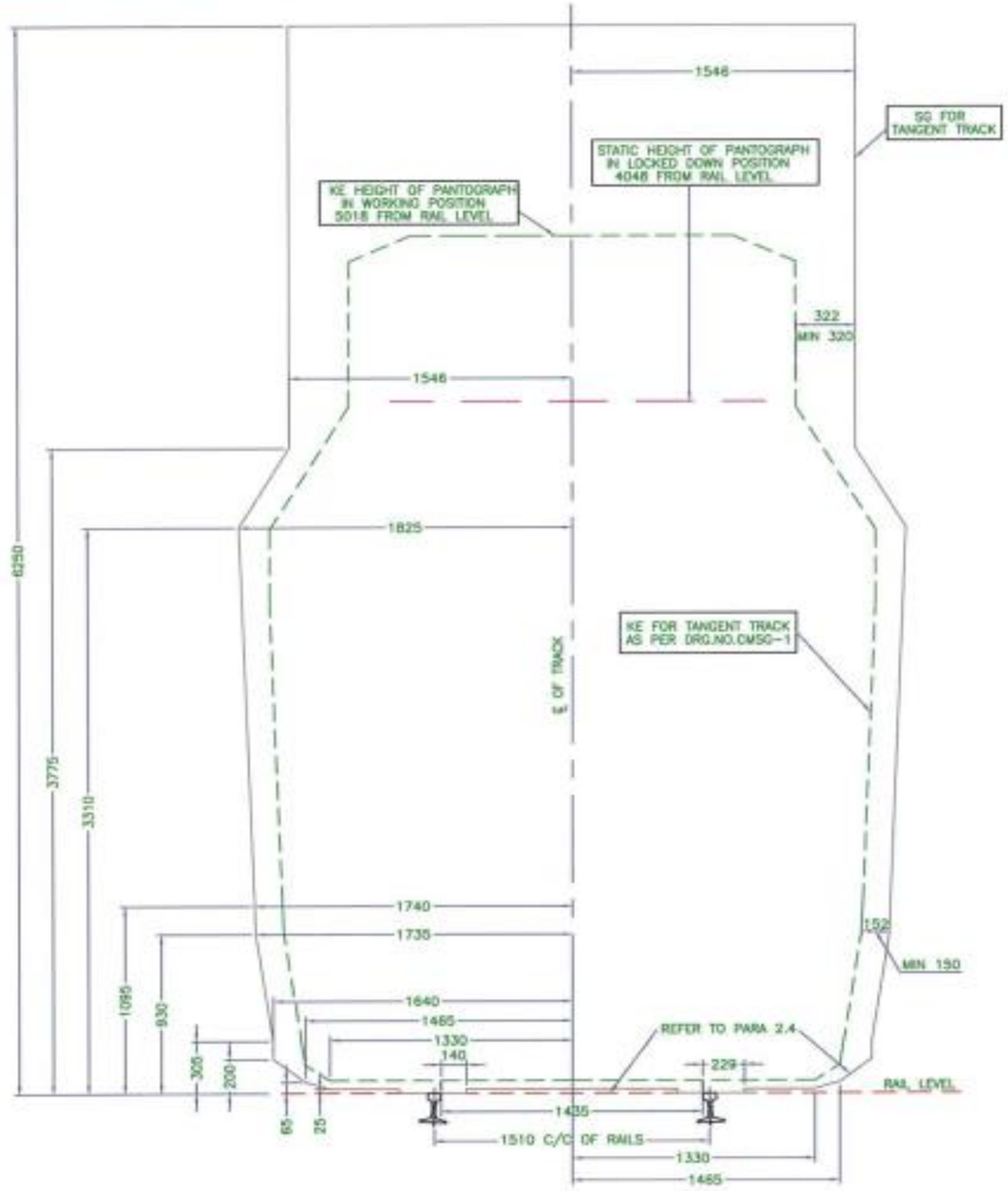
REV	DATE	DESCRIPTION	APPROVED
2	07.01.12	Dimensions shown in MM.	
1	23.11.12	Drawing No Changed.	

APPROVED:
CHECKED:
DRAWN:
DATE: 21-11-2009

DRAWING NAME:
KINEMATIC ENVELOPE
AT 55Kmph SPEED ON LEVEL OR
CONSTANT GRADE TANGENT TRACK AT STATIONS

DRAWING NUMBER: **CMSG-1A REF:PARA 1.4.c**

SHEET NO: 1 of 1
SHEET SIZE: A3
SCALE: NOT TO SCALE
REV: 2



NOTES:

1. ALL DIMENSIONS ARE IN MM.
2. THIS STRUCTURE GAUGE WILL ALSO BE APPLICABLE FOR ROBs/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. KINEMETIC 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 SHELL BE EXTRA.
9. FOR KINEMATIC ENVELOPE, REFER TO DRG.NO:CMSG-1.

LEGEND:

– – – – – KINEMATIC GAUGE
——————— STRUCTURE GAUGE

CHENNAI METRO RAIL LIMITED,
Metro Towers, No.7, Connor Smith Road,
Egmore, Chennai, Tamil Nadu-600 008.
Ph: +91 - 44 - 2843 0929
Fax: +91 - 44 - 2855 1401
Email: chennaimetrorail@gmail.com

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

GENERAL NOTES:

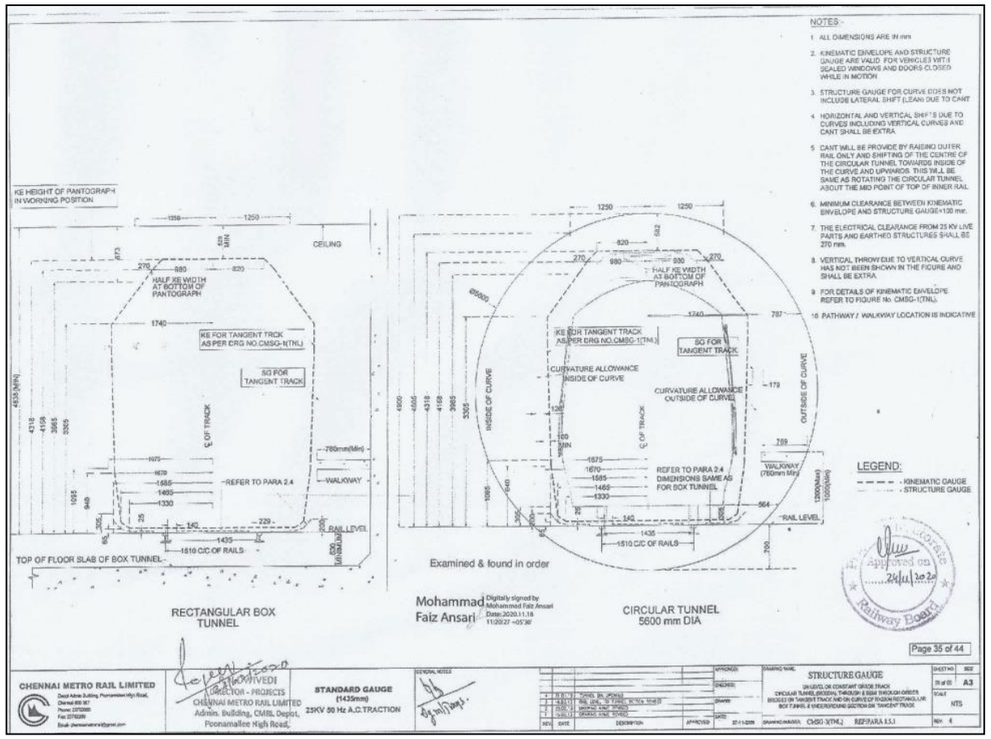
REV.	DATE	DESCRIPTION	APPROVED
1	26.02.13	DRAWING NAME REVISED.	

APPROVED:
CHECKED:
DRAWN:
DATE: 27-11-2009

DRAWING NAME:
STRUCTURE GAUGE
AT–GRADE AND ELEVATED SECTIONS ON LEVEL OR CONSTANT GRADE TANGENT TRACK

DRAWING NUMBER: **CMSG–2 REF:PARA 1.5.2&1.5.3**

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


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 PROVIDE 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=100 mm.
7. THE ELECTRICAL CLEARANCE FROM 25 KV 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 FIGURE No. CMSG-1(TML).
10. PATHWAY / WALKWAY LOCATION IS INDICATIVE
KE HEIGHT OF PANTOGRAPH IN WORKING POSITION
CEILING
HALF KE WIDTH AT BOTTOM OF PANTOGRAPH
KE FOR TANGENT TRCK AS PER DRG NO.CMSG-1(TML)
SG FOR TANGENT TRACK
REFER TO PARA 2.4
WALKWAY
RAIL LEVEL
TOP OF FLOOR SLAB OF BOX TUNNEL
1510 C/C OF RAILS
RECTANGULAR BOX TUNNEL
CURVATURE ALLOWANCE INSIDE OF CURVE
CURVATURE ALLOWANCE OUTSIDE OF CURVE
REFER TO PARA 2.4 DIMENSIONS SAME AS FOR BOX TUNNEL
INSIDE OF CURVE
OUTSIDE OF CURVE
CIRCULAR TUNNEL 5600 mm DIA
LEGEND:
KINEMATIC GAUGE
STRUCTURE GAUGE
Examined & found in order
Mohammad Faiz Ansari
Digitally signed by Mohammad Faiz Ansari
Date: 2020.11.18 11:20:27 +05'30'
Approved on 24/11/2020
Railway Board
Page 35 of 44
CHENNAI METRO RAIL LIMITED
Depot Admin Building, Poonamallee High Road, Chennai 600 087
Phone: 23720000
Fax: 23720200
Email: chennaimetro@gmail.com
APPROVED
DIRECTOR - PROJECTS
CHENNAI METRO RAIL LIMITED
Admin. Building, CMRL Depot,
Poonamallee High Road,
STANDARD GAUGE (1435mm)
25KV 50 Hz A.C.TRACTION
REVISIONAL NOTES
REV. 1 TUNNEL DIA UPGRADED
REV. 2 RAIL LEVEL 10 mm HIGHER
REV. 3 WALKWAY LEVEL CHANGED
REV. 4 GRADIENT LINE CHANGED
DRAWING NAME: STRUCTURE GAUGE
SHEET NO. 35 of 55
SIZE A3
SCALE NTS
DRAWING NO. CMSG-3(TML)
REFERS TO 5.5.1
REV. 4

$\tan\theta = (r-D1)/(g/2)$

$\theta = \tan^{-1}[(r-D1)/(g/2)]$

$\sin\alpha = cant/g$

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

Chord $C_1C_2 = 2 \times [(r-D1)/\sin\theta) \times (\sin\alpha/2)]$

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

$= 2 \times [(r-D1)/\sin\theta) \times (\sin\alpha/2)] \times \cos(90-\theta-\alpha/2)$

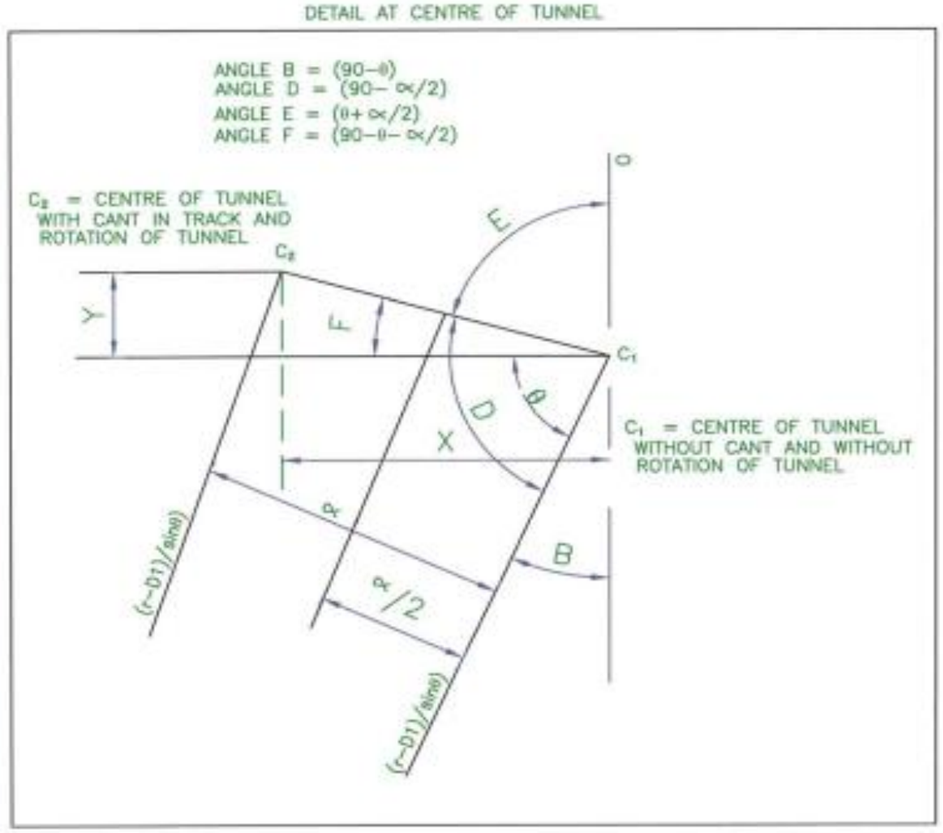
$Y = 2 \times [(r-D1)/\sin\theta) \times (\sin\alpha/2)] \times \sin(90-\theta-\alpha/2)$

where 'r' is internal radius of tunnel,

D_1 = depth from Rail level to invert of tunnel

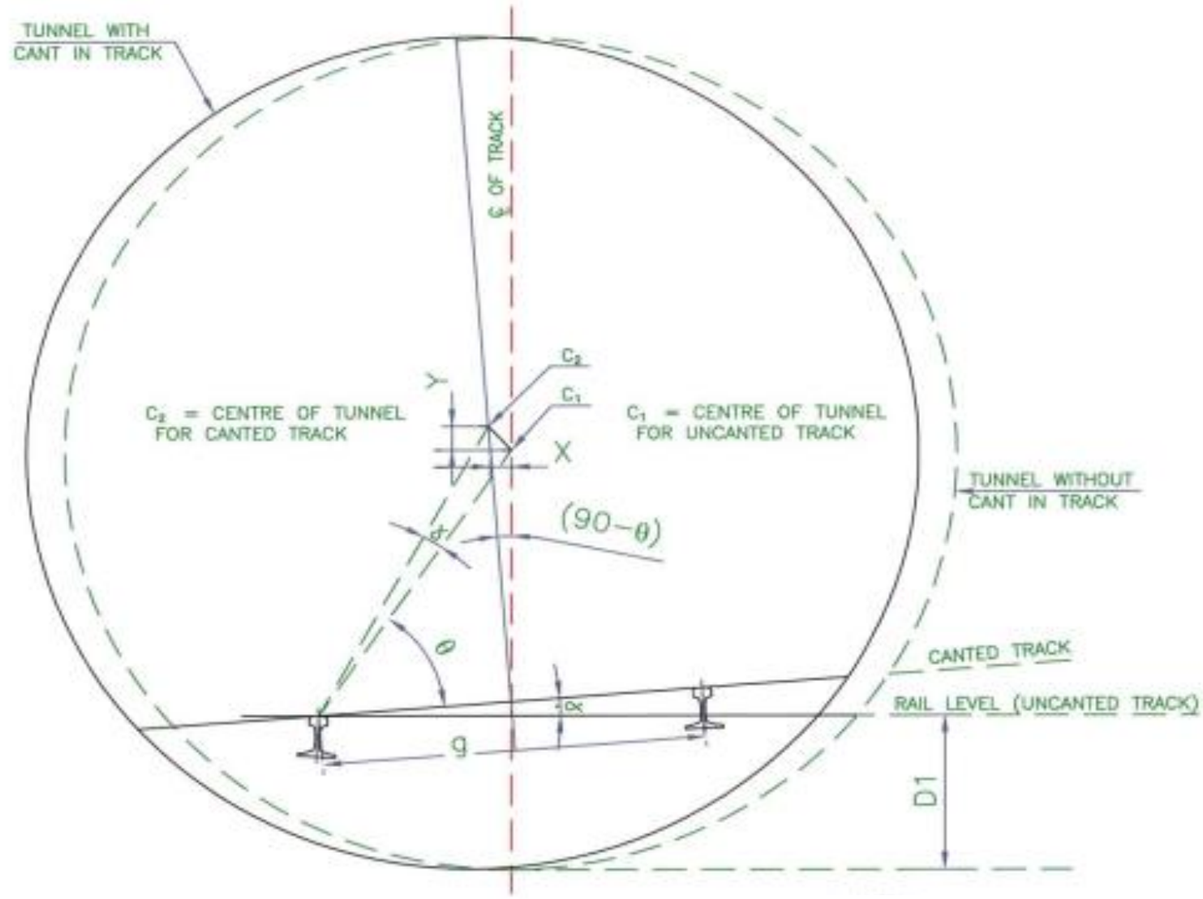
g = distance between centres of rails = 1510 mm

DETAIL AT CENTRE OF TUNNEL



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



CHENNAI METRO RAIL LIMITED,
Metro Towers, No.7, Corvan Smith Road, Gopalapuram, Chennai, Tamil Nadu-600 086
Ph: +91 - 44 - 28436000
Fax: +91 - 44 - 28551481
Email- chennaimetrorail@gmail.com

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

GENERAL NOTES:

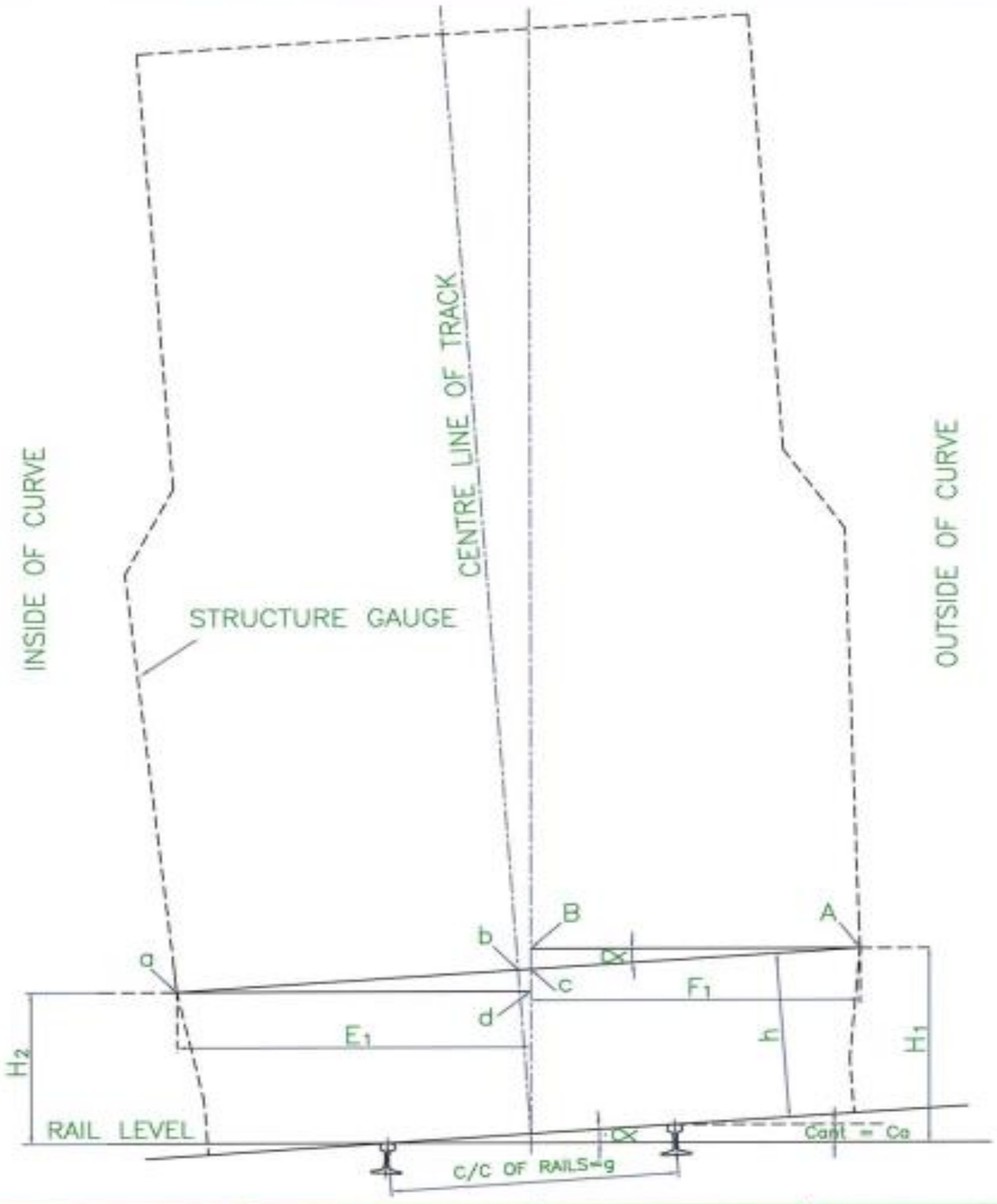
REV	DATE	DESCRIPTION	APPROVED

APPROVED:
CHECKED:
DRAWN:
DATE: 27-11-2008

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

DRAWING NUMBER: **CMSG-3 REF:PARA NO 1.6.1(B)-b & 1.6.2(B)-b**

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



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

$\sin\alpha$ = cant/g

g = 1510mm

Ca = 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,

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

GENERAL NOTES :

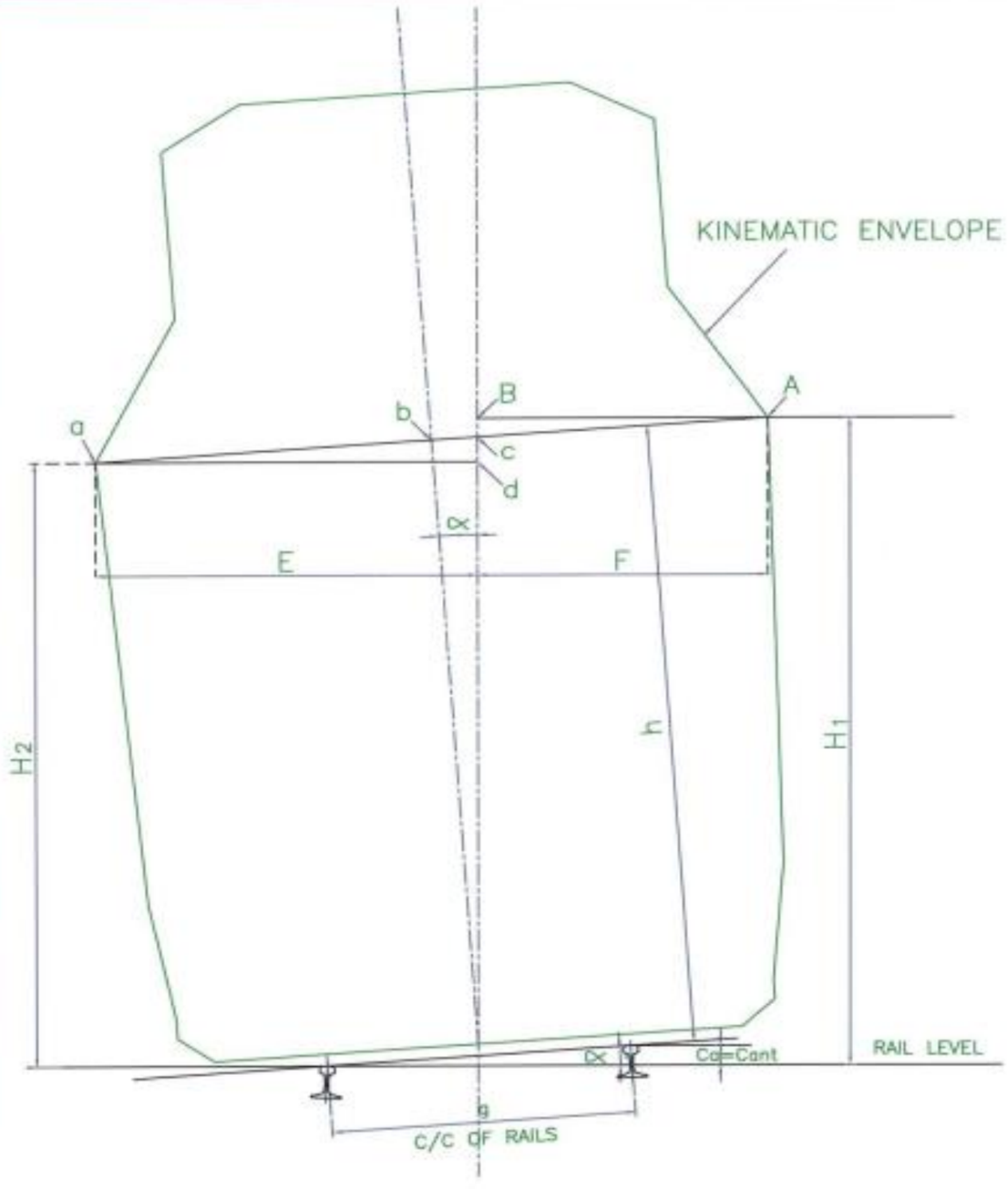
REV.	DATE	DESCRIPTION	APPROVED

APPROVED:
CHECKED:
DRAWN:
DATE: 23-11-2018

DRAWING NAME: **EFFECT OF CANT ON STRUCTURE GAUGE**

DRAWING NUMBER: **CMSG–4** **REF:PARA 1.7.2**

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



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

$\sin \propto = cant/g$

g = 1510mm

Ca = Cant applied

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

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

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

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

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,
Metro Towers, No.7, Conran Smith Road, Gopalapuram, Chennai, Tamil Nadu-600 086.
Ph: +91-44-28430020
Fax: +91-44-28351461
Email: chennaimetrorail@gmail.com

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

GENERAL NOTES:

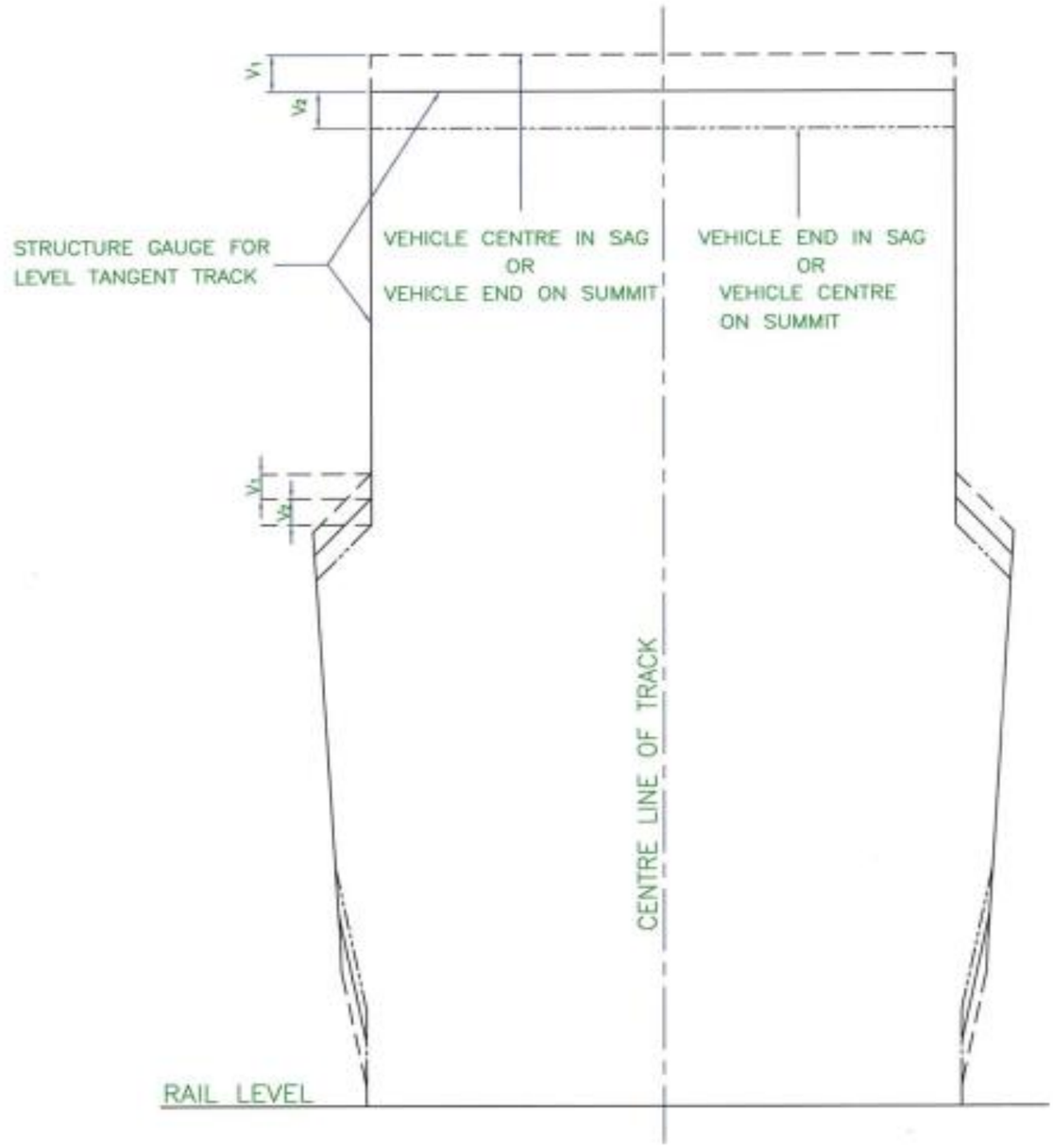
REV	DATE	DESCRIPTION	APPROVED

APPROVED:
CHECKED:
DRAWN:
DATE: 27-11-2009

DRAWING NAME: **EFFECT OF CANT ON KINEMATIC ENVELOPE**

DRAWING NUMBER: CMSG-4A REF:PARA 1.7.1

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



VERTICAL THROW

RADIUS OF VERTICAL CURVE metres	V_1 mm	V_2 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,
Metro Towers, No.1, Conran Smith Road,
Gopalapuram, Chennai, Tamil Nadu 600 086
Ph: +91 - 44 - 28408520
Fax: +91 - 44 - 28551401
Email: chennaimetrorail@gmail.com

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

GENERAL NOTES:

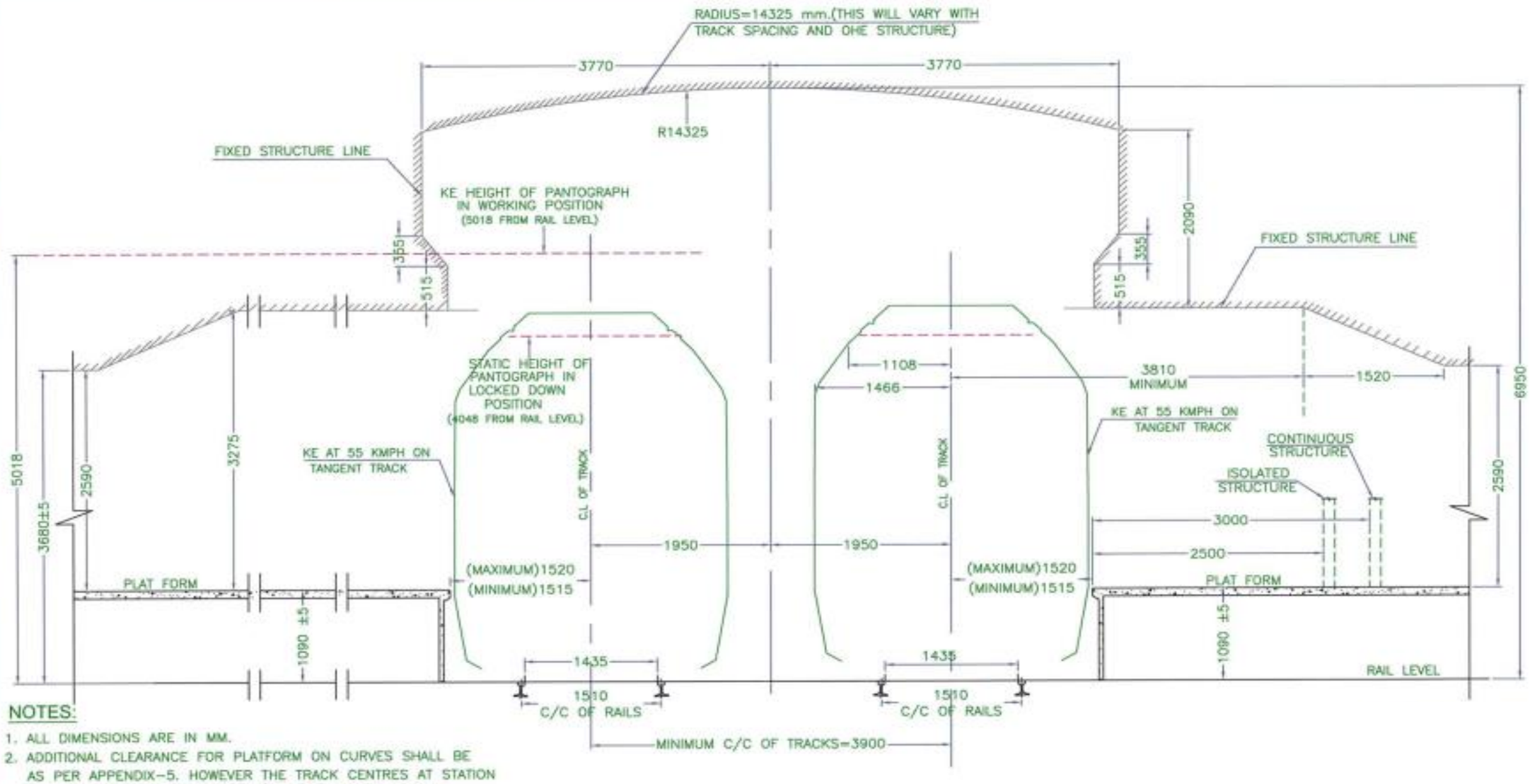
REV.	DATE	DESCRIPTION	APPROVED

APPROVED:
CHECKED:
DRAWN:
DATE: 27-11-2009

DRAWING NAME:
EFFECT OF VERTICAL CURVE ON STRUCTURE GAUGE

DRAWING NUMBER: CMSC-G REF:PARA 1.0.1(C) & 1.0.2(C)

SHEET NO: 1 of 1
SHEET SIZE: 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 GAUGE IS VAILD FOR VEHICLES WITH SEALED WINDOWS AND DOORS CLOSED WHILE IN MOTION.
4. OHE IS SUSPENDED FROM CEILING BY DROP ARM.

CHENNAI METRO RAIL LIMITED,
Hanin Towers, No.7, Connor Smith Road,
Gopalapuram, Chennai, Tamil Nadu-600 086.
Ph: +91 - 44 - 28430020
Fax: +91 - 44 - 28351401
Email: chennaimetrorail@gmail.com

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

GENERAL NOTES :

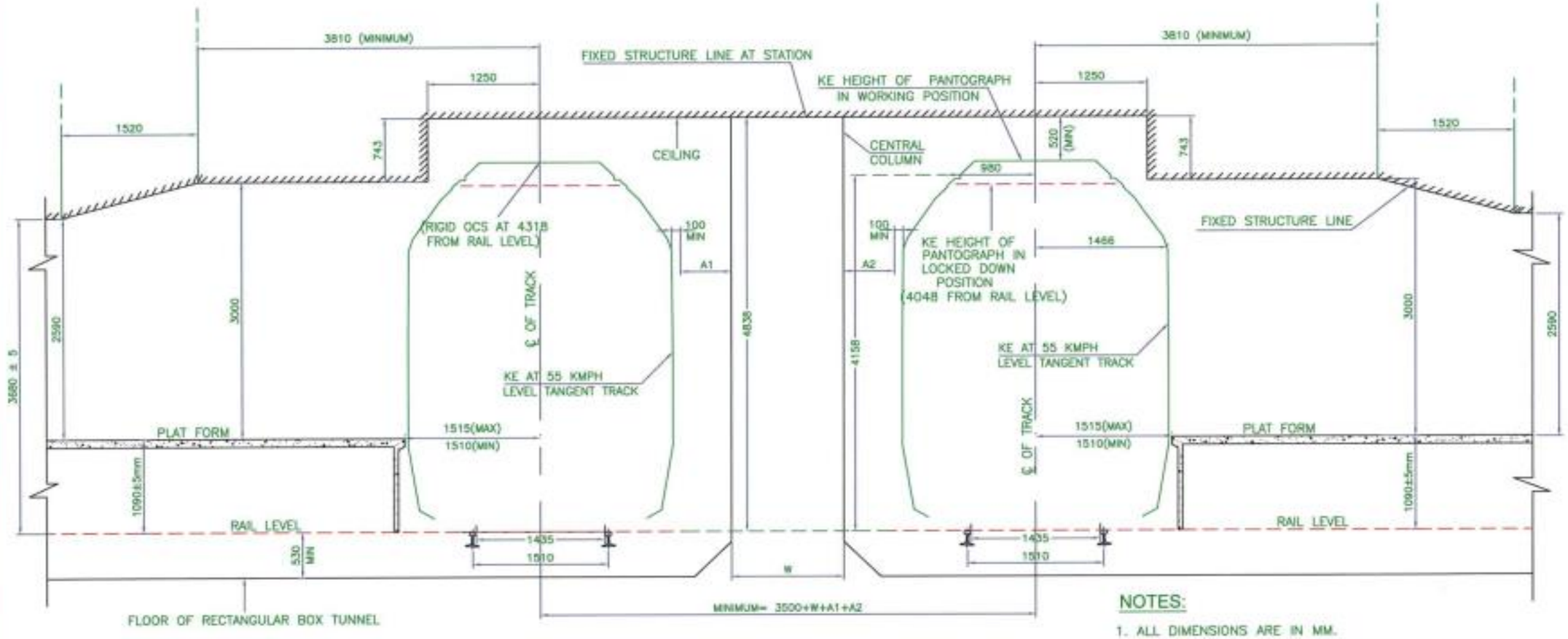
REV.	DATE	DESCRIPTION	APPROVED
1	27-01-10	Minimum C/C Of Tracks Corrected.	

APPROVED:
CHECKED:
DRAWN:
DATE: 23-11-2009

DRAWING NAME:
STRUCTURAL CLARENCE AT ELEVATED/AT–GRADE STATION WITH SIDE PLATFORMS LEVEL OR CONSTANT GRADE TANGENT TRACK

DRAWING NUMBER: **CMSG–6 REF:PARA 2.2.5.b**

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



NOTES:

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

CHENNAI METRO RAIL LIMITED,
Hariri Towers, No.7, Conran Smith Road,
Gopalapuram, Chennai, Tamil Nadu-600 086.
Ph: +91-44-2833020
Fax: +91-44-2833160
Email: chennaimetrorail@gmail.com

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

GENERAL NOTES :

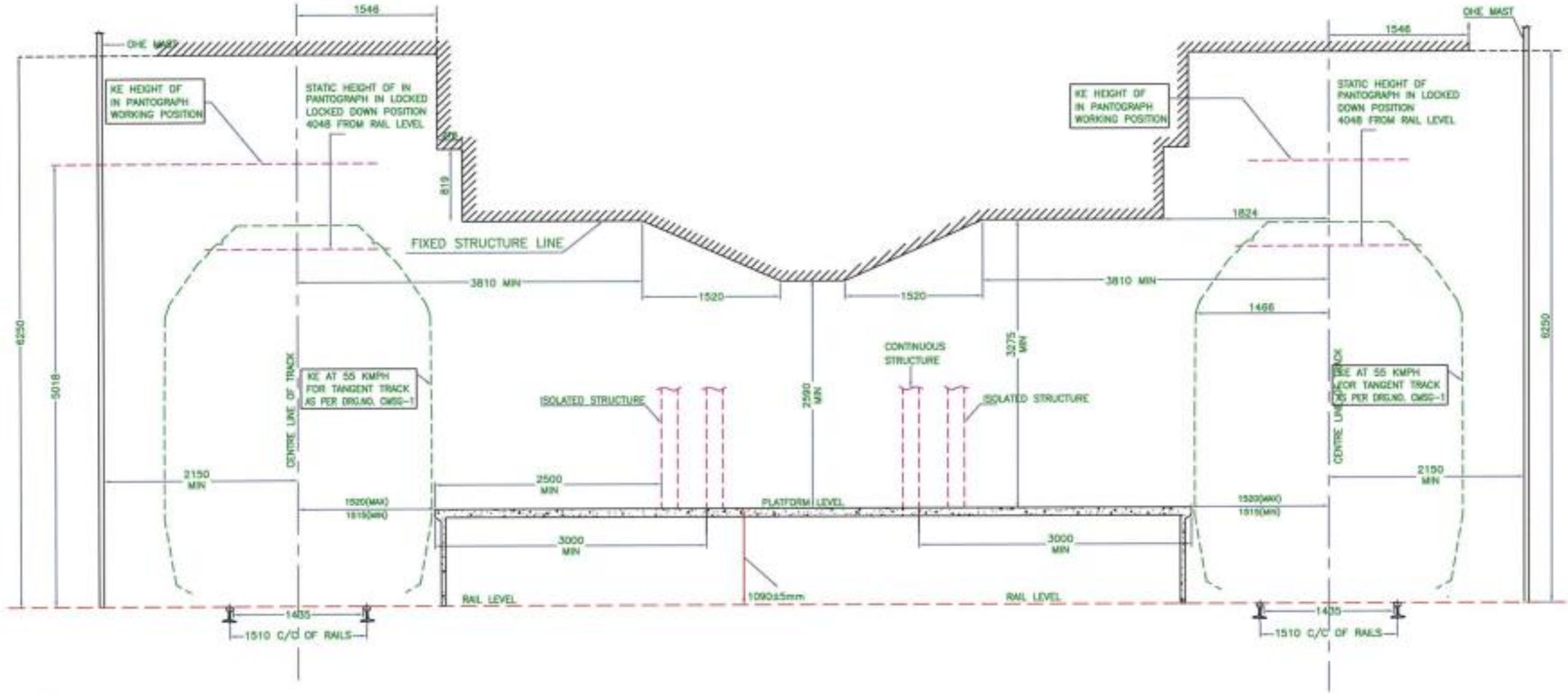
REV	DATE	DESCRIPTION	APPROVED

APPROVED:
CHECKED:
DRAWN:
DATE: 27-11-2009

DRAWING NAME:
STRUCTURAL CLEARANCE
AT UNDER–GROUND STATION WITH SIDE PLATFORMS
RECTANGULAR BOX TUNNEL
ON LEVEL OR CONSTANT GRADE TANGENT TRACK

DRAWING NUMBER: **CMSG–6(TNL) REF:PARA 2.2.5.a**

SHEET NO: 1 of 1
SHEET SIZE: 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.
3. STRUCTURE GAUGE IS VALID FOR VEHICLES WITH SEALED WINDOWS AND DOORS CLOSED WHILE IN MOTION.

CHENNAI METRO RAIL LIMITED,
Hanni Towers, No.7, Conran Smith Road,
Gopalapuram, Chennai, Tamil Nadu-600 086
Ph: +91 - 44 - 2940 8020
Fax: +91 - 44 - 2555 1401
Email- chennaimetrorail@gmail.com

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

GENERAL NOTES :

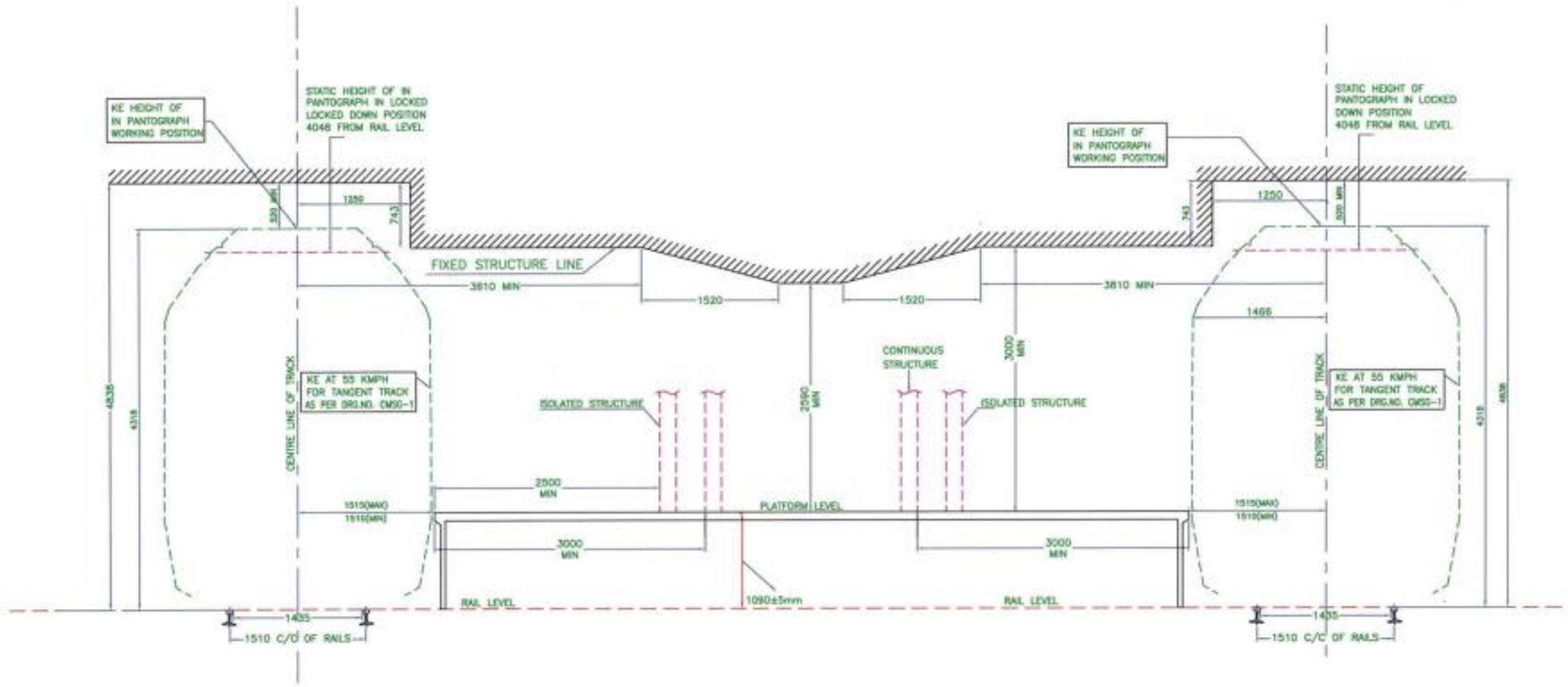
REV	DATE	DESCRIPTION	APPROVED

APPROVED:
CHECKED:
DRAWN:
DATE: 27-11-2009

DRAWING NAME:
STRUCTURAL CLEARANCE
AT ELEVATED/AT–GRADE STATION WITH
ISLAND PLATFORMS
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	



NOTES:

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

CHENNAI METRO RAIL LIMITED,
Hariri Towers, No.7, Connor Smith Road,
Gopalapuram, Chennai, Tamil Nadu-600 086.
Ph: +91-44-2843020
Fax: +91-44-2835401
Email- chennaimetrorail@gmail.com

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

GENERAL NOTES :

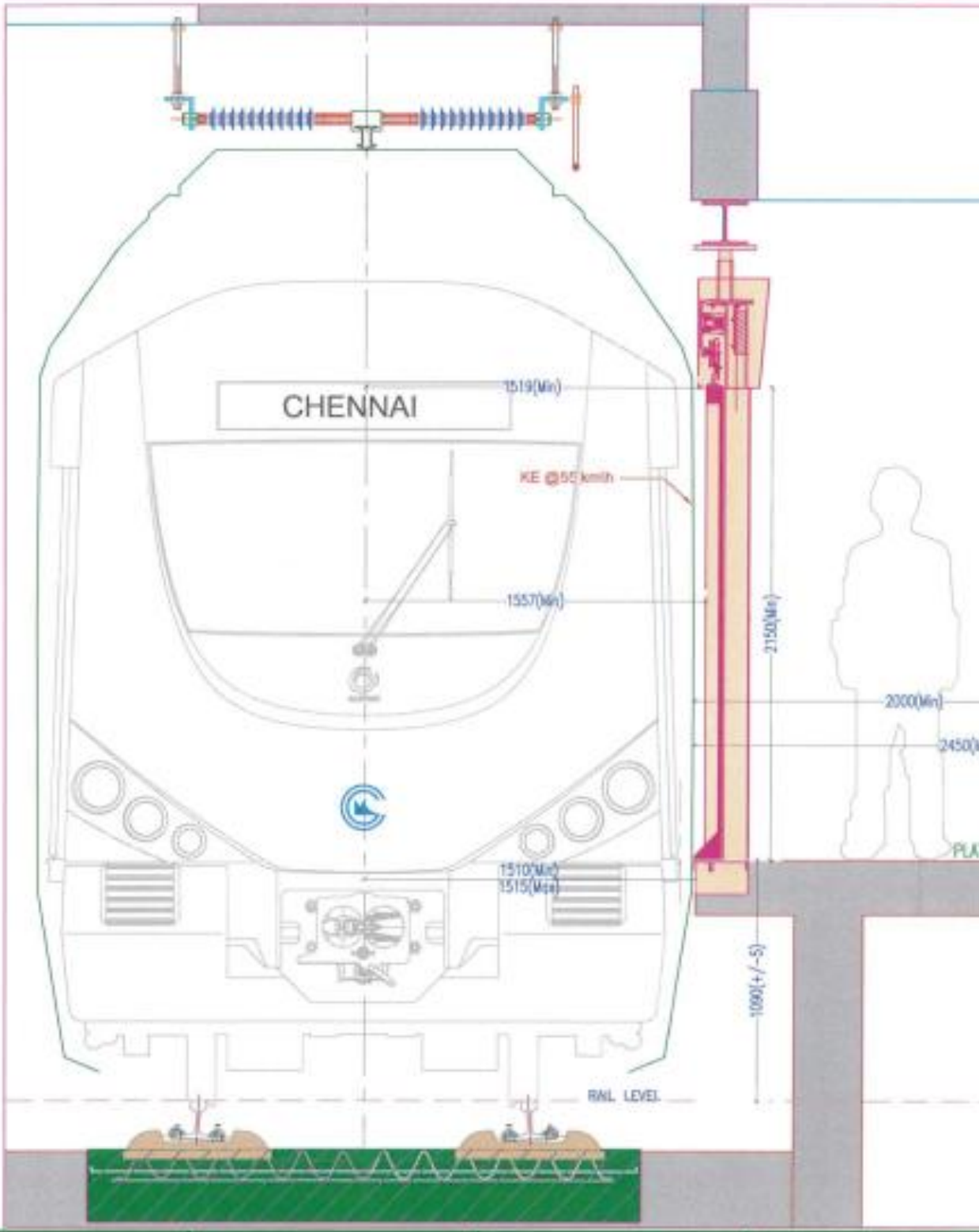
REV.	DATE	DESCRIPTION	APPROVED

APPROVED:
CHECKED:
DRAWN:
DATE: 07-03-2013

DRAWING NAME:
STRUCTURAL CLEARANCE
AT UNDERGROUND STATION WITH
ISLAND PLATFORMS
ON LEVEL OR CONSTANT GRADE TANGENT TRACK

DRAWING NUMBER: CMSG-7(TNL)

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

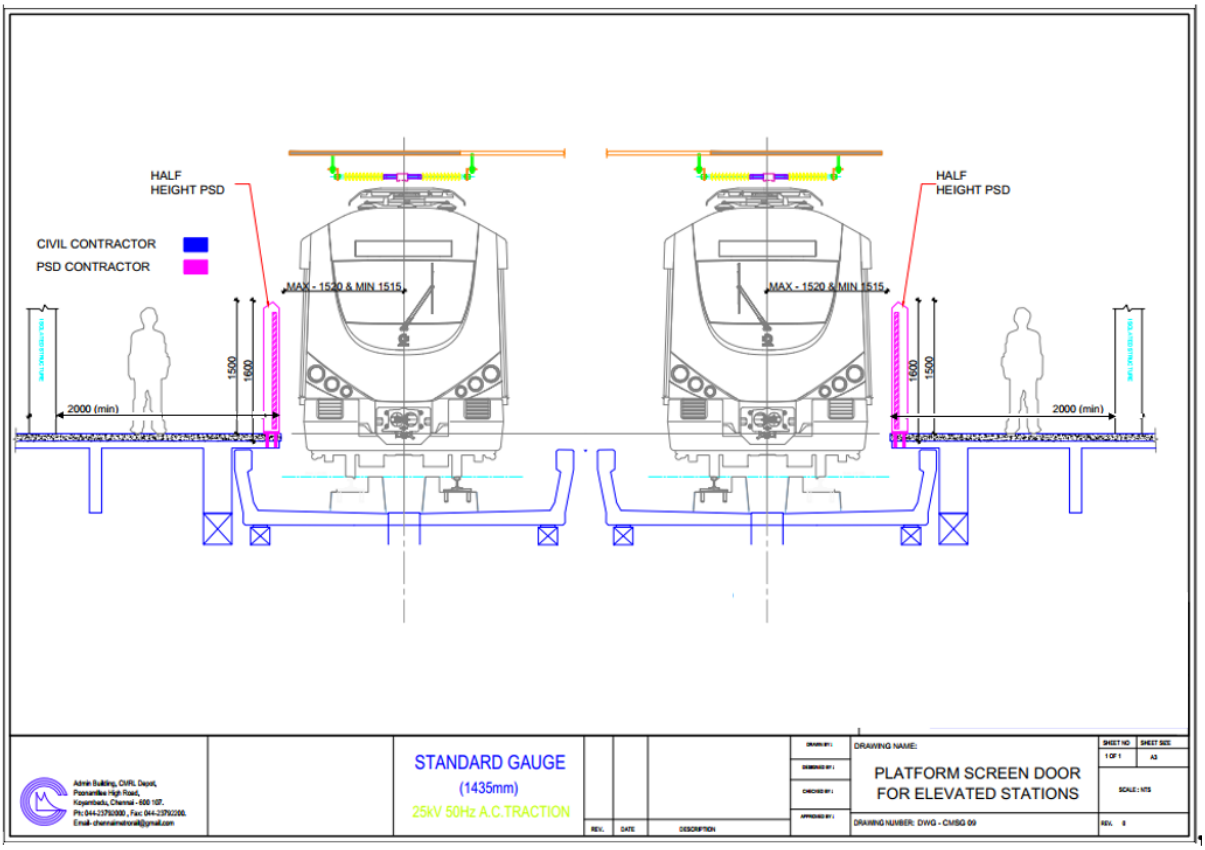


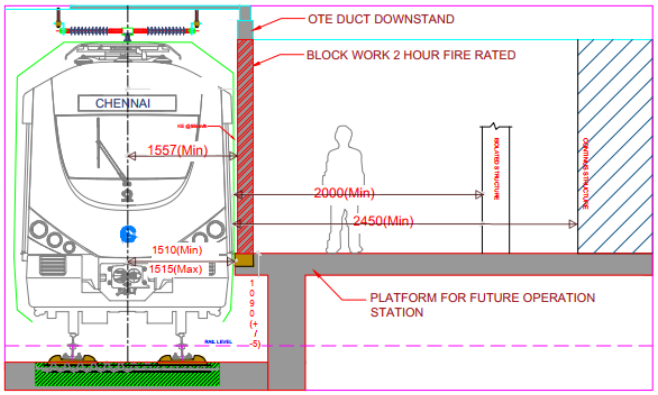
CHENNAI METRO RAIL LIMITED,

Metro Towers, No.7, Conran Smith Road,
Gopalapuram, Chennai, Tamil Nadu-600 086.
Ph: +91 - 44 - 2540 0820
Fax: +91 - 44 - 2833 1401
E-mail: chennaimetrorail@gmail.com

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

GENERAL NOTES





NOTES:

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

APPENDIX 2P

LIST OF INTERFACE APPENDICES

1	Appendix 2P-1	Interface protocol between Rolling stock and Platform Screen Doors (PSD) System
2	Appendix 2P-2	Interface protocol between Signalling and Train Control system (S&TC) and Platform Screen Doors (PSD) system
3	Appendix 2P-4A	Interface protocol between Civil (UG) and Platform Screen Doors (PSD) system (Full Height)
4	Appendix 2P-4B	Interface protocol between Civil (Elevated) and Platform Screen Doors (PSD) system (Half Height)
5	Appendix 2P-5	Interface protocol between Track and Platform Screen Doors (PSD) system
6	Appendix 2P-6A	Interface protocol between MEP(UG) and Platform Screen Doors (PSD) system (Full Height)
7	Appendix 2P-6B	Interface protocol between MEP (Elevated) and Platform Screen Doors (PSD) system (Half Height)
8	Appendix 2P-7	Interface protocol between VAC and Platform Screen Doors (PSD) system (Full Height)
9	Appendix 2P-8	Interface protocol between TVS and Platform Screen Doors (PSD) system (Full Height)

Appendix 2P-1

Interface protocol between Rolling stock and Platform Screen Doors (PSD) System

Rolling stock- Platform Screen Doors (PSD) CONTRACTS:

1 INTRODUCTION

1.1 General

1.1.1 This section describes the interface requirements between Rolling Stock (RS) Contract and **Platform Screen Doors** (PSD) Contractor.

1.1.2 The **Platform Screen Doors** (PSD) system will be awarded as a separate multiple contracts for in all the three corridors of Phase 2 and in-between the corridors as inter-corridor operation. There will be a four PSD contracts and three Rolling stock contracts for the complete Phase 2. The Contractor shall interface accordingly with all the PSD and all the RS contractors of Phase 2.

1.1.3 The contractors shall ensure that all the requirements of the Metro Railway General Rules 2020 are duly met by incorporating appropriate alarms, remote commands and other features.

1.1.4 The Contractors as above shall ensure that all requirements of the Specification pertaining to interfaces are properly satisfied.

1.1.5 All Interface Meetings, unless specifically approved by CMRL shall be held at CMRL site and they shall be given sufficient notice to attend the meeting.

1.1.6 Each contractor shall be responsible for interface identification, establishment, construction and testing works either in the capacity as the Lead Contractor or Participating Contractor.

1.1.7 The requirements specified herein are by no means exhaustive and it remains the responsibility of the Contractors to develop and execute an interface plan during execution of the work to ensure that:

a) All interface issues between the different contracts are satisfactorily resolved

b) Supply, installation and testing of equipment and software are fully co-ordinated

c) All equipment supplied in the contract are fully compatible with each other

d) UTO mode of operation, Non UTO modes of operation and all other degraded mode of operation shall be achieved with all its inherent features in the mainline and in all depots of CMRL Phase 2.

e) All the system tolerances at the interface shall meet the requirements of the respective specifications relating to the interface points

f) Interface contractors shall mutually respect each other's project timelines with respect to the interface requirements.

g) Interface contractors shall finalize their respective interface equipment only after clear agreement on interface requirements with the other designated contractors.

h) Interface contractors shall ensure that in any case, no equipment of their system shall be put into production or installation without meeting the interface

requirements spelt out in this Appendix or in the Technical Specification of respective contracts.

i) Test procedures, troubleshooting manuals and any other documentation shall be updated with technical details from of each contractor and shall be submitted to CMRL

1.1.8 The trains shall be designed, tested and commissioned such that they will be operated in UTO mode from the initial stage of passenger service. Hence, there is no dedicated operator cabins in the train.

1.1.9 UTO mode of operation and other Non-UTO modes shall be achieved by all designated contractors right after the commissioning of train by the Rolling Stock contractor.

1.1.10 All the trains of the CMRL phase 2 project shall be capable of being operated within specifically the sections of Corridor 3, Corridor 4 and Corridor 5 and also inter-operable between Corridor 3, Corridor 4 and Corridor 5 of CMRL Phase 2 project. The trains shall be capable of operating in Bi-directional way during passenger services & during commissioning in all these corridors, in the related depots and other related lines. All the systems and Interface contractors shall design their equipment for the same.

1.2 Interface Management

1.2.1 RS Contractor shall be the Lead Contractor. The Lead Contractor will be responsible to initiate, plan, coordinate and produce jointly with the Participating Contractors all the required interfaces and interface design documents and interface progress reports for submission to CMRL for acceptance. The Lead Contractor will also prepare and issue all interface meeting of minutes after incorporating PSD Contractors comments within 3 days of the meeting and provide bi-weekly interface progress reports to all the participating contractors for information. Later, forwarding of issued minutes of meeting and bi-weekly interface progress reports to concerned Contractors shall be lead contractor’s responsibility.

1.2.2 PSD contractor will be the participating contractor. The Participating Contractors shall collaborate fully with the Lead Contractor in the development and finalization of the interface design, joint production of the interface documents and interface progress reports.

1.2.3 All the participating contractors shall ensure that copy of the Interface design documents submitted to CMRL.

1.2.4 The costs for all interface design and testing works shall be deemed to be included in the Contract sum of respective contracts regardless of the actual extent of effort required or expended by the Contractor.

1.2.5 The Contractors shall be fully responsible for the management and control of his subcontractors in relation to all interfacing activities carried out under the Contract.

1.2.6 The interface design currently shall be functional for 3 car configuration train. The system capability, interface design, the Input output points, command buttons, Data communication telegram fields, Communication network bandwidth designs etc shall be

designed with a provision for extending the car configuration from 3 car to 6 car with minimum changes. The details of the future three additional cars of the 6 Car configuration shall also be incorporated in the initial design.

The rake formation shall generally be as follows:

3-Car rake: DMC+TC+DMC (67% Traction power)

Future 6-car rakes will have the following configuration:

6-car rake: DMC+TC+MC + MC+TC+DMC (67% traction power)

1.2.7 The PSD Contractor shall provide necessary support and modifications in their system, to resolve all pending or new interface related issues arising during the operation of the trains till completion of RS Contractor defect Notification period. RS Contractor shall provide necessary support and modifications in their system, to resolve all pending or new interface related issues arising during the operation of trains till completion of PSD Contractor's defect liability/Notification period for the respective corridors of the CMRL Phase 2.

1.2.8 Both RS and PSD contractors shall ensure that complete and detailed logs of the signals exchanged regarding this interface shall be retrievable on demand for diagnostics from the OCC, BCC and DCC control panels.

1.2.9 Where-ever requirements of OCC are mentioned in this chapter, the same shall mean to be implemented for both Operations Control Center (OCC) and Backup Control Center (BCC) for the respective corridor.

1.2.10 STC Contractor shall prepare a comprehensive Operating Modes and Principle Document (OMPD). RS, PSD and TETRA, Telecommunication Contractors will provide required inputs to the STC Contractor in preparation of the document. The traction contractors and Tunnel Ventilation Contractors will also assist STC Contractor in preparation of the documents. CMRL will provide necessary inputs such as standard operating procedure. The document shall establish the principles related to system and interface design under normal, degraded and emergency modes of operation. For each operating principle, the document shall describe the scenario, action to be taken by operator and system in a structured process flow chart. The additional requirement generated while preparing OMPD document shall be treated as the requirement within the contract without any cost implication.

1.2.11 PSD Contractor and the RS contractor shall prepare a joint compliance matrix for this interface specification which includes the relevant clauses of the Metro Railway General Rules 2020, especially in UTO operation related and submit to CMRL for review.

1.3 Train Operating Modes

General System Description

1.3.1 The train-borne Automatic Train Control (ATC) system will consist of Unattended Train Operation (UTO), Driverless train operation (DTO), Automatic Train Operation (ATO) system and Automatic Train Protection (ATP), RM, ROS, Cut out.

1.3.2 Rolling Stock will be fitted with all ATP, ATO, UTO system. The UTO system will conform up-to Grade of Automation 4 (GoA4) as defined in IEC 62290-1.

1.4 Requirement of standardisation of certain aspects of rolling stock related to PSD interface to enable inter-operability with PSDs among ARE-02, ARE-03 and ARE-04 (non-exhaustive list).

1.4.1 The exterior layout of the three rolling stocks shall be the same for the following characteristics

a) Rake's inter-door distances of any two corresponding doors of all rolling stocks shall be the same. (centre to centre distance)

b) The width of the doors (1400 mm or the value mentioned in RS contract)

c) The location of Emergency Egress Device (EED), Emergency Ingress Device, Crew switch and parking brake release lever

1.4.2 The width of the rolling stock car (at the passenger floor level) in static condition, in the passenger door area, shall be same for all the three types of Rolling stocks of Phase 2.

1.4.3 The door numbering strategy of all the three types of Rolling stock of Phase 2 shall be maintained the same for all PSD related communication telegrams with Signalling.

1.4.4 The Operator Keys related to RS doors (that for opening the RS door from inside or outside mechanically and that for isolation of the train door) shall be the same for all the three types of Rolling stocks of Phase 2

1.5 Interface Requirements

1.5.1 RS contractor shall provide KE and door drawings (door position, width & pitch) of train to PSD contractor for placement of Platform Screen Doors and shall share the location of Emergency Egress Device (EED)/ Emergency Ingress Device, Crew switch and parking brake release lever with the PSD Contractor and also share their operating mechanism. The access for these equipments with respect to the PSD shall be analysed and agreed upon by both the contractors in view of the stopping accuracy band of ±300mm.

1.5.2 The rolling stock contractor shall share the details of the Operator key/keys of the rolling stock for door opening, from outside and inside and for manual door isolation. The details shall include the profile of the key, available manufacturers, License/ approval for the manufacturing or procurement of the particular keys etc. The details shall be adequate and shall authorise the PSD contractor to manufacture or procure the key in a rightful legal manner for usage in CMRL PSD system. PSD contractor shall procure/manufacture the key and use in PSD system, so that Operators can use the same set of key for similar functionalities in RS door and PSD door. Necessary approval shall be taken from CMRL before the procuring/ manufacturing.

1.5.3 Signalling system shall be the medium between RS system & PSD system for electronic command/status signals. Both RS & PSD Contractors shall provide necessary signals to the STC Contractor for proper functioning.

1.5.4 RS and PSD contractor shall prepare the numbering scheme of the RS doors and PSD doors respectively for the door specific information communication through Signalling system. The numbering shall be independent of the car identifier number/alphabet and shall be in a manner that irrespective of the direction of travel, the number which points to a particular door does not change.

1.5.5 The train passenger door matching with the corresponding Platform screen doors shall be designed for future 6 car train from the initial design stage itself. Adequate precaution shall be taken to identify the numbering the doors in sequence to match the PSD doors when the platform active cab change is done. Similarly, the details of the future three additional cars of the 6 Car configuration shall also be incorporated in the initial design.

1.5.6 RS and PSD Contractors shall exchange the defective/Isolated train door and PSD door information, through signalling system so that if a particular train door is defective/isolated, the corresponding PSD shall not open and vice versa. The function shall include both Audio and visual in their respective panels to facilitate passengers.

1.5.7 Not Used.

1.5.8 **Door synchronization:**

The doors of the PSD and the RS shall synchronize, in the very similar manner, while opening and closing, irrespective of the combination of suppliers of PSD (four suppliers in Phase 2) or RS (three suppliers in Phase 2). All the PSD suppliers and the Rolling stock suppliers shall arrive at the synchronization parameters (transmission timing, processing time, delays etc) to ensure the same. The synchronization timings shall be validated in the CMRL test track to ensure similar behaviour for any combination of RS and PSD contractors. The timing diagram from STC contractor shall also be considered for the calculation.

1.5.9 The design of the passenger door control system shall ensure that the train passenger doors open before the PSDs open and PSD doors close before closure of train passenger doors. The operation of the “Door Close” pushbutton/ door close command from UTO/ATO shall broadcast an audible warning in each saloon, signifying that both the PSD doors and passenger doors shall subsequently close.

1.5.10 After the pre-set time, adjustable between 0 and 5 seconds, following the finish of the audible warning, the control system shall synchronously “Close and Latch” all the passenger doors and PSD on the corresponding side. The design of the passenger door control system shall ensure that the PSD doors close before the train passenger doors close.

1.6 Integrated Testing and Commissioning:

1.6.1 RS, STC, Telecom TETRA and PSD contractors shall jointly setup an integrated test bed at CMRL premise to arrange for the integration testing of various subsystems, as a

minimum but not limited to ATS, ATO, on-board CCTV management system by signalling contractor, On-board passenger information system, on-board driver display units, TCMS, On-board NVR, RTR-DMS by RS contractors, station passenger information systems etc of the Telecom contractors, SCADA of PSD systems. The test bed shall have provision for testing the actual softwares over the actual hardware. Necessary train running mimicking simulator shall be provided by the SIG contractor to simulate a train running. RS contractors shall provide necessary simulators to simulate various failure and operational scenarios in the TCMS pertaining to the Interface data.

1.6.2 This integrated test bed shall be designed in a manner that it mimics the real-world test scenario.

1.6.3 This test bed can share the hardware from the hardware test bed, if envisaged in respective contracts. The tests for vital interface tests and the tests pertaining to the driving parameters of the train or ATO are excluded from this test bed scope.

1.6.4 This test bed shall be used for the initial preliminary type tests of the interface, regression tests, software tests after modifications, preliminary interface tests pertaining to stage integration etc. This test bed shall not completely replace the original testing using the train.

1.6.5 RS, STC, Telecom -TETRA & PSD Contractors shall perform Joint Integration Test and tests shall include but not limited to traction and braking control, precision stopping, turn back, jog function, door operation, PSD, train wake up and PA/PIS functioning test, remote command & control for Rolling Stock monitoring & troubleshooting from OCC to train and safety related test etc. All contractors shall jointly produce a protocol document for Integrated Testing and Commissioning.

1.6.6 Integrated testing of each train shall comply with the accepted international standards agreed between the Contractors and agreed with the CMRL.

1.6.7 Joint Integration testing specific to each train shall be done at the rolling stock factory, depot and main line of CMRL to ensure satisfactory performance of all train control, STC, telecom - TETRA and PSD interfaces.

1.6.8 This Joint Integration tests subsequently shall be signed-off jointly by the Rolling Stock, Signaling & Train Control, Telecom-TETRA and PSD Contractors.

1.6.9 For UTO and other non-UTO modes of operation, the Joint Integration test between the Rolling Stock, Signaling & Train Control, Telecommunications and PSD Contractors shall include tests on mainline to confirm below minimum features:

a) realization of demanded acceleration rate, deceleration rate, Jerk in all UTO and non-UTO modes of operation,

b) train stopping accuracy in stations, wet rail conditions/adhesion levels

c) synchronization with PSDs,

d) automatic train operation with all the train controls from OCC/DCC,

e) Train RTR-DMS data transmission to OCC server and display of fault information at OCC and Depot controller console

f) Verification of alarms and other vital information transmission from train to OCC and vice versa.

g) Passenger to OCC communication and vice versa

h) Train radio verification

i) Automatic route related passenger announcements in train

j) Pre-recorded and manual announcement from OCC

k) Streaming of CCTV videos of train in OCC & DCC.

l) Any other tests necessitated by the technical specification of the interfacing contractors.

RS contractor shall highlight any other required interface testing in the test plan.

1.6.10 All the above requirements shall be tested in all the sections of Corridor 3, corridor 4 and corridor 5 and their extensions if any.

1.6.11 UTO shall be the predominant mode of operations. Contractor shall develop and submit the detailed scheme for tests (in addition to the tests mentioned in Appendix C required to be done for the safe and reliable operation in UTO mode. Contractor shall successfully conduct these tests. CMRL shall witness these tests.

1.6.12 These above tests mentioned shall be completed before the start of the Rolling Stock Burn-in trials for each train individually.

1.7 INTERFACE- Division of Responsibility

RS Contractor shall coordinate with PSD Contractors in order to achieve the functional and operational requirements of the system. The roles and activities of the Contractors shall broadly include minimum but not limited to those mentioned in table below. Apart from the below table, RS and PSD contractors shall also adhere to all the requirements of Appendix C and their referred sub-clauses of ERTS mentioned in this Appendix C.

S.No.	***Item***	***PSD Contractor***	***RS Contractor***
1	Kinematic envelope, height of train floor (in unloaded and fully loaded condition) and car width of RS SoD document shall be complied.	PSD contractor shall design the PSD taking this into account.	RS contractor shall furnish the KE details at platforms and the car width details to the PSD contractor.
2	The PSD façade layout	PSD contractor shall design the PSD taking this into account.	RS contractor shall provide the general arrangement drawing of RS exterior which indicates, the door widths, inter door distances, train door widths, its pitch, location of Emergency Egress Device (EED)/Emergency ingress device, crew switch, and parking brake release lever
3	The Operator Key details related to doors.	PSD contractor shall use the key profile provided by the RS contractor in PSD for similar functions comparing to RS doors.	RS contractor shall provide the Lock & key details, Lock & key licences, authorization for the PSD contractor to procure/manufacture the key and lock with same profile for PSD
4	The PSD and RS Door numbering scheme	RS and PSD contractor shall agree on the door numbering scheme of PSD and RS. All the door inhibition/obstruction telegrams through Signalling system shall follow this scheme.	RS and PSD contractor shall agree on the door numbering scheme of PSD and RS. All the door inhibition/obstruction telegrams through Signalling system shall follow this scheme.
5	Door synchronization	RS and PSD contractor shall assess the processing time, transmission time, polling cycle etc and estimate the system delay in the door operation actuation (duly taking input from STC contractor) and synchronize the doors	RS and PSD contractor shall assess the processing time, transmission time, polling cycle etc and estimate the system delay in the door operation actuation (duly taking input from STC contractor) and synchronize the doors

6	Joint test protocols for testing of the interface	Shall support RS contractor for the preparation of test documents.	Shall prepare the tests incorporating PSD contractor inputs
7	Any other requirements from Employer - Technical Specification. (for RS PSD & STC, as many interfaces are through signalling system)	RS contractor shall ensure all the interface requirements pertaining to PSD Contractor are shared and agreed mutually.	PSD contractor shall ensure all the interface requirements pertaining to RS Contractor are shared and agreed mutually.
8	Detailed Interface document (DID)	PSD contractor shall provide the necessary information as requested by RS contractor.	RS contractor shall prepare DID and shall ensure that it covers Design, Interface Hazard log, Construction, Testing & Commissioning, Test report formats, Maintenance, etc.,
9	Stopping Accuracy	PSD contractor shall open the door according to the train stopping accuracy. PSD contractor shall ensure that when doors are opened, it shall be minimum of 1400mm.	RS Contractor shall ensure that the train stops within ±300mm of station stopping point. This information shall be share to PSD contractor.

Appendix-2P2

Interface protocol between Signalling and Train Control system (S&TC) and Platform Screen Doors (PSD) system

Appendix 2P-2

Interface protocol between Signalling and Train Control system (S&TC)

and Platform Screen Doors (PSD) system

1 INTRODUCTION

1.1 General

1.1.1 This specification covers the interface requirements between Signalling & Train Control Contract ASA-04 and Platform Screen Doors Contract(s).

1.1.2 This document shall be read in conjunction with the relevant paragraphs of the General Specification. The Contractors shall ensure all requirements of the General Specification and PS pertaining to interfaces are fully resolved and implemented.

1.1.3 In the event of a conflict between any provisions of the respective Particular Specification and this specification, the requirements of this Interface Specification shall prevail.

2 Interface Responsibilities

2.1.1 The responsibility for specification and provision of the requirements for the works that interface with Designated Contractors' equipment are tabulated in corresponding section of the document.

2.1.2 The requirements specified herein are by no means exhaustive and it remains the Contractors responsibilities to develop and execute jointly an Interface Plan after the commencement of the works and throughout the execution of works, to ensure that:

a) All interfacing issues between the two Contracts are satisfactorily resolved.

b) Supply, installation and testing of equipment and software are fully co-ordinated.

c) That all equipment supplied under the Contracts is fully compatible with each other, whilst meeting the requirements of the respective Specifications.

d) All the construction tolerances at the interface shall meet the requirements of the respective specifications relating to the interface points

e) Interface contractors shall mutually respect each other's project timelines with respect to the interface requirements.

f) Interface contractors shall finalize their respective interface equipment only after clear agreement on interface requirements with the other designated contractors.

g) Interface contractors shall ensure that in any case, no equipment of their system shall be put into production or installation without meeting the interface requirements spelt out in this Appendix or in the Technical Specification.

h) Test procedures, troubleshooting manuals and any other documentation shall be updated with technical details from each contractor and shall be submitted to CMRL

3 Interface Management

3.1.1 Signalling and Train Control Contractor shall be the Lead Contractor. The Lead Contractor shall be responsible to initiate, plan, coordinate and produce jointly with the Participating Contractors all the required interfaces and interface design documents and interface progress reports for submission to The Engineer/ CMRL for acceptance. The Lead Contractor shall also prepare and issue all interface meeting of minutes within 3 days of the meeting and provide bi-weekly interface progress reports to all the participating contractors for information. Later, forwarding of issued minutes of meeting and bi-weekly interface progress reports to concerned Contractors shall be lead contractor's responsibility.

3.1.2 PSD contractor(s) shall be the participating contractor. The Participating Contractors shall collaborate fully with the Lead Contractor in the development and finalization of the interface design, joint production of the interface documents and interface progress reports.

3.1.3 All the participating contractors shall ensure that copy of the Interface design documents are submitted to the Engineer/CMRL.

3.1.4 The costs for all interface design and testing works shall be deemed to be included in the Contract sum of respective contracts regardless of the actual extent of effort required or expended by the Contractor.

3.1.5 The Contractors shall be fully responsible for the management and control of their respective subcontractors in relation to all interfacing activities carried out under the Contract.

3.1.6 Where-ever requirements of OCC are mentioned in this chapter, the same shall mean to be implemented for both Operations Control Centre (OCC) and Backup Control centre (BOCC).

3.1.7 STC Contractor and the PSD contractor(s) shall prepare a joint compliance matrix for this interface specification and relevant clauses of the Metro Railway General Rules 2020, EN 62290-1,2 especially that of UTO operation (GoA 4 operation) related and submit to CMRL for review.

4 Interface Requirements

4.1.1 STC Contractor shall prepare a comprehensive Operating Modes and Principle Document (OMPD). RS, PSD and TETRA, Telecommunication Contractors will provide required inputs to the STC Contractor in preparation of the document. The PS/OHE contractors and Tunnel Ventilation Contractors will also assist STC Contractor in preparation of the documents. CMRL will provide necessary inputs such as standard operating procedure. The document shall establish the principles related to system and interface design under normal, degraded and emergency modes of operation. For each operating principle, the document shall describe the scenario, action to be taken by operator and system in a

structured process flow chart. The additional requirement generated while preparing OMPD document shall be treated as the requirement within the contract without any cost implication.

4.1.2 Any single point failure in equipments, relays or communication/cable links in the interface shall not cause any effect on the proper functioning of this Interface.

4.1.3 Both the contractors shall ensure that the equipments and the associated devices are immune to EMI/RFI and do not cause any EMI/RFI issues to the other system.

4.1.4 **Signalling-PSD Interface to support RS- PSD Interface:** All the functional interfaces between the Rolling stock and PSD is through Signalling system. The signalling system shall interface with the PSD system and the Rolling stock system to implement all these interfaces. The interface document between Rolling stock and PSD is described in Appendix 2P-1.

4.1.5 **PSD Open Close commands- Functional details:** The PSD Open and close commands shall be from three sources.

- From the train, after it stopped within the prescribed stopping position
- From the Operator, as a command from the ATS workstation.
- From the Operator, as a command from the Manual Control Panel (MCP) of PSD.

4.1.6 In all the above scenarios, the Interface shall be devised that

- Proper door synchronization is ensured.
- Proper safety is ensured for vital commands.
- All door inhibition commands are respected.

4.1.7 **PSD control from Train**: Once the train stops in the prescribed stopping window (docked), and the on-board ATC provides door authorization for the train doors, train doors and PSDs can be opened and closed by the Train Operator (in manual mode) or the ATO/UTO equipment of the train borne signalling in a synchronized manner. This facility shall be functional even when the ATS system is in failed/non-functional condition. The performance requirements (transmission time, Operation time etc) specified in the respective particular specifications shall be adhered to.

4.1.8 **PSD control from ATS**: The operator shall be provided with facilities in the ATS workstation at OCC, BOCC and SCR for Opening and closing the doors of the PSD and the Train doors in a synchronized manner. The stoppage of a train in the stopping window and door authorization by the train borne signalling shall be ensured as a precondition for enabling this control. This control will be useful if the direct communication from the train borne to PSD system fails or when the Operator requires to open and close the Train doors and PSD to meet any operational requirements.

4.1.9 **PSD (and train door) control from Manual Control Panel**: The operator shall be provided with facilities in the Manual control Panel at Platform for Opening and closing the doors of the PSD and the Train doors in a synchronized manner. Manual control panel can be used for Opening and closing PSDs irrespective of availability of correct docking of the train, on that platform. But whenever the train is in the docked condition with door

authorization from the train borne ATC, If MCP is operated, the train doors also shall get operated synchronously with PSD.

4.1.10 **Staff Access Passenger Door (SAPD) Opening from ATS**: The first and the last door of a train (on both sides) are assigned as Staff Access Passenger Door to access the interior of the train. Operator shall be provided with facility in ATS from OCC/BOCC or SCR to open and close one or more Staff Access passenger door of a train. Whenever a Staff Access passenger door is Opened, the corresponding PSD also shall Open (only the corresponding doorway) if the train is physically in the prescribed stopping position on a platform.

4.1.11 The contractors shall prepare a detailed functional interface description for door Open and close functions with all overlapping and conflicting scenarios and submit to the Engineer for NoNO.

4.1.12 **PSD and Train Door numbering:** All communication telegrams between Signalling system & Rolling stock as well as communication telegrams between Signalling system & PSD system shall be based on fixed numbering of train and PSD doors. The door numbers shall not change based on the direction of travel and the active cab details.

4.1.13 All the communication telegrams shall be provided with fields corresponding to 6-car trains. Based on the relative position of the 3-car PSD on the 6 car platform, the beginning and the sequence of the numbering shall be identified.

4.1.14 **PSD - Train door inhibition function:** Whenever a PSD door or a train door is 'unavailable' the corresponding door of the PSD or train also needs to be inhibited. The unavailability of a door can be because of any fault causing non-operation of a particular doorway which causes inhibition from the system or is isolated by the Operator using the Operator key or is inhibited by the Operator from the ATS or TCMS system.

4.1.15 **PSD to Train information**: The inhibition information to train doors corresponding to a particular platform shall be communicated immediately once the train leaves the previous platform. Any change in the status of PSD doors to train, including change of platform, if any, shall be updated on real time basis.

4.1.16 **Train to PSD information**: The inhibition information to PSDs corresponding to the train doors shall be communicated for the next approaching train. Any change in the status of train doors, including change in approaching train ID, shall be updated to the PSD system on real time basis.

4.1.17 The operator shall be provided facility in ATS to inhibit or override an already inhibited door (PSD or train door) with no restriction on time or location of train. The information to the corresponding door of the other system (PSD or train door system) shall be communicated immediately after these operator interventions.

4.1.18 The system shall be capable of handling the ATS triggered inhibition to match the door opening strategy of the timetable as per the provisions for the operator in the timetable editor.

4.1.19 Any operator intervention to reroute the trains or re-sequence the trains, the train doors and PSDs shall be provided with updated information on real time basis.

4.1.20 All the information on door inhibition, if triggered on any platform, shall be communicated to the on-board passenger information systems as well as station passenger information systems appropriately.

4.1.21 **Vital communication (SIL 4 system related) between Signalling and PSD:** Some of the communications shall be safety rated between the signalling system and the PSD system. Door Open enable for two type (3 car & 6 car) configurations from signalling, all doors closed and locked signal, Interlock override signal from PSD to be communicated vitally and in a very safe manner.

4.1.22 Not used

4.1.23 All vital communication shall follow the fail-safe principles, including double cutting, where applicable.

4.1.24 All vital communication shall be interfaced through potential free relay contacts. Multiple relays shall be used for ensuring safety and integrity of the communication. Adequate redundancy shall be built into to avoid failure of the interface owing to any single interfacing relay failure.

4.1.25 The signalling system contractor shall design the interface and advise the PSD contractor(s) to follow. The design shall be standardized for all types of PSD.

4.1.26 Door Open enable for 3 car and balance 3 car (for 6 car operation) shall be separate circuit with separate sets of Interfacing relays. Currently only the 3-car circuit will be wired by the PSD contractor(s). The balance 3 car area will be installed with same or different PSD make in future. In the Signalling system, wiring shall be done for both circuits to meet both 3 car and 6 car operation concurrently. The balance 3 car circuit shall be inhibited in software or hardware till 6 car operation starts in future.

4.1.27 Opening of PSD by the train and by the operator through ATS shall require the door open enable signal. The opening of PSD from the Manual control panel shall not require the enable signal from Signalling as the MCP opening of PSD is an internal feature of PSD.

4.1.28 The open enable signals shall be provided by the SIL 4 vital safety systems of Signalling duly for appropriate car configuration of the train, ensuring the docking of train in the prescribed stopping window.

4.1.29 "All doors closed and locked" (ADCL) signal shall be continuously provided by the PSD system as a vital signal communicating all doors including the sliding doors, emergency egress doors and manual secondary doors (track access doors) as closed and locked.

4.1.30 "All doors closed and locked" signal shall be different for 3 car PSD area and for the Balance 3 car area. The circuit and relays for supporting 3 car operation and Balance 3 car area (for 6 car operation) shall be segregated. Currently, only the 3 car PSD will be operational. The future circuit for Balance 3 car area (supporting 6 car) shall be wired in Signalling system but disabled in the software or hardware.

4.1.31 "All Doors closed and Locked" for each Manual secondary door shall be separate ADCL from the normal ADCL of a PSD. The ADCL for manual secondary door shall be independent for each MSD, to be interlocked with the respective Staff Protection Key of Signaling.

4.1.32 "All door closed and locked" signals from PSD system shall be read by the SIL 4 vital safety systems of Signalling and shall be processed for the starting of train from the platform.

4.1.33 The "Interlock override" signal from the PSD system shall be read by the SIL 4 vital safety systems of Signalling.

4.1.34 The Local door override signal can be created by PSD system when the Operator places any one or more doors (sliding door) in the override position. The overridden door will bridge all doors closed and locked signal for that particular sliding door but shall also provide the local door override signal to the signalling system.

4.1.35 The Interlock override signal can also be provided by the PSD system when the operator triggers the override signal from the MCP using a non-latching, self-normalising rotatory switch. Accordingly, the Signalling system will impose a speed limit of 20 kmph, for trains being received on the Platform, using the interlock over-ride feature.

4.1.36 When the All doors closed and locked signal is not available, the signalling system shall stop the trains at the approach to the stations or in platform area. When the interlock override signal is available ,along with all doors closed and locked, system shall generate a Temporary speed restriction of 20 kmph. The following table explains the scenario;

All doors closed and locked Signal	**Local door override Signal (from LCP)**	**Interlock Override Signal (from MCP)**	**Signalling behaviour**	**Remarks**
Yes	No	-	Full speed for trains	NO failure condition
No	No	-	Stop train	A failure/ obstruction/ opening occurred
Yes	Yes	-	20 kmph TSR with audible warning	Failure but Operator intervention done.
No	Yes	-	Stop train	A second failure/ obstruction/ opening occurred after first failure intervened by operator.
No	-	Yes	20 kmph TSR with audible warning	Failure but Operator intervention done.
No	-	No	Stop train	A failure/ obstruction/ opening occurred

4.1.37 Based on the system design, interface design, and safety case, the contractors shall propose to increase or decrease the vital information to be transferred as a part of this Interface. Such proposals shall be submitted to the Engineer for NoNO before commencement of implementation works.

4.1.38 **Door Open and Close command (Signalling to PSD):** The Open and close command from Signalling to PSD shall be separate.

4.1.39 The communication between signalling and PSD systems for Door Open and Door close shall be based on electrical signals exchange using potential free relays (with sufficient

double cutting and redundancies) as proposed by the Signalling contractor. The Open and close commands shall comply to minimum SIL 3 requirements.

4.1.40 The door Open/close command for the Staff Access Passenger Door (SAPD) shall be separate from that of the complete platform door Open. For a platform, the Open/close circuity shall cater for as a minimum to

- 3 car Open/Close circuit
- Balance 3 car Open/close circuit
- SAPD 1 Open/close circuit
- SAPD 2 Open/Close circuit
- SAPD 3 Open/close circuit (For 6 car Operation)
- SAPD 4 Open/close circuit (For 6 car Operation)

4.1.41 **(a) Communication between Signalling (ATS) and PSD systems:** The protocol for the exchange of information between Signalling and PSD system including door inhibition details and status/alarms of various parts of PSD, including the description of various fields and their contents will be proposed by signalling contractor which the PSD contractor has to follow. The complete details to be finalised through the interface forum.

4.1.41 (**b)** The inhibition signals shall be communicated between Signalling and PSD systems in agreed manner. Whenever a status change occurs for PSD doors or train doors the information shall be re-sent to the Train or PSD system by the Signalling system on a real time basis as mentioned in relevant paragraphs of this document.

4.1.42 The open/close status of each door shall be communicated to the Signalling system by the PSD system. This shall include all the sliding doors, Emergency doors and all manual secondary doors (track access doors). The ATS shall suitably display the information in a layout in the ATS screen which the Operator can select and see in OCC and SCR as a openable window. The information shall address to each door so that the Operator is able to identify the precise number and location of the Open or close door. The communication shall independently address each sliding door, each emergency door and each manual secondary door. The overall status summary shall be indicated in the Line overview of the ATS itself.

4.1.43 Health status of each doors, driving mechanisms, and other critical status shall be communicated to the Signalling system by PSD systems. All the health-related alarms from the PSD system shall be suitably displayed in the ATS system. Any pre-failure alarms from PSD (over current detection of any motors etc), if any, shall also be displayed in the ATS system for the Operator.

4.1.44 The unauthorized opening of sliding doors, Emergency doors and manuals secondary doors shall be appropriately prioritised in the ATS alarm list.

4.1.45 Door obstruction information shall be communicated by the PSD system to the Signalling system. Signalling system shall use this information for appropriate display in the ATS system, and to provide trigger to CCTV system for auto pop-up of video stream.

4.1.46 **Door synchronization of train Doors and PSD doors:** The doors of the PSD and the train shall synchronize on a predefined manner, while opening and closing, irrespective of the combination of suppliers of PSD contractors or Rolling Stocks (three in

Phase 2). All the PSD suppliers and the Rolling stock suppliers shall arrive at the synchronization parameters (actual transmission timing, processing time, delays etc) to ensure the same. The synchronization timings shall be validated in the CMRL test track to ensure similar behaviour for any combination of RS and PSD contractors. The timing diagram from STC contractor is also part of this interface. The Signalling contractor shall coordinate for this synchronization as the common link between all RS and PSD suppliers.

4.1.47 **Failure modes affecting the PSD-Signalling Interface:** In the case of ATS failure, the functioning of Signalling PSD interface shall work which includes opening and closing of the PSD doors, except the Door Open/Close command from ATS and the door inhibition functions. At the time of ATS failure inhibitions applied on any door because of the failure of any RS doors shall be released.

4.1.48 In the case of ATS failure, if the train is docked and door authorisation is available from the on-board ATC, the synchronous opening and closing of train doors and PSD doors by ATC or by the Operator from the MCP shall function.

4.1.49 Any single point failure in Interlocking or ATC shall NOT cause any effect on the proper functioning of all interface functionalities.

4.1.50 **The Actuation time for various critical signals:** Signalling system shall ensure that PSD related commands in ATP, ATO, DTO and UTO mode shall be transferred between On-board ATC or Interlocking to PSD directly or by faster route so that response time from instance of giving command from on-board ATC to reach the PSD system shall be less than 1000 milli seconds.

4.1.51 The PSD system shall ensure that once the command from the Signalling is received, the PSD door opening shall start within 500 milli seconds.

4.1.52 PSD system shall ensure that once the PSD doors are closed and locked, the All Doors Closed and Locked Signal shall be provided to Signalling within 300 milli seconds.

4.1.53 Once the All Doors closed and locked signal is received from the PSD system, the Signalling shall not take more than 300 milli second to initiate the command for the movement of the train, if all other departure conditions are met.

4.1.54 **Workstations at OCC, BOCC:** The PSD contactor shall provide the details of the PSD remote diagnostics workstation in OCC and BOCC. The signalling contractor shall incorporate the same in the layout, console design and ergonomic study and provide network.

4.1.55 **PSD Interface panel:** The signalling contractor shall design, procure, install and commission the PSD interfacing panel at the PSD equipment room. The Signalling contractor shall do the wiring of this cabinet from the signalling system till the Interfacing relays and the communication ports. The PSD contractor shall do the wiring from the Interfacing relays and the communication ports to their control systems.

4.1.56 This panel shall have communication ports and relay interfaces for all vital and non-vital communication of Signalling system with PSD systems. The vital and non-vital circuits shall be completely segregated internally.

4.1.57 **Physical Key Interlocking- Manual Secondary Door:** The manual secondary doors shall have special locks to open from the platform side. The special locks shall only open with the staff protection key of the section. The signalling contractor and the PSD contractor(s) shall interface to ensure the compatibility of staff protection key in the lock of manual secondary Doors. The provision of special locks on MSDs is in the scope of the PSD Contractor. The PSD Contractor shall also interface with the Signaling Contractor, to ensure the compatibility of the Special Locks on MSDs with the respective Staff Protection Key of the Signaling system.

INTERFACE- Division of Responsibility

Signalling Contractor shall coordinate with PSD contractor(s) in order to achieve the functional and operational requirements of the system. The roles and activities of the Contractors shall broadly be as under as the minimum but not limited to those mentioned in table below. Apart from the below table, the contractors shall also adhere to all the Interface specifications (as above) and the GS and PS requirements.

S.No ST/PS	***Item***	***Signalling Contractor***	***PSD contractor***
01	Relative position of PSD on platform and door numbering	Shall incorporate the same in all interface communications	Shall provide the numbering and incorporate the same in all interface communications.
02	OMPD	Shall coordinate and prepare	Shall provide inputs.
03	Vital communication and circuitry	Shall identify the communication links jointly and design the interface circuit	Shall identify the communication links jointly and follow the interface circuit
04	Non- vital communication	Shall identify the communication links jointly and propose the communication protocols and network parameters	Shall identify the communication links jointly and follow the communication protocols and network parameters
05	Workstations layouts in OCC, SCC BOCC	Shall integrate into overall OCC/ SCC/BOCC ergonomic study	Shall provide details.
06	Space proofing for Interfacing panel	To provide inputs	Shall accommodate in equipment layouts
07	Joint testing on Integration test platform	Shall coordinate and establish the integrated test platform,for testing the working of the ATS-PSD interface through required simulation of various situations, in an off-line mode.	Shall coordinate and provide feeds from PSD side, to set up the integration test platform for offline testing
08	Joint Construction methodology and installation sequencing	Shall prepare any joint coordination required for construction methodology or installation	Shall coordinate and provide inputs for the same.
09	PSD positioning in relation to Platform centre & Signal Stopping Position	In Co-Ordination with Civil & Track Contractors, to agree on Platform Centre co-ordinates & chainage and decide the normal stopping	Shall install the PSD façade, based on platform centre and the Signal Stopping Point, duly ensuring perfect alignment of PSD façade with corresponding Train doors

S.No ST/PS	***Item***	***Signalling Contractor***	***PSD contractor***
01	Relative position of PSD on platform and door numbering	Shall incorporate the same in all interface communications	Shall provide the numbering and incorporate the same in all interface communications.
02	OMPD	Shall coordinate and prepare	Shall provide inputs.
03	Vital communication and circuitry	Shall identify the communication links jointly and design the interface circuit	Shall identify the communication links jointly and follow the interface circuit
04	Non- vital communication	Shall identify the communication links jointly and propose the communication protocols and network parameters	Shall identify the communication links jointly and follow the communication protocols and network parameters
05	Workstations layouts in OCC, SCC BOCC	Shall integrate into overall OCC/ SCC/BOCC ergonomic study	Shall provide details.
06	Space proofing for Interfacing panel	To provide inputs	Shall accommodate in equipment layouts
07	Joint testing on Integration test platform	Shall coordinate and establish the integrated test platform,for testing the working of the ATS-PSD interface through required simulation of various situations, in an off-line mode.	Shall coordinate and provide feeds from PSD side, to set up the integration test platform for offline testing
		point , in consultation with the PSD Contractor	
10	Joint Testing plan	Joint testing plan shall be prepared and conducted to validate the design coordination to check the functionalities.	Shall coordinate to prepare the test document and participate in the test.
11	Joint maintenance plan	Shall prepare the joint maintenance plan.	Shall provide the inputs for the same.

APPENDIX-2P-4A

Interface protocol between Civil (UG) and Platform Screen Doors (PSD) system (Full Height)

Appendix 2P-4A

Interface Specifications Civil Contractors & FHPSD

1 INTRODUCTION

1.1 General

1.1.1 PSD scope will be 3 car platform length (appx 70 mtrs) and MSDs. Beyond these limits are considered as Civil Contractor scope, with a maximum of 10 mm gap from the PSD structure, which will be filled by the PSD contractor with a suitable gap filler. The MSD door may or may not be at the end of PSD door (the details are to be finalized during detailed design, through the interface forum).

1.1.2 The responsibilities of the PSD & Civil Contractors in respect of work scope shall be as described below. Other than those responsibilities of the Civil Contractor clearly spelt out below, it is the PSD Contractor's responsibility to ensure provision of gap fillers/sealants/ gaskets etc to close all gaps at the interface with the Civil/MEP structures, with the idea of preventing escape of cold air from the platform side to the tunnel section & vice versa for the hot air. This is necessary to minimize the power consumption of the ventilation & air-conditioning system. Even in respect of EEDs, only the bare minimum working clearance above floor level to be kept to enable operation/opening of these doors from the Track side.

2 Interface Specifications

2.1 This document shall be read in conjunction with the relevant paragraphs of the General Specification & Technical Specification. Civil contractor will be lead interface partner and PSD contractor shall ensure all requirements of the General Specification and the Technical Specification (TS) pertaining to interfaces are fully implemented duly co-ordinating the lead interface partner (Civil Contractor).

2.2 In the event of a conflict between General /Technical Specification and this specification, the requirements of this Specification shall prevail.

2.3 This specification outlines the contractor's interface requirements, which are based on the technical studies carried out during the early stages of the project. However, the requirements specified herein are by no means exhaustive and it remains the joint responsibility of the PSD and Designated contractors to develop, update and execute jointly interface management details during design & throughout the execution of the work.

2.4 PSD contractor, shall interface and liaise with other designated contractors in accordance with the requirements of TS and the Interface Specification at Appendix 2P of the TS.. The PSD contractor shall develop and execute an interface plan during execution of the work to ensure that:

(i) All interface issues between the PSD contractor and other designated contractors are satisfactorily resolved.

(ii) Supply, Installation and testing of equipment and software are fullycoordinated.

(iii) All the equipment supplied in the contract are fully compatible with each other.

3 Interface Management Plan

3.1 Within 90 days of notification from the Engineer of the identity of each designated contractor, the PSD contractor shall develop and submit to the Engineer for review an Interface Management Plan that is mutually acceptable to both, the PSD contractor and other designated contractors. The Interface Management Plan shall:

(i) Identify the sub-systems as well as the civil works and facilities with interfacing requirements.

(ii) Define the authority and responsibility of PSD contractor and other designated contractors (and any relevant sub-contractors') staff involved in interface management and development.

(iii) Include considerations of the Interface hazard analysis.

(iv) Specify the configuration and version control procedures in accordance with PSD contractor and other designated contractor (and any relevant sub-Contractors') quality management system; and

(v) Address the design, supply, installation, testing and commissioning programme of the contracts to meet the key dates of each contract, and highlight any programme risks requiring management attention.

3.2 Once the Interface Management Plan has been reviewed by the Engineer, PSD contractor shall coordinate with other interface contractors and ensure the feasibility of proposed interface management plan. If any difficulty in developing a mutually acceptable Interface Management Plan, contractor shall approach the Engineer immediately to resolve the same. Once Interface management plan is mutually agreed, PSD contractor shall execute the works in accordance with the Interface Management Plan.

The Interface Specification appended to the TS as Appendix 2P, shall form the basis of the Interface management plan for the designated contractors mentioned therein. However, this does not relieve PSD contractor's obligation to identify any new interface requirements to meet this specification.

The PSD Contractor shall align to The Engineer's Master Interface management plan.

3.3 Interfaces exist between PSD contractor and Designated contractors for systems, where the systems are mutually dependent, or interactive for satisfactory and safe operation. PSD contractor shall maintain close coordination/ interface during design, manufacturing, testing, commissioning, integrated testing, trial run and defect liability period with the designated contractors and consultants who may be working in the project, whether or not especially mentioned in the contract. PSD contractor shall perform all design duties and provide all materials, equipment and labour to ensure the satisfactory accomplishment of interface of the systems for which PSD contractor is responsible.

(i) It shall be the responsibility of PSD Contractor to settle all disagreements with the designated contractors. If such disagreement cannot be resolved, despite having made all reasonable efforts, then the decision of the Engineer shall be final .

(ii) PSD contractor shall submit and maintain all agreed Interface Documents as specified in the General Specification. At all stages of the work, all interfaces shall be discussed and agreed upon, through the Engineer, between PSD contractor and other designated contractors.

(iii) It shall be the responsibility of PSD contractor that interface requirements be agreed, accepted and endorsed by stakeholders as early as possible. Contractual delays and consequential implications as a result of delay in such co-ordination on account of reasons attributable to PSD contractor, as concluded by Engineer, shall bethe sole responsibility of PSD contractor.

4 Coordination

4.1 Technical Coordination

(i) PSD contractor shall be responsible for identifying information required from other designated contractors and/ or the Engineer and providing information in a timely manner to other Interfacing contractors and the Engineer.

(ii) PSD contractor shall communicate and coordinate with the Engineer and ensure that all interfacing details are reviewed with notice of no objection by the Engineer. Major coordination works include but not limited to:

(1) PSD installation- structural attachments to station and platform elements to support PSD,

(2) Physical routing of all pipe work, cable containment and associated ancillaries, supports, secondary steel and structural attachments,

(3) Layouts of PSD Room taking cognizance of lighting (to include maintained emergency lighting), ECS, drainage, S&TC interface panel, LV cabling, earthing provisions installed by others,

(4) Coordination with S&TC Contractor within Signaling equipment room.

5 FH PSD/PED design Interface

5.1 Station drawings layout and delivery route plan

5.1.1 PSD contractor is responsible to design FH PSD/PED as per station latest Good For Construction (GFC) drawings. The design also to suit straight or curved platform including expansion joints wherever applicable.

5.1.2 PSD contractor and Civil contractor shall interface for the agreement of planned delivery route and execution plan.

5.2 FH PSD/PED load and fixing details.

5.2.1 Civil contractor to indicate minimum clear distance between platform edge & the PSD base plate fixing holes PSD Contractor shall accordingly finalise the PSD fixing arrangements, base plate, fixing bolt sizes etc, duly also considering the load to be transferred to the

supporting surface.

5.2.2 PSD Contractor will share the loading levels in all the axes at the PSD mounting point (this will include the load transferred to platform edge recess at the bottom as well as the load transferred to the mounting plate at the top, from the PSD top fixing arrangements). They will also indicate the fixing bolt sizes & spacing from platform edge. Engineer/DDC will review the safety of the structure, based on inputs provided by the PSD Contractor.

5.2.3 PSD contractor to design the base plate size, thickness, and bolt sizes as per their design requirements.

5.2.4 The Civil Contractor shall design the continuous top fixing plate (typically 200x16mm), suspended from a plate/angle integral with the OTE Duct, in order to accommodate the top fixing arrangements of the PSD, duly taking into account the loads in various axes transferred by the PSD to the Civil Contractor's continuous fixing plate. The position of the continuous fixing plate at the top, as explained above, has to respect the horizontal & vertical spacing from (a) track centre and (b) from the rail top respectively, as per requirements of horizontal & vertical spacing indicated by the PSD Contractor, for maintaining the SOD requirements (Appendix - 2 'N').

5.2.5 Respective Contractors to ensure any support and fixing as well as structures erected by them, do not encroach in to train kinematic envelop area and satisfy the Schedule of Dimensions (SOD) requirements (Appendix - 2 'N').

5.2.6 During FHPSD design stage, PSD Contractor to advise the fixing hole positions along the full length of the PSD, for the bottom fixing arrangements. Both Contractors will jointly attempt (subject to the adjustment margin available in PSD installation) to minimize need for cutting through rebars.

5.3 Access and delivery route layout and timeline programme.

5.3.1 PSD contractor shall share the required information for the preparation of master layout of access and delivery route with timeline programme and coordinate the same with the Civil contractor, who will prepare the commonly agreed layout.

5.4 PSD equipment room

5.4.1 PSD equipment room shall be mostly part of signaling room and required minimum area of 15Sqm will be set apart in the combined room, for PSD requirements. PSD contractor to design their equipment layout and interface the same with Designated contractors.

5.4.2 The equipment room is to be shared between PSD & Signaling. Both Contractors have to agree on the combined equipment layout , including wall mounted sub-assemblies and the agreed drawing has to be submitted to the Engineer, for his comments, if any.

5.4.2.1 PSD contractor to share the structural loads of the PSD Equipment room due to the self-weight of the Platform Screen Control Cubicle (PSCC), PSD -Signaling interface panel and Power Distribution Panel (PDP-2) etc, to Civil works contractor for the design of false flooring.

5.5 PSD layout interface

5.5.1 PSD contractor has the responsibility to design the PSD/Fixed Panel/EED/DED/MSD layout in line with SOD requirements (Appendix - 2 'N').

5.5.2 PSD Contractor to ensure that the position of PSD is in line with train stopping locations, and coordinate the same with Designated contractor to finalize the train stopping location.

5.5.3 The PSD Contractor will install the PSD Façade at the nominated place for 3 car train length from end to end and it is for the Civil Contractor to close the rest of the area from the PSD outer structural members, leaving a maximum gap of upto 10mm, which shall be closed with a suitable filler material by the PSD Contractor.

5.5.4 For the 3 car length (appx 70 mtrs) of the Platform, it is the PSD Contractor's responsibility to ensure that cold air does not escape from platform side to the track side and vice versa. Other than the works agreed to be done by the Civil Contractor, as per the interface agreement, it is the PSD Contractor's responsibility to provide all required sealants & gap fillers with suitable fire-retardant materials, between PSD structures & Civil structures, to achieve this requirement of preventing loss of cold air from platform side to track side.

5.5.5 PSD Contractor to coordinate with civil works contractor for the integration of PSD with the Civil structures at either end of the PSD scope.

5.6 Coordination of Combined service drawings

5.6.1 PSD contractor shall participate or organize a coordination meeting with Designated Contractors to agree their cable routing layout, PSD equipment room cable routing layout, etc., but not limited to this scope. These will be suitably reflected in the Combined Service Drawings. PSD Contractor to give number & types of cables, their sizes, bending radii, minimum separation between different cable types (like power & data cables). It is for the MEP Contractor to provide the necessary main cable routes to suit PSD requirements, from SER to SCR and from SER to PSD platform level till entry to the header box and also to be extended to the MSDs at both ends of each platform. PSD Contractor shall also co-ordinate with the Civil Contractor regarding matching with architectural finishes of the Station, in respect of PSD structural members & over all colour scheme & appearance matching with the architectural finishes of the Station.

5.7 FH PSD interface during Installation stage

5.7.1 Work area access for PSD/MSD

5.7.1.1 PSD contractor to collect & verify the as built details of Platform edge as well as the recess (distance from track centre & height above actual rail level) .

5.7.1.2 PSD contractor to collect & verify the as built details of continuous steel plate provided below the OTE duct by the Civil Contractor , for PSD upper top fixing arrangements(distance from track centre & height above actual rail level) and ensure that these are as per PSD requirements.

5.7.1.3 Should also collect the reference coordinates of the Station from Civil Contractor and adjust the PSD design as per actual site conditions (civil as well as track). The PSD contractor shall obtain the train stopping point in consultation with the Civil Contractor and the Signalling contractor.

5.7.1.4 Civil Contractor to ensure that platform edge is within 1510-1515 mm of track centre , as per SOD (Appendix - 2 'N'), for the full length, before asking PSD Contractor to take over the work area for PSD installation. The heights of the platform recess to be as per mutually agreed

interface drawings and the area where the PSD base plates are to be fixed is to be levelled, before handing over to PSD Contractor.

5.7.1.5 All items shall be delivered to site in batches as required based on installation phase. However, a temporary storage area with a minimum size of appx 150 Sq.mtrs is required at the platform level to store the delivered items prior to installation. Hence PSD contractor to ensure the agreed area provided by civil works contractor, during takeover of work area.

5.7.2 Setting out of PSD/EED/DED/MSD layout

5.7.2.1 Setting out of the FHPSD System shall be derived from the Station Centre Line Coordinates (to be provided by the Civil Contractor) and the Kinematic Envelope (to be obtained from the Rolling Stock Contractor).

5.7.2.2 The PSD contractor shall obtain the train stopping point in consultation with the Civil Contractor and the Signalling contractor. The PSD contractor shall also obtain the reference co-ordinates at the platform as per PSD installation requirements and also obtain the platform center point.

5.7.2.3 Civil contractor to ensure that, the finished floor level from the top of the rail shall be 1090 ± 5 mm, but within 1.5 m from the edge of the platform recess where the EED is located, the floor level shall be reduced by 6 mm when the threshold finish level of the PSD is 1090 mm. PSD contractor to advise the same. This vertical gap of 6 mm, to be closed by the PSD Contractor, with a suitable sealant.

5.7.2.4 The checking of any setting out of any line or level by the Engineer shall not in any way relieve PSD contractor of his responsibility for the correctness thereof and PSD contractor shall carefully protect and preserve all benchmarks, sight rails, pegs and other things used in setting-out the Works.

5.7.2.5 MSD is proposed only at the edge of platform, so MSD may or may not be at end panel of PSD. PSD contractor to ensure that integration of PSD/MSD and its control system and cable through agreed cable routing to be done considering the position of MSD away from PSD end panel. In respect of the MSDs, for the door loop circuit, the cables are to be taken through over-head cable trays to be provided by MEP Contractor, which needs to be co-ordinated with them. Where required, the cables may have to be taken through a race way (to be provided by the PSD Contractor); laying of cables for the entire length and its termination in the termination box of the respective MSD, is in the scope of the PSD Contractor. The finishing of the race-way viz-a -viz the finished platform flooring, has to be suitably -co-ordinated with the Ciivil Contractor.

5.7.3 Work area access for PSD room

5.7.3.1 PSD contractor to ensure that the PSD room shall be to the level of finishes to degree three level completion before taking over of PSD room from the designated contractor.

5.7.3.2 PSD contractor shall ensure that the setting out of plant or equipment permits it to fit into the space allocated and allows access for maintenance and replacement purposes.

5.7.3.3 PSD contractor to ensure that the PSD room false flooring and false ceiling if any shall be as per the coordinated Combined service drawings with Designated contractor.

5.7.3.4 PSD contractor to carryout works without interference or obstruction of Designated contractors works.

5.7.4 Interface requirements during installation, testing and validation

5.7.4.1 PSD contractor to ensure the installation of PSD shall be in compliance to SOD requirements.

5.7.4.2 PSD contractor shall be responsible for interfacing with the S&TC, Civil & RS Contractors to ensure that placement of FHPSD system on the platform are in perfect alignment with the Train Doors when the train stops at the ideal stopping point ± 0 mm.

5.7.4.3 Finished flooring beyond PSD threshold is Civil Contractor responsibility. PSD will only confirm the final as-built level of threshold/height above as-built rail level.

5.7.4.4 PSD contractor to interface with Civil Contractor and ensure to provide gap filler to seal the gap of 10-mm between the end PSD structures and corresponding Civil structures.

5.7.4.5 PSD contractor to share the as built BIM LOD500 standards of PSD /EED/DED/MSD doors and PSD room lay-out to Civil works contractor to integrate the same. PSD contractor to continuously update if there is any modification in the submissions.

5.8 INTERFACE- Division of Responsibility

The roles and activities of PSD contractor & Civil Contractor shall broadly include minimum but not limited to those mentioned in table below in order to achieve the functional and operational requirements of the system.

Table 1a- Interface between PSD and Under Ground Station Civil works		
Chennai Metro Interface Sheet	***Sheet #1***	***Rev # : A1***
Contract A : PSD	**Contract B : Civil works (U/G Stations)**	
PSD Contractor (Interface Lead)		
Brief description of interface scope: 1. GFC drawings of station coordinates, layout and relevant sections. 2. Execution plan including time schedule and work sequence. 3. FHPSD fixing load. 4. MSD location 5. False flooring layout 6. Takeover of work area access PSD /EED/DED/MSD 7. Takeover of work area access PSD room. 8. Independent test and validation. 9. Comprehensive interface hazard analysis		
Sl. No.	**Contract A (PSD)**	**Contract B (Civil U/G)**
Design Stage		
01	Collect the GFC latest drawings from Civil contractor for PSD design works.	Share the latest GFC drawings with PSD contractor.
02	Agree for the proposed execution plan	Agree each other for the proposed execution

	including work area sequence of access, Installation coordination plan showing the space / input requirement and timeline of programme	plan including sequence & details of work area access, Installation coordination plan showing the space / input requirement and timeline of programme.
03	Share and agree the design load on the bolts in various axes for fixing of FHPSD at platform edge, in respect of bottom mounting arrangements. Share and agree the locations, fixing details, requirements, tolerances of FHPSD bottom fixing arrangements including platform end recess finished level, its distance from track centre etc.	Verify the station elements for the provided load, locations, and method statements. Shall design the platform edge recess accordingly.
04	Share and agree the design load in various axes on the top fixing plate, in respect of the top fixing arrangements of the FHPSD. Shall also share the requirements of height above rail level & distance of the top plate centre from track centre, with applicable tolerances, to suit FHPSD mounting arrangements	Shall design a continuous steel plate (typically 200 mmx16mm thick), suitably suspended from the OTE slab above, based on FHPSD load levels as well as installation tolerances
05	Verify and agree the MSD locations.	Verify and agree the MSD locations. In line with emergency evacuation and maintenance access.
06	Shall furnish the installation location and method of Platform Screen Doors Manual Control Panel on platform level.	Shall validate the locations of Platform screen doors Manual control panel and incorporate these in the Combined Services Drawings.
Installation stage		
07	Shall verify the same and do the PSD installation accordingly.	Shall provide the reference co-ordinates of the platform for PSD installation requirements. Shall also advise the stopping position of the train and centre of platform.
08	Ensure the following during takeover of work area. a) Platform edge of base concrete is crack free, and smooth surface, also there should not be floor screed/finishes into the space underneath the PSD base plates area. PSD mounting recess at platform edge, to be suitable for PSD installation requirements.	Ensure following during handover of work area. a) Platform edge of base concrete is crack free, and smooth surface, also there should not be floor screed/finishes into the space underneath the PSD base plates area. PSD bottom mounting surface as per agreed interface drawing and fulfilment of SOD requirement (Appendix-2N) in respect of spacing from Track Centre to Platform edge as well as to the recess, has to be ensured for the full platform length, before the work area is offered to PSD Contractor for

	b) Continuous fixing plate at the top, to be suitable for PSD top fixing arrangements including height above rail top as well as distance of the centre of the plate from track centre. c) Ensure the agreed storage area at platform level is as per FHPSD requirements.	commencing the installation work. b) Continuous steel plate to be provided for FHPSD top fixing arrangements, as per mutually agreed interface drawings. c) Agreed storage area at platform level, to be made available.
09	Ensure the following during takeover of work access a) PSD room shall be to the level of finishes to degree three level completion b) The setting out of plant or equipment permits it to fit into the space allocated and allows access for maintenance and replacement purposes c) Ensure that the PSD room wall mounted and floor mounted equipments and the opening requirements in false flooring & false ceiling and wall openings for cable routing, are as per the coordinated Combined service drawings with Designated contractor.	Ensure the following during handover of work access a) PSD room shall be to the level of finishes to degree three * level completion b) The provisions are as per agreed Installation plan layout and equipment layout. c) The provisions are as per agreed CSD drawings and agreed equipment layout drawings.
10	Shall install the Platform Screen Doors, Emergency Escape Doors, Manual Secondary doors and Platform screen doors local control panels (duly maintaining proper co-ordination to conceal the cable trunking in the walls/pipes, as appropriate. The responsibility for extension of cabling from the main cable tray/header box until the MCP location, through concealed conduit/race way, is under the scope of the PSD Contractor.	Shall provide necessary supports to install the platform screen doors and local control panels.
Testing and Validation stage		
11	Carryout Independent test and validation of complete PSD system.	Support necessary agreed interface requirements to carryout PSD Independent test and validation of complete PSD system
12	If any modification on civil works is necessary, same shall be coordinated during comprehensive interface hazard analysis in accordance with the relevant system safety and assurance standards.	Support necessary agreed interface requirements to carryout comprehensive interface hazard analysis.

* **Degree 3 Finishes Details:**

- Complete Wall Plastering and painting

- Complete raised floor, and false flooring except for locations where panels have to be installed after ccompletion of works by the Interfacing contractor
- Complete internal glazing
- Permanent doors and ironmongery installed
- Plumbing and Sanitary fittings complete and ready for testing

Table 1b- Interface between PSD and Civil works Under Ground station		
Chennai Metro Interface Sheet	***Sheet #1***	***Rev # : A1***
Contract A : PSD	**Contract B : Civil works (U/G Stations)**	
Civil works Contractor (Interface Lead)		
Brief description of interface scope: 1. Access and delivery route and its timeline programme. 2. Cable route layout 3. False flooring layout 4. Surface finishes requirements. 5. Fixed panel and gap filler 6. Compliance of CSD 7. As built BIM model LOD500		
Sl. No.	**Contract A (PSD)**	**Contract B (Civil U/G)**
Design Stage		
01	Participate in the coordination meeting and agree on delivery route plan with timeline as per PSD design and execution plan requirements.	Organize a meeting with all Designated Contractors and prepare a delivery route drawings with timeline programme.
O2	Participate in the coordination meeting and agree their Cable routing layout.	Organize a meeting with all Designated Contractors and prepare a Combined service drawing (CSD). Agree the CSD with Designated contractors and submit to Engineer for NONO.
03	Contractor to agree their equipment room layout with Designated Contractor.	Contractor to agree the false flooring layout with Designated Contractors.
Installation Stage		
04	Check the platform flooring finishes until PSD with 6 mm gap, PSD shall seal the gap. The scope is not limited to above and also to verify surface finishes wherever required.	The scope is to ensure surface finishes as required by PSD contractor.
05	PSD contractor to interface with Civil Contractor regarding maximum gap of 10 mm between PSD& MSD boundary & adjacent civil structures like fixed panels and also arrange to close this 10 mm gap with suitable sealant.	Civil Contractor to provide structures in continuation of PSD for 3 car length as well as in continuation of all MSDs, leaving a maximum gap of 10mm, which shall be closed by PSD Contractor.
06	Coordinate with Civil works contractor and	Contractor to ensure the implementation of

	agree the coordinated CSD.	agreed CSD drawings.
Testing and Validation stage		
07	Share the as built BIM model	Synchronize the information with master as built BIM model.

APPENDIX-2P-4B

Interface protocol between Civil (Elevated) and Platform Screen Doors (PSD) system (Half Height)

Appendix 2P-4B

Interface Specifications Civil Contractors & HHPSD:

1 General

PSD scope will be 3 car platform length and MSDs. Beyond these limits are considered as Civil Contractor scope, with a maximum of 10 mm gap from the PSD structure, which will be filled by the PSD contractor with a suitable gap filler. The MSD door may or may not be at the end of PSD door (the details are to be finalized during detailed design, through the interface forum).

2 Interface Specifications

2.1 This document shall be read in conjunction with the relevant paragraphs of the General Specification & Technical Specification. Civil contractor will be the lead contractor and PSD contractor shall ensure all requirements of the General Specification and the Technical Specification (TS) pertaining to interfaces are fully implemented duly co-ordinating with the lead interface partner (Civil Contractor).

2.2 In the event of a conflict between General /Technical Specification and this specification, the requirements of this Specification shall prevail.

2.3 This specification outlines the contractor's interface requirements, which are based on the technical studies carried out during the early stages of the project. However, the requirements specified herein are by no means exhaustive and it remains the joint responsibility of the PSD and Designated contractors to develop, update and execute jointly interface management details during design & throughout the execution of the work.

2.4 PSD contractor shall interface and liaise with other designated contractors in accordance with the requirements of TS and Interface Specification at Appendix 2P of this TS. The PSD contractor shall develop and execute an interface plan during execution of the work to ensure that:

(i) All interface issues between the PSD contractor and other designated contractors are satisfactorily resolved.

(ii) Supply, Installation and testing of equipment and software are fully coordinated.

(iii) All the equipment supplied in the contract are fully compatible with each other.

3 Interface Management Plan

3.1 Within 60 days of notification from the Engineer of the identity of each designated contractor, the PSD contractor shall develop and submit to the Engineer for review an Interface Management Plan that is mutually acceptable to both, the PSD contractor and other designated contractors. The Interface Management Plan shall:

(i) Identify the sub-systems as well as the civil works and facilities with interfacing

requirements.

(ii) Define the authority and responsibility of PSD contractor and other designated contractors (and any relevant sub-contractors') staff involved in interface management and development.

(iii) Include considerations of the Interface hazard analysis.

(iv) Specify the configuration and version control procedures in accordance with PSD contractor and other designated contractor (and any relevant sub-Contractors') quality management system; and

(v) Address the design, supply, installation, testing and commissioning programme of the contracts to meet the key dates of each contract, and highlight any programme risks requiring management attention.

3.2 Once the Interface Management Plan has been reviewed by the Engineer, PSD contractor, as lead, shall coordinate with other interface contractors and ensure the feasibility of proposed interface management plan. If any difficulty in developing a mutually acceptable Interface Management Plan, contractor shall approach the Engineer immediately to resolve the same. Once Interface management plan is mutually agreed, PSD contractor shall execute the works in accordance with the Interface Management Plan.

3.3 The Interface Specification appended to the TS as Appendix 2P, shall form the basis of the Interface management plan for the designated contractors mentioned therein. However, this does not relieve PSD contractor's obligation to identify any new interface requirements to meet this specification.

3.4 The PSD Contractor shall align to The Engineer's Master Interface management plan.

3.5 Interfaces exist between PSD contractor and Designated contractors for systems, where the systems are mutually dependent, or interactive for satisfactory and safe operation. PSD contractor shall maintain close coordination/ interface during design, manufacturing, testing, commissioning, integrated testing, trial run and defect liability period with the designated contractors and consultants who may be working in the project, whether or not especially mentioned in the contract. PSD contractor shall perform all design duties and provide all materials, equipment and labour to ensure the satisfactory accomplishment of interface of the systems for which PSD contractor is responsible.

(i) It shall be the responsibility of PSD Contractor, as lead contractor, to settle all disagreements with the designated contractors. If such disagreement cannot be resolved by lead contractor, despite having made all reasonable efforts, then the decision of the Engineer shall be final.

(ii) PSD contractor shall submit and maintain all agreed Interface Documents as specified in the General Specification. At all stages of the work, all interfaces shall be discussed and agreed upon, through the Engineer between PSD contractor and other designated contractors.

(iii) It shall be the responsibility of PSD contractor that interface requirements be agreed, accepted and endorsed by stakeholders as early as possible. Contractual delays and consequential implications as a result of delay in such co-ordination on account of

reasons attributable to PSD contractor, as concluded by Engineer, shall be the sole responsibility of PSD contractor.

4 Coordination

4.1 Technical Coordination

(i) PSD contractor, as lead, shall be responsible for identifying information required from other designated contractors and/ or the Engineer and providing information in a timely manner to other Interfacing contractors and the Engineer.

(ii) PSD contractor shall communicate and coordinate with the Engineer and ensure that all interfacing details are reviewed with notice of no objection by the Engineer. Major coordination works include but not limited to:

(1) PSD installation- structural attachments to station and platform elements to support PSD,

(2) Physical routing of all pipe work, cable containment and associated ancillaries, supports, secondary steel and structural attachments,

(3) Layouts of PSD Room taking cognizance of lighting (to include maintained emergency lighting), ECS, drainage, S&TC interface panel, LV cabling, earthing provisions installed by others,

(4) Coordination with S&TC Contractor within Signaling equipment room.

5 HH PSD/PED design Interface

5.1 Station drawings layout and delivery route plan

5.1.1 PSD contractor, as lead, is responsible to design HH PSD/PED as per station latest Good For Construction (GFC) drawings. The design also to suit straight or curved platform including expansion joints wherever applicable.

5.1.2 PSD contractor and Civil contractor shall interface for the agreement of planned delivery route and execution plan.

5.2 HH PSD/PED load and fixing details.

5.2.1 Civil contractor to indicate minimum clear distance between platform edge & the PSD fixing holes PSD Contractor shall accordingly finalise the PSD fixing arrangements, base plate, fixing bolt sizes etc, duly also considering the load to be transferred to the supporting surface.

5.2.2 PSD Contractor will share the loading levels in all the axes at the PSD mounting points. They will also indicate the fixing bolt sizes & spacing from platform edge. Engineer/DDC will review the safety of the structure, based on inputs provided by the PSD Contractor.

5.2.3 PSD contractor to design the base plate size, thickness, and bolt sizes as per their design requirements.

5.2.4 Respective Contractors to ensure any support and fixing as well as structures erected by them, do not encroach in to train kinematic envelop area and satisfy the Schedule of Dimensions (SOD) requirements.

5.2.5 During HHPSD design stage, PSD Contractor to advise the fixing hole positions along the full length of the PSD. Both Contractors will jointly attempt (subject to the adjustment margin available in PSD installation) to minimize need for cutting through rebars.

6 Co-ordination is also required to ensure that platform edge finishing (recess on which PSD is mounted) is suitable for PSD installation (as per mutually agreed interface drawings) and also that the height above rail level of the PSD mounting surface as well as its lateral distance from Track Centre, are as per mutually agreed interface drawings and also respecting the requirements of Schedu/le of Dimensions.

6.1.1

5.3 Access and delivery route layout and timeline programme;

5.3.1 PSD contractor, shall share the required information for the preparation of master layout of access and delivery route with timeline programme and coordinate the same with all designed contractor to prepare the commonly agreed layout.

5.4 PSD equipment room

5.4.1.1 PSD equipment room shall be mostly along with signaling room and required a minimum area of 15Sqm. PSD contractor to design their equipment layout and interface the same with Designated contractors.

5.4.1.2 The equipment room is to be shared between PSD & Signaling. Both Contractors have to agree on the combined equipment layout , including wall mounted sub-assemblies and the agreed drawing has to be submitted to the Engineer, for his comments, if any.

5.4.1.3 PSD contractor to share the structural loads of the PSD Equipment room due to the self-weight of the Platform Screen Control Cubicle (PSCC), PSD -Signaling interface panel and Power Distribution Panel (PDP-2) to Civil works contractor for the design of false flooring.

5.5 PSD layout interface

5.5.1 PSD contractor has the responsibility to design the PSD/Fixed Panel/EED/DED/MSD layout in line with SOD requirements.

5.5.2 PSD Contractor to ensure that the position of PSD is in line with train stopping locations, and coordinate the same with Designated contractor to finalize the train stopping location.

5.5.3 The PSD Contractor will install the PSD Facade at the nominated place for 3 car train length from end to end and it is for the Civil Contractor to close the rest of the area from the PSD outer structural members, leaving a maximum gap of upto 10mm, which shall be closed with a suitable filler material by the PSD Contractor.

5.5.4 PSD Contractor to coordinate with Civil works contractor for the integration of PSD with the Civil structures at either end of the PSD scope.

5.6 Coordination of Combined service drawings

5.6.1 PSD contractor shall participate or organize a coordination meeting with Designated Contractors to agree their cable routing layout, PSD equipment room cable routing layout, etc., but not limited to this scope. These will be suitably reflected in the Combined Service Drawings. PSD Contractor to give number & types of cables, their sizes, bending radii, minimum separation between different cable types (like power & data cables). It is for the MEP Contractor to provide the necessary main cable routes to suit PSD requirements, from SER to SCR and from SER to PSD cable trunking under the platform coping trays (through structural openings). PSD Contractor shall also co-ordinate with the Civil Contractor regarding matching with architectural finishes of the Station, in respect of race-way arrangements from PSD Cable trunking under the platform coping, until the respective MSD and also in respect of PSD structural members & over all color scheme & appearance matching with the architectural finishes of the Station.

5.6.2 The space available for PSD cable routing beneath the Platform slab in side platform stations as well as island platform stations, is indicated in the sketches at Annexure A to this appendix. In the L shaped brackets provided by Civil Contractor , PSD Contractor has to design the cable routing for both Power & data cables. As per separation/EMC requirements required GI pipes/conduits have to be supplied & installed by the PSD Contractor in these brackets for data/power cables as the case may be, with openings in the GI Pipe/conduit at required intervals, to take out the data & power cables inside each ASD mechanism/EED/DED termination box (as the case may be). Necessary coring holes to bring these cables above platform slab, is to be done by the PSD Contractor, in consultion with the Civil Contractor, duly taking care to avoid damage to any re-enforcement bars of the concetre (as far as possible).

5.6.3 In respect of the MSDs, for the door loop circuit, the cables are to be taken beneath the Platform slab, brought up through coring holes and then through a race way (to be provided by the PSD Contractor), bring the cable near the termination box of the respective MSD. The finishing of the race-way viz-a -viz the finished platform flooring, has to be suitably -co-ordinated with the Ciivil Contractor

5.7 HH PSD interface during Installation stage

5.7.1 Work area access for PSD/MSD

5.7.1.1 PSD contractor to collect & verify the as built details of Platform edge recess (distance from track centre & height above actual rail level) . Should also collect the reference coordinates of the Station from Civil Contractor and adjust the PSD design as per actual site conditions (civil as well as track).

5.7.1.2 Civil Contractor to ensure that platform edge is within 1515-1520 mm of track centre, as per SOD, for the full length, before asking PSD Contractor to take over the work area for PSD installation. The heights of the platform recess to be as per mutually agreed interface drawings and the area where the PSD base plates are to be fixed is to be levelled, before handing over to PSD Contractor.

5.7.1.3 All items shall be delivered to site in batches as required based on installation phase. However, a temporary storage area with a minimum size of appx. 150 sq.mtrs is required at

the platform level to store the delivered items prior to installation. Hence PSD contractor to ensure the agreed area provided by civil works contractor, during takeover of work area.

5.7.2 Setting out of PSD/EED/DED/MSD layout

5.7.2.1 Setting out of the HHPSD System shall be derived from the Station Centre Line Coordinates (to be provided by the Civil Contractor) and the Kinematic Envelope (to be obtained from the Rolling Stock Contractor).

5.7.2.2 The PSD contractor shall obtain the train stopping point in consultation with the Civil Contractor and the Signalling contractor. The PSD contractor shall also obtain the reference co-ordinates at the platform as per PSD installation requirements and also obtain the platform center point.

5.7.2.3 Civil contractor to ensure that, the finished floor level from the top of the rail shall be 1090 ± 5 mm, but within 1.5 m from the edge of the platform recess where the EED is located, the floor level shall be reduced by 6 mm when the threshold finish level of the PSD is 1090 mm. PSD contractor to advise the same. This vertical gap of 6 mm, to be closed by the PSD Contractor, with a suitable sealant.

5.7.2.4 The checking of any setting out of any line or level by the Engineer shall not in any way relieve PSD contractor of his responsibility for the correctness thereof and PSD contractor shall carefully protect and preserve all benchmarks, sight rails, pegs and other things used in setting-out the Works.

5.7.2.5 MSD is proposed only at the edge of platform, so MSD may or may not be at end panel of PSD. PSD contractor to ensure that integration of PSD/MSD and its control system and cable through agreed cable routing to be done considering the position of MSD away from PSD end panel. PSD contractor to agree with civil contractor for coring of holes and execute the same.

5.7.3 Work area access for PSD room

5.7.3.1 PSD contractor to ensure that the PSD room shall be to the level of finishes to degree three level completion before taking over of PSD room from the designated contractor.

5.7.3.2 PSD contractor shall ensure that the setting out of plant or equipment permits it to fit into the space allocated and allows access for maintenance and replacement purposes.

5.7.3.3 PSD contractor to ensure that the PSD room false flooring and false ceiling if any shall be as per the coordinated Combined service drawings with Designated contractor.

5.7.3.4 PSD contractor to carryout works without interference or obstruction of Designated contractors works

5.7.4 Interface requirements during installation, testing and validation

5.7.4.1 PSD contractor to ensure the installation of PSD shall be in compliance to SOD requirements.

5.7.4.2 PSD Contractor, during PSD installation stage, will indicate coring holes requirement for cable entry to the Civil Contractor. The coring shall be done by PSD Contractor, under the guidance of Civil Contractor.

5.7.4.3 PSD contractor shall be responsible for interfacing with the S&TC, Civil & RS Contractors to

ensure that placement of HHPSD system on the platform are in perfect alignment with the Train Doors when the train stops at the ideal stopping point ± 0 mm.

5.7.4.4 Finished flooring beyond PSD threshold is Civil Contractor responsibility. PSD will only confirm the final as-built level of threshold/height above as-built rail level.

5.7.4.5 PSD contractor to interface with Civil Contractor and ensure to provide gap filler to seal the gap of 10-mm between the end PSD structures and corresponding Civil structures.

5.7.4.6 PSD contractor to share the as built BIM LOD500 standards of PSD /EED/DED/MSD doors and PSD room lay-out to Civil works contractor to integrate the same. PSD contractor to continuously update if there is any modification in the submissions.

5.8 INTERFACE- Division of Responsibility

The roles and activities of PSD contractor & Civil Contractor shall broadly include minimum but not limited to those mentioned in table below in order to achieve the functional and operational requirements of the system.

Table 1a- Interface between PSD and Elevated Station Civil works		
Chennai Metro Interface Sheet # : A1		**Rev**
Contract A : PSD		**Contract B : Civil works (Elevated Stations)**
PSD Contractor (Interface Lead)		
Brief description of interface scope: 1. GFC drawings of station coordinates, layout and relevant sections. 2. Execution plan including time schedule and work sequence. 3. HHPSD fixing load. 4. MSD location 5. False flooring layout 6. Takeover of work area access PSD /EED/DED/MSD 7. Takeover of work area access PSD room. 8. Independent test and validation. 9. Comprehensive interface hazard analysis		
Sl. No.	**Contract A (PSD)**	**Contract B (Civil Elevated)**
Design Stage		
01	Collect the GFC latest drawings from Civil contractor for PSD design works.	Share the latest GFC drawings with PSD contractor.
02	Agree for the proposed execution plan including work area sequence of access, Installation coordination plan showing the space / input requirement and timeline of programme	Agree each other for the proposed execution plan including sequence & details of work area access, Installation coordination plan showing the space / input requirement and timeline of programme.
03	Share and agree the design load on the bolts in various axes for fixing of HHPSD at platform edge, in respect of bottom mounting arrangements. Share and agree the locations, fixing details , requirements, tolerances of HHPSD bottom fixing arrangements including platform end recess finished level, its distance from track	Verify the station elements for the provided load, locations, and method statements. Shall design the platform edge recess accordingly.

	centre etc.	
04	Verify and agree the MSD locations.	Verify and agree the MSD locations. In line with emergency evacuation and maintenance access.
05	Shall furnish the installation location and method of Platform Screen Doors Local Control Panel on platform level.	Shall validate the locations of Platform screen doors Manual control panel and incorporate these in the Combined Services Drawings.
Installation stage		
06	Ensure the following during takeover of work area. a) Platform edge of base concrete is crack free, and smooth surface, also there should not be floor screed/finishes into the space underneath the PSD base plates area. PSD mounting recess at platform edge, to be suitable for PSD installation requirements. b). Ensure the agreed storage area at platform level is as per HHPSD requirements	Ensure following during handover of work area a). Platform edge of base concrete is crack free, and smooth surface, also there should not be floor screed/finishes into the space underneath the PSD base plates area. PSD bottom mounting surface as per agreed interface drawing and fulfilment of SOD requirement (Appendix-2P) of spacing from Track Centre to Platform edge as well as to the recess, has to be ensured for the full platform length, before the work area is offered to PSD Contractor for commencing the installation work. b) Agreed storage area at platform level, to be made available.
07	Ensure the following during takeover of work access a) PSD room shall be to the level of finishes to degree three level completion b) The setting out of plant or equipment permits it to fit into the space allocated and allows access for maintenance and replacement purposes c) Ensure that the PSD room wall mounted and floor mounted equipments and the opening requirements in false flooring & false ceiling and wall openings for cable routing, are as per the coordinated Combined service drawings with Designated contractor.	Ensure the following during handover of work access a) PSD room shall be to the level of finishes to degree three * level completion b) The provisions are as per agreed Installation plan layout and equipment layout. c) The provisions are as per agreed CSD drawings and agreed equipment layout drawings.
08	Coring holes requirement for cable entry shall be done by PSD Contractor, under the	Both Contractors will jointly attempt to minimize need for cutting through rebars.

	guidance of Civil Contractor.	
09	Shall install the Platform Screen Doors, Emergency Escape Doors, Manual Secondary doors and Platform screen doors local control panels (duly maintaining proper co-ordination to conceal the cable trunking in the walls/pipes, as appropriate. The responsibility for extension of cabling from the main cable tray under platfrom edge until the MCP location, through concealed conduit/race way, is under the scope of the PSD Contractor.	Shall provide necessary supports to install the platform screen doors and local control panels.
Testing and Validation stage		
10	Carryout Independent test and validation of complete PSD system.	Support necessary agreed interface requirements to carryout PSD Independent test and validation of complete PSD system
11	If any modification on civil works is necessary, same shall be coordinated during comprehensive interface hazard analysis in accordance with the relevant system safety and assurance standards.	Support necessary agreed interface requirements to carryout comprehensive interface hazard analysis.

* **Degree 3 Finishes Details:**

- Complete Wall Plastering and painting
- Complete raised floor, and false flooring except for locations where panels have to be installed after ccompletion of works by the Interfacing contractor
- Complete internal glazing
- Permanent doors and ironmongery installed
- Plumbing and Sanitary fittings complete and ready for testing

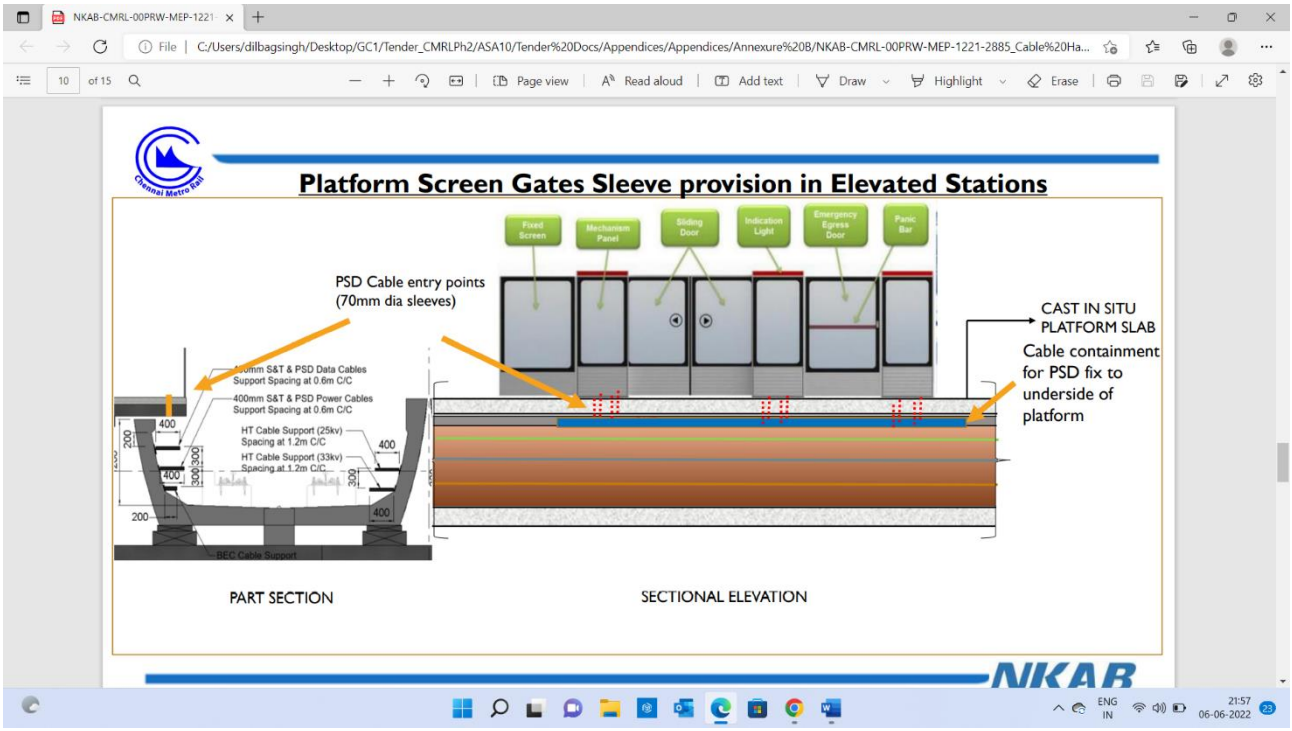
Table 1b- Interface between PSD and Civil works Elevated station	
Chennai Metro Interface Sheet A1	**Rev # :**
Contract A : PSD	**Contract B : Civil works (Elevated)**
Civil works Contractor (Interface Lead)	
Brief description of interface scope: 1. Access and delivery route and its timeline programme. 2. Cable route layout 3. False flooring layout 4. Surface finishes requirements.	

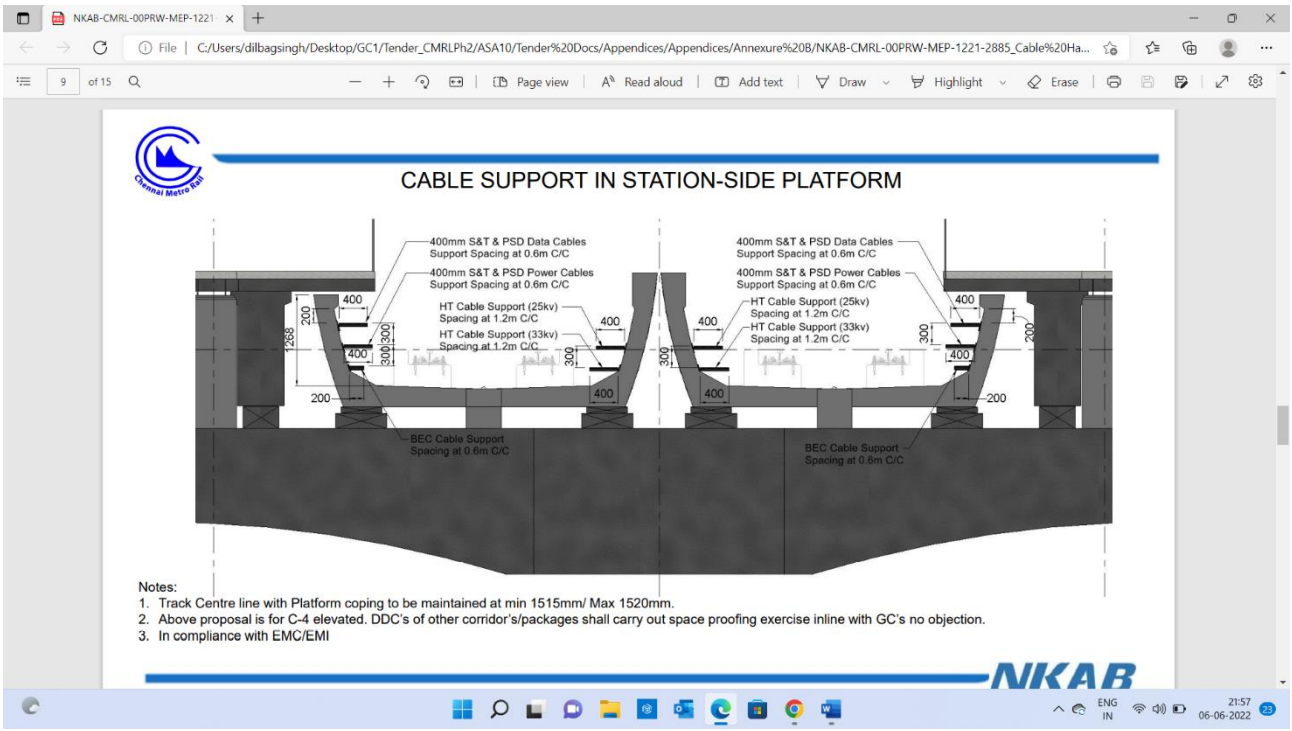
5. Fixed panel and gap filler
6. Compliance of CSD
7. As built BIM model LOD500

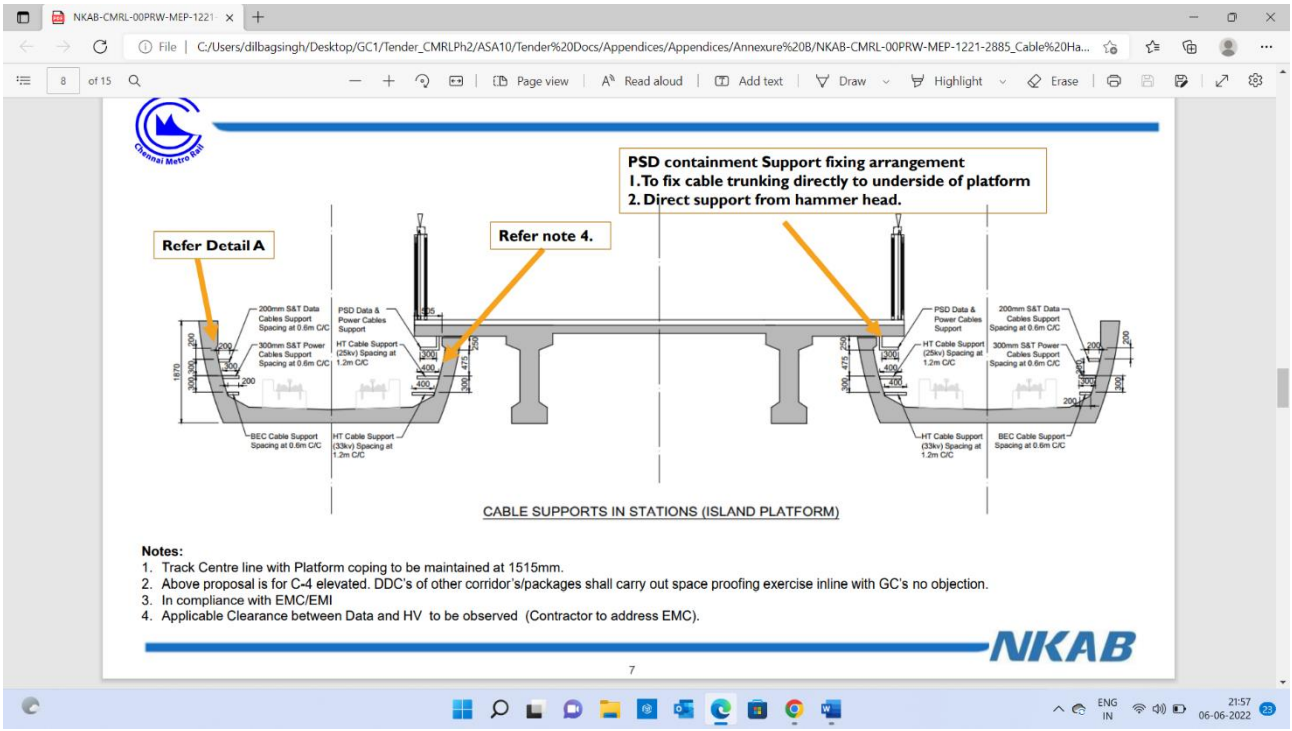
Sl. No.	Contract A (PSD)	Contract B (Civil Elevated)
Design Stage		
01	Participate in the coordination meeting and agree on delivery route plan with timeline as per PSD design and execution plan requirements.	Organize a meeting with all Designated Contractors and prepare a delivery route drawings with timeline programme.
O2	Participate in the coordination meeting and agree their Cable routing layout.	Organize a meeting with all Designated Contractors and prepare a Combined service drawing (CSD). Agree the CSD with Designated contractors and submit to Engineer for NONO.
03	Contractor to agree their equipment room layout with Designated Contractor.	Contractor to agree the false flooring layout with Designated Contractors.
Installation Stage		
04	Check the platform flooring finishes until PSD with 6 mm gap, PSD shall seal the gap. The scope is not limited to above and also to verify surface finishes wherever required.	The scope is to ensure surface finishes as required by PSD contractor.
05	PSD contractor to interface with Civil Contractor regarding maximum gap of 10 mm between PSD& MSD boundary & adjacent civil structures like fixed panels and also arrange to close this 10 mm gap with suitable sealant.	Civil Contractor to provide structures in continuation of PSD for 3 car length as well as in continuation of all MSDs, leaving a maximum gap of 10mm, which shall be closed by PSD Contractor.
06	Coordinate with Civil works contractor and agree the coordinated CSD.	Contractor to ensure the implementation of agreed CSD drawings.
Testing and Validation stage		
07	Share the as built BIM model	Synchronize the information with master as built BIM model.

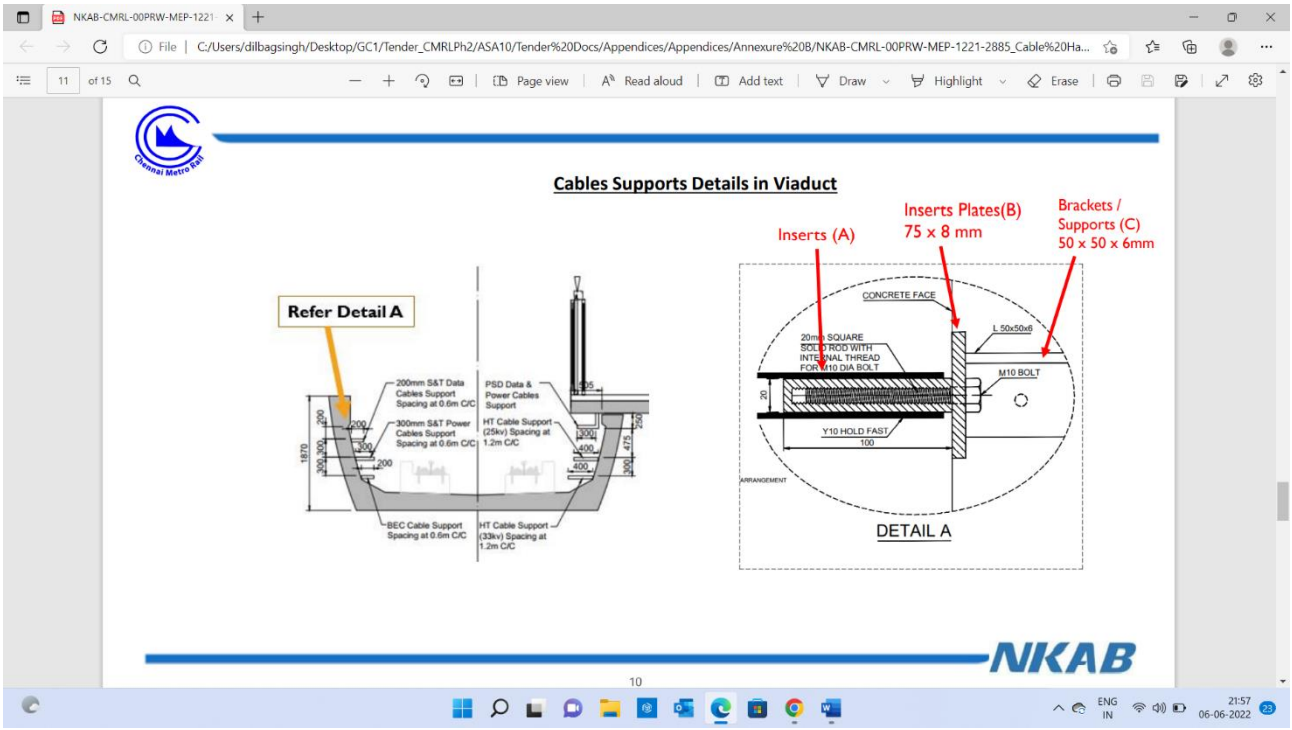
Annexure 'A' to Appendix-2P-4B

Under Platform Cable support






PSD containment Support fixing arrangement
1.To fix cable trunking directly to underside of platform
2. Direct support from hammer head.
Refer Detail A
Refer note 4.
CABLE SUPPORTS IN STATIONS (ISLAND PLATFORM)
Notes:
1. Track Centre line with Platform coping to be maintained at 1515mm.
2. Above proposal is for C-4 elevated. DDC's of other corridor's/packages shall carry out space proofing exercise inline with GC's no objection.
3. In compliance with EMC/EMI
4. Applicable Clearance between Data and HV to be observed (Contractor to address EMC).
NKAB
7


Cables Supports Details in Viaduct
Refer Detail A
Inserts (A)
Inserts Plates(B)
75 x 8 mm
Brackets /
Supports (C)
50 x 50 x 6mm
CONCRETE FACE
L 50x50x6
M10 BOLT
Y10 HOLD FAST
100
DETAIL A
NKAB
10

APPENDIX-2P-5

Interface protocol between Track and Platform Screen Doors (PSD) system

Appendix 2P-5

Interface Specification between PSD & Track Contractor

1 Interface Specifications

1.1 This document shall be read in conjunction with the relevant paragraphs of the General Specification & Technical Specification. PSD contractor shall ensure all requirements of the General Specification and the Technical Specification (TS) pertaining to interfaces are fully implemented.

1.2 In the event of a conflict between General /Technical Specification and this specification, the requirements of this Specification shall prevail.

1.3 This specification outlines the contractor's interface requirements, which are based on the technical studies carried out during the early stages of the project. However, the requirements specified herein are by no means exhaustive and it remains the joint responsibility of the PSD and Designated contractors to develop, update and execute jointly interface management details during design & throughout the execution of the work.

1.4 PSD contractor shall interface and liaise with other designated contractors in accordance with the requirements of TS and the Interface Specification at Appendix 2P of the TS. The PSD contractor shall develop and execute an interface plan during execution of the work to ensure that:

(i) All interface issues between the PSD contractor and other designated contractors are satisfactorily resolved.

(ii) Supply, Installation and testing of equipment and software are fully coordinated.

(iii) All the equipment supplied in the contract are fully compatible with each other.

2 Interface Management Plan

2.1 Within 90 days of notification from the Engineer of the identity of each designated contractor, the PSD contractor shall develop and submit to the Engineer for review an Interface Management Plan that is mutually acceptable to both, the PSD contractor and other designated contractors. The Interface Management Plan shall:

(i) Identify the sub-systems as well as the works and facilities with interfacing requirements.

(ii) Define the authority and responsibility of PSD contractor and other designated contractors (and any relevant sub-contractors') staff involved in interface management and development.

(iii) Include considerations of the Interface hazard analysis.

(iv) Specify the configuration and version control procedures in accordance with PSD contractor and other designated contractor (and any relevant sub-Contractors') quality management system; and

(v) Address the design, supply, installation, testing and commissioning programme of the contracts to meet the key dates of each contract, and highlight any programme risks requiring management attention.

2.2 Once the Interface Management Plan has been reviewed by the Engineer, PSD contractor, as lead, shall coordinate with other interface contractors and ensure the feasibility of proposed interface management plan. If any difficulty in developing a mutually acceptable Interface Management Plan, contractor shall approach the Engineer immediately to resolve the same. Once Interface management plan is mutually agreed, PSD contractor shall execute the works in accordance with the Interface Management Plan.

The Interface Specification appended to the TS as Appendix -2P, shall form the basis of the Interface management plan for the designated contractors mentioned therein. However, this does not relieve PSD contractor's obligation to identify any new interface requirements to meet this specification.

The PSD Contractor shall align to The Engineer's Master Interface management plan.

2.3 Interfaces exist between PSD contractor and Designated contractors for systems, where the systems are mutually dependent, or interactive for satisfactory and safe operation. PSD contractor shall maintain close coordination/ interface during design, manufacturing, testing, commissioning, integrated testing, trial run and defect liability period with the designated contractors and consultants who may be working in the project, whether or not especially mentioned in the contract. PSD contractor shall perform all design duties and provide all materials, equipment and labour to ensure the satisfactory accomplishment of interface of the systems for which PSD contractor is responsible.

(i) It shall be the responsibility of the PSD Contractor, as lead contractor, to settle all disagreements with the designated contractors. If such disagreement cannot be resolved by lead contractor, despite having made all reasonable efforts, then the decision of the Engineer shall be final.

(ii) PSD contractor shall submit and maintain all agreed Interface Documents as specified in the General Specification. At all stages of the work, all interfaces shall be discussed and agreed upon, through the Engineer between PSD contractor and other designated contractors.

(iii) It shall be the responsibility of PSD contractor that interface requirements be agreed, accepted and endorsed by stakeholders as early as possible. Contractual delays and consequential implications as a result of delay in such co-ordination on account of reasons attributable to PSD contractor, as concluded by Engineer, shall be the sole responsibility of PSD contractor.

3 Coordination

3.1 Technical Coordination

(i) PSD contractor shall be responsible for identifying information required from other designated contractors and/ or the Engineer and providing information in a timely manner to other Interfacing contractors and the Engineer.

(ii) PSD contractor shall communicate and coordinate with the Engineer and ensure that all interfacing details are reviewed with notice of no objection by the Engineer. Major coordination works include but not limited to those mentioned in table below.

INTERFACE- Division of Responsibility

PSD Contractor shall coordinate with Track contractor(s) in order to achieve the functional and operational requirements of the system. The roles and activities of the Contractors shall broadly be as under as the minimum but not limited to those mentioned in table below. Apart from the below table, the contractors shall also adhere to all the Interface specifications (as above) and the GS and PS requirements.

Table 1- Interface between PSD & Track		
Chennai Metro Interface Sheet	Sheet # : 1	Rev # : A1
Contract A : PSD	Contract B : Track	
PSD (Interface Lead)		
Brief description of interface scope: 1. Good for construction Track Alignment drawings in Platform zone, to enable PSD Contractor to assess the need for gap fillers, if any,to keep the gap between PSD threshold & Train floor, to within 75 mm 2. Furnishing of as-built track rail levels & track centres and joint checking of the same , to enable PSD Contractor to finalise the threshold offset and height, so as to maintain SOD requirements for the full platform length 3. PSD, Civil Contractors to jointly check the marking of Platform Centre and its co-ordinates and Track Contractor to give the chainage of the marked Platform Centre 4. Comprehensive interface hazard analysis 5. Co-Ordination during Testing & Commissioning		
Sl. No.	**Contract A : PSD**	**Contract B : Track**
Design Stage		
1	Shall check the same, decide on the need for Platform Gap Fillers and design the same accordingly.	To furnish the Good for construction Track Alignment drawings in Platform zone, to enable PSD Contractor to assess the need for gap fillers, if any,to keep the gap between PSD threshold & Train floor, to within 75 mm.

Installation Stage		
02	Shall participate in the Joint checking and accordingly position the PSD threshold offset and height above rail level (subject to the adjustment margins available in the PSD system), to respect SOD requirements	Shall Furnish the as-built track rail levels & track centres and organize joint checking of the same , to enable PSD Contractor to finalise the threshold offset and height, so as to maintain SOD requirements for the full platform length
03	Shall co-ordinate with the Civil Contractor to get the marking & co-ordinates of Platform Centre; shall co-ordinate with the Track Contractor, to obtain the chainage of the marked platform centre	PSD, Civil Contractors to jointly check the marking of Platform Centre and its co-ordinates and Track Contractor to give the chainage of the marked Platform Centre
Testing and Validation stage		
04	Shall organize the Testing & Commissioning of the PSD system	Shall assist the PSD Contractor, in complying with the SOD requirements, through adjustment of track parameters, as required

Appendix-2P-6A

Interface protocol between MEP (UG) and Platform Screen Doors (PSD) system (Full Height)

Appendix 2P-6A

Interface Specification between FHPSD & MEP Contractor

1 Interface Specifications

1.1 This document shall be read in conjunction with the relevant paragraphs of the General Specification & Technical Specification. PSD contractor shall ensure all requirements of the General Specification and the Technical Specification (TS) pertaining to interfaces are fully implemented.

1.2 In the event of a conflict between General /Technical Specification and this specification, the requirements of the General/Technical Specification shall prevail.

1.3 This specification outlines the contractor's interface requirements, which are based on the technical studies carried out during the early stages of the project. However, the requirements specified herein are by no means exhaustive and it remains the joint responsibility of the PSD and Designated contractors to develop, update and execute jointly interface management details during design & throughout the execution of the work.

1.4 PSD contractor, as lead, shall interface and liaise with other designated contractors in accordance with the requirements of TS and the Interface Specification at Appendix-2P of the TS. The PSD contractor shall develop and execute an interface plan during execution of the work to ensure that:

(i) All interface issues between the PSD contractor and other designated contractors are satisfactorily resolved.

(ii) Supply, Installation and testing of equipment and software are fully coordinated.

(iii) All the equipment supplied in the contract are fully compatible with each other.

2 Interface Management Plan

2.1 Within 60 days of notification from the Engineer of the identity of each designated contractor, the PSD contractor shall develop and submit to the Engineer for review an Interface Management Plan that is mutually acceptable to both, the PSD contractor and other designated contractors. The Interface Management Plan shall:

(i) Identify the sub-systems as well as the works and facilities with interfacing requirements.

(ii) Define the authority and responsibility of PSD contractor and other designated contractors (and any relevant sub-contractors') staff involved in interface management and development.

(iii) Include considerations of the Interface hazard analysis.

(iv) Specify the configuration and version control procedures in accordance with PSD contractor and other designated contractor (and any relevant sub-Contractors') quality management system; and

(v) Address the design, supply, installation, testing and commissioning programme of the contracts to meet the key dates of each contract, and highlight any programme risks requiring management attention.

2.2 Once the Interface Management Plan has been reviewed by the Engineer, PSD contractor shall coordinate with other interface contractors and ensure the feasibility of proposed interface management plan. If any difficulty in developing a mutually acceptable Interface Management Plan, contractor shall approach the Engineer immediately to resolve the same. Once Interface management plan is mutually agreed, PSD contractor shall execute the works in accordance with the Interface Management Plan.

The Interface Specification appended to the TS as Appendix-2P, shall form the basis of the Interface management plan for the designated contractors mentioned therein. However, this does not relieve PSD contractor's obligation to identify any new interface requirements to meet this specification.

The PSD Contractor shall align to The Engineer's Master Interface management plan.

2.3 Interfaces exist between PSD contractor and Designated contractors for systems, where the systems are mutually dependent, or interactive for satisfactory and safe operation. PSD contractor shall maintain close coordination/ interface during design, manufacturing, testing, commissioning, integrated testing, trial run and defect liability period with the designated contractors and consultants who may be working in the project, whether or not especially mentioned in the contract. PSD contractor shall perform all design duties and provide all materials, equipment and labour to ensure the satisfactory accomplishment of interface of the systems for which PSD contractor is responsible.

(i) It shall be the responsibility of the PSD Contractor, as lead contractor, to settle all disagreements with the designated contractors. If such disagreement cannot be resolved by lead contractor, despite having made all reasonable efforts, then the decision of the Engineer shall be final .

(ii) PSD contractor shall submit and maintain all agreed Interface Documents as specified in the General Specification. At all stages of the work, all interfaces shall be discussed and agreed upon, through the Engineer between PSD contractor and other designated contractors.

(iii) It shall be the responsibility of PSD contractor that interface requirements be agreed, accepted and endorsed by stakeholders as early as possible. Contractual delays and consequential implications as a result of delay in such co-ordination on account of reasons attributable to PSD contractor, as concluded by Engineer, shall be the sole responsibility of PSD contractor.

3 Coordination

3.1 Technical Coordination

(i) PSD contractor shall be responsible for identifying information required from other designated contractors and/ or the Engineer and providing information in a timely manner to other Interfacing contractors and the Engineer.

(ii) PSD contractor shall communicate and coordinate with the Engineer and ensure that all interfacing details are reviewed with notice of no objection by the Engineer. Major coordination works include but not limited to:

1) Physical routing of all pipe work, cable containment and associated ancillaries, supports

2) Layouts of PSD Room taking cognizance of lighting (to include maintained emergency lighting), ECS, drainage, S&TC interface panel, LV cabling, earthing & cable routing provisions installed by others,

3.2 Earthing and Bonding

3.2.1 MEP Contractor to provide one Main Earth Terminal (MET) at one end of each platform, for PSD contractor to earth all PSD metal work. At both ends of the each platform, the AEC/BEC/Return Rail are to be connected to the Station main earth by the Power Supply & OHE Contractor. This will ensure that PSD metal work & train body are at same potential and there is no need to provide an insulating layer to isolate the PSD end of the platform from main building earth. PSD Contractor shall check & ensure this through the PS & OHE Contractor.

3.2.2 The cable tray will be extended by the MEP Contractors upto PSD room and station control room and until the entry point to header box and till all the MSDs (at the platform end). PSD contractor's responsibility is to install of all control and power cables and provide the connections to individual devices within PSD room and also to individual doors on the platform. The extension of the cables to MSDs from the overhead cable trays, through appropriate race-ways as required, is in the scope of the PSD Contractor.

PSD Contractor will provide necessary tail cables conduits & supports and needs to coordinate with designated contractors for laying of cable tray along the full length of PSD and upto both sides MSD locations.

3.2.3 PSD Contractor to ensure through joint checking with the MEP as well as Power Supply & OHE Contractor that, the MET earth resistance value is less than 1 ohm (<1.0 ohm) ; PSD Contractor shall also ensure that the lead resistance of the connection from main MET terminals in the PSD equipment room, Station Control Room as well as at the end of each platform until the Station main earth , is within the prescribed limits and meets the earthing requirements of PSD equipment as well as PSD Façade metal work.

3.2.4 Earth Bar in the PSD Equipment room , Station Control room as well as each Platform end, shall be provided by MEP (The method of terminating PSD earth connections on these Earth bars, shall be mutually agreed between the PSD & MEP Contractors).

3.3 UPS Power Supply for PSD:

3.3.1 The PSD Contractor shall specify the static condition load as well as operating electrical loads of the PSD system. PSD Contractor also to specify the number of UPS outlets required for the PSD and the termination details of the UPS Power supply outlets through circuit

breakers as applicable. The MEP Contractor shall design the UPS system, based on these requirements. The PSD Contractor shall lay the required number of cables between the UPS termination point (as mutually agreed) until the PSD equipment room. The electrical characteristics of the interconnecting cable, shall be mutually agreed.

3.4 EMI/EMC issues

3.4.1 The PSD Contractor shall ensure that the equipment to be supplied & installed, meets the emission & compatibility requirements as specified in the Contract. The two contractors to agree on the method of checking and resolving EMC issues, if any, based on the EMC requirements as per respective contracts.

Table 1- Interface between PSD & MEP (U/G)works

Chennai Metro Interface Sheet		***Sheet # : 1***	***Rev # : A1***
Contract A : PSD	**Contract B : MEP (U/G)**		
PSD (Interface Lead)			
Brief description of interface scope: 1. Power requirements for FH PSD. 2. Provision for cable containment within station premises. 3. Installation of cables and PSD equipment's in stations. 4. Time schedule/Work Sequence 5. Earthing provision for PSD façade & Equipment room cabinets. 6. UPS provision for PSD loads 7. EMC issues resolution 8. Independent test and validation. 9. Comprehensive interface hazard analysis			

Sl. No.	**Contract A**	**Contract B**
Design Stage		
01	Shall furnish electrical load requirements for the PSD Equipment's. Shall also propose number of UPS outlets for PSD load in UPS room, details of protecting CBs etc.	Shall include the same in power load calculation and facilitate uninterruptible power supply. The details of UPS outlets for PSD load in UPS room, protection CBs etc to be mutually agreed between the two Contractors.
02	Shall furnish the number of cables,, dimensions, weight and quantity of cable trays as well as minimum separation between them, in respect of connectivity between SER and SCR and between SER	Shall design the cable routing arrangements and number of cable trays, based on the technical requirements of the PSD Contractor and in co-ordination with the Station Civil Contractor in respect of space-proofing, cut-

	and entry point to header box,	outs in walls & Civil structures etc.
03	Shall furnish the earthing arrangements & termination arrangements for earthing the PSD metal work on the platforms, (including MSDs) as also for the PSD cabinets/work stations in the equipment & control rooms.	Shall design the earthing arrangement & termination arrangements, as per the requirements of the PSD Contractor.
04	Shall furnish the EMI/EMC parameters of the PSD equipment, as specified in the Contract. Both Contractors to agree on the methodology of checking & resolving EMC issues, that might arise during the progress of the works	Shall furnish the EMI/EMC parameters of the MEP equipment, as specified in the Contract. Both Contractors to agree on the methodology of checking & resolving EMC issues, that might arise during the progress of the works
Installation stage		
05	a) Shall furnish the detailed drawings of PSD equipment to be installed in SER and SCR. b) Shall furnish the detailed drawings & locations of equipment to be installed like PSD, EED, MSD as well as MCPs.	a) Shall provide the main cable tray upto PSD equipment room, SCR and upto the entry point to header box and also to MSD location to cover all PSDs & EEDs & ,MSDs for the full usable length of the platform b) Shall work together and provide the cable trays , in co-ordination with the civil contractor.
06	Shall verify the provision of earthing earth bars and leads from the earth bars till the Station Main Earth.	Shall design earths and MET earth bars for Platform screen doors (at all the agreed locations and as per agreed design, one on each platform at the ends of PSD and one in the Equipment room as well as Station Control Room), for earthing the PSD metal work as also PSD equipments in the Equipment & Control rooms. Shall also provide the earth leads from these earth bars until Station Main Earth..
07	Shall install all control and power cables and provide the connections to individual devices. Extension of cabling from the main cable tray to individual Sliding Doors, EEDs as well as MSDs, through concealed conduiting/ race way till the end device, is in PSD contractor scope, including till the MCPs.	Cable trays shall be provided in the platform area till entry to header box, till all the MSDs as well as till the SER as well as SCR
08	Shall lay the cable to take the UPS power from UPS room and extend the power to	Shall provide the required UPS output terminations through circuit breakers , in the

	the PSD equipment room.	UPS room.
09	Shall work in close co-ordination with MEP Contractor, to ensure smooth progress of works, duly avoiding damage to structures / Equipment / Cables, already installed.	Shall make out a schedule for sequencing of works and associated duration, with a view to provide proper site access to PSD Contractor, to ensure smooth progress of works , duly avoiding damage to structures / Equipment / Cables already installed.
Testing and Validation stage		
10	(a) Shall check that the values are within the agreed limits (b) Shall ensure through PS & OHE Contractor that the return rails/AEC & BEC are bonded together and connected to Station main earth at both ends of the platform. (C) Shall attend the joint test and ensure that the continuity & lead resistance values , meet the earthing requirements of the PSD System.	a) Shall provide joint test results of main earth pit with the PS & OHE Contractor, in support of the value being less than 1 ohm. (b) Shall also ensure the connection of return rails/AEC/BEC to the Station main earth at both ends of the platform (C) Shall organise joint test of earth lead resistance from Main earth bars at each Platform end/SCR/SER until the main earth pit and demonstrate that the value meets the earthing requirements of the PSD system.
11	The interconnecting cable should be jointly tested by the two Contractors.	**S**hall test the PSD cable between equipment room & UPS room and switch on the UPS power, as per jointly agreed work schedule.
12	Carryout Independent test and validation of complete PSD system.	Support necessary agreed interface requirements to carryout PSD Independent test and validation of complete PSD system
13	If any modification on MEP works becomes necessary, same shall be coordinated during comprehensive interface hazard analysis in accordance with the relevant system safety and assurance standards.	Support necessary agreed interface requirements to carryout comprehensive interface hazard analysis.
14	In case any EMC issues are identified during Testing & Commissioning, both Contractors to co-ordinate, analyse the problem and take corrective measures for their part based on EMC specifications of their Contract.	In case any EMC issues are identified during Testing & Commissioning, both Contractors to co-ordinate, analyse the problem and take corrective measures for their part based on EMC specifications of their Contract.

APPENDIX-2P-6B

Interface protocol between MEP (Elevated) and Platform Screen Doors (PSD) system

Appendix 2P-6B

Interface Specification between HHPSD & MEP Contractor

1 Interface Specifications

1.1 This document shall be read in conjunction with the relevant paragraphs of the General Specification & Technical Specification. PSD contractor shall ensure all requirements of the General Specification and the Technical Specification (TS) pertaining to interfaces are fully implemented.

1.2 In the event of a conflict between General /Technical Specification and this specification, the requirements of the General/Technical Specification shall prevail.

1.3 This specification outlines the contractor's interface requirements, which are based on the technical studies carried out during the early stages of the project. However, the requirements specified herein are by no means exhaustive and it remains the joint responsibility of the PSD and Designated contractors to develop, update and execute jointly interface management details during design & throughout the execution of the work.

1.4 PSD contractor, as lead, shall interface and liaise with other designated contractors in accordance with the requirements of TS and the Interface Specification at Appendix 2P of the TS. The PSD contractor shall develop and execute an interface plan during execution of the work to ensure that:

(i) All interface issues between the PSD contractor and other designated contractors are satisfactorily resolved.

(ii) Supply, Installation and testing of equipment and software are fully coordinated.

(iii) All the equipment supplied in the contract are fully compatible with each other.

2 Interface Management Plan

2.1 Within 60 days of notification from the Engineer of the identity of each designated contractor, the PSD contractor shall develop and submit to the Engineer for review an Interface Management Plan that is mutually acceptable to both, the PSD contractor and other designated contractors. The Interface Management Plan shall:

(i) Identify the sub-systems as well as the works and facilities with interfacing requirements.

(ii) Define the authority and responsibility of PSD contractor and other designated contractors (and any relevant sub-contractors') staff involved in interface management and development.

(iii) Include considerations of the Interface hazard analysis.

(iv) Specify the configuration and version control procedures in accordance with PSD contractor and other designated contractor (and any relevant sub-Contractors') quality management system; and

(v) Address the design, supply, installation, testing and commissioning programme of the contracts to meet the key dates of each contract, and highlight any programme risks requiring management attention.

2.2 Once the Interface Management Plan has been reviewed by the Engineer, PSD contractor shall coordinate with other interface contractors and ensure the feasibility of proposed interface management plan. If any difficulty in developing a mutually acceptable Interface Management Plan, contractor shall approach the Engineer immediately to resolve the same. Once Interface management plan is mutually agreed, PSD contractor shall execute the works in accordance with the Interface Management Plan.

The Interface Specification appended to the TS as Appendix 2P, shall form the basis of the Interface management plan for the designated contractors mentioned therein. However, this does not relieve PSD contractor's obligation to identify any new interface requirements to meet this specification.

The PSD Contractor shall align to The Engineer's Master Interface management plan.

2.3 Interfaces exist between PSD contractor and Designated contractors for systems, where the systems are mutually dependent, or interactive for satisfactory and safe operation. PSD contractor shall maintain close coordination/ interface during design, manufacturing, testing, commissioning, integrated testing, trial run and defect liability period with the designated contractors and consultants who may be working in the project, whether or not especially mentioned in the contract. PSD contractor shall perform all design duties and provide all materials, equipment and labour to ensure the satisfactory accomplishment of interface of the systems for which PSD contractor is responsible.

(i) It shall be the responsibility of the PSD Contractor, as lead contractor, to settle all disagreements with the designated contractors. If such disagreement cannot be resolved by lead contractor, despite having made all reasonable efforts, then the decision of the Engineer shall be final .

(ii) PSD contractor shall submit and maintain all agreed Interface Documents as specified in the General Specification. At all stages of the work, all interfaces shall be discussed and agreed upon, through the Engineer between PSD contractor and other designated contractors.

(iii) It shall be the responsibility of PSD contractor that interface requirements be agreed, accepted and endorsed by stakeholders as early as possible. Contractual delays and consequential implications as a result of delay in such co-ordination on account of reasons attributable to PSD contractor, as concluded by Engineer, shall be the sole responsibility of PSD contractor.

3 Coordination

3.1 Technical Coordination

(i) PSD contractor shall be responsible for identifying information required from other designated contractors and/ or the Engineer and providing information in a timely manner to other Interfacing contractors and the Engineer.

(ii) PSD contractor shall communicate and coordinate with the Engineer and ensure that all interfacing details are reviewed with notice of no objection by the Engineer. Major coordination works include but not limited to:

1) Physical routing of all pipe work, cable containment and associated ancillaries, supports

2) Layouts of PSD Room taking cognizance of lighting (to include maintained emergency lighting), ECS, drainage, S&TC interface panel, LV cabling, earthing & cable routing provisions installed by others,

3.2 Earthing and Bonding

3.2.1 MEP Contractor to provide one Main Earth Terminal (MET) at one end of each platform, for PSD contractor to earth all PSD metal work. At both ends of the each platform, the AEC/BEC/Return Rail are to be connected to the Station main earth by the Power Supply & OHE Contractor. This will ensure that PSD metal work & train body are at same potential and there is no need to provide an insulating layer to isolate the PSD end of the platform from main building earth. PSD Contractor shall check & ensure this through the PS & OHE Contractor.

3.2.2 The cable tray will be extended by the MEP Contractors upto PSD room & Station control room and until the entry point to the cable supports under the platform coping. PSD contractor's responsibility is to install all control and power cables and provide the connections to individual devices within PSD room and also to individual doors on the platform. The extension of the cables to MSDs from the main cable trunking under the platform coping, through appropriate race-ways as required, is in the scope of the PSD Contractor.

PSD Contractor will provide necessary tail cables conduits & supports and needs to coordinate with designated contractors for laying of cable tray along the full length of PSD and upto both sides MSD locations.

3.2.3 PSD Contractor to ensure through joint checking with the MEP as well as Power Supply & OHE Contractor that, the MET earth resistance value is less than 1 ohm (<1.0 ohm) ; PSD Contractor shall also ensure that the lead resistance of the connection from main MET terminals in the PSD equipment room, Station Control Room as well as at the end of each platform until the Station main earth , is within the prescribed limits and meets the earthing requirements of PSD equipment as well as PSD Façade metal work.

3.2.4 Earth Bar in the PSD Equipment room , Station Control room as well as each Platform end, shall be provided by MEP (The method of terminating PSD earth connections on these Earth bars, shall be mutually agreed between the PSD & MEP Contractors).

3.3 UPS Power Supply for PSD:

3.3.1 The PSD Contractor shall specify the static condition load as well as operating electrical loads of the PSD system. PSD Contractor also to specify the number of UPS outlets required

for the PSD and the termination details of the UPS Power supply outlets through circuit breakers as applicable. The MEP Contractor shall design the UPS system, based on these requirements. The PSD Contractor shall lay the required number of cables between the UPS termination point (as mutually agreed) until the PSD equipment room. The electrical characteristics of the interconnecting cable, shall be mutually agreed.

3.4 Heat load for Air-Conditioning

3.4.1 The PSD Contractor shall advise the heat load generated by PSD equipment in the SER. Also the locations of cabinets/panels etc inside the room. The MEP shall take this into account in designing the Air-Conditioning system for the PSD equipment room and also in locating the AC ducts etc in such a manner as to avoid water condensation over PSD cabinets/panels.

3.5 EMI/EMC issues

3.5.1 The PSD Contractor shall ensure that the equipment to be supplied & installed, meets the emission & compatibility requirements as specified in the Contract. The two contractors to agree on the method of checking and resolving EMC issues, if any, based on the EMC requirements as per respective contracts.

Table 1- Interface between PSD & MEP works

Chennai Metro Interface Sheet		***Sheet # : 1***	***Rev # : A1***
Contract A : PSD	**Contract B : MEP**		
PSD (Interface Lead)			
Brief description of interface scope: 1. Power requirements for HH PSD. 2. Provision for cable containment within station premises. 3. Installation of cables and PSD equipment's in stations. 4. Time schedule/Work Sequence 5. Earthing provision for PSD façade & Equipment room cabinets. 6. UPS provision for PSD loads 7. EMC issues resolution 8. Independent test and validation. 9. Comprehensive interface hazard analysis			
Sl. No.	**Contract A**	**Contract B**	
Design Stage			
01	Shall furnish electrical load requirements for the PSD Equipment's. Shall also propose number of UPS outlets for PSD load in UPS room, details of protecting CBs etc.	Shall include the same in power load calculation and facilitate uninterruptible power supply. The details of UPS outlets for PSD load in UPS room, protection CBs etc to be mutually agreed between the two Contractors.	
02	Shall furnish the number of cables,, dimensions, weight and quantity of cable trays	Shall design the cable routing arrangements and number of cable trays, based on the	

	as well as minimum separation between them, in respect of connectivity between SER and SCR and between SER and entry point to the cable supports under the Platform coping,	technical requirements of the PSD Contractor and in co-ordination with the Station Civil Contractor in respect of space-proofing, cut-outs in walls & Civil structures etc.
03	Shall furnish the earthing arrangements & termination arrangements for earthing the PSD metal work on the platforms, (including MSDs) as also for the PSD cabinets/work stations in the equipment & control rooms.	Shall design the earthing arrangement & termination arrangements, as per the requirements of the PSD Contractor.
04	PSD shall advise the heat load generated by PSD equipment in the SER. Also the locations of cabinets/panels etc inside the room	Shall take this into account in designing the Air-Conditioning system for the PSD equipment room and also in locating the AC ducts etc in such a manner as to avoid water condensation over PSD cabinets/panels.
05	Shall furnish the EMI/EMC parameters of the PSD equipment, as specified in the Contract. Both Contractors to agree on the methodology of checking & resolving EMC issues, that might arise during the progress of the works	Shall furnish the EMI/EMC parameters of the MEP equipment, as specified in the Contract. Both Contractors to agree on the methodology of checking & resolving EMC issues, that might arise during the progress of the works
Installation stage		
06	b) Shall furnish the detailed drawings of PSD equipment to be installed in SER and SCR. b) Shall furnish the detailed drawings & locations of equipment to be installed like PSD, EED, MSD as well as MCPs.	a) Shall provide the main cable tray upto PSD equipment room, SCR and upto the entry point to the cable trunking beneath the platform coping ,to cover all PSDs & EEDs & MSDs for the full usable length of the platform b) Shall work together and provide the cable trays , in co-ordination with the civil contractor.
07	Shall verify the provision of earthing earth bars and leads from the earth bars till the Station Main Earth.	Shall design earths and MET earth bars for Platform screen doors (at all the agreed locations and as per agreed design, one on each platform at the ends of PSD and one in the Equipment room as well as Station Control Room), for earthing the PSD metal work as also PSD equipments in the Equipment & Control rooms. Shall also provide the earth leads from these earth bars until Station Main Earth..
08	Shall install all control and power cables and provide the connections to individual devices. Provision of conduits of required sizes and at required spacing ,based on EMC requirements, over the cable tray supports	Cable trays shall be provided in the platform area till entry to cable trunking beneath the Platform coping , as well as till the SER as well as SCR

	beneath the Platform coping is in the scope of the PSD Contractor. Extension of cabling from the main cable trunking beneath the Platform coping, to individual Sliding Doors, EEDs as well as MSDs, through concealed conduiting/ race way till the end device, is in PSD contractor scope, including till the MCPs.	
09	Shall lay the cable to take the UPS power from UPS room and extend the power to the PSD equipment room.	Shall provide the required UPS output terminations through circuit breakers , in the UPS room.
10	Shall work in close co-ordination with MEP Contractor, to ensure smooth progress of works, duly avoiding damage to structures / Equipment / Cables, already installed..	Shall make out a schedule for sequencing of works and associated duration, with a view to provide proper site access to PSD Contractor, to ensure smooth progress of works , duly avoiding damage to structures / Equipment / Cables already installed.
Testing and Validation stage		
11	(a) Shall check that the values are within the agreed limits (b) Shall ensure through PS & OHE Contractor that the return rails/AEC & BEC are bonded together and connected to Station main earth at both ends of the platform. (C) Shall attend the joint test and ensure that the continuity & lead resistance values , meet the earthing requirements of the PSD System.	a) Shall provide joint test results of main earth pit with the PS & OHE Contractor, in support of the value being less than 1 ohm. (b) Shall also ensure the connection of return rails/AEC/BEC to the Station main earth at both ends of the platform (C) Shall organise joint test of earth lead resistance from Main earth bars at each Platform end/SCR/SER until the main earth pit and demonstrate that the value meets the earthing requirements of the PSD system.
12	The interconnecting cable should be jointly tested by the two Contractors.	**S**hall test the PSD cable between equipment room & UPS room and switch on the UPS power, as per jointly agreed work schedule.
13	Carryout Independent test and validation of complete PSD system.	Support necessary agreed interface requirements to carryout PSD Independent test and validation of complete PSD system
14	If any modification on MEP works becomes necessary, same shall be coordinated during comprehensive interface hazard analysis in accordance with the relevant system safety and assurance standards.	Support necessary agreed interface requirements to carryout comprehensive interface hazard analysis.

15	In case any EMC issues are identified during Testing & Commissioning, both Contractors to co-ordinate, analyse the problem and take corrective measures for their part based on EMC specifications of their Contract.	In case any EMC issues are identified during Testing & Commissioning, both Contractors to co-ordinate, analyse the problem and take corrective measures for their part based on EMC specifications of their Contract.

APPENDIX-2P-7

Interface protocol between VAC and Platform Screen Doors (PSD) system (Full Height)

Appendix 2P-7

Interface Specification between FHPSD & VAC Contractor

1 Interface Specifications

1.1 This document shall be read in conjunction with the relevant paragraphs of the General Specification & Technical Specification. PSD contractor shall ensure all requirements of the General Specification and the Technical Specification (TS) pertaining to interfaces are fully implemented.

1.2 In the event of a conflict between General /Technical Specification and this specification, the requirements of the General/Technical Specification shall prevail.

1.3 This specification outlines the contractor's interface requirements, which are based on the technical studies carried out during the early stages of the project. However, the requirements specified herein are by no means exhaustive and it remains the joint responsibility of the PSD and Designated contractors to develop, update and execute jointly interface management details during design & throughout the execution of the work.

1.4 PSD contractor, as lead, shall interface and liaise with other designated contractors in accordance with the requirements of TS and the Interface Specification at Appendix 2P of the TS. The PSD contractor shall develop and execute an interface plan during execution of the work to ensure that:

(i) All interface issues between the PSD contractor and other designated contractors are satisfactorily resolved.

(ii) Supply, Installation and testing of equipment and software are fully coordinated.

(iii) All the equipment supplied in the contract are fully compatible with each other.

2 Interface Management Plan

2.1 Within 90 days of notification from the Engineer of the identity of each designated contractor, the PSD contractor shall develop and submit to the Engineer for review an Interface Management Plan that is mutually acceptable to both, the PSD contractor and other designated contractors. The Interface Management Plan shall:

(i) Identify the sub-systems as well as the works and facilities with interfacing requirements.

(ii) Define the authority and responsibility of PSD contractor and other designated contractors (and any relevant sub-contractors') staff involved in interface management and development.

(iii) Include considerations of the Interface hazard analysis.

(iv) Specify the configuration and version control procedures in accordance with PSD contractor and other designated contractor (and any relevant sub-Contractors') quality management system; and

(v) Address the design, supply, installation, testing and commissioning programme of the contracts to meet the key dates of each contract, and highlight any programme risks requiring management attention.

2.2 Once the Interface Management Plan has been reviewed by the Engineer, PSD contractor, as lead, shall coordinate with other interface contractors and ensure the feasibility of

proposed interface management plan. If any difficulty in developing a mutually acceptable Interface Management Plan, contractor shall approach the Engineer immediately to resolve the same. Once Interface management plan is mutually agreed, PSD contractor shall execute the works in accordance with the Interface Management Plan.

The Interface Specification appended to the TS as Appendix 2P, shall form the basis of the Interface management plan for the designated contractors mentioned therein. However, this does not relieve PSD contractor's obligation to identify any new interface requirements to meet this specification.

The PSD Contractor shall align to The Engineer's Master Interface management plan.

2.3 Interfaces exist between PSD contractor and Designated contractors for systems, where the systems are mutually dependent, or interactive for satisfactory and safe operation. PSD contractor shall maintain close coordination/ interface during design, manufacturing, testing, commissioning, integrated testing, trial run and defect liability period with the designated contractors and consultants who may be working in the project, whether or not especially mentioned in the contract. PSD contractor shall perform all design duties and provide all materials, equipment and labour to ensure the satisfactory accomplishment of interface of the systems for which PSD contractor is responsible.

(i) It shall be the responsibility of the PSD Contractor, as lead contractor, to settle all disagreements with the designated contractors. If such disagreement cannot be resolved by lead contractor, despite having made all reasonable efforts, then the decision of the Engineer shall be final .

(ii) PSD contractor shall submit and maintain all agreed Interface Documents as specified in the General Specification. At all stages of the work, all interfaces shall be discussed and agreed upon, through the Engineer between PSD contractor and other designated contractors.

(iii) It shall be the responsibility of PSD contractor that interface requirements be agreed, accepted and endorsed by stakeholders as early as possible. Contractual delays and consequential implications as a result of delay in such co-ordination on account of reasons attributable to PSD contractor, as concluded by Engineer, shall be the sole responsibility of PSD contractor.

3 Coordination

3.1 Technical Coordination

(i) PSD contractor, as lead, shall be responsible for identifying information required from other designated contractors and/ or the Engineer and providing information in a timely manner to other Interfacing contractors and the Engineer.

(ii) PSD contractor shall communicate and coordinate with the Engineer and ensure that all interfacing details are reviewed with notice of no objection by the Engineer. Major coordination works include but not limited to:

INTERFACE- Division of Responsibility

PSD Contractor shall coordinate with VAC contractor(s) in order to achieve the functional and operational requirements of the system. The roles and activities of the Contractors shall broadly be as under as the minimum but not limited to those mentioned in table below. Apart

from the below table, the contractors shall also adhere to all the Interface specifications (as above) and the GS and PS requirements.

Table 1- Interface between FH PSD & VAC works		
Chennai Metro Interface Sheet	***Sheet # : 1***	***Rev # : A1***
Contract A : PSD	**Contract B: VAC**	
PSD (Interface Lead)		
Brief description of interface scope: 1. Heat Load of the PSD system as well as the lay-out of cabinets & panels in the Equipment room, to enable the VAC Contractor to design the VAC system as per PSD heat loads and in a way to avoid condensation over PSD cabinets & panels 2. Co-Ordination during installation stage 3. Provision of VAC system in time to meet the Testing & Commissioning needs of the PSD system 4. Comprehensive interface hazard analysis 5. Co-Ordination during Testing & Commissioning		
S. No.	**Contract A**	**Contract B**
Design Stage		
01	To furnish the Heat Load of the PSD system as well as the lay-out of cabinets & panels in the Equipment room, to enable the VAC Contractor to design the VAC system as per PSD heat loads and in a way to avoid condensation over PSD cabinets & panels.	To Design the VAC system, based on inputs provided by the PSD Contractor.
Installation Stage		
02	Shall install the PSD system , duly taking care to avoid damage to VAC equipment, piping & ducts	Shall install the VAC system , duly taking care to avoid condensation over PSD cabinets/panels and also taking care to avoid damage to PSD cabinets/panels/ cables/cable trays as well as Platform PSD equipment
Testing and Validation stage		

03	Shall organize the Testing & Commissioning of the PSD system	Shall arrange for commissioning of VAC system as per PSD T&C schedule and provide all necessary assistance during T&C stage, to ensure smooth functioning of the VAC System

APPENDIX-2P-8

Interface protocol between TVS and Platform Screen Doors (PSD) system (Full Height)

Appendix 2P-8

Interface Specification between FHPSD & TVS Contractor

1 Interface Specifications

1.1 This document shall be read in conjunction with the relevant paragraphs of the General Specification & Technical Specification. PSD contractor shall ensure all requirements of the General Specification and the Technical Specification (TS) pertaining to interfaces are fully implemented.

1.2 In the event of a conflict between General /Technical Specification and this specification, the requirements of the General/Technical Specification shall prevail.

1.3 This specification outlines the contractor's interface requirements, which are based on the technical studies carried out during the early stages of the project. However, the requirements specified herein are by no means exhaustive and it remains the joint responsibility of the PSD and Designated contractors to develop, update and execute jointly interface management details during design & throughout the execution of the work.

1.4 PSD contractor, as lead, shall interface and liaise with other designated contractors in accordance with the requirements of TS and the Interface Specification at Appendix - 2P of the TS.. The PSD contractor shall develop and execute an interface plan during execution of the work to ensure that:

(i) All interface issues between the PSD contractor and other designated contractors are satisfactorily resolved.

(ii) Supply, Installation and testing of equipment and software are fully coordinated.

(iii) All the equipment supplied in the contract are fully compatible with each other.

2 Interface Management Plan

2.1 Within 60 days of notification from the Engineer of the identity of each designated contractor, the PSD contractor shall develop and submit to the Engineer for review an Interface Management Plan that is mutually acceptable to both, the PSD contractor and other designated contractors. The Interface Management Plan shall:

(i) Identify the sub-systems as well as the works and facilities with interfacing requirements.

(ii) Define the authority and responsibility of PSD contractor and other designated contractors (and any relevant sub-contractors') staff involved in interface management and development.

(iii) Include considerations of the Interface hazard analysis.

(iv) Specify the configuration and version control procedures in accordance with PSD contractor and other designated contractor (and any relevant sub-Contractors') quality management system; and

(v) Address the design, supply, installation, testing and commissioning programme of the contracts to meet the key dates of each contract, and highlight any programme risks requiring management attention.

2.2 Once the Interface Management Plan has been reviewed by the Engineer, PSD contractor, as lead, shall coordinate with other interface contractors and ensure the feasibility of proposed interface management plan. If any difficulty in developing a mutually acceptable Interface Management Plan, contractor shall approach the Engineer immediately to resolve the same. Once Interface management plan is mutually agreed, PSD contractor shall execute the works in accordance with the Interface Management Plan.

The Interface Specification appended to the TS as Appendix -2P, shall form the basis of the Interface management plan for the designated contractors mentioned therein. However, this does not relieve PSD contractor's obligation to identify any new interface requirements to meet this specification.

The PSD Contractor shall align to The Engineer's Master Interface management plan.

2.3 Interfaces exist between PSD contractor and Designated contractors for systems, where the systems are mutually dependent, or interactive for satisfactory and safe operation. PSD contractor shall maintain close coordination/ interface during design, manufacturing, testing, commissioning, integrated testing, trial run and defect liability period with the designated contractors and consultants who may be working in the project, whether or not especially mentioned in the contract. PSD contractor shall perform all design duties and provide all materials, equipment and labour to ensure the satisfactory accomplishment of interface of the systems for which PSD contractor is responsible.

(i) It shall be the responsibility of the PSD Contractor, as lead contractor, to settle all disagreements with the designated contractors. If such disagreement cannot be resolved by lead contractor, despite having made all reasonable efforts, then the decision of the Engineer shall be final .

(ii) PSD contractor shall submit and maintain all agreed Interface Documents as specified in the General Specification. At all stages of the work, all interfaces shall be discussed and agreed upon, through the Engineer between PSD contractor and other designated contractors.

(iii) It shall be the responsibility of PSD contractor that interface requirements be agreed, accepted and endorsed by stakeholders as early as possible. Contractual delays and consequential implications as a result of delay in such co-ordination on account of reasons attributable to PSD contractor, as concluded by Engineer, shall be the sole responsibility of PSD contractor.

3 Coordination

3.1 Technical Coordination

(i) PSD contractor, as lead, shall be responsible for identifying information required from other designated contractors and/ or the Engineer and providing information in a timely manner to other Interfacing contractors and the Engineer.

(ii) PSD contractor shall communicate and coordinate with the Engineer and ensure that all interfacing details are reviewed with notice of no objection by the Engineer. Major coordination works include but not limited to:

INTERFACE- Division of Responsibility

PSD Contractor shall coordinate with TVS contractor(s) in order to achieve the functional and operational requirements of the system. The roles and activities of the Contractors shall broadly be as under as the minimum but not limited to those mentioned in table below. Apart from the below table, the contractors shall also adhere to all the Interface specifications (as above) and the GS and PS requirements.

Table 1- Interface between FH PSD & TVS works			
Chennai Metro Interface Sheet		***Sheet # : 1***	***Rev # : A1***
Contract A: PSD		**Contract B: TVS**	
PSD (Interface Lead)			
Brief description of interface scope: 1. Details of pressure effects on the PSD due to train running as well as operation of TVS fans. 2. Comprehensive interface hazard analysis 3. Co-Ordination during Testing & Commissioning			
S. No.	**Contract A**	**Contract B**	
Design Stage			
01	Shall get the details of pressure effects on PSD induced by train piston effect when train is entering in the station or running through the Station and design the PSD and its mounting arrangements accordingly	Shall provide the details of pressure effects on PSD induced by train piston effect when train is entering into the station or running through the Station	
02	Shall take these pressure effects into account while designing the PSD system & its operational parameters	Shall provide the details of pressure exerted on the PSD system due to operation of TVS Fans in various modes	
Testing and Validation stage			
03	Shall jointly organize testing of PSD operation under various scenarios of	Shall support the conduct of the joint test by creating various TVS operational scenarios and participate	

	TVS Operation	in the joint test

APPENDIX 2T

RAMS REQUIREMENTS

(FH & HHPSD)

Appendix 2T

RAMS Requirements (FH & HHPSD)

1. Introduction

1.1 The Chennai Metro Phase II Project is to be developed applying the highest standards for Reliability Availability, Maintainability and Safety (RAMS).

RAMS is two folded:

(i) The Safety activity is about risk management. Basically, risks must be managed (i.e. identified, assessed and mitigated) then closed before Revenue Service. Most of the System Safety activities are performed before Revenue Service in such a way to ensure safety from day one.

(ii) The RAM activity is about ensuring a high level of system dependability in order to achieve best service to passengers. A defined level of service to passengers shall be offered at Revenue Service time and shall grow over the years.

1.2 This document addresses these two aspects and also indicates both the Safety Targets and the RAM Targets, i.e. the actual values to be reached. Furthermore, a specific Appendix deals with the Software RAMS Assurance Requirements.

2. Purpose of the document

2.1 The present document presents the main requirements of RAMS to be developed for the Project. The purpose of this document is to define the main principles that the Contractor shall implement to manage the system RAMS requirements throughout the Project.

2.2 These principles regarding the management of system RAMS requirements throughout the project shall apply to any Contractor/ Subcontractor involved in the development of the Project's RAMS-related systems/subsystems.

2.3 The goal of RAMS management is to prevent the occurrence of random faults and systematic faults over the whole System lifecycle in order to ensure a high level of service to passengers.

2.4 Therefore, this document covers RAMS and quality, methodological and technical, operational and managerial issues of the safety-related systems/subsystems.

3. Scope of the document

This document details the requirements with respect to RAMS.

(i) The requirements defined within this document shall apply to the System, including its interfaces with Civil Works in general and to all safety-related systems in particular.

(ii) Generally speaking, the Contractor shall demonstrate and implement his ability to conform to all phases of the RAMS management process from the System Requirements to the System Validation activities. The RAMS Requirements pointing to O&M activities shall also be identified by the Contractor.

In order to picture this, a model of the Transportation System lifecycle is found in Appendix of this document. The Appendix also gives the corresponding Project stakeholders' safety responsibilities based on the Standards.

3.1 Abbreviations

ALARP	As Low As Reasonably Practicable
E&M	Electrical & Mechanical
FMECA	Failure Mode Effects Criticality Analysis
FRACAS	Failure Reporting Analysis and Corrective Action System
HL	Hazard Log
HVAC	Heating, Ventilation, and Air Conditioning
IHA	Interface Hazard Analysis
ISA	Independent Safety Assessor
LRU	Line Replaceable Unit
MCBFF	Mean Cycles Between Functional Failures
MEP	Mechanical, Electrical and Plumbing
MTBSAF	Mean time between service affecting failures
MTTR	Mean time to repair
OSHA	Operating & Support Hazard Analysis
PHA	Preliminary Hazard Analysis
QA	Quality Assurance
RBD	Reliability Block Diagram
SHA	System Hazard Analysis
T&C	Testing and Commissioning

3.2 Definitions

Accident	An unintended event or series of events that results in death, injury,loss of a system or service, or environmental damage.
Availability	The ability of a product / equipment / system to be in a state to performa required function under given conditions at a given instant of time or over a given time interval assuming that the required external resourcesare provided.
Failure rate	Number of failures per period, distance or cycle.
Hazard	A physical situation with a potential for human injury.
Maintainability	The probability that a given active maintenance action, for an item under given conditions of use can be carried out within a stated timeinterval when the maintenance is performed under stated conditionsand using stated procedures and resources.
Maintainer	The entity that shall be responsible for the maintenance of the Transportation system
Mean time to repair	Is the average time taken to restore a faulty module/line replaceable unit back to working condition. This will include the time to access the defective unit (access time), time taken to localize the fault & time taken to complete the corrective action by means of repair/adjustment/re-configuration or substitution. It assumes that the Maintainer has the requisite skills to localize the fault and to repair it; it also assumes that all requisite tools & test equipment as well as spare units are readily available at site, for use by the Maintainer in his task.
Mean time between service affecting failures	Is the mean time interval between two successive failures of a LRU/Module , taking into account the total hours for which the system is used for train operations.
Operator	The entity that shall be responsible for the operation of the Transportation System, or the shadow operator when applicable.
Plan	Specifies the preconditions, documents, persons involved, equipment required, time schedule, sequence and actions required for the task tobe done.
Reliability	The probability that the system or subsystem shall perform satisfactorily for a given period of time when used under statedconditions.
Review	Covers all activities to perform a thorough examination of a documentrelated to a defined subject
Risk	The probable rate of occurrence of a hazard causing harm and the degree of severity of the harm.
Safety	Freedom from unacceptable risk of harm.
Safety critical	Necessary to achieve Safety.
Safety Lifecycle	The activities occurring during a period of time that starts when a system is conceived and ends when the system is no longer availablefor use, is decommissioned and is disposed.

Safety Regulatory Authority	. EN 50126-1 give the following definition for the Safety Regulatory Authority : “Often a national government body responsible for settingor agreeing the safety requirements for a railway and ensuring that therailway complies with the requirements.”
SubContractor	A subsystem supplier responsible for design, manufacture, delivery,installation, and commissioning of a subsystem.
System	System comprises subsystems, which are combined in the system tofulfil required functions under given conditions.
Transportation System	The Metro System object of the Project.
Validation	Confirmation by examination and provision of objective evidence that the particular requirements for a specific intended use have been fulfilled.
Verification	Confirmation by examination and provision of objective evidence that the specified requirements have been fulfilled.

3.3 References

STANDARDS	SUBJECT
IEC 62278 Same asEN 50126-1	Railway Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS)
EN 50128	Railway Applications - Communication, Signalling and ProcessingSystems - Software for Railway Control And Protection Systems
IEC 62425 Same asEN 50129	Railway Applications - Communication, Signalling and ProcessingSystems - Safety Related Electronic Systems For Signalling
EN 50159	Railway applications - Communication, signalling and processingsystems - Safety-related communication in transmission systems
IEC 62267 Same asEN 62267	Railway applications – Automated urban guided transport (AUGT) – Safety Requirements
IEC 61703:2001 Same as EN 61703	Mathematical expressions for reliability, availability, maintainability and maintenance support terms
IEC 62290-1:2014 Same as EN 62290-1	Railway applications – Urban guided transport management andcommand/control systems – Part 1: System principles and fundamental concepts (as applicable)
IEC 62290-2:2014 Same as EN 62290-2	Railway Applications - Urban Guided Transport Management and Command/Control Systems - Part 2: Functional Requirements Specification (as applicable)
IEEE 1474.1:2004	Communications-Based Train Control (CBTC) Performance and Functional Requirements
IEEE 1474.2:2003	User Interface Requirements in Communications Based TrainControl (CBTC) Systems

NFPA 130: 2014	Standard for Fixed Guideway Transit and Passenger Rail Systems.
ISO 9000:2005	Quality management systems – Fundamentals and vocabulary
ISO 9001:2008	Quality management systems – Requirements
ISO/IEC 90003:2004	Software engineering - Guidelines for the application of ISO9001:2000 to computer software

4. System Assurance Plan

4.1 Within ninety (90) days of the date of the signing of the contract, the Contractor shall provide a System Assurance Plan. The System Assurance Plan shall be a standalone document. The Contractor shall seek the Notice of No Objection of the System Assurance Plan from the Engineer..

4.2 The System Assurance Plan shall demonstrate that the organisation, resources and procedures exist to manage all system assurance activities that the Contractor shall be responsible for.

4.3 The System Assurance Plan shall take account of:

(a) The design of the railway;

(b) Interfaces within the works and between the works and Civil Works;

(c) Interfaces to works provided by other Designated Contractors;

(d) Testing and inspection procedures associated with the works; and

(e) Commissioning and handover procedures associated with the works.

4.4 The subjects to be covered in the System Assurance Plan shall include, but notbe limited to, the following:

(i) The scope and purpose of the System Safety Plan;

(ii) The scope and purpose of the System RAM Plan;

(iii) The method of dealing with interfaces between the System Safety Plan and the System RAM Plan;

(iv) The Contractor's proposals for internal and Subcontractor system assurance and safety audits.

4.5 The Contractor shall be responsible for the review and acceptance of Subcontractor’s System Assurance Plans to ensure consistency in approach with his own System Assurance Plan.

4.6 The Contractor shall monitor the performance of each Subcontractor on a regular basis, for compliance with the system assurance activities identified in the System Assurance Plan.

5. Interaction with the Employer/ISA

5.1 The Contractor shall provide the requisite information, documentation, clarification, justification and access to facilities when requested for the following:

5.2 The Employer and / or the ISA shall carry out audits in the premises of the Contractor and / or Subcontractors when the Employer and / or the ISAdeem it necessary.

5.3 If deemed necessary, the Employer and / or the ISA may perform any audits or tests in addition to those planned by the Contractor in his plans.

5.4 All submissions and / or comments made by the ISA should be considered and addressed to the satisfaction of the ISA, by the Contractor throughout the project.

6. Requirements for Safety Assurance

6.1 General Safety Requirements

6.1.1 Safety risk management shall include those risks related to the prevention of death, injury and material loss (i.e. property and/or environmental damage).

6.1.2 The Contractor shall carry out pro-active identification of hazards relating to the works and wherever reasonably practical, hazards shall be eliminated at thedesign stages.

6.1.3 Where it is not reasonably practical to eliminate such hazards at the design stage, risk assessment shall be carried out to ensure that the risks associated with residual hazards are in order of precedence:

i. Minimised at the design stage.

ii Mitigated wherever possible, and;

iii Can be subsequently managed.

6.1.4 The basis of safety risk management shall follow the “as low as reasonably practicable” (ALARP) principle as stipulated in Standard EN 50126-1.

6.1.5 The Contractor shall pay attention to the management of safety at all the system interfaces and the means by which adequate safety justification of the system shall be assured at various stages in the system life cycle.

6.1.6 In order to ensure a seamless approach to safety management of all aspects of thePSD System, the Contractor shall assist the Employer to identify all risks arising from the Operation and Maintenance of the works and shall bring all such risks to the attention of the Employert via a separate document called SRAC: Safety Related Application Conditions.

6.1.7 The Contractor shall consider human factors in his safety studies and demonstrate that the design is consistent with the minimisation of human delayand error, so far as is reasonably practicable, and the optimisation of the efficiency of operatives. This demonstration is carried out using recognised techniques of ergonomics, human error and task analysis with suitable reference to the proposed method of operating the PSD System. Assumptions concerning procedures and staffing arrangements shall be clearlydefined by the Contractor.

6.1.8 The Contractor shall develop and maintain a system Hazard Log for all identified hazards and this hazard log shall form part of the Proof of Safety documentation.

6.1.9 The Contractor shall support the Employer in securing the necessary safety approvals from relevant Safety Authority like the Employer’s Independent Safety Assessor & The Commissioner for Metro Rail Safety (CMRS) One approach relies on cross- acceptance by the Safety Authority of the Safety Cases from other projects, which have been assessed, reviewed and approved by an independent agency or other recognised competent body. Whichever approach is adopted, the Contractor is responsible for providing the appropriate level of documentation., justification, clarification to convince the relevant Safety Authority as to the inherent safety of the System, as per the specifications.

6.1.10 For all systems containing software, the Contractor shall apply the Standard EN 50128 over their whole lifecycle.

6.2 Organisational Safety Requirements

6.2.1 The Contractor's organisation shall include a Safety Assurance Manager.

6.2.2 The Safety Assurance Manager shall be independent from the teams in charge of the Design, Construction, Manufacturing and T&C and report directly to the Project Manager.

6.2.3 To perform his tasks, the Safety Assurance Manager shall be supported by safety engineers who shall be under his direct management.

6.3 Technical Safety Requirements

6.3.1 The technical requirements which are described here below correspond to general guidelines. These guidelines shall be developed further by the Contractor when the contract is awarded.

6.3.2 Development Lifecycle and Documentation;

- All the phases constituting the development V-cycle implemented by the Contractor shall be detailed in terms of:
- Objectives of the phase;
- Methodologies used to carry out the phase;
- Input documentation;
- Output documentation.

6.3.3 The Contractor shall produce and maintain a Traceability Matrix that demonstrates that all requirements have been achieved and no untraceable material has been included.

6.4 System Safety Plan

6.4.1 The Contractor shall produce and maintain a System Safety Plan. The System Safety Plan shall be a standalone document.

6.4.2 The Contractor shall seek the notice of no objection of the Engineer, for the System Safety Plan .

6.4.3 The subjects to be covered in the System Safety Plan and the associated system safety works to be carried out by the Contractor shall include, but not be limited to, the following:

- Referenced safety standards and documents,
- Safety management principles,
- Safety Policy,
- Description of the systems,
- Safety organisation,
- Independence of Safety Team,

- Safety responsibility,
- Requirement for competence of key personnel,
- Safety requirements,
- Safety and Risk Acceptance Criteria,
- Safety V-cycle,
- Safety documentation and deliverables,
- Template of safety analysis
- Safety Case methodology,
- Safety Approval process,
- Monitoring and control of safety programme,
- Ongoing Management of Safety.

6.5 Safety Policy

6.5.1 The Contractor shall set down his approach and commitment to safety in a statement of safety policy endorsed by senior management.

6.5.2 Safety and Risk Acceptance Criteria

6.5.2.1 The risk acceptance criteria are driven by the Risk Assessment Matrix (seehereafter): risks shall be mitigated until an acceptable level.

6.5.2.2 To demonstrate the risk has been reduced ALARP, the following criteria shallbe used (in order of priority):

- show compliance with international standards.
- use of product already accepted by internationally recognised railways agency
- perform a Cost Benefit Analysis

6.5.2.3 The Cost Benefit Analysis should be used as less as possible; priority shall begiven to technical argument.

6.6 Design

6.6.1 Preliminary Hazard Analysis

6.6.1.1 The Contractor shall produce and maintain a Preliminary Hazard Analysis.The Preliminary Hazard Analysis shall be a standalone document.

6.6.1.2 The Contractor shall seek the notice of no objection of his Preliminary Hazard Analysis by the Engineer.

6.6.1.3 The purpose of the Preliminary Hazard Analysis shall be to identify and record all reasonably foreseeable hazards in the operation of the works and assess the risk that each hazard represents to this operation.

6.6.1.4 The Contractor shall manage the process of hazard identification and initial risk assessment with input from all involved parties.

6.6.2 Hazard Log

6.6.2.1 The outputs of the Preliminary Hazard Analysis shall be recorded by the Contractor in a System Hazard Log. The System Hazard Log shall be a standalone document.

6.6.2.2 The Contractor shall seek the notice of no objection of his System Hazard Log by the Client.

6.6.2.3 The System Hazard Log shall be in the form of a database that can be used to track progress in the implementation of mitigating actions and provide an easily accessible reference for the future O&M Entity of all actions taken with respect to any hazard of any type in any location for any area of activity.

6.6.2.4 The Contractor shall maintain the System Hazard Log and identify and record actions proposed to mitigate hazards against all involved parties.

6.6.2.5 The System Hazard Log shall be fed by sub-system Hazard Logs and the result of system wide safety analysis.

6.6.2.6 The Contractor shall expedite and record in the System Hazard Log the responses to all identified mitigating actions from all involved parties and report progress to the Engineer on a regular basis.This shall be continued till the involved party confirms mitigation of the hazard to acceptable levels, along with details of mitigation measures.

6.6.2.7 The Contractor shall prepare a Hazard Review Procedure that shall cover all the processes applicable to the establishment, development and maintenance of the System Hazard Log including the process of identifying and adding a new hazard and new mitigating measures.

6.6.2.8 The Hazard Review Procedure shall include the process for communicating safety requirements applicable to other Contractors, obtaining their agreement and recording their evidence of compliance. In the event of failure to agree, the matter shall be referred to the Engineer.

6.6.2.9 The Hazard Review Procedure shall be submitted to the Engineer for review and notice of no objection.

6.6.2.10 The final risk assessment, acceptance of mitigation and close out of hazards shall conform to the approved safety and risk acceptance criteria.

6.6.2.11 Basically:

- Each hazard recorded in the System Hazard Log that can be addressed before Service Trial shall be closed prior to commencement of Service Trial;

- If any hazard record in the System Hazard Log cannot be closed before Service Trial, then it shall be demonstrated that the Hazard is addressed sufficiently to allow safe Service Trial and;
- Each hazard record shall be closed before Revenue Service and the System Hazard Log shall be handed over to the Employer complete in all respects prior to the commencement of Revenue Service.

6.6.2.12 Handover shall include a fully functional soft copy of the database together with all passwords, supporting software and instructions on its use and further development during Revenue Service.

6.6.3 Design safety studies

6.6.3.1 The purpose of the Design Safety Studies is to document the process of design to ensure that it incorporates the general principle of minimising risk in design as a first priority.

6.6.3.2 Design Safety Studies shall be prepared by the Contractor for system and sub- system elements that are considered to be safety critical and that requirehazard analysis to a greater level of detail and with a greater level of knowledge of the Detailed Design of the hardware and software components that may affect the safety of the system and sub-system designs.

6.6.3.3 The Design Safety Studies shall be commissioned using recognized quantitative and qualitative techniques which may be expected to include ,according to specific requirements,

6.6.3.3.1 At the beginning of the Design and Build stage, the Contractor shall perform a Preliminary Hazard Analysis. This analysis can be based onhis experience of similar systems but shall take into account the specificities of the Project, especially the environmental conditions;

6.6.3.3.2 At interim design stage, the Contractor shall carry out a functional FMECA: this analysis shall assess the consequence of the failure of eachfunction performed by each system. The purpose of this analysis is to identify the criticality of the function and allocate the appropriate SIL. This allocation shall be summarised in the SIL Allocation Report. Criteria for allocation of SIL are described hereafter.

6.6.3.4 The Contractor shall then perform detailed Hazard Analyses:

- System Hazard Analysis (SHA);
- Interface Hazard Analysis (IHA);
- Operating and Support Hazard Analysis (OSHA).

6.6.3.5 The traceability shall be done with the design document to ensure theexhaustiveness of the analyses.

6.6.3.6 The Hazard Analyses shall be considered tin he following modes:

- Normal operations including maintenance;
- Degraded modes of operation;
- Emergency situations.

6.6.3.7 The purpose of these safety analyses shall be to identify the Safety Requirements to be

implemented by design or operation/maintenance procedure.

6.6.3.8 Each hazard identified during these safety analyses shall be logged in the hazard log(s), the closure of the hazards shall be done when the evidence is given that the requirements are met.

6.6.3.9 During the IHA, the Contractor shall identify the safety requirements to be met by other systems.

6.6.3.10 Additional safety studies are required for safety critical components:

- FMECA at component level;
- Fault Tree Analysis to demonstrate the wrong side failure rate corresponding to the SIL;
- Quantitative Risk Assessment to demonstrate frequency of hazards has been reduced to an acceptable level.

6.6.4 Safety Critical Items List

6.6.4.1 The Safety Critical Items List shall identify the equipment whose failure directly impacts safety. This list shall be prepared based on the results of the FMECA and the Fault Tree Analysis.

6.6.4.2 The Contractor shall produce a Safety Critical Items List. The Safety Critical Items List shall be a standalone document.

6.6.4.3 The Contractor shall seek the notice of no objection of the Engineer of his Safety Critical Items List.

6.6.5 Design safety case

6.6.5.1 By the end of the Detailed Design Stage, the Contractor shall produce a Design Safety Case which shall summarize the safety analyses and bring the evidence:

6.6.5.1.1 That the overall risk criteria for the works have been addressed satisfactorily at the Detailed Design stage and that the Detailed Design proposals are mutually compatible with such risk criteria.

6.6.5.1.2 That all safety critical systems have been identified at the DetailedDesign stage and the apportionment of risk factors between the major systems and sub-systems support the overall safety criteria approved in the System Safety Plan.

6.6.5.1.3 That the results of the Design Safety Studies have been incorporated intothe design, and shall be carried forward into the Final Design, manufacturing and installation processes.

6.6.5.1.4 That where management by operating and/or maintenance procedure or other management control measures have been identified during theDesign Safety Studies, auditable methods by which such measures shall be introduced into operating/maintenance provisions have been established.

6.6.5.1.5 That robust process has been implemented to validate the safety critical aspects of software design.

6.6.5.1.6 That processes for assessing the potential safety impact of designchanges exist.

6.6.5.2 The technical section of the Design Safety Case shall address but not belimited to the following subjects:

- Status of the design of the works.
- The standards used in the design which are related to safety.
- The assumptions concerning how the item or items of equipment shall be used and/or maintained.
- Conformance of sub-systems and component items of equipment to the risk criteria specified within the core safety management section.
- Status of all system and or sub-system internal and external interfaces.
- Specification of any on-site testing and integrated system testing parameters that shall be required to be met in order that the item or items may be demonstrated to function safely as an individual item or item(s) and or as part of a system and or sub-system.

6.6.5.3 The format of the Design Safety Case should be identical to the one of the Safety Case (see hereafter).

6.6.5.4 As an annex of the Design Safety Case, the Contractor shall submit the updated System Hazard Log showing the hazards have all been mitigated at design stage.

6.6.6 Manufacturing and Installation

6.6.6.1 The Manufacturing and Installation section of the System Safety Plan shall cover safety considerations for all manufacturing and installation activities both on and or off site and shall include, but not be limited to, the following elements.

- The identification of the safety management organisation to be used during the manufacturing and installation stages including the provision of appropriate levels of site management, supervision and safety personnel.
- The arrangements for ensuring that the results of the Design Safety Studies shall be carried forward into the manufacturing and installation processes.
- The processes by which the safety impact of changes occurring during the manufacturing and or installation stages shall be assessed.
- The formulation and implementation of safe systems of work to carry out the required activities and the issue of the necessary procedures, rules and regulations to secure implementation of such safe systems of work.
- The specification of all training needs arising from the requirements for safe working procedures.

6.6.6.2 FRACAS shall be established by the Contractor to provide a documented history of problems

and failures that occur during manufacture, construction and installation and commercial operation stage. It shall indicate how and why each problem arose and present corrective action options.

6.6.6.3 FRACAS shall be implemented by the Contractor for monitoring the safety and RAM performance of the equipment, during manufacture, installation, testing and commissioning into operation and also the maintenance of the Works to provide feedback to the design of this equipment.

6.6.6.4 FRACAS shall be used to monitor the performance of components and to identify patterns of failures so that corrective action can be taken.

6.6.6.5 In addition, FRACAS shall be used:

- To promote reliability growth of equipment beyond achievement of the target values,
- To consolidate failure data of equipment for reference of design review, and
- To verify the capacity and possible decline of equipment performance during the T&C, trial run and revenue operation in order to ensure the reliability level of equipment is sustainable.

6.6.7 On-Site Testing and Integrated System Testing

6.6.7.1 The On-site Testing and Integrated System Testing section of the System Safety Plan shall demonstrate as a minimum the following requirements.

- That the safety management organisation to control the on-site Testing and Integrated System Testing is in place.
- That the scope of activities to be carried out during the on-site Testing and Integrated System Testing period covers all Safety Critical functions.
- That the segregation of on-site Testing and Integrated System Testing activities from residual construction and installation activities shall be implemented.
- That the procedures required to conduct the on-site Testing and Integrated System Testing activities safely, including where necessary, the protection measures for any part of the railway which may be in operation shall be implemented.
- That the processes which are to be implemented to validate the safety critical aspects of software installation and testing shall be implemented.
- That the processes required to assess the safety implications of the results of tests and inspections carried out during the periods of on-site Testing and Integrated System Testing activities shall be implemented.
- That the processes required to control and validate the safety implications of modifications carried out during the period of on-site Testing and Integrated System Testing activities shall be implemented.
- That the arrangements which are to be utilised to record, report and investigate accidents and incidents together with the systems necessary to formulate and implement measures to prevent reoccurrence shall be implemented.
- That effective control shall be implemented in respect of the activities of all other

Contractors.

6.6.7.2 For the period of Service Trial, the System Safety Plan shall describe specific activities to be carried out, such as validation of safety related procedure.

6.6.7.3 The period of Service Trial shall include as a minimum the following activities:

- Demonstration of system performance and adherence to timetables by running a simulated revenue service at progressively increasing levels of service.
- Evaluation of the effectiveness of normal operating procedures including those that deal with minor disruptions and staff unavailability.
- Evaluation of the effectiveness of system fault reporting, fall back systems, operating procedures and maintenance responses in the event of a number of system failures and degraded operating scenarios by simulating such scenarios during simulated revenue service.
- Evaluation of the effectiveness of operating procedures and other incident management responses in the event of a serious incident including but not limited to fire by simulating such scenarios during simulated revenue service.

6.7 Proof of Safety

6.7.1 The Contractor is responsible for providing the Proof of Safety, taking into account inputs from the Operator and Maintenance wings

6.7.2 The Proof of Safety shall demonstrate that the works are fit for the purpose of commencing Revenue Service.

6.7.3 The Proof of Safety shall make traceable reference to system documentation that shall demonstrate as a minimum the following requirements have been met.

(i) That the works have been manufactured, installed and tested up to and including Integrated System Testing in a manner to ensure that the PSD System can be operated and maintained within the parameters of risk as approved in the Design Safety Case and that there are no safety issues outstanding.

(ii) That the recommended safety performance criteria and safety thresholds for the safe operation and maintenance of the works have been set.

(iii) That the standards and specifications upon which the safe operation and maintenance of the works are based have been met.

(iv) That the safe systems of work, rules and procedures required to operate and maintain the works within the defined parameters of risk as approved in the Design Safety Case have been verified.

6.8 Ongoing Management of Safety

6.8.1 The Ongoing Management of Safety section of the System Safety Plan shall describe the process by which the management of safety issues passes from thecontrol of the Contractor under the System Safety Plan to the Operator under the Operational Safety Plan.

6.8.2 Especially, Change Management Procedures shall be prepared by theContractor for the Engineer's review and notice of no objection.

6.9 Safety Cases

6.9.1 The demonstration of the PSD System safety by the Contractor shall be undertaken via the concept of Safety Cases.

6.9.2 The structure of each of these Safety Cases shall be according to the following:

- Part 1: Definition of System,
- Part 2: Quality Management Report,
- Part 3: Safety Management Report,
- Part 4: Technical Safety Report,
- Part 5: Related Safety Cases,
- Part 6: Conclusion.

6.9.3 For existing safety related electronic systems the Contractor in charge of this system can follow the pattern mentioned in the standard EN 50129, comprising, for each safety-related system:

- A Generic Product Safety Case, covering the unmodified safety items,
- A Generic Application Safety Case, covering those safety items generic to several systems and composing the system,
- A Specific Application Safety Case, covering those safety items especially developed for the Project.
- These Safety Cases are meant to be reviewed by the Engineer and will also be assessed by the ISA and before their acceptance by the Safety Authority (CMRS)

6.9.4 Safety Management Requirements

6.9.5 Quality Assurance Plan

6.9.5.1 The Contractor involved in the Project shall be, as a minimum, an ISO 9001 certified company.

6.9.5.2 Based on this certification, the Contractor shall produce a Quality Assurance Plan indicating the specific arrangements undertaken to fit the Project's needs.

6.9.5.3 In order to support the safety process, the Quality Assurance Plan shall describe how the requirements of Standards EN 50126-1, EN 50128 and EN 50129 are addressed.

6.9.6 Quality Assurance Process

6.9.6.1 The objective of the system quality assurance is to ensure that the development of the systems is performed in such a way the desired quality has been achieved. This is performed by creating a process which provides a clear framework for the safety activities.

6.9.7 System Configuration Management

6.9.7.1 The system configuration management activity shall be carried out by the Contractor and shall comply with the principles depicted in the System Configuration Management Plan.

6.9.7.2 The System Configuration Management Plan shall address the configuration management in terms of configuration control, problem reporting, change control, media control and configuration management tools.

6.9.8 Project Management

6.9.8.1 It is the Contractor's responsibility to ensure the systems are developed, tested and delivered on time.

6.9.8.2 To do so, a Detailed Work Schedule shall be created and maintained in orderto identify and control every single task to be performed.

6.9.8.3 From this schedule it shall be possible to identify critical paths, slippage and resources, including the tasks related to the safety process.

6.9.8.4 As part of any overall reporting mechanism to the Employer, progress informationshall be included relating to the PSD Syatem. In addition to submitting an updated Detailed Work Schedule the Contractor shall indicate which phases are not started, in progress or completed.

6.9.8.5 The Progress Report shall also provide information regarding the safety activities, to ensure their progress is consistent with the progress of design activities.

6.9.9 Hold Point between Installation and T&C activities

6.9.9.1 For the safety of T&C activities, installation completion should be confirmed and approved by the Engineer, prior to starting tests.

6.9.9.2 An installation checklist prepared and maintained by the Contractor shall be counter-signed by the Engineer, after the satisfactory completion of each part constituting a system.

6.9.9.3 On satisfactory completion of all installation checklists (including safety- related items) for a group of works, the relevant authority shall issue anInstallation Clearance Certificate which is a prerequisite to commence System,Subsystems or Component T&C.

6.9.9.4 The Design Safety Case and the System Hazard Log showing the evidence thatthe hazards have been mitigated at design stage is required to start the installation activity, the T&C activity.

6.9.9.5 Any non-conformity shall be identified and analysed from a safety point of view before the authorisation is granted to carry out dynamic testing.

6.9.9.6 In the event of a safety related non-conformity is covered by a procedure during the testing period, this procedure shall be reviewed and notice of no objection obtained from theEngineer.

6.9.10 T&C activities

6.9.10.1 The safety procedures for T&C shall be specified in the relevant testing procedures of each T&C Plan, including, where necessary, the protectionmeasures for any part of the railway system which are already in operation.

6.9.10.2 In the period of T&C, modifications on design or installation may become necessary when non-conformance to the safety validation occurs. If modifications in design are needed, they shall follow the procedures of boththe System Development Plan and the System Configuration Management Plan.

6.10 Safety Targets

6.10.1 Risk Definition and Categorisation

Since safety is about managing risk, risk must be first defined.

6.10.1.1 Risk is defined as a combination between the frequency of occurrence ofhazard(s) and severity of the corresponding hazard(s).

6.10.1.2 Hazards shall be categorised according to both their frequency of occurrence and their severity as per the EN 50126-1 approach.

6.10.2 Frequency of Occurrence of Hazards

6.10.2.1 The following categories shall be used to classify the frequency of occurrence of hazards:

Category		Frequency per year	Description
A	Frequent	> 10	Likely to occur frequently. The hazardwill be continually experienced. (>10 times per year).
B	Probable	< 10 > 1	Will occur several times. The hazard canbe expected to occur often. (>1 time per year)
C	Occasional	< 1 > 0.1	Likely to occur several times in the systemlifecycle. The hazard can be expected to occur several times. (>1 time in 10 years).
D	Rare	< 0.1 > 0.01	Likely to occur in the system life cycle. The hazard can be expected to occur a fewtimes in the life cycle of the system. (>1 time in 100 years).
E	Unlikely	< 0.01 > 0.001	Not expected to occur with the system lifecycle. The hazard is not expected to occurin the life cycle of the system. (>1 time in 1,000 years).
F	Remote	< 0.001 > 0.0001	Very unlikely to occur within the systemlife cycle. (>1 time in 10,000 years).
G	Improbable	< 0.0001 > 0.00001	Extremely unlikely to occur within thesystem life cycle. (>1 time in 100,000 years).
H	Incredible	< 0.00001	Not conceivably possible. It can be assumed that the hazard may not occur during the whole system life. (<1 time in 100,000 years).

Table 1: Frequency of Occurrence of Hazards

6.10.3 Severity of Hazards

6.10.3.1 Thus, the following levels shall be used to classify the severity of the consequences of the hazards. Consequences taken into account are consequences for people, system and environment.

Table 2:

Severity level		Consequences for people or environment	Consequences for service
1	Catastrophic	Fatalities and/or multiple severe injuries and/or majordamage to the environment.	-
2	Critical	Single fatality and /or severe injury and/or significant damage to the environment.	Loss of a majorsystem
3	Marginal	Minor injury and/or significant threat to the environment	Severe system(s)damage
4	Insignificant	Possible minor injury	Minor systemdamage

Severity of Hazards

6.10.4 Risk Assessment Matrix

6.10.4.1 As shown in the matrix below, frequency of occurrence and severity of the consequences are combined together in order to further process the risks as per EN 50126-1. The following matrix presents the possible combinations of frequency of occurrence and severity of the consequences of the hazards. It also presents the various zones of acceptability of the risk.

		Severiy			
		4-Insignificant	**3-Marginal**	**2-Critical**	**1-Catastrophic**
Frequency	**A-Frequent**	**R2**	**R1**	**R1**	**R1**
	B-Probable	**R2**	**R2**	**R1**	**R1**
	C-Occasional	**R3**	**R2**	**R1**	**R1**
	D-Rare	**R3**	**R3**	**R2**	**R1**
	E-Unlikely	**R4**	**R3**	**R2**	**R2**
	F-Remote	**R4**	**R4**	**R3**	**R2**
	G-Improbable	**R4**	**R4**	**R3**	**R3**
	H-Incredible	**R4**	**R4**	**R4**	**R4**

Table 3: Risk Assessment Matrix

6.10.4.2 The following table presents the risk acceptance principles that shall be applied:

Risklevel	Risk Category	Actions to be applied against each category
R4	Negligible	Acceptable without any agreement of the Employer.
R3	Tolerable	Acceptable with adequate control and with the agreement of the Employer
R2	Undesirable	Shall only be accepted when risk reduction is impracticable andwith the agreement of the Employer or the Safety Regulatory Authority, as appropriate.
R1	Intolerable	Shall be eliminated.

Table 4: Risk acceptance principles

6.10.4.3 Each risk shall be assessed to determine which category it belongs to.

6.10.5 Risk Mitigation Strategy

6.10.5.1 According to the level of their acceptability, the risks shall be managed in different ways:

6.10.5.2 R4 risks: since no prevention / mitigation measures shall cover these risks, the allocation of risks to this category has to be thoroughly documented.

6.10.5.3 R1, R2 and R3: these risks need to be discussed in writing and submittedto the Engineer and/or the Safety Authority for review and notice of no objection of both the risks and the corresponding prevention / mitigation measures.

6.10.5.4 The following shall be addressed:

(i) Residual risk, feasibility and cost of the mitigation measures. Alternative measures shall be proposed.

(ii) Input data used in the assessment, justification, discussion shall be provided with reference of their origin and copy of the statements to be considered.

6.10.5.5 Safety analysis(s) must be conducted which the following minimum requirements:

(i) The safety objective is reached when the level of risk has reached the “Acceptable” area (i.e. the 'Negligible', 'Tolerable' and 'Undesirable' categories) with satisfactory justification.

(ii) Every safety related function shall be identified and assessed for its related hazards.

(iii) Every safety related constituent shall be identified and assessed for its related hazards.

(iv) Every safety related interface shall be identified and assessed for its related hazards.

6.10.6 Links between Safety Objectives and SILs

6.10.6.1 The following links shall be used:

(i) Functions which failure can lead to an R1 risk with catastrophicconsequences shall be supported with SIL4 constituents.

(ii) Functions which failure can lead to an R1 risk with critical and marginalconsequences shall be supported with SIL3 constituents.

(iii) Functions which failure can lead to an R3 or R2 risk shall be supportedwith SIL2 constituents.

(iv) Functions which failure can lead to an R4 risk shall be supported with SIL1 constituents.

6.10.7 Implementation of SIL4, SIL3, SIL2 and SIL1 constituents

6.10.7.1 Equipment shall have a SIL at least equal to the functions it implements.

6.10.7.2 As a minimum, SIL4, SIL3, SIL2 and SIL1 constituents shall comply with the following requirements.

(i) Compliance to standards: EN 50126-1, EN 50129, EN 50128, EN 50159 Standards shall be complied with.

(ii) Quality assurance: Quality of the constituents shall be verified accordingto a Quality Assurance Plan over the construction and operation phases.

(iii) Safety assurance: Safety of the constituents shall be demonstrated according to a System Safety Plan over the construction and operation phases.

6.10.8 Safety Techniques to be used.

6.10.8.1 Recognised techniques used in the railway application for implementation of SIL4 or SIL3 constituents are as follows:

(i) “Fail safe” technique: a constituent (or component) of a system is built on "fail safe" technique when a failure of this constituent cannot lead to amore permissive status of that system. For example, a failure of a fail- safe relay cannot lead to a green signal when the signal should be red. For this technique there is no mathematical estimate of the level of safetyof a constituent. The constituent is considered of SIL4 once every hypothesis is verified. It is assumed that the SIL4 component complies as per safety requirements inside the limits of its specification.

(ii) “Checked safety” technique: a constituent (or component) of a system is built on "checked safety" technique when certain failures of this constituent can be detected by another independent device. This independent device reads a safety status of the constituent. When the safety status becomes unsafe due to certain failures of the constituent, the independent device inhibits the outputs of the constituent. This

independent device can be built on "fail safe" technique.

(iii) "Probabilistic safety" technique: A constituent (or component) of a system is built on "Probabilistic safety" technique when it can be demonstrated that failures cannot happen more often than a certain limit. This limit must be considered as sufficient. This technique shall be handled carefully.

(iv) For the implementation of SILx functions by the means of "probabilistic safety", the frequency rate of dangerous failure per operating hour is given in the following table: -

	Safety Integrity Level	**Frequency rate of dangerous failure per operating hour**
(i)	4	≥ 10-9 to < 10-8
(ii)	3	≥ 10-8 to < 10-7
(iii)	2	≥ 10-7 to < 10-6
(iv)	1	≥ 10-6 to < 10-5

Table 5: SIL Safety Targets

6.10.8.2 "Safety concept" approach of the programmable electronic equipment safety equipment use safety concepts of the sort defined above. Safety analysis and demonstration shall include:

(i) The identification and description of the safety concept used,

(ii) The definition of the hypothesis on which safety relies,

(iii) The complete and precise definition of the safety technique used,

(iv) The safety criteria and requirements to be abided by,

(v) The methods of verification and validation that need to be unfolded toassure safety,

(vi) The specific program plan to be unfolded for ensuring safety,

(vii) The identification of the techniques or mechanisms that have not yet been proven as safe by a certification body.

6.10.8.3 Use of "safety software" Safety software, i.e. executing SIL4 or SIL3 functions shall be developed and demonstrated safe according to EN 50128. The use of formal methods for

demonstrating that the software is error free is highly recommended.

6.10.8.4 Use of “proven safety techniques” Only proven safety technique shall be allowed to be used for the Project. The safety techniques to be used shall be presented by the Contractor. Proven safety techniques are those that:

(i) Have been already approved as safe by an independent competent party.

(ii) Have been used successfully in revenue service for at least two years since the end of guarantee of the system, at the date of the Contractor’sbid.

(iii) Allow to be easily customized to the needs of a new project.

6.10.8.5 Techniques not complying with those requirements or for which the documentation establishing compliance with the present requirements is not available or insufficient shall be rejected.

6.10.9 Safety Deliverables

As a minimum, the following documents shall be delivered by the Contractor:

(i) System Assurance Plan
(ii) System Safety Plan
(iii) Preliminary Hazard Analysis
(iv) Hazard Analyses (SHA, IHA, OSHA)
(v) Traceability Matrix
(vi) FMECA (functional and component levels)
(vii) Fault Tree Analysis
(viii) Safety Critical Items List
(ix) Quantitative Risk Assessment
(x) SIL Allocation Report
(xi) System Hazard Log
(xii) Design Safety Case
(xiii) Safety Case
(xiv) SRAC: Safety Related Application Conditions

6.10.10 **Safety Targets**:

6.10.10.1 The DCU Software that controls many safety features of PSD Functioning, shall meet SIL 2 requirements, as a minimum.

6.10.10.2 The Drive circuit of Sliding doors, starting from the PSD-Signaling Safety Relays based interface panel, shall be fully wired with double cutting arrangements of controlling relay contacts

6.10.10.3 The design of the system that detects over-current drawn by the Sliding door motors and automatically trips the current to the motors on detection of over-laod (due to an obstacle or any other reason)has to meet SIL 3 requirements

6.10.10.4 The All doors closed & locked loop from the PSD side being input to the Signaling CBTC system, shall be a SIL 4 rated design, including use of highly reliable & rugged door close & locked contacts, proved on both limbs of the Safety Loop. This Safet Loop, shall like wise prove the closed & locked status of all Sliding Doors, EEDs, DEDs & MSDs.

6.10.10.5 The PSD part of the Sinaling-PSD interface panel that executes the Door Open & Door Close commands (for all Sliding doors or the end doors for maintenance access) shall incorporate highly rugged & reliable Relays that are Safety Rated and also a proven arrangement as adopted in other Metro Systems for similar Safety applications. The circuit diagram for controlling the Opening/Closing of Sliding doors shall incorporate the controlling relay contacts on both lims of the circuit. The choice of relays, their rating and the interface circuit design is subject to a notice of no objection from the Engineer.

6.11 Requirements for RAM Assurance

6.11.1 General RAM Requirements

6.11.1.1 The Contractor shall demonstrate that his design meets both the RAM requirements specified for the PSD system, as under.

6.11.1.2 To demonstrate this, it is necessary for the Contractor to take into consideration the effect of potential failures of system components, corrective and preventive maintenance times and redundancies built into the design.

6.11.1.3 The Contractors shall follow the Standard EN 50126-1 approach over the whole system lifecycle.

6.11.1.4 The Contractor shall demonstrate in his, Systems/Subsystems or Components RAM Studies and RAM Validation Studies that the RAM Targets are reached.

6.11.1.5 The System RAM Plan and RAM analyses shall be developed to a lifecycle model in accordance with EN 50126-1.

6.11.1.6 As for Safety, the RAM requirements rely on the Contractor’s Quality Assurance. Therefore, the Quality Assurance requirements set for Safety are applicable for RAM also.

6.11.2 Organisational RAM Requirements

6.11.2.1 The Contractor’s organisation shall include a RAM Assurance Manager.

6.11.2.2 The RAM Assurance Manager shall be independent from the teams in charge of the Design, Construction, Manufacturing and T&C and report directly to the Project Manager.

6.11.2.3 To perform his tasks, the RAM Assurance Manager shall be supported by RAM engineers who shall be under his direct management.

6.11.3 Technical RAM Requirements

6.11.3.1 The technical requirements which are described here below correspond to general guidelines. These guidelines shall be developed further by the Contractor when the contract is awarded.

6.11.4 Development Lifecycle and Documentation

6.11.4.1 Please refer to the System Safety Assurance Requirements.

6.11.5 System RAM Plan

6.11.5.1 The Contractor shall produce and maintain a System RAM Plan. The System RAM Plan shall be a standalone document.

6.11.5.2 The Contractor shall seek the Notice of No Objection of the Engineer for the System RAM Plan

6.11.5.3 The subjects to be covered in the System RAM Plan and the associated system RAM works to be carried out by the Contractor shall include, but not be limited to, the following:

6.11.5.4 Referenced RAM standards and documents,

(i) RAM management principles,
(ii) Description of the systems,
(iii) The organisation and resources put into place for performing the RAManalyses,
(iv) Independence of RAM Team,
(v) RAM responsibility,
(vi) Requirement for competence of key personnel,
(vii) RAM requirements,
(viii) The RAM objectives of the systems/subsystems which are part of theworks,
(ix) RAM V-cycle,
(x) The description of the methodology and tools to be used for RAM analyses,
(xi) The mission profile taken into account to perform the RAMcalculation,
(xii) Assessing that RAM Targets are met,
(xiii) Performing RAM assessments for any potential alternative designs,
(xiv) Verification and validation of all RAM analyses performed,
(xv) Validation of RAM requirements during manufacture, installation,commissioning and maintenance
(xvi) RAM documentation and deliverables.

6.11.6 Data Collection and Operation Assumptions

6.11.6.1 The data collection activity has to be carried out for equipment which are already in revenue service. The objective is to be able to base the reliability prediction on field data which are more representative than theoretical reliability figures.

6.11.6.2 The determination of operation assumptions corresponds to a refinement of the mission profile. It provides additional data to be considered in the RAM predictions

6.11.7 Reliability Block Diagrams

6.11.7.1 For each system, a Reliability Block Diagram shall be prepared to model the architecture and highlight the redundancies. This will be the basis for end-to-end reliability of sub-systems as well as the entire PSD system.

6.11.8 RAM Allocation

6.11.8.1 The RAM allocation is based on the Reliability Block Diagrams. Each block is allocated a RAM target to ensure the overall RAM target for the system shall be met.

6.11.8.2 The appropriateness of the architecture shall be verified at this stage by checking that each component receives a realistic reliability target.

6.11.8.3 The Contractor shall produce a RAM Allocation Report, as part of the System RAM Plan.

6.11.8.4 The Contractor shall seek the Notice of No Objection of the Engineer for the System RAM Plan.

6.11.9 Failure Mode, Effects and Criticality Analysis

6.11.9.1 The FMECA is performed in parallel of the RBD activity in order to analyse the consequences of a failure of each equipment of the system.

6.11.9.2 This analysis aims to identify the equipment which are critical for the reliability of the system and assess the need for redundancy.

6.11.10 Reliability and Availability Prediction

6.11.10.1 The reliability and availability prediction is based on a down to top approach:

6.11.10.2 the reliability of each equipment is predicted based on field data or theoretical failure rate of components;

6.11.10.3 the reliability of a system is predicted by injecting the equipment failure rate in the RBD;

6.11.10.4 availability is derived, using the MTTR and the reliability.

6.11.10.5 The RAM Analysis and Prediction Report shall give predictions of system reliability, availability and maintainability based on data collected.

6.11.10.6 The Contractor shall produce a RAM Analysis and Prediction Report. The RAM Analysis and Prediction Report shall be a standalone document.

6.11.10.7 The Contractor shall seek the notice of no objection from the Engineer, for the RAM Analysis and Prediction Report.

6.11.11 Reliability Critical Items List

6.11.11.1 The Reliability Critical Items List shall identify the equipment whose failure directly impacts the reliability objectives. This list shall be prepared based on the result of the FMECA and the RBDs.

6.11.11.2 The Contractor shall produce a Reliability Critical Items List. The Reliability Critical Items List shall be an essential part of the RAM Analysis & Prediction Report.

6.11.11.3 The Contractor shall seek the notice of no objection from the Engineer, to the Reliability Critical Items List , as part of the RAM Analysis & Prediction Report

6.11.12 Maintainability Prediction

6.11.12.1 For each Line Replaceable Unit (LRU), a Mean Time To Repair (MTTR) shall be estimated by the Contractor, taking into account the accessibility and the complexity of the equipment.

6.11.12.2 For each LRU, the weight, dimensions and the need for special maintenance tools shall be provided by the Contractor.

6.11.13 Spare Parts Quantity Calculation

6.11.13.1 The requirement of quantity of spares for each LRU/LLRU (lowest level line replaceable unit) shall be worked out on completion of detailed design, based on the principles enunciated under the Section “Spares” of this Specification.

6.11.13.2 Where the RAMS prediction report indicates that the failure rate of an item is too low (based on actual field records in similar projects under comparable environmental conditions), the quantity can be reduced below the minimum requirement of 10%, with the notice of no objection from the Engineer. Convesely, where the RAMS Prediction report or the performance during the actual DLP period of 2 years, indicates a failure rate higher than the failure rate assumed in the RAMS prediction report, the quantity of spares for that item shall be suitably increased above the minimum requirement of 10%, to last for the same duration worked out ,based on failure rates indicated in the RAMS prediction report, in the section forming part of the scope of the Contract.

6.11.14 RAM Analysis & Prediction Report

6.11.14.1 The Contractor shall submit a RAM Analysis & Prediction Report at the end of the Design phase, summarizing the activities which have been carried out. The RAM Analysis & Prediction Report shall be a standalone document.

6.11.14.2 The Contractor shall seek the notice of no objection to the RAM Analysis & Prediction Report , from the Engineer..

6.11.14.3 The report shall provide the evidence that the technical choices (architecture, equipment) shall make it possible to achieve the contractual RAM targets.

6.11.14.4 In the event the system does not comply with RAM targets, design will not be accepted by the Engineer and manufacturing shall not be authorised to begin until improvement in the design are proposed as proof of achievement of the RAM targets.

6.11.15 Manufacturing and Installation

6.11.15.1 In the event where some design modifications become necessary as a result of new developments during the manufacturing or installation, the impact on RAM performance shall be assessed by the Contractor. It shall be demonstrated that the achievement of the RAM targets is not jeopardized by the modifications of the design.

6.11.16 Failure Recording and Corrective Action System

6.11.16.1 FRACAS shall be established by the Contractor as described in the System Safety Assurance Requirements.

6.11.17 RAM Demonstration Plan

6.11.17.1 At least 90 days of the commencement of service trials, , the Contractor shall provide a RAM Demonstration Plan. The RAM Demonstration Plan shall be a standalone document. This document shall explain the proposed detailed methodology to assess the RAM performance, viz-a-viz the RAM targets,

6.11.17.2 The Contractor shall seek the notice of no objection from the Engineer for the RAM Demonstration Plan .

6.11.17.3 The RAM Demonstration Plan shall be used to prove and monitor RAM during the Service Trial period and subsequently during the revenue service period.

6.11.17.4 The Contractor shall also review Subcontractors' RAM Demonstration Plans to ensure that these are compatible with system level tests and that all major system level issues have been addressed.

6.11.17.5 The Contractor shall perform a series of RAM demonstrations for the works, as described in the RAM Demonstration Plan.

6.11.17.6 The Contractor shall provide the required assistance for this activity including mobilisation of equipment and resources.

6.11.17.7 The Contractor shall record and review the information generated during the RAM demonstration period and provide an assessment of the demonstration in terms of achieving the RAM requirements.

6.11.17.8 The outcome of the RAM demonstrations shall be presented in a RAM Demonstration Report, which is subject to the notice of no objection of the Engineer.

6.11.18 Maintainability Demonstration

6.11.18.1 The demonstration aims to confirm the MTTR by measuring the actual times needed for replacing the LRU, knowing that during design phase, maintainability predictions have been carried out by the Contractor to determine the MTTR of the Line Replaceable Units (LRU).

6.11.18.2 This demonstration is performed on a sample basis; detailed modalities shall be described in the RAM Demonstration Plan.

6.11.19 On-Site Testing and Integrated System Testing

6.11.19.1 This period shall give the opportunity to identify the requirements and facilitate the mobilization of equipment and resources needed for the RAM performance follow-up and to record the first trends of the RAM performance and allowing the detection of any RAM issue at an early stage.

6.11.19.2 This period is part of the system's debugging, and it is not part of the RAM performance demonstration period.

6.11.20 Service Trial and Guarantee Period

6.11.20.1 The Contractor shall continue to implement system assurance activities during the Service Trial and after the transition to Revenue Service including, but not limited to, the following requirements.

6.11.20.2 During the Defects Notice Period, day to day monitoring of the RAM performance shall be carried out and the findings shall be used to enable systematic means of data analysis and recording of the RAM performance.

6.11.20.3 A monthly RAM Performance Report shall be issued to the Employer during the guarantee period to provide the evidence of the achievement of the RAM targets .The format of this Report shall be included in the RAM demonstration plan and is subject to notice of no objection from the Engineer.

6.11.20.4 In the event where a system does not meet its RAM targets, the Contractor shall proceed to failure root-cause investigation and rectification or retrofit.

6.11.21 RAM Targets

6.11.21.1 The RAM Targets provided herein are meant to ensure the Railway Systems have a high level of dependability.The targets have been set to correspond to the current state of the art for these types of systems.

6.11.21.2 The following targets must be understood as applicable criteria , for the RAM Demonstration period.

6.11.21.3 The method of classification of failures, based on their impact on train operations and the corresponding Mean Time between service affecting failures (MTBSAF) shall be as under (for calculating total service hours , it is assumed that the Metro will be operating for 19 hours

a day.

S. No	Failure category	System failure mode	Effect on operation	MTBSAF
1	Significant	Total failure	Operation non possible on the whole corridor or delay in operation more than 2 hours at system level or closure of a station for more than 1 day	34675 for both Up & Down lines put together
2	Major	Critical functional failure	Local failure of the traffic requiring an intervention on the track (viaduct or tunnel) on to recover the normal mode of operation (e.g. handle of the switches, etc.) or delay in operation between 15 minutes and 2 hours at system level or closure of a station during a period of time between 2 hours and 1 day	>10 000h for both Up & Down lines put together
3	Minor	Non-critical functional failure	Local failure of the traffic occurring a delay in operation comprised between 2 minutes and 15 minutes at system level and requiring a distant action to recover the normal mode of operation (from SCR or OCC)	> 2 000 h for for both Up & Down lines put together
4	Negligible	Negligible functional failure,	Local failure of the traffic occurring a delay of less than 2 minutes in operation at system level	> 1 000 h for for both Up & Down lines put together

6.11.21.4 The objective in respect of mean cycles between failures shall be as under:

Mean Cycles between Failures (MCBF) for PSD

A doorset cycle is defined as one complete open and close operation of one pair of doors. The Mean Cycles Between Failures shall be 300,000 doorset cycles. The MCBF shall be calculated using the following equations:

$$MCBF = \frac{\text{Total No. of Doorset Cycles}}{\text{No. of Failures}}$$

6.11.21.5 In this clause, the term "failure" shall apply to any event which results in the inability of the PSD to perform its intended function, either through shut down or through impaired performance which is not in accordance with the performance criteria. It shall include the failure of primary indications and the alarm system, but shall exclude those incidents due to the loss of external inputs (e.g. loss of external power supply) or failures which would not affect the operations of PSD. The use of alternative means of control via the PSD Local Control Panel shall not be included in the evaluation of MCBF for each doorset.

6.11.21.6 The resulting objectives of the reliability for the PSD are to be achieved respectively at the end of the stabilization period of one year from the revenue service and during the stabilization period.

During the stabilization period of 9 months, the objectives of PSD reliability (MTBSAF and MCBF) for each platform are to improve as followed:

a. After 3 months of operation, the reliability objectives divided by 3

b. After 6 months of operation, the reliability objectives divided by 2

c. After 9 months of operation, the reliability objectives

6.11.21.7 Availability Objective

System = PSD A > 99.8% for Up & Down lines put together

For the purposes of availability calculations, the Contractor shall assume that the service operating hours are 19 hours per day (04:30 am to 11:30 pm), for 365 days a year.

In all availability calculations the following access times shall be assumed:

a. 60 minutes for equipment located in equipment rooms or on the platform that are accessible during traffic hours; and

b. 10 hours for trackside equipment or equipment located such that it is only accessible during non-traffic hours.

6.11.22 RAM Deliverables

6.11.22.1 As a minimum, the following documents shall be delivered by the Contractor:

(i) System RAM Plan

(ii) Reliability Block Diagrams as part of RAM Analysis & Prediction Report

(iii) RAM Allocation Report as part of RAM Analysis & Prediction Report

(iv) FMECA

(v) RAM Analysis and Prediction Report

(vi) Reliability Critical Items List as part of RAM Analysis & Prediction Report

(vii) RAM Demonstration Plan

(viii) RAM Demonstration Report

(ix) Monthly RAM Performance Report as per format agreed through the RAM Demonstration Report