



BANGALORE METRO RAIL CORPORATION LIMITED

BID No. 5 RS-DM

**DESIGN, MANUFACTURE, SUPPLY, INSTALLATION, TESTING AND COMMISSIONING
OF 318 NOS. OF STANDARD GAUGE METRO CARS AND TRAINING OF PERSONNEL
INCLUDING COMPREHENSIVE MAINTENANCE UPTO FIFTEEN (15) YEARS UNDER
BANGALORE METRO RAIL PROJECT PHASE-2, 2A AND 2B**

PART- 2

SECTION-VI B: EMPLOYER'S REQUIREMENTS – TECHNICAL SPECIFICATIONS

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1. INTRODUCTION

1.1. Scope

- 1.1.1. The objective of this document is to provide the Technical and Functional requirements that shall be implemented for the supply of new metro trains to be operated on the following lines of Bangalore Metro Rail project:

Table 1.1: Line/Corridor details

Sl. No	Lines/Corridor	Number of 6-car Train sets (Cars)	Signalling System	Grade of Automation
1	Line-6 (Kalena Agrahara-IIIMB-Nagavara)	16 (96)	CBTC	GoA2/GoA4
2	Phase 2A (Central Silk Board Junction – K. R. Puram)	21 (126)	CBTC	GoA2/GoA4
3	Phase 2B (K. R. Puram - Kempegowda International Airport)	16 (96)	CBTC	GoA2/GoA4
	Total	53 (318)		

- 1.1.2. The specification establishes requirements for the design, development, manufacture, supply, testing, delivery, commissioning and integrated testing of light weight fully furnished modern passenger cars with microprocessor control 3-phase induction motor drive and suitable for Unattended train operation conforming to Grade of Automation-GoA4 as specified in IEC62290 all parts (latest version), including the training of operating and maintenance staff of the Employer. The trains shall initially be operated in 'GoA2' and shall be progressively used in 'GoA4'.

The elevated and underground section shall have ballast-less track and at-grade sections (depot) have ballasted track. The car shall be designed to meet the performance requirement given in Chapter-3 of this specification. The track gauge shall be 1435 mm.

- 1.1.3. The scope of supply shall also include:

- Design, Supply, Installation, Testing and Commissioning of Depot Machinery & Plant and Driving Simulator.
- 15 years comprehensive maintenance of Rolling Stock, Depot Machinery & Plant, Driving Simulator for line R6, Phase-2A and Phase-2B.
- Supply of spares, special tools, jigs & fixtures, special test and diagnostic equipment, special training equipment and any other items required for the comprehensive maintenance of cars in sufficient quantities.
- Execution including supervision of all maintenance activities of all the train sets of this bid as well as Depot M&P, Mechanical & Electrical Measuring and testing equipment, Mechanical, pneumatic and electric tools, special tools, jigs & fixtures, maintenance of gauges, testing & diagnostic equipment and overhauling kit.
- To provide all the documentation and support material associated with the operation and maintenance of the cars as specified in the bid document for all the corridors.

- (vi) ~~Ongoing technical support and Defects Liability coverage until the start of Defect Liability Maintenance Period (DLMP) and rectifying the defects and deficiencies as communicated by the Project Manager.~~

Addendum-1 dated 05.12.2022, Sl. No. 3

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- (vii) Interfacing with other Designated Contractors who have either physical, functional or design interfaces with this Contract.
- (viii) Training of engineers, operations and maintenance staff including providing the training materials, training kits and demonstration equipment.
- (ix) Initial supply and installation of all consumables and materials required for testing, commissioning and operation.
- (x) To provide final drawings, design calculations and other documents including operations and maintenance manuals for review and acceptance by the Project Manager.
- (xi) To provide supporting information including samples for design development items such as mock-ups, studies and reports.
- (xii) Preparation of documents for obtaining approvals by Employer from the appropriate statutory authorities.

1.1.4. Traction supply shall be 750V DC third rail bottom current collection system.

1.1.5. The following types of cars and configuration shall be adopted:

- DMC : Driving Motor Car.
 - MC : Motor car.
 - TC : Trailer Car.
- 6-Car Train Composition : *DMC - TC - MC - MC - TC – DMC*
- Where,
- * Automatic coupler.
 - Semi permanent coupler.



- 1.1.6. All DMC, MC and TC supplied under this Contract shall be totally interchangeable with all other DMC, MC and TC respectively, supplied under this Contract, without modification.
- 1.1.7. The scope of supply includes all items of work which may be required to meet the performance requirements, trouble free and efficient operation of trains and meeting the best international practices even if not specifically mentioned in the bid specifications.
- 1.1.8. The cars required for the various Lines shall be delivered and commissioned by the Contractor at the nominated Train Maintenance Depots of BMRCL. The Contractor shall base his Testing, Commissioning Organization and Maintenance Organization at the nominated depots.

1.2. Deliverables

Not applicable

2. OPERATIONAL ENVIRONMENT**2.1. Climatic and Environmental Conditions**

2.1.1. Extreme climatic conditions observed in Bangalore during the last 15 years are given in Table 2.1

Table 2.1: Climatic & Environmental Conditions:

Description	Limiting Values
Maximum ambient temperature	42 °C
Minimum ambient temperature	8 °C
Humidity	92% saturation during rainy season
Rainfall	Rain occurs generally from May to October. Average annual rainfall is approximately 1065 mm. Maximum rainfall in any 24h period is 178mm.
Atmosphere during hot season	Extremely dusty
Maximum wind load	125 Km/hr
SO ₂ level in atmosphere	6.7 - 80 micro g/m ³
NO _x level in atmosphere	16 - 80 micro g/m ³
Respiratory Suspended Particles Matter in atmosphere (RSPM)	49 - 120 micro g/m ³
Total Suspended Particles Matter in atmosphere (TSPM)	111 - 360 micro g/m ³
Altitude	1000 m
Conditions in stations	All underground stations will be fully air-conditioned. Above ground stations will have air-conditioning for certain designated rooms only.

2.1.2. The Rolling Stock must be able to operate regardless of the external conditions. They must also be so designed as to avoid abnormal wear due to adverse weather. They can be parked outdoors regardless of the atmospheric conditions.

2.1.3. The temperature inside of an “inactive” metro train parked in the sun can easily exceed +60 °C.

2.1.4. In addition to the climatic aspect of the surrounding air, allowance must be made for a variety of products carried in the air such as grease, conducting dust, textile fluff, long fibres, various papers and sulphuric gas.

2.1.5. Environmental Conditions in Tunnel:

- i) Tunnel ventilation is achieved primarily by the movement of vehicles inside the tunnel under normal working conditions. The relief of the piston effect generated

by the train is achieved by means of draft relief shafts. Tunnel ventilation fans installed at each end of each station will be used to provide supplementary ventilation at times of high temperature, and under congested traffic or emergency conditions. These fans will provide reversible airflow and will intake from, and exhaust to the outside through ventilation shafts. The maximum design temperature inside the tunnel is expected to be 46°C under normal as well as congested conditions.

- ii) Under emergency conditions of tunnel fire, the tunnel ventilation system will be used for smoke extraction by operating tunnel fans in push-pull mode. The allowable maximum temperature inside the tunnel during such smoke extraction will be below 60°C.
- iii) Track-way exhaust systems will be provided to extract a portion of train-generated heat while the train is within the bounds of a station. During normal conditions, under-platform exhaust as well as over-track-way exhaust fans will operate. In addition, control of these fans shall be possible during congested and emergency conditions for the purpose of aiding tunnel ventilation and providing additional smoke removal capability for the station and tunnel. During emergency fire conditions within a station, the station air handling system will be operated to supplement smoke removal.
- iv) Tunnel walls may be wet and seepage water will normally be present in the invert. Rolling Stock supplied must therefore be capable of withstanding the effects of seepage and continue to operate in such wet and humid conditions.

2.2. Line characteristics

- 2.2.1. i) Length of Line-6 from Kalena Agrahara to Nagavara is 21.5 km.
- ii) Length of Phase 2A from Central Silk Board Junction to K. R. Puram is 19.8 km.
- iii) Length of Phase 2B from K. R. Puram to Kempegowda International Airport is 38.4 km.
- 2.2.2. Station name, number, location, inter distance, platform location, line profile, gradient and curves radius are given in Appendix- E of this document.
- 2.2.3. Presently, trains of East-West Corridor and North-South Corridor of Phase-I are being maintained in Baiyappanahalli and Peenya depot respectively. In future, the trains which will operate on East-West Corridor shall be maintained at Whitefield and Challaghatta depots (new depots). Baiyappanahalli depot will provide the maintenance facilities for trains operating on Phase 2A line and trains operating on Phase 2B line shall be maintained at Airport Depot (new depot). Trains which will operate on Line-6 shall be maintained at Kothanur depot (new depot).

2.3. Track characteristics

- 2.3.1. The Track Structure Parameters for At-grade, Elevated and Underground sections are set out in Table 2.2

Table No 2.2: Track Structure Parameters

Description	Elevated and at-grade sections		Tunnel sections
	Ballasted	Ballast-less (DFF)	Ballast-less (DFF)
Track Laying Gauge	1435mm		
Rail Type			
Main Line	UIC 60 Head hardened (1080)		
Depot	UIC 60 (880)		
Rail Profile	60E1 (UIC 60) 880 grade	60E1 (UIC 60) 1080 grade HH	60E1 (UIC 60) 1080 grade HH
Inclination Of Rail	1 / 20		
* Rail Seat spacing, Main line	650 mm ± 10 mm	650 mm ± 10 mm	700 mm ± 10 mm
Sleeper Spacing, depot	650mm ± 20mm		
Ballast Cushion			
Depot	250mm		
Standard Rail Length	13m and 18m		
Rail Panel Lengths	Long welded rails		
Minimum Radius of Curvature	Depot – 100m	120m with grade compensation	200m with grade compensation
Minimum Turn Out Depot	1 in 7, R-140		
Minimum Turn Out Main line	1 in 7, R-140		
Maximum Cant Permissible in curves	125 mm		
Maximum Cant Deficiency Permissible	100mm		
Maximum Permissible Cant Gradient	1 in 440		
Turn-out Speed: Turn-out (Main line) 1 in 9, R-300	45 km/h		
Turn-out Speed: Turn-out (Main line) 1 in 7, R-140	25 km/h		
Turn-out Speed: Scissors (Main line)	25 km/h		
Turn-out Speed: In Depots	25 km/h		
Maximum Gradient (Main Line)	4% (compensated)		
Minimum vertical curve radius crest	1500m		

Description	Elevated and at-grade sections		Tunnel sections
	Ballasted	Ballast-less (DFF)	Ballast-less (DFF)
Widening of track Gauge on curves	Upto 9 mm for curves sharper than 500m radius		
Structural gauge and passing clearance in straight line, in curves, in open air grade, in tunnel	Refer to appendix E of this document for typical sections		
Tunnel Profile	Drawings showing section of cut and cover and bored tunnel in the Underground sections and details of various equipment/cables etc. located therein are mentioned in are enclosed in Appendix E		
Line profile	The drawings showing the line profiles of all corridors are enclosed in Appendix E of this document:		

Note:

* Rail Seat spacing, Main line can be confirmed only after finalization of track design. Rolling Stock contractor has to liaison with Track contractor to obtain this information. The values given here are the values used in BMRCL Phase-I project.

2.3.2. The Track tolerances for At-grade, Elevated and Underground sections are set out in Table 2.3. final track tolerances will be confirmed by the Project Manager during the preliminary design of the vehicle.

Table 2.3 Track Tolerances:

Description	Ballasted	Ballast-less (DFF)
Laying Tolerance of Vertical Alignment measured by 20m chord (Designed level)	±2mm	±2mm
Alignment (Laying) (Horizontal)		
Straight track	±2mm over 10m chord	±2mm over 20m chord
Curve track	5mm variation over theoretical versine on 20m chord on curves of radius more than 600m and 10mm variation over theoretical versine on 20m chord on curves of radius less than 600m	±2mm over 20m chord
Cross Level Laying Tolerance (Designed)	±3mm (recorded on every 4 th sleeper)	±2mm

Description	Ballasted	Ballast-less (DFF)
Twist (Other than transition curve) (to be measured over a 3m base)	Straight/Curve – 1.67mm/m	Straight/Curve – 1.67mm/m
Cross Level Difference (Maintenance)	±10mm	±10mm
Gauge measured at a point 14mm below crown of rail (laying) (with respect to 1435 mm)	±2mm	±2mm
Unevenness (Maintenance) (Base 3m)	±6 mm	±6 mm
Alignment (Maintenance) (Base 7.5m)	±5 mm	±5 mm
Gauge variation (Maintenance)	±6 mm	±6 mm
Gauge (Maintenance) – Tangent track (with respect to 1435 mm)	±6 mm	±6 mm
Gauge (Maintenance) - >500m radius (with respect to 1435 mm)	±6 mm	±6 mm
Gauge (Maintenance) - <500m radius (with respect to 1435 mm)	±6 mm	±6 mm
Gauge Face Wear	Straight – 6mm Curve – 8mm	Straight – 6mm Curve – 8mm

2.3.3. Platform interfaces are set out in Table 2.4

Table 2.4 Platform interfaces:

Particulars		Measurements
Length		135 m (6 coaches)
Width: Island type		8.0 to 12.0 m
Width: Side type		4.0 to 6.0 m
Height above Top of Rail level	Ballasted Track	1090 mm ±5 mm
	Ballast-less Track	1080 mm ±5 mm
Maximum horizontal distance from centre of the track to face of passenger platform coping		As per para. 2.2.1 of SOD (December 2015)
Minimum horizontal distance from centre of the track to face of passenger platform coping		As per para. 2.2.2 of SOD (December 2015)
Minimum horizontal curvature at platform		1000m
Structural gauge and passing clearance in platform		Refer to Appendix E of this document

2.4. Flood Proofing

The Traction Equipment mounted on the under-frame shall be designed to permit propulsion of the train at 10 km/h through water up to a depth of 75mm above rail level. Traction equipment shall be made splash proof in accordance with International Standards.

2.5. Current Collection System

- 2.5.1. The principal details of the Current Collection Systems as required in IEC 60850 are set out in Table 2.5.

Table 2.5 Current Collection System:

System Particulars	For all sections and depots
Supply Voltage System	750V DC.
Type of Current collection	Through Third Rail (Inverted Rail) in all sections.
Current Collection	Through current collector shoes mounted on the driving motor cars and motor cars
Minimum height from rail level to Current collecting surface of the conductor rail	As per para 4.1.1 (a) of chapter 4 of SOD (December 2015)
Maximum height from rail level to Current collecting surface of the conductor rail	As per para 4.1.1 (b) of chapter 4 of SOD (December 2015)
Minimum distance of Centre line of the Conductor rail and track centre	As per para 4.1.2 (a) of chapter 4 of SOD (December 2015)
Maximum distance of Centre line of the Conductor rail and track centre	As per para 4.1.2 (b) of chapter 4 of SOD (December 2015)
Nominal voltage	750 V DC
Minimum voltage	500 V DC
Maximum voltage	900 V DC
Occasional maximum voltage	950V D.C
Occasional maximum voltage during regenerative braking	1000 V D.C
Voltage for guaranteed performance	725 V DC.

- 2.5.2. Typical third rail schematic, gauge and dimensions are given in Appendix E of this document.

2.6. Signalling System

- 2.6.1. Principal details of the Signalling and Train Control System are set out in Appendix D (interfaces).

Table 2.6: Signalling System

Item	Description
Train Control system	CBTC based on-board Continuous Automatic Train Control system (CATC) consisting of: (i) Automatic Train Protection (ATP)

	(ii) Automatic Train Operation (ATO) (iii) Automatic Train Super-vision (ATS) (iv) Automatic Turn Back (ATB) (v) Attended/Unattended train operation (GoA2/GoA4)
Train control mode	(i) Automatic mode (ii) Coded Manual mode (iii) Restricted Manual Forward mode (iv) Standby (v) Restricted Manual Reverse Mode (vi) Run on Sight mode (vii) Cut-out mode (viii) UTO (ix) OFF mode

2.7. Telecommunication System

2.7.1. The communications links are required to be provided, for trains on all lines, as appropriate. For full details and division of responsibilities, see Appendix D (Interfaces).

2.8. Kinematic Envelopes

2.8.1. The Bidder shall develop and furnish a typical family of Kinematic Envelopes to define the metro train behaviour on the lines. Width of the vehicle (external faces at widest point) shall be set at minimum to 2880 mm according to structure gauge, swept envelope, dynamic movement and passing clearances. The Bidder shall optimise the vehicle width in order to give more space and passenger capacity. The configuration of the vehicle, length of element, distances between bogie pivots, face profiles, swept envelope shall be adapted to the characteristic of the line, infrastructure structural gauge and passing clearances (in station, in curves, in straight line open grade, tunnel refer to Appendix E).

2.8.2. The Kinematic envelope shall be calculated taking into account the permissible track construction and wear tolerance. Structural gauge on tangent level track for At-grade, Elevated sections, tunnel sections and platforms are given in Appendix E. No part of any car shall infringe the respective structural gauge, under any circumstance. Trains shall provide the same kinematics performance in either direction of travel and either in underground or elevated tracks.

2.8.3. During the detailed design phase, the Contractor shall develop and furnish detailed calculations showing lateral and vertical shifts due to each factor separately and Kinematic Envelopes of the proposed metro trains for both inflated and deflated conditions of springs, separately for At-grade and Elevated sections and for tunnel sections, taking into account all car displacements resulting from the simultaneous occurrence of all normal conditions specified and any one abnormal condition specified below. Track curves and tolerance shall be taken into account. **(CDRL-2-1)**

2.8.4. Normal Conditions:

- i) All vehicle speeds between 0 and 90 km/h (design speed)
- ii) All vehicle loads between AW0 (Tare) and AW4 (8 persons standing /m²).

- iii) Any degree of vehicle wheel wear between new and fully worn.
- iv) Any degree of vehicle suspension, wear or adjustment from new to fully worn, including all service tolerances and potential variations in setting.
- v) Maximum cant deficiency.
- vi) Maximum cant excess.
- vii) Vehicle lateral and rolling movements due to wind forces with a wind speed of 125 km/h on the At-grade and Elevated corridors.
- viii) Vehicle yaw and vertical movements.
- ix) Track tolerances.

2.8.5. Abnormal Conditions

- i) Any combination of bogie air spring deflated.

2.8.6. The Contractor shall submit detailed KE calculations and corresponding KE envelope on platform lines both for straight and curved tracks in step of 10 Kmph at various speed starting from 20 Kmph to 90 Kmph under normal condition as per sub clause 2.8.4 and abnormal condition as per sub clause 2.8.5 above and also for new wheel new rail and worn wheel worn rail condition. The Contractor shall ensure that the train shall enter and exit the platform at the maximum speed as achievable with the specified performance parameters up to wind speed of 60 Kmph. The same shall be demonstrated through calculation/simulation and through tests under new wheel new rail condition and worn wheel worn rail condition. For worn wheel and worn rail condition the clearances will be estimated based on new wheel and new rail clearances. **(CDRL-2-2)**

2.8.7. The Contractor shall submit the detailed calculations/simulation of minimum clearances of car body exterior and walkways in steps of 10 Kmph at various speed starting from 10 Kmph to 50 Kmph on the sharpest curve of 120 m both for inside and outside curve both for normal condition as per sub clause 2.8.4 and 2.8.5 for abnormal condition above for new wheel new rail and worn wheel worn rail conditions. For this calculation, minimum walkway width will be considered as per para 1.8 of SOD (December 2015). The detailed drawing of the cross section of the elevated and underground corridor showing the walkway and its dimension shall be obtained in interface with elevated/underground contractors. **(CDRL-2-3)**

2.9. Deliverables

Contract deliverables required by this section of the technical provisions are summarized below.

CDRL-2-1:	Contractor shall develop and furnish detailed calculations of Kinematic Envelopes (ref. ERTS 2.8.3)
CDRL-2-2:	KE calculation for platform clearances (ref. ERTS 2.8.6)
CDRL-2-3:	KE calculation for walkway clearances (ref. ERTS 2.8.7)

3. OPERATIONAL PERFORMANCES

3.1. Operation Plan Requirements

3.1.1. Salient features of the proposed train operation plan are:

- i) High frequency of train service (2-minutes Peak head way), off-peak periods (3–5-minute headway).
- ii) Running of services for 19 hours of a day (5 AM to Midnight) with a station dwell time of 30 seconds.
- iii) Reverse minimum time in terminal stations, 120 seconds with Automatic Turn Back (ATB) feature.
- iv) Minimum 8 % coasting is expected to achieve the specified commercial speed.
- v) Average kilometre per year for a metro train in the range of 1,50,000 km.
- vi) Motorization rate expected is 66 % for a 6 car train composition.
- vii) Total power of the 6 car metro train shall be defined and calculated by the bidder/Contractor in order to achieve the operation performances. **(CDRL-3-1)**
- viii) Tractive and braking effort shall be defined and calculated for the 6 car metro train in the limit of the wheel rail adhesion ratio (18 % in tunnel and 16 % at grade and super-elevated structures) by the Bidder/Contractor in order to achieve the operation performances. **(CDRL-3-2)**
- ix) Driving mode: ATP/ATO/UTO.
- x) Normal 6-Car train set operation, double 6-Car train set operation only for rescue conditions.

3.2. Commercial Speed Requirements

3.2.1. Performances of the metro train in AW4 (8 persons standee /m²) under normal conditions shall be compliant to achieve a minimum commercial speed of 34 kmph (excluding reverse time in terminal station). Curves and alignment are given in Appendix-E.

3.2.2. The trains shall operate in the following modes:

- a) Normal Mode:
 - Accelerate the train using the designed Speed-Tractive Effort characteristic of the Rolling Stock.
 - Coast (minimum 8% by time) to achieve the specified schedule speed.
 - Average service deceleration as specified in para 3.7.2 from at least 65 kmph running speed till 5 kmph shall be achieved with Electro-Dynamic (ED) brake only and blended brake with Electro-Pneumatic in the range from 80Kmph to 65 Kmph and from 5 kmph till the train comes to a stop. The regenerative power shall be used to the maximum extent possible.
 - The above steps should be taken in a manner such that prescribed scheduled speed is achieved and energy consumption is minimised. The scheduled speeds are to be obtained with a dwell time of 30 seconds at each station.

b) All-out Mode:

- This will mean maximum acceleration and deceleration with no coasting till maximum speed is achieved and thereafter speed is maintained within 5 kmph below than the maximum speed. During braking, maximum regenerative braking shall be utilised to achieve the specified retardation rate from top speed till train stops and the Jerk rate shall be limited within the specified limit.

- c) The Control system shall be such that the train will achieve the specified speed time curves at all payload subject to keeping the loading of traction system within the boundary limits of the design.
- d) Normal mode will be used when trains are running in time and time table can be maintained. All-out mode will be used to make up time when trains are running late.
- e) When the train is in ATO/UTO mode, the train will get appropriate commands from Signaling system.

3.2.3. Bidders shall indicate the total runtime and the Guaranteed "Declared Schedule Speed (DSSP)" in kmph for a round trip from, KalenaAgrahara to Nagavara and back (Line-6) and Central Silk Board Junction to K.R. Puram and back (Phase 2A) and K.R. Puram to Kempegowda International Airport and back (Phase 2B) under following conditions:

- i) Train loaded: AW4
- ii) Mode of operation: ALL OUT MODE (ATP)
- iii) Acceleration rates: Equal to or better than the rates specified in ERTS clause 3.6.6.
- iv) Average service brake rate from maximum speed to standstill shall be equal to or better than the specified brake rate in ERTS clause 3.7.2.
- v) Round Trip from KalenaAgrahara to Nagavara (Line-6) i.e. the travel of a 6-car train set from KalenaAgrahara to Nagavara, Turnaround at Nagavara then travel from Nagavara to KalenaAgrahara and again Turnaround at KalenaAgrahara so as to reach the same point from where the journey started.
- vi) Dwell time at each station shall be 30 secs (including door opening and closing time)
- vii) Total Turnaround time at both KalenaAgrahara and Nagavara stations including Dwell time at both the stations shall be 4 minutes (i.e. 2 minutes at each terminal station) with Automatic Turn Back (ATB).
- viii) Bidders shall indicate total time for the round trip as round trip time i.e. RTT_{DSSP} .
- ix) Round trip time, dwell time and turnaround time for Phase 2A i.e. Central Silk Board Junction to K.R. Puram shall be considered in similar manner as specified in para (v) to (vii) above.
- x) Round trip time, dwell time and turnaround time for Phase 2B i.e. K.R. Puram to Kempegowda International Airport shall be considered in similar manner as specified in para (v) to (vii) above.

3.3. Computer simulation results

3.3.1. The Contractor shall submit the round trip computer simulation run results of 6-Car train set in AW4, AW3, AW2 and AW0 loaded train under the specified voltage and wheel conditions in ALL OUT mode and NORMAL mode in Line-6, Phase 2A and Phase 2B with the following details:

- i) Round Trip Schedule speeds in "NORMAL" mode with 8% coasting excluding terminal station turnaround time and with a dwell time of 30 sec
- ii) Round Trip Schedule speeds in "All Out" mode excluding terminal station turnaround time.
- iii) Inter-station running time for each corridor, each way.
- iv) Line current/RMS current plots for each corridor, each way.
- v) Total energy consumed for each corridor, each way showing the break-up of energy consumed in traction, energy regenerated, energy consumed by Auxiliary Power Supply (APS), regenerated energy lost in brake resistor, regenerated energy used by APS, regenerated energy sent to the line, net energy consumption of APS.
- vi) Specific energy consumption for each corridor considering the design value of specific energy consumption of HVAC.
- vii) Specific energy consumption for each corridor considering the traction energy and Auxiliary power consumption. **(CDRL-3-3)**

3.4. Software Package

3.4.1. The Contractor shall hand over the software package employed by him for the above studies along with the requisite documentation, to the Employer.

3.4.2. The software shall simulate Run Time performance of the train viz inter station timing, schedule speeds with different coasting percentage(s) under varied loads, route profiles, headway, inter-station distances, train resistance, adhesion and Tractive Effort/Braking Effort characteristics etc. The software shall not be restrictive to the above and shall be for general application with Project Manager selective parameters. Software shall be user friendly and menu driven. List of variable inputs that the software should be designed for shall be decided by the Project Manager during detailed design. Decision of Project Manager will be final & binding-

3.4.3. Full access to the software for the purpose above shall be provided. Any hardware/software tool required for this purpose shall also be provided. The documentation including flow charts shall be provided. The Employer's representatives shall be fully trained and made fully conversant by the Contractor for this purpose. **(CDRL-3-4)**

3.5. Passenger Capacity

3.5.1. The following data and assumptions shall be used by the Bidder for all normal and degraded performance requirements and calculations.

For a 6-Car metro train composition, the seating and standee capacity expected are as under:

	AW2 (4 pers standee /m²)	AW3 (6 pers standee /m²)	AW4 (8 pers standee /m²)
Seats	286	286	286
Standees	861	1289	1718
Total capacity	1147	1575	2004
% of seats	24.9	18.15	14.27

3.6. Tractive efforts, Braking efforts and Metro train acceleration performances

- 3.6.1. The bidder shall provide typical tractive effort and braking effort curves including Train Resistance Formula "Davis adapted for metro" in normal and first degraded mode (loss of one traction inverter) in different typical gradients for the different cases of passenger load (AW0, AW2, AW3, AW4) for a 6-car metro train composition. Davis formula adapted for metro train shall be demonstrated during test trial.
- 3.6.2. Maximum rail wheel adhesion limit of 16% shall be taken into account for At-grade and Super- elevated sections and 18% for tunnel sections.
- 3.6.3. Not used.
- 3.6.4. The bidder shall provide typical acceleration curves and average acceleration values from 0 to 30 km/h, 0 to 60 km/h and 0 to 80 km/h in normal and first degraded mode (loss of one traction inverter group) in different typical gradients for the different cases of passenger load (AW0, AW2, AW3, AW4). **(CDRL-3-5)**
- 3.6.5. On dry, tangent and level track at 750 V DC for AW4 car weight (8 passengers/m²), Train performance calculations shall be based on half worn wheels with maximum rail wheel adhesion.
- 3.6.6. Average accelerations expected on dry, tangent and level track at 750 V DC for AW4 car weight and adhesion limits are.
- (i) Average acceleration rate from 0 to 30 km/h : 1 m/s² ± 5%
 - (ii) Jerk : 0.7 m/s³ ± 0.05

3.7. Metro train performances in braking mode

- 3.7.1. The bidder shall provide typical braking curves in normal and first degraded mode (loss of one traction inverter group) in different typical gradients for the different cases of passenger load (AW0, AW2, AW3, AW4). **(CDRL 3-5)**
- 3.7.2. All rates specified herein are net rates in AW4 car weight (8 passengers/m²) on clean, dry, well-maintained tangent track. Braking performance is achieved under all conditions of line receptivity up to 100% (maximum regenerative brake) and includes intermediate degrees of partial receptivity. Performance, deceleration and jerk are specified and measured according to European standards EN 13452-1 and EN 13452-2.
- i) Average service deceleration from 80 to 0 km/h: 0.95 m/s² ± 5%
 - ii) Instantaneous full-service deceleration: 1.1 m/s²
 - iii) Maximum adhesion limit in open grade/ super-elevated grade: 16 %
 - iv) Maximum adhesion limit in tunnel: 18%
 - v) Maximum jerk (dy/dt): 0.7 m/s³ ± 0.05

- vi) Minimum average emergency deceleration: 1.3 m/s²
- vii) Maximum equivalent response time taken into account for the calculations is for service and emergency braking shall be compliant with EN 13452-1.

Average service deceleration from 65 Kmph to 5 Kmph as specified in (i) above shall be achieved from Electro-Dynamic (ED) brake only.

3.8. Metro train speed performances

3.8.1. The bidder shall provide typical speed performances curves in normal and first degraded mode (loss of one traction inverter group) in different typical gradients for the different cases of passenger load (AW0, AW2, AW3, AW4). **(CDRL-3-5)**

3.8.2. ~~Speed on normal condition of adhesion at 750 V DC for AW4 car load:~~

- ~~i) The maximum permissive speed in operation on tangent and level track is 80 km/h.~~
- ~~ii) The maximum permissive speed (design) on tangent and level track is 90 Km/h.~~
- ~~iii) The train shall be able to start at 4% gradient and shall achieve the maximum operating speed of 80 Kmph in a section with 4% gradient and sufficient length of tangent track.~~
- ~~iv) All intermediate speed shall be available step less.~~

Addendum-1 dated 05.12.2022, Sl. No. 71

Speed on normal condition of adhesion at 750 V DC for AW4 car load:

- i) The maximum permissive speed in operation on tangent and level track is 80 km/h.
- ii) The maximum permissive speed (design) on tangent and level track is 90 Km/h.
- iii) The train shall be able to start at 4% gradient and shall achieve the maximum operating speed of 80 Kmph in a section **with tangent track of sufficient length.**
- iv) All intermediate speed shall be available step less

3.9. Rescue mode performances

3.9.1. A 6-car metro train with AW4 load in normal working condition, without any damage regarding one hour rating of traction motor and other equipments, shall be capable to start and to push or haul a defective metro train with the same composition with AW4 load, on all Lines including sections of 4% gradient up to the next station.

3.9.2. Thereafter, the healthy train shall, after all the passengers have de-trained at the station, continue to push the defective train up to the terminal station. There shall be no equipment damage or degradation, while maintaining safe operation.

3.9.3. Typical tractive effort curves shall be provided and relevant information as wheel rail adhesion ratio, speed. **(CDRL-3-5)**

3.10. Degraded conditions

3.10.1. The Bidder should also furnish the inter-station running time for a fully loaded train, under the 2 degraded conditions of running, for Line-6, Phase 2A and Phase 2B, each way for:

- i) 25% of motorization out;
- ii) 50% of motorization out.

- 3.10.2. ~~The continuous thermal rating of the traction system shall be sufficient to meet all the conditions of All Out mode. The short term rating of the traction system shall be sufficient to meet all the conditions of All Out mode for one round trip without dwell time at stations, in Line-6, Phase 2A and Phase 2B. Also, during degraded mode of operation (25% of motorization out, 50% of motorization out), short term thermal rating of the traction system should not be exceeded for one round trip, in Line-6, Phase 2A and Phase 2B.~~

Addendum-1 dated 05.12.2022, Sl. No. 72

The continuous thermal rating of the traction system shall be sufficient to meet all the conditions of All Out mode. The short-term rating of the traction system shall be sufficient to meet all the conditions of All Out mode for one round trip without dwell time at stations, in Line-6, Phase 2A and Phase 2B. Also, during degraded mode of operation (25% of motorization out, 50% of motorization out), short term thermal rating of the traction system should not be exceeded for one round trip in Line-6, Phase 2A and Phase 2B **in All Out mode with dwell time (30sec).**

- 3.10.3. ~~A 6-car metro train in AW4 condition shall be capable to complete the round trip of Line-6, Phase 2A and Phase 2B without loss of time with one motor car cut out (25% motorization rate cut) in All Out mode.~~

Addendum-1 dated 05.12.2022, Sl. No. 73

A 6-car metro train in AW4 condition shall be capable to complete the round trip of Line-6, Phase 2A and Phase 2B without loss of time with one motor-car cut out (25% motorization rate cut) in All Out mode **with dwell time (30sec).**

3.11. Energy Consumption and saving performances

- 3.11.1. Bidders shall note that 'SPECIFIC ENERGY CONSUMPTION (SEC)' to be verified in Line-6 (KalenaAgrahara to Nagavara) and Phase 2A (Central Silk Board Junction to K.R. Puram) and Phase 2B (K.R. Puram to Kempegowda International Airport) under conditions detailed hereafter in this clause shall not exceed 60Wh/GTKM, referred to as SECs.

This Specific Energy Consumption shall be total of two components viz. SEC for a 6-car train (with HVAC switched off) i.e. 'SEC_P' value and SEC of HVAC for a 6-car train i.e. 'SEC_H' value. These two values shall be declared by the Contractor (SEC_{P-declared} + SEC_{H-declared}) during pre-final design stage and the same shall be validated as detailed in this clause. The total declared SEC value i.e. SEC_{declared} for a 6-car train as declared by the Contractor i.e. SEC_{P-declared} + SEC_{H-declared} shall not exceed the SEC_s i.e. 60Wh/GTKM as mentioned above.

Bidders shall note that no adjustments of the 'SEC' values obtained during validation (SEC_{P-A} (Achieved value of SEC_P) and SEC_{H-A} (Achieved value of SEC_H)) will be permissible on account of any of the following:

- a) Increase in length of the network in Line-6 and Phase 2A and Phase 2B by upto 5% of the total length of the section in Line-6 (KalenaAgrahara to Nagavara) and Phase 2A (Central Silk Board Junction to K.R. Puram) and Phase 2B (K.R. Puram to Kempegowda International Airport) including change in alignment.
- b) Increase in number of stations by 2 (two) stations in Line-6, Phase 2A and Phase 2B.

- c) Any changes in station locations with consequent changes in inter-station distances/rationalization of curves & gradients in Line-6 (KalenaAgrahara to Nagavara) and Phase 2A (Central Silk Board Junction to K.R. Puram) and Phase 2B (K.R. Puram to Kempegowda International Airport).

Bidders shall also note that irrespective of any tolerances specified in any relevant International Standards or relevant other engineering documents of other metros or in the submitted bid documents, with respect to the measured or SEC values, no tolerance/margin shall be considered applicable in this case.

A. COMPONENTS OF SPECIFIC ENERGY CONSUMPTION (SEC):**A1. SEC for a 6-car train (with HVAC switched off) in Line-6 (KalenaAgrahara to Nagavara), Phase 2A (Central Silk Board Junction to K.R. Puram) and Phase 2B (K.R. Puram to Kempegowda International Airport) (Say 'SEC_P' Wh/GTKM)**

The 'SEC_P' value as declared by the Contractor i.e. SEC_{P-declared} shall be validated under following conditions: -

A 1.1. (i) For Combined Test Bed: Round Trip Time corresponding to KalenaAgrahara - Nagavara and Central Silk Board Junction - K.R. Puram and K.R. Puram - Kempegowda International Airport (RTT_{R6} or RTT_{ORR} or RTT_{ALM}) shall be considered.

(ii) For Field Trial in Line-6: Actual Round Trip on main line for Line-6 in ATP/ATO/UTO i.e. the travel of a 6-car train set in Line-6 i.e. KalenaAgrahara to Nagavara, turnaround at Nagavara then travel from Nagavara to KalenaAgrahara and again turnaround at KalenaAgrahara so as to reach the same point from where the journey started.

For Field Trial in Phase 2A: Actual Round Trip on main line for Phase 2A in ATP/ATO/UTO i.e. the travel of a 6-car train set in Phase 2A i.e. Central Silk Board Junction to K.R. Puram, turnaround at K.R. Puram then travel from K.R. Puram to Central Silk Board Junction and again turnaround at Central Silk Board Junction so as to reach the same point from where the journey started.

For Field Trial in Phase 2B: Actual Round Trip on main line for Phase 2B in ATP/ATO/UTO i.e. the travel of a 6-car train set in Phase 2B i.e. K.R. Puram to Kempegowda International Airport, turnaround at Kempegowda International Airport then travel from Kempegowda International Airport to K.R. Puram and again turnaround at K.R. Puram so as to reach the same point from where the journey started.

Contractor shall note that train may be required to run for approximately 500 meters at each turnaround i.e. at Line-6, Phase 2A and Phase 2B. In case the actual run during turnaround is more than 500 meters but the overall increase in the length of the network is within 5 % of the total length of the section, no adjustments of the SEC values shall be permissible.

A 1.2. Dwell time at each intermediate station shall be 30 seconds (including door opening and closing time).

A 1.3. Turn back time for Line-6, Phase 2A and Phase 2B including dwell time at both the terminal stations shall be 4 minutes (i.e., 2 minutes at each terminal station which may be corrected based on ATB implementation).

A 1.4. Loading conditions:

i) For Combined test bed: AW4 loading condition.

ii) For Field Trial: 2004 passengers (DMC=316, MC=343, TC=343) for 6-Car train set, 65kg weight per passenger.

A 1.5. The train operation in All-Out mode shall be as per clause 3.2.2(b).

A 1.6. For Combined test bed: All-Out ATP mode as per clause 3.2.3 shall be considered.

For Field Trial: All-out ATP/ATO/UTO mode as per clauses 24.6.3, as decided by the Project Manager during design stage shall be considered. The decision of the Project Manager shall be final and binding.

A 1.7. During field trials in ATP/ATO/UTO, the door opening & closing time shall be within dwell time of 30 seconds (refer A1.2 above).

A 1.8. During the run and during the reversal at both Terminal stations, full auxiliary load with all auxiliaries functioning at full load at unity duty cycle shall be in operation. However, HVAC shall be switched off during this run and if more than one air compressor is installed, only one compressor shall be working.

A1.8.1. Contractor shall submit the Average Equivalent Auxiliary load in kW at CCD level for a round trip detailed above. The declared average equivalent auxiliary load (D_{Aux}) at CCD level shall consider the following factors:

- i) Operation of all auxiliary loads (including doors opening and closing at stations /terminals) as noted above.
- ii) Efficiency of Auxiliary Power Supply (APS).

Contractor shall also take into account this D_{Aux} while declaring the value of $SEC_{P-declared}$ during design stage.

Contractor shall note that detailed supporting data sheet for determination of D_{Aux} considering the above factors shall be submitted during design stage.

For calculation of the auxiliary load (D_{Aux}), following shall be considered:

- Load of one main air compressor and one air dryer shall be considered.
- HVAC and associated control loads shall not be considered.
- The battery charger load shall be considered as only 25 % of the rated load.

Submission of above data shall be a pre-requisite for accomplishment of milestone A13 (Pre-final design submission) as specified in Cost Centre 'A' of Annexure PD-2 of Price Schedule: Section IV: Bidding Forms.

A 1.9. In support of the declared SEC value ' $SEC_{p-declared}$ ' during design stage, the Contractor shall submit the calculations, ratings and technical data sheet comprising of but not limited to:

- i) Complete simulation report (including run curve simulation, input data and assumptions made). The simulation report in xls format shall include the details of distance travelled, train speed, acceleration or deceleration achieved, electric effort (tractive or regenerative), mechanical effort and motion resistance at interval of 0.25 sec of run.
- ii) Traction motor voltage, current and DC link voltage at different speeds during powering and braking. Values shall be submitted in MS-Excel spread sheet for speed increment of one tenth of kmph.
- iii) Tractive Effort, Braking Effort values for powering and regeneration shall be submitted in MS-Excel spread sheet for speed increment of one tenth of kmph.

- iv) Efficiency values of Filter Inductor (FL), Inverter (VVVF), Traction motor, Gear drive and Auxiliary Power Supply (APS) inverter shall be submitted in MS-Excel spread sheet for speed increment of one tenth of kmph.

Note: The above data including the detailed data [i.e.(i) to (iv)] of 0.25 sec interval for the complete run of round trip (A 1.1) shall be furnished in MS-Excel spread sheet. Submission of above data shall be a pre-requisite for accomplishment of milestone A13 (Pre-final design submission) as specified in Cost Centre 'A' of Annexure PD-2 of Price Schedule: Section IV: Bidding Forms. **(CDRL-3-6)**

A2. SEC of HVAC for a 6-car train (Say 'SEC_H'Wh/GTKM)

Specific Energy Consumption for functioning of HVACs of a 6-car train - ('SEC_H') as declared by the contractor i.e. SEC_{H-declared} shall be validated by conducting test on one car under following conditions in climatic chamber:

- A2.1. Round Trip Time corresponding to KalenaAgrahara – Nagavara, Central Silk Board Junction - K.R. Puram and K.R. Puram - Kempegowda International Airport (RTT_{R6} or RTT_{ORR} or RTT_{ALM}) shall be considered as mentioned in clause 3.2.3 shall be considered.
- A2.2. Dwell time for each intermediate station shall be 30 seconds including doors opening and closing. At terminal station, door opening and closing shall be considered twice, one on arrival and second before leaving the terminal.
- A2.3. The train shall be considered to be operated as explained in Clause 3.2.3 and the run time between stations shall be corresponding to RTT as per Clause 3.2.3 and the same shall be considered for testing during validation.
- A2.4. ~~Inside car temperature shall be maintained at 25° C. Contractor to note that the car inside temperature before opening of the saloon doors at each station shall be within 25° C.~~

Addendum-1 dated 05.12.2022, Sl. No. 74

Inside car temperature shall be maintained at 25 degree C. Instantaneous average interior temperature at 1.1 m above floor can be 25 degree C +/- 2 C(as per EN14750), but the average of instantaneous average interior temperature at 1.1 m above floor during the Round Trip time shall not exceed 25 degree C. This round trip time shall include the times when the doors are open for passengers to board and de-board the train. Contractor to note that the car inside temperature just before opening of the saloon doors at each station shall be within EN 14750 limits.

- A2.5. ~~Ambient (summer) conditions to be maintained outside the car. Ambient temperature, humidity and air speed of outside car shall be monitored as per EN 14750-2. Energy Consumption test shall be conducted at an air speed of 40 kmph.~~

Addendum-1 dated 05.12.2022, Sl. No. 75

Ambient (summer) conditions to be maintained outside the car. Ambient temperature, humidity and air speed of outside car shall be monitored as per EN 14750-2. Energy Consumption test shall be conducted at an air speed **of 0 to 15 kmph.**

- A2.6. ~~Loading Condition: Heat load of AW3 (6 standee per square metre) numbers of persons as per EN 14750-1, throughout the round trip including the terminal turnaround time.~~

Addendum-1 dated 05.12.2022, Sl. No. 76

Loading Condition: Heat load of **AW4 (8 standee per square meter)** numbers of persons as per EN 14750-1, throughout the round trip except for the terminal station turn around time when the doors are closed at terminal station for turning around the train, AW0 passenger load to be considered.

- A2.7. Doors opening and closing as per scheduled to and fro run on the route.
- A2.8. For terminal stations, 2 times opening as well as closing of doors shall be considered.
- A2.9. Contractor shall submit the efficiency value of Auxiliary Power Supply Inverter and calculation sheets for:
 - i) Cable losses between Auxiliary Power Supply Inverter and HVAC with size and length of cables.
 - ii) Efficiency curve of Auxiliary Power Supply Inverter.
 - iii) Cable loss between CCD and Auxiliary Power Supply Inverter

Submission of above data shall be a pre-requisite for accomplishment of milestone A13 (Pre-final design submission) as specified in Cost Centre 'A' of Annexure PD-2 of Price Schedule: Section IV: Bidding Forms. **(CDRL-3-6)**

The energy measured on one car (M Car) in the climatic chamber will be multiplied by six (6) to determine the energy consumption by HVACs of a 6-car train in climatic chamber (SEC_{H-CC}). Energy loss on account of items listed at A2.9(i) to A2.9(iii) shall then be added to the measured value above i.e. SEC_{H-CC} to determine the value of SEC_H i.e. ' SEC_{H-A} '.

B. Validation of Specific Energy Consumption:

The validation of the declared values $SEC_{P-declared}$ and $SEC_{H-declared}$ shall be done as described below. However, the conclusion of validation shall be done in totality after the Contractor has established the compliance of specified Specific Energy Consumption i.e. SEC_S value.

B1 Validation of " $SEC_{P-declared}$ ":

Validation of ' $SEC_{P-declared}$ ' under conditions noted above shall be carried out by the following method in two stages:

B1.1 Validation on COMBINED TEST BED (Stage-1):

- B1.1.1 The test protocol shall be prepared in detail and got approved from the Project Manager before commencement of the test. In the "Combined Test Bed", all original relevant equipment such as Filter Inductor, Inverter (VVVF), Traction Motor and Auxiliary Power Supply Inverter shall be considered. Type test results including efficiency curves at different loads for Filter Inductor, Gear Case, Inverter (VVVF) and Auxiliary Power Supply Inverter shall be considered for finalizing the test protocol.

For measurement, CT and PT of accuracy class 0.1 or better as in IEC: 60044 shall be used. Energy meter of accuracy 0.15% or better shall be used.

- B1.1.2 The declared auxiliary load (D_{Aux}) multiplied by the total round trip time (corresponding to RTT as per clause 3.2.3) shall be added to the measured value while calculating specific energy consumption in the combined test bed set up. This value shall be the $SEC_{P-A-Stage 1}$.

B1.2 Validation during Field Trial (Stage-2):

B1.2.1 The value of 'SEC_{P-declared}' shall also be validated in actual line run - round trip of a 6-car train set for Line-6, Phase 2A and Phase 2B (under ATP/ATO/UTO mode of operation) as per conditions stated in para 3.11 (A1) above. This measured value during field trial shall be the SEC_{P-A-Stage 2}.

B1.3 Bidders shall note that, to determine compliance of the total specified SECs' value, the actual values determined on "Combined Test Bed" (B1.1) as well as the actual measured value in the line run test - round trip under ATP/ATO/UTO mode of operation (B1.2) would be considered.

B1.4 To determine compliance, higher of the determined Specific Energy Consumption values on the combined test bed i.e. SEC_{P-A-Stage1} and measured value in actual line test i.e. SEC_{P-A-Stage2} shall prevail. The higher of the two values (SEC_{P-A-Stage1} and SEC_{P-A-Stage 2}) shall be considered as SEC_{P-A} (Achieved SEC_P).

B1.5 Not Used.

B1.6 Combined Test Bed test for validation of 'SEC_{P-declared}' shall be conducted and concluded during the design stage and before dispatch of the prototype train set. Completion of Combined test bed validation shall be a pre-requisite for accomplishment of milestone for delivery of prototype train set and related key date i.e. KD No. 4 (ATTACHMENT TO APPENDIX LB-1, Section IV – Bidding Forms). **(CDRL-3-6)**

B2 Validation of "SEC_{H-declared}":

B2.1 Before conducting Specific Energy Consumption test, the car level type test of the HVAC system should have been completed and the HVAC & Air duct system should have been found suitable.

B2.2 Validation of 'SEC_{H-declared}' value shall be done in a climatic chamber as per conditions specified in 3.11 (A2).

B2.3 To determine compliance with the declared specific energy consumption value for HVAC i.e. 'SEC_{H-declared}', the Contractor shall carry out test on a single car (M Car) in the climatic chamber.

B2.4 Suitable necessary arrangements shall be made for providing almost evenly distributed sensible heat and humidity load inside the car with the help of thin film resistors, other heating devices and humidifiers for simulating the specified passenger heat loads and other heat loads. Heaters and humidifiers will be placed such that real life like situation is created.

B2.5 Doors shall be opened and closed as detailed for a round trip and passenger load throughout the Round Trip (including terminal detention) shall be AW4.

B2.6 Detailed instrumentation of the HVAC, car interior and exterior, and the climate chamber shall be done to monitor, if the specifications and standards specified criteria are not getting violated at any time in during the test.

- B2.7 The bidders shall note that the 'SEC_{H-declared}' value validation test shall be carried out only after ensuring compliance of "Air Flow" and "Cooling Capacity test" exactly in line with the relevant standards and specifications of this bid.
- B2.8 Energy Consumption for HVACs for the car under test shall be multiplied by the number of cars in a train (i.e. 6-cars) to determine the Energy Consumption of HVACs for one train ("SEC_H" Wh/GTKM).
- B2.9 Not Used.
- B2.10 Completion of Climatic Chamber test shall be a pre-requisite for accomplishment of milestone for delivery of prototype train set and related key date i.e. KD No. 4 (ATTACHMENT TO APPENDIX LB-1, Section IV – Bidding Forms).
- B2.11 In case, the round trip time i.e. RTT_{FT} during field trial for measurement of SEC_P is higher than the declared round trip time by the bidder during Bid submission (as per clause 3.2.3) i.e. RTT_{R6} or RTT_{ORR} or RTT_{ALM}, the adjustment (i.e. increase) in the achieved specific energy consumption of HVAC (SEC_{H-A}) on pro-rata basis shall be made. For example, say the round trip time declared by the bidder during Bid submission is 50 minutes and during actual run, the round trip time was found to be 55 minutes.

RTT_{R6} or RTT_{ORR} or RTT_{ALM} = 50 minutes

RTT_{FT} = 55 minutes

Achieved value of SEC_H i.e. SEC_{H-A} = 17 Wh/GTKM (say) Then, the adjusted value of SEC_{H-A} shall be

SEC_{H-A-adjust} = (SEC_{H-A} / RTT_{R6} or RTT_{ORR} or RTT_{ALM}) x RTT_{FT}

SEC_{H-A-adjust} = (17/50) x 55 = 18.7 Wh/GTKM

However, if the round trip time i.e. RTT_{FT} during field trial for measurement of SEC_P is lower than the declared round trip time by the bidder during Bid submission (as per clause 3.2.3) i.e. RTT_{R6} or RTT_{ORR} or RTT_{ALM}, no adjustment will be made in the achieved specific energy consumption of HVAC (i.e. SEC_{H-A}) calculated as specified in para A2 above.

- B3.0 Based on the achieved value of SEC i.e. SEC_A [SEC_{P-A} + {SEC_{H-A} or SEC_{H-A-adjust} (as applicable)}], after conclusion of the validation of SEC_S, if the Contractor is unable to validate and establish compliance of total Specific Energy Consumption value i.e. SEC_S to the entire satisfaction of the Project Manager, the Contractor shall carry out necessary modifications (hardware as well as software) in the Rolling Stock to achieve the specified Specific Energy Consumption value (SEC_S) and re-validate the same. In such cases, the revalidation will be again carried out after modifications as per clause 'B1' and 'B2' above including Air Flow Test & Cooling Capacity Test of HVACs.

Bidders shall note that the achieved values i.e. 'SEC_{P-A}' and 'SEC_{H-A}' shall be considered up to one tenth of the unit with the one tenth component rounded up to the next value. For example:

- i) If the achieved value of 'SEC_P' on combined test bed and/or during field trial is 26.11 Wh/GTKM, the value would be considered as 26.2 Wh/GTKM.

- ii) (If the achieved value of SEC_H is 16.89Wh/GTKM, then value would be considered as 16.9 Wh/GTKM.

For validation, the energy measured with external energy meter during field trials shall prevail. Contractor shall submit calibration certificate for the energy meters used for measurement from an independent laboratory and such certificate shall not be more than 3 months old.

B3.1 Measurements to be made for:

Sl. No.	Description	Symbol
1.	Energy Consumption input at CCD during 'Non-braking' (Traction & Coasting)	E_{231}
2.	Energy consumption at input of APS (Auxiliary Power Supply Inverter) during 'Non-braking'	E_{221}
3.	Energy consumption at Inverter (VVVF) unit during 'Non-braking'	E_{211}
4.	Energy consumption input at CCD during 'Braking'	E_{131}
5.	Energy exported during 'Braking' at CCD	E_{132}
6.	Energy Consumption at APS (Auxiliary Power Supply Inverter) from Line during 'Braking'	E_{121}
7.	Regenerated Energy utilized by APS (Auxiliary Power Supply Inverter) (input to APS) during 'Braking'	E_{122}
8.	Regenerated Energy at Inverter (VVVF) input during 'Braking'	E_{112}

$$\text{Traction Energy Consumption} = E_{211} - E_{112}$$

$$\text{Auxiliary Energy Consumption} = E_{221} + E_{121} + E_{122}$$

$$\text{Total Input } (E_{IN}) = E_{231} + E_{131}$$

$$\text{Regeneration Output } (E_{OP}) \text{ exported to CCD during braking} = E_{132}$$

$$\text{Net Input} = E_{231} + E_{131} - E_{132}$$

Notations are explained below:

E_{XYZ}

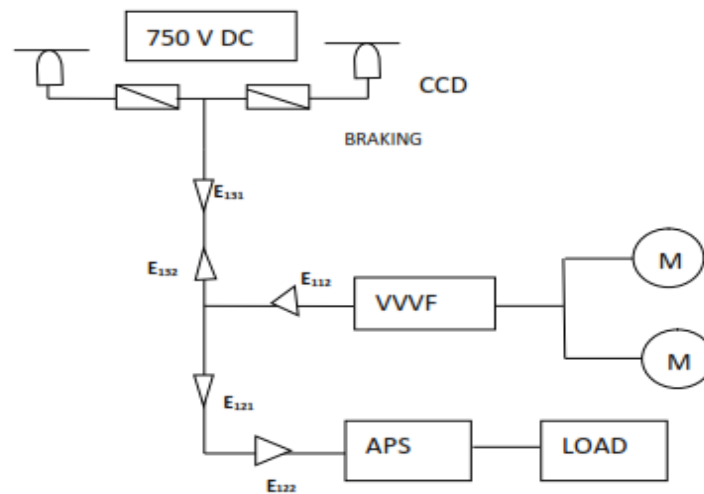
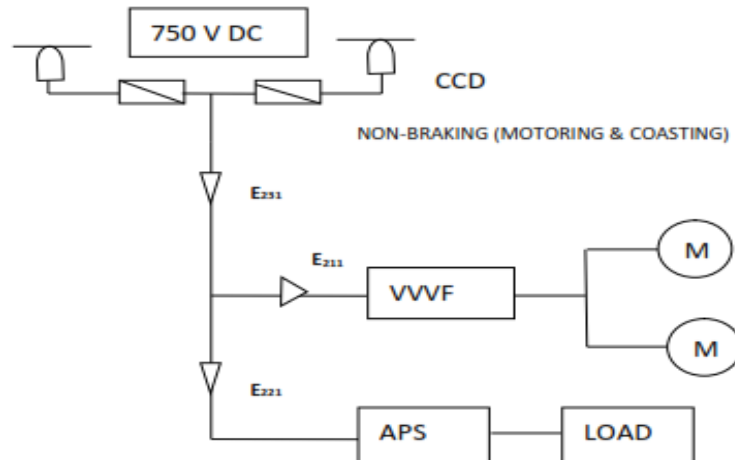
Where, x specifies the mode of operation,

y specifies the equipment under consideration,

z specifies whether the energy consumed from line or energy regenerated.

Subscript	Value	Description
X	1	Braking Mode
	2	Non-Braking Mode
Y	1	Inverter (VVVF)
	2	APS (Auxiliary Power Supply Inverter)
	3	CCD
	1	Energy consumed from line

Z	2	Energy regenerated
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C. ~~Penalty in case of NON-COMPLIANCE by the Contractor:~~

~~Contractor shall note that even if the specified energy consumption (SEC_s) is achieved either in Line-6 (KalenaAgrahara to Nagavara) or in Phase 2A (Central Silk Board Junction to K.R. Puram) or in Phase 2B (K.R. Puram to Kempegowda International Airport), no penalty shall be imposed on the Contractor.~~

~~Contractor shall further note that in case the total achieved Specific Energy Consumption (SEC_A) is higher than the specified Specific Energy Consumption (SEC_s) value (i.e. 60Wh/GTKM), the penalty shall be imposed for the excess energy consumption.~~

Addendum-1 dated 05.12.2022, Sl. No. 77

Penalty in case of NON-COMPLIANCE by the Contractor:

Contractor shall note that even if the specified energy consumption (SEC_s) is achieved either in Line-6 (KalenaAgrahara to Nagavara) or in Phase 2A (Central Silk Board Junction to K.R. Puram) or in Phase 2B (K.R. Puram to Kempegowda

International Airport), no penalty shall be imposed on the Contractor. **Contractor shall select the suitable Line based on their simulation studies for validation trials.**

Contractor shall further note that in case the total achieved Specific Energy Consumption (SECA) is higher than the specified Specific Energy Consumption (SECS) value (i.e. 60Wh/GTKM), the penalty shall be imposed for the excess energy consumption.

The Penalty (P) shall be calculated as under:

C1.1 Penalty for Non-Compliance of total Specific Energy Consumption:

$$P = [(SEC_A - SEC_S)] / 1000 \times E \times W \times RTD$$

'P': Calculated Penalty for non-compliance of "SEC_S"

'SEC_S': Specified Specific Energy Consumption i.e. 60Wh/GTKM

'SEC_A': Achieved total Specific Energy Consumption value [SEC_{P-A} + {SEC_{H-A} or SEC_{H-A-adjust} (as applicable)}]

SEC_{P-A}: Achieved of SEC_P

SEC_{H-A}: Achieved value of SEC_H

SEC_{H-A-adjust}: Adjusted value of SEC_{H-A} as per B2.11 above

'NRT': Number of round trips considered per train per day (considered '10' in the below example).

'T': Electricity Tariff per unit (considered as INR 5- per unit in below example)

'NT': Total number of trains (considered as '30' trains in below example)

'L': Life of the stock in years (considered as '35' years in below example)

'D_y': No. of days in commercial / revenue operation in a year (considered as 345 days in below example)

'E': $D_y \times NRT \times L \times T \times NT = 345 \times 10 \times 35 \times 5 \times 30 = 18,112,500$

'W': Gross weight of train under AW4 loading condition of 2004 passengers/train (354.36T)

'RTD_{R6}': Round Trip Distance for Line-6 (considered 42.16 Km in below example)

Contractor shall note that no 'bonus' is payable for achieving specific energy consumption figures better than specified ones.

For example, say the SEC values as achieved during validation are as follows:

Achieved value of SEC_P i.e. SEC_{P-A} = 42 Wh/GTKM

AND

Achieved value of SEC_H i.e. SEC_{H-A} = 20 Wh/GTKM

So, the total measured SEC i.e. SEC_A = SEC_{P-A} + SEC_{H-A}

SEC_A = 42+20 = 62 Wh/GTKM

Therefore, the penalty amount for non-compliance of SEC_S shall be as follows:

$$P = [(SEC_A - SEC_S) / 1000] \times E \times W \times RTD_{R6}$$

$$P = [(62-60) / 1000] \times 18,112,500 \times 354.36 \times 42.16$$

$$P = \text{INR } 541,194,892$$

C1.2 In case, the Contractor fails to establish the compliance of SEC_S during combined bed test and climatic chamber test, the penalty amount shall be deducted in equal proportions from the amount payable under the Cost Centre – B (Offshore manufacturing) / C (Indigenous manufacturing) (Annexure PD-2 of Price Schedule, Section IV- Bidding Forms) (as applicable) for delivery of the trains.

C1.3 In case, the Contractor established the compliance during combined bed test and climatic chamber test but fails to establish the compliance of SEC_S during field trial, the

penalty amount shall be deducted in equal proportions from the balance amounts payable to the contractor under any cost Centre and if still not recovered, it shall be adjusted by encashing the balance amounts from the Performance Bank Guarantee.

C1.4 If the Contractor fails to establish the compliance of SEC_s in both combined bed test & climatic chamber test as well as during field trials, then the final penalty amount shall be calculated based on the higher of the two SEC measurements (i.e. during combined bed test and field trial). However, the recovery of the penalty shall be made in accordance with clause C1.2 and C1.3 above.

C1.5 ~~The maximum amount of penalty calculated as per this clause 3.11 'C' shall however not exceed 10% of the total contract price.~~

Addendum-1 dated 05.12.2022, Sl. No. 78

The maximum amount of penalty calculated as per this clause 3.11 'C' shall however not exceed 10% of the total Contract Price. **(Excluding the price for Cost Centre F)**

C1.6 Contractor shall submit design related submission specified in clause 3.11 during design phase **(CDRL-3-6)**.

3.12. Electro-Magnetic Compatibility performances

3.12.1. The Contractor shall submit an Outline Environmental Plan for the Project Manager review including an EMC analysis report as required in Chapter 2 of Employer's Requirements - General Specification. It shall contain sufficient information to demonstrate clearly the proposed method of achieving the Environmental objectives with particular reference to EMC/EMI protection features. **(CDRL-3-7)**

3.12.2. The EMC analysis report shall include measures to reduce conducted, induced and radiated emissions to acceptable levels as specified by the relevant international standards. The plan shall specify measures to increase immunity of the train and all its subsystems.

3.12.3. The report shall specify basic protective measures proposed for all electrical and electronic subsystems and components and specific measures to be adopted for selected subsystems and components.

3.12.4. The report shall analyse EMI and EMC impacts on the design of the train, all other train-borne equipment and track-side equipment as well as the general environment. Particular attention should also be paid to additional requirements in grounding bonding, shielding, filtering and cabling arrangements.

3.12.5. All components on the vehicle shall be designed and constructed to fulfil the requirements of EN 50121-3-2.

3.12.6. The complete 6-Car metro train shall meet the requirements of standard EN 50121-3-1.

3.12.7. The Contractor shall ensure that the return current limits specified by the respective Signalling and Train Control contractors are met (see Appendix D). **(CDRL-3-8)**

3.12.8. Emission (radiated and conducted) and Immunity tests for all individual equipments provided on vehicles shall be performed under normal operating condition according to EN 50121-3-2.

3.12.9. The conducted emission test shall be performed under selected fault condition. The conducted emission test shall also satisfy special requirements of the ATO/UTO.

3.12.10. The complete 6-car metro trains shall be tested to meet the requirements of standard EN 50121-3-1.

3.12.11. The Contractor shall carry out joint testing with respective Signalling and Train Control contractors as detailed in Appendix D.

3.13. Noise and Vibrations performances

3.13.1. **General:** The Contractor shall ensure that the cars and equipment are designed and built so that specified noise and vibration limits are not exceeded. Particular attention shall be given to the design of all equipment to minimise generation of noise and vibration. The design of the vehicle shall have adequate attenuation of airborne and structural-borne vibration along potential paths from the sources to passenger saloon and to wayside receptors.

- i) Exterior and individual systems and equipment noise measurements are to be made in accordance with ISO 3095, and interior noise measurements are to be made in accordance with ISO 3381, except where otherwise specified.
- ii) Ride quality vibration measurements shall be carried out in accordance with ISO 2631.

3.13.2. (i) The Contractor shall submit an Outline Environmental Plan for the Project Manager review including a noise and vibration analysis report as required in Chapter 2 of Employer's Requirements-General Specification

(ii) Noise and vibration Analysis shall include:

- Expected total car noise levels, and sub-system noise levels for all equipment and systems.
- Expected vibration levels for equipment, system and measurement locations specified herein.
- Expected dynamic characteristics of the primary and secondary suspension.
- Details of proposed approach to determining noise and vibration of the cars.
- All codes and standards to be used during the design and verification of the cars.
- Plan for noise and vibration design reviews.
- Details of proposed sub-system testing to be carried out during the design and manufacture of the cars.
- Details of proposed rake testing to demonstrate specification compliance.

3.13.3. The Plan shall be updated at each Design Stage by the Contractor and be submitted to the Project Manager for review. In the detailed design reviews, the Contractor shall submit noise level and vibration prediction, calculations, design information material property information, test results and other relevant data.

3.13.4. Interior Noise Level ($L_{PAeq20sec}$) shall not be more than those specified as follows:

- i) The tests will be conducted according to Standards ISO 3381 for the internal noise levels.

- ii) When the train is stopped in free field conditions with all the auxiliary equipment are operated normally, windows and doors closed, the internal noise level ($L_{PAeq20sec}$) measured at a height 1.5 meters from the floor at the centre of the vehicles will be less than 68 dBA in the passenger area and 68 dBA in the driving cab at driver ear level.
 - iii) When the train is stopped in tunnel with all the auxiliary equipment are operated normally, windows and doors closed, the internal noise level ($L_{PAeq20sec}$) measured at a height 1.5 meters from the floor at the centre of the vehicles will be less than 75 dBA in the passenger area and 72 dBA in the driving cab at driver ear level.
 - iv) When the train is running at stabilised speed of 75kmph in free field conditions with all the auxiliary equipment are operated normally, windows and doors closed, the internal equivalent noise level ($L_{PAeq20sec}$) measured at 1.5 meters from the floor will be lower than 75 dBA in the passenger area and 70 dBA in the driving cab at driver ear level.
- 3.13.5. Door Operation Noise produced by simultaneous operation of all saloon doors on one side of the car shall not exceed 72 dBA during the sliding operation and 78 dBA for the locking/unlocking. This should be measured at all points in the car 300mm from the doors and 1000mm above the floor level.
- ~~3.13.6. Depending of the type of track the architecture of the tunnel and the tunnel covering materials in metro infrastructures, the internal equivalent noise level ($L_{PAeq20sec}$) could show a difference of 6 dBA to 8 dBA at 75 kmph between free field and tunnel.~~

[Addendum-1 dated 05.12.2022, Sl. No. 79](#)

~~Deleted.~~

- 3.13.7. Exterior Noise Levels for elevated and at-grade sections (free field) shall not be more than those specified as follows.
- i) When measured at 7.5m from the centre of the track along the train, the equivalent continuous noise level ($L_{PAeq20sec}$) measured over an observation period of 5 sec in free field conditions as specified in ISO 3095 while a train is stationary all auxiliary equipment operating simultaneously at maximum capacity will not exceed 67 dBA at 1.2 meters above the rail.
 - ii) When measured at 7.5m from the centre of the track, the equivalent continuous noise level ($L_{PAeq20sec}$) measured while a train running in the free field conditions, specified in the ISO 3095, is passing will not exceed 82 dB(A), at a stabilised speed of 75 kmph.
- ~~3.13.8. Exterior and interior noise levels obtained in underground tunnels and platforms shall be measured by the Contractor under the same conditions (as far as possible). These shall be submitted to the Project Manager. (CDRL-3-9)~~

[Addendum-1 dated 05.12.2022, Sl. No. 80](#)

Noise levels obtained in underground tunnels and platforms shall be measured by the Contractor under the same conditions (as far as possible). These shall be submitted to the Project Manager for reference purposes. (CDRL-3-9).

3.13.9. The Contractor shall take in to consideration "Guidelines for Noise and Vibration", Sept-2015 issued by Research Design and Standards Organisation, Ministry of Railways attached at Part 4: Section-XIII in Rolling Stock design.

3.13.10. Vibrations

- i) Provisions are taken to limit transmission of vibrations produced by on-board equipment to the passengers.
- ii) Vibration measurements shall be carried out in accordance with the following ISO 2631-1 (1997), ISO 2631-4 (2001) standards
- iii) Equipment and auxiliaries mounted at any position on the car or bogie during stationary position shall not cause vibration on any portion of the car floor, walls, ceiling panels, stanchions, handholds or seat frames in excess of 2.0mm peak-to-peak amplitude for the frequency range from 1.4Hz to 20Hz, and in excess of 0.8mm per second peak vibration velocity for the frequency range above 20Hz.
- iv) All equipments, sub-assemblies and components shall be capable of withstanding shock and vibrations of the Rolling Stock satisfactorily such that they do not fail prematurely on this account earlier to the designed life. To establish this requirement, all of equipments, sub-assemblies and components shall be subjected to shock and vibration test to IEC 61373 or other equivalent standard.

3.14. Fire protection performances

3.14.1. General

- i) Each train shall be designed to minimise the risk of a fire starting, as far as is practically possible.
- ii) Materials used in the construction of each train shall be selected to reduce to the maximum extent practical the heat load, rate of heat release, propensity to ignite, rate of flame spread, smoke emission and toxicity of combustion gases.
- iii) ~~The train shall be designed to prevent fire propagation through the use of fire barriers in the floor, and in walls at the sides and ends and fire-resistant equipment housings. The vehicle floor shall provide a fire barrier of thirty minutes duration tested in accordance with EN 45545 part 1 to 7 (Hazard level HL3) latest editions or equivalent standard. There shall be no hatches in the floor of passenger areas. Floor hatches in the driving console shall be avoided.~~

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The train shall be designed to prevent fire propagation through the use of fire barriers in the floor, and in walls at the sides and ends and fire resistant equipment housings. **Flammable materials shall be well contained and protected.** The vehicle floor shall provide a fire barrier of minutes duration tested in accordance with EN45545 Part 1 to 7(Hazard level HL3) latest editions or better equivalent standard. There shall be no hatches in the floor of passenger areas. Floor hatches in the driving console shall be avoided.

The design and the materials used in the cars shall conform to fire safety requirements of EN45545 Part 1 to 7 (Hazard level HL3) latest editions or better international standards for similar metro operations, subject to the acceptance of the Project Manager

- iv) The Contractor shall submit a fire safety design management plan to the Project Manager for review which shall describe the process that will be used to systematically identify and eliminate fire hazards, to avoid the use of combustible materials whenever practical and to reduce to the extent practical the energy content and heat release rates of the combustible material that are used.
- v) The plan shall include the Standards to be followed and the tests to be completed and shall be submitted for review by the Project Manager. **(CDRL-3-10).**

3.14.2. Material Properties. Materials used in the cars shall meet the Flammability, Smoke Emission and Toxicity requirements of the specification EN 45545 part 1 to 7 (Hazard level HL3) latest editions or equivalent standard.

3.14.3. The Contractor shall minimise the total fire load of potentially flammable materials on a Vehicle as far as is practicable and submit the calculated figures. In any situation it shall not exceed the following

- i) Above floor level (including floor and gangway) : 22 000 MJ
- ii) Below floor level : 26 000 MJ

Contractor shall submit the fire load calculation at design stage separately for above & below the floor level. Fire load calculations shall be furnished with relevant data, certifications etc. of the items considered in fire load calculations. The calculations and validation shall conform to the standard as specified in clause 3.14.2 **(CDRL-3-11)**

3.14.4. Fire Detection System

The fire detection system shall be able to detect any fire originating inside the cars. The focus is on protection of passengers and staff in rolling stock. The objective shall be to detect incipient fires in an early stage in order to warn Train Operator/OCC. A fire event shall be detected early during the development phase, the affected area shall be located exactly by identifying which sensor(s) is actuated and further system's actions shall be activated without any delay.

Contractor shall submit the sequence of actions (status of dampers, air conditioning enable/disable, ventilation control etc.) which will be implemented on detection of internal fire/smoke and external fire/smoke separately.

i) System Design Requirements:

- a) The fire detection system shall consist of dual smoke and heat detectors (multi-sensors) in passenger area, Linear Heat Detectors (LHD) in technical areas (enclosures/cubicles) integrated with Fire Detection & Control Unit (FDCU)/ Local control panel. The FDCU shall interface with TCMS in a redundant manner. The interface of the system shall be suitably ensured with the overall system integration and GoA4 requirements.
- b) All the major events (alarms, faults etc.) shall be recorded in TCMS and shall be retrievable on maintenance terminal for analysing any issue.
- c) The system shall provide a dynamic two detector dependency (smoke and/or heat) in the passenger areas along with provision of drift compensation in order to decrease the risk of false, or unwanted alarm.

- d) The system shall be able to detect and distinguish smoke coming into the interior via the fresh air inlet and smoke originating from inside the Trains saloon; in such a case, the fresh air & return air dampers shall open or close automatically."
- e) The detection system shall be designed to give a fast and accurate response with minimised nuisance activation.
- f) Faulty or dirty detector shall be reported to the TCMS and the OCC.
- g) The detection system shall be able to be checked, calibrated and replaced from the saloon including the sensitivity test.
- h) ~~Alarm sounders/ Beacons shall be provided in train at a suitable location as well as in OCC.~~

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Alarm sounders/ Beacons shall be provided in train at a suitable location and RS contractor shall interface for alarms in OCC.

- i) The Contractor shall provide necessary diagnostic tools (softwares, hardwares etc.) in order to identify failures immediately.
 - j) The system should generally be SIL2 compliant. Any change in SIL level shall be subject to the hazard analysis and acceptance or otherwise of the same by the Project Manager whose decision shall be final and binding.
- ii) **Fire Detectors (Smoke & Heat Detectors) for passenger area to detect internal smoke/fire:**

Minimum 4 no. of Smoke & Heat detectors (multi-sensors) shall be installed in passenger area of each car. The sensitivity of smoke detector has to fulfil the requirements of ARGE guidelines. The actuating temperature of heat detector shall be settable according to the international norms and standards. Alarm from heat detectors shall be sent to the local control panel and shall be communicated to TCMS and OCC.

- iii) **Fire Detectors (Smoke & Heat Detectors) to detect external smoke/fire:**

In case of external smoke/fire, the smoke shall be detected through smoke detector provided in HVAC. Alarm from smoke detectors shall be sent to the local control panel and shall be communicated to TCMS and OCC.

- iv) **Linear Heat Detectors (LHD) for Enclosures/Cubicles (Electrical cabinets):**

A linear heat detector suitable for Rolling Stock applications shall be provided in the electrical cabinets. The linear heat detector is to be actuated in case of any fire/overheating in the electrical cabinets.

LHD shall also be provided in Underframe Electrical enclosures as mentioned in different chapters of this document. Alarm from heat detectors shall be sent to the local control panel and shall be communicated to TCMS and OCC. However, final decision on use of LHD/Heat detector in Underframe Electrical enclosures will be taken during design stage.

- v) Provision for bypassing any faulty/malfunctioning detector may be required, for which final decision shall be taken during design stage.

- vi) The smoke detection logic, number of smoke/heat detectors, LHD and their exact location may vary and shall be finalized during design stage. The fire detection system and layout of the detectors should be able to meet the criteria for the performance to be done as per the ARGE guidelines or any other applicable international standard.
- vii) Smoke Alarm
 - a) Indication for individual smoke alarm shall be provided on the local control panel inconspicuous to passengers.
 - b) Upon detection of smoke, a smoke alarm shall be provided on the TCMS and sent to the OCC.
 - c) After the system resumes normal, the smoke alarm shall be capable of being reset locally from the saloon and via the TCMS and remotely by the OCC. If the alarm is not manually reset within a pre-set period (to be configurable), it shall be automatically reset. The air conditioning system shall resume normal operation after the alarm is reset.

Details shall be submitted for Project Manager's review during design phase. (**CDRL-3-12**)

3.15. Fire Extinguisher

- i) Each passenger car shall be equipped with two 9 Kg fire extinguishers (one on either side).
- ii) Each Driver's cab shall be equipped with a Fire extinguisher (minimum 6 kg capacity).
- iii) The fire extinguishers shall be securely mounted to prevent rattle and accidental dislodgement but enable easy access in the event of an emergency. The fire extinguishers shall be in accordance with the "MONTREAL PROTOCOL" and suitable for use in confined areas. The extinguishers used shall be suitable for the environment in which it is situated and shall not be subject to detrimental settling.
- iv) The fire extinguishers shall be covered, although easily identified, and shall be easily removable without the use of special tools and/or keys. After use the cover shall not be damaged in any way and shall be capable of immediate re-use. It shall be possible to view the fire extinguisher through the cover.

3.16. Life Cycle Cost

- 3.16.1. The Contractor shall develop a life cycle cost plan in accordance with IEC 60300-3-3 with an aim to minimize the overall life cycle cost whilst meeting the safety, quality and reliability requirement of this particular specification. This plan shall be submitted during the PDR stage.
- 3.16.2. Recycling of the material at the end of the Rolling Stock life shall be taken into account following recommendations of the UIC project PROSPER (Procedure for Rolling Stock Procurement with Environmental Requirements). Material recycling rate and material to be incinerated shall be indicated by the Contractor.
- 3.16.3. The Contractor shall submit Life Cycle Cost calculation to the Employer after design approval and before the revenue operation of 1st train. The LCC shall include, the capital cost, cost of operation (including energy consumption), maintenance (both

material and labour), depreciation, refurbishment, inflation etc. Per unit energy consumption cost may be considered as INR. 5.0. **(CDRL 3-13)**

3.17. Deliverables

Contract deliverables required by this section of the technical provisions are summarized below: -

CDRL-3-1:	Total power of the 6-car metro train shall be defined and calculated by the Contractor in order to achieve the operation performances. (ref. ERTS 3.1.1 (vii))
CDRL-3-2:	Tractive and braking effort shall be defined and calculated for the 6-car metro train in the limit of the wheel rail adhesion ratio (18 % in tunnel and 16 % at grade and super-elevated structures) by the Contractor in order to achieve the operation performances (ref. ERTS 3.1.2(viii)).
CDRL-3-3:	Computer Simulation (ref. ERTS 3.3.1)
CDRL-3-4:	Full access to the software for the purpose above shall be provided. Any hardware/software tool required for this purpose shall also be provided. The documentation including flow charts shall be provided. Project Manager's Engineers shall be fully trained and made fully conversant by the Contractor for this purpose. (ref. ERTS 3.4.3)
CDRL-3-5:	Train performances curves (ref. ERTS 3.6.4, 3.7.1, 3.8.1 & 3.9.3)
CDRL-3-6:	Energy Consumption and saving performance (ref. ERTS 3.11, ERTS 3.11.1 {A1.9, A2.9, B1.6, C1.6})
CDRL-3-7:	The Environmental objectives with particular reference to EMC/EMI protection features. (ref. ERTS 3.12.1)
CDRL-3-8:	Contractor shall submit the simulation study to show that the return current limit specified by the signalling and train control contractors are met and the same to be demonstrated through joint tests. (ref. ERTS 3.12.7)
CDRL-3-9:	Exterior and interior noise levels obtained in underground tunnels and platforms shall be measured by the Contractor under the same conditions (re. ERTS 3.13.8)
CDRL-3-10:	The plan shall include the Standards to be followed and the tests to be completed and shall be submitted for review by the Project Manager (ref. ERTS 3.14.1(v))
CDRL-3-11:	Contractor shall submit the fire load calculation at design stage separately for above & below the floor level. Fire load calculations shall be furnished with relevant data, certifications etc. of the items considered in fire load calculations. The calculations and validation shall conform to the standard as specified in clause 3.14.2 (ref. ERTS 3.14.3).
CDRL-3-12:	Fire Detection system (ref. ERTS-3.14.4)
CDRL-3-13:	Life Cycle Cost Calculation (ref. ERTS 3.16.3)

4. TRAIN OPERATING MODES

4.1 Principle

- 4.1.1. The CBTC based train-borne Continuous Automatic Train Control (CATC) system in 6-Car Metro trains shall be equipped with Unattended Train Operation (UTO), Automatic Train Operation (ATO) and Automatic Train Protection (ATP) systems allowing automatic train operations with or without a driver in the cab.
- 4.1.2. Supply of the ATP/ ATO/ UTO System shall be responsibility of the Signalling and Train Control Contractor. The Division of Responsibility between Signalling and Train Control contractor and Rolling Stock contractor for installation, testing and commissioning of Signalling and Train Control Equipment including ATO/ATP/UTO features shall be implemented in accordance to Table-1-Division of Responsibility in Appendix-D: Interfaces with Signalling & Train control.
- 4.1.3. Trains shall employ the following modes of operation:
- a) ATO Mode
 - b) ATP (or Coded Manual) Mode
 - c) Restricted Manual Forward (RMF) and Run on Sight (ROS) Mode
 - d) Standby Mode
 - e) Restricted Manual Reverse Mode (RMR)
 - f) OFF Mode.
 - g) ATB (Automatic Turn Back)
 - h) UTO (Unattended Trains Operation)
 - i) Cut-out (or By-Pass) Mode
- The Employer intends to operate the train initially in ATP/ATO mode of operation and subsequently in UTO mode of operation. The Contractor shall submit a "Migration Plan" to explain how migration from GoA2 to GoA4 operations can be carried out without disruption to revenue operation.
- 4.1.4. Detailed description of train operating modes is described in Appendix-D clause 24.6.3 of Interface between Rolling Stock and Signalling & Train control contractors.

5. VEHICLE DESIGN AND ARCHITECTURE

5.1 Proven Design

5.1.1 The Contractor shall develop the design based on this specification and on sound proven and reliable engineering practices. The broad design details shall be submitted with technical data in the technical bid. Detailed calculations shall be submitted to the Project Manager during the design process stage for review and approval.

5.1.2 Sub-systems other than propulsion system

The Rolling Stock including Carbody, bogies, brake system components (valves etc.) all subsystems, equipment's and major components etc. (hereinafter referred as 'sub-systems') shall be state-of-art and of proven design. Proposed sub-systems shall have been in use and have established their satisfactory performance and reliability on at least three mass rapid transit systems in commercial / revenue service over a period of three years or more (in each MRTS) either outside the country of origin in three different countries or in MRTS in India. Sub-systems/components used in existing Rolling Stock in MRTS in India do not get automatically qualified for use unless specifically approved by the Project Manager for this project. If required by the Project Manager, Contractor shall provide certificate of satisfactory performance for a period of three years or more from the Metro operators. Where similar sub-systems of a different rating are already proven in service as per the above criteria then the design shall be based on such sub-systems.

All 'sub systems' shall be procured from the approved vendors and sourced from only such manufacturing units that have supplied the sub-systems that fulfil the proven design requirements as above. The Contract envisages commencement of manufacturing only after completion of Pre-final design. Accordingly, the number of years in commercial / revenue service and operation for the above requirements shall be calculated as on the contracted Key Date No. 3.1 corresponding to 'Pre-Final Design Completion.

In case the Contractor proposes to use sub-system(s) that do not fulfil the above said criteria then the Contractor shall furnish sufficient information to prove the basic soundness and reliability of the offered sub-system(s) for review of the Project Manager. The Project Manager's decision on Contractor's proposal shall be final and binding.

5.1.3 ~~Propulsion System (Traction motor, VVVF-Inverter, Auxiliary Power supply unit),~~

~~Propulsion systems manufacturer shall have atleast 10 years' experience of design and manufacturing of similar system. Proposed propulsion systems from the proposed manufacturing unit shall have been in use and have established their satisfactory performance and reliability for 5 years in minimum aggregate 500 cars comprising of both powered and non-powered cars, supplied against minimum five (5) different contracts in the Metros (i.e. MRT, LRT, Sub urban Railways and High Speed Railway) of minimum two (2) different countries outside his country of origin. If required by the Project Manager, the Contractor shall provide certificate of satisfactory performance (for the supplies made from the proposed manufacturing unit) for a period of five years or more from the Metro operators. Where similar Propulsion systems of a different rating are already proven in service as per the above criteria, then the design shall be based on such systems.~~

~~Propulsion equipment shall be sourced from such manufacturing units that have supplied the equipment that fulfil the requirement of as specified above.~~

- ~~i) In case, the manufacturer of the proposed propulsion system is not a member of the Consortium/Joint venture and the Contractor has indicated more than one manufacturer as the possible propulsion system supplier, final supplier out of the proposed manufacturers for the propulsion equipment shall be decided only after BMRCL's specific approval.~~
- ~~ii) In case the Contractor proposes to use sub-system(s) that do not fulfil the above said criteria then the Contractor shall furnish sufficient information to prove the basic soundness and reliability of the offered sub-system(s) for review of the Project Manager. The Project Manager's decision on Contractor's proposal shall be final and binding.~~

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Propulsion System (Traction motor, VVVF-Inverter, Auxiliary Power supply unit), Propulsion systems manufacturer shall have at least 10 years' experience of design and manufacturing of similar system. Proposed propulsion systems from the proposed manufacturing unit shall have been in use and have established their satisfactory performance and reliability for 5 years in minimum aggregate 500 cars comprising of both powered and non-powered cars, supplied against minimum five (5) different contracts in the Metros (i.e. MRT, LRT, Sub-urban Railways and High Speed Railway) of minimum two (2) different countries outside his country of origin **or in India**. If required by the Project Manager, the Contractor shall provide certificate of satisfactory performance (for the supplies made from the proposed manufacturing unit) for a period of five years or more from the Metro operators. Where similar Propulsion systems of a different rating are already proven in service as per the above criteria, then the design shall be based on such systems.

Propulsion equipment shall be sourced from such manufacturing units that have supplied the equipment that fulfil the requirement of as specified above.

- i) In case, the manufacturer of the proposed propulsion system is not a member of the Consortium/Joint venture and the Contractor has indicated more than one manufacturer as the possible propulsion system supplier, final supplier out of the proposed manufacturers for the propulsion equipment shall be decided only after BMRCL's specific approval.
- ii) In case the Contractor proposes to use sub-system(s) that do not fulfil the above said criteria then the Contractor shall furnish sufficient information to prove the basic soundness and reliability of the offered sub-system(s) for review of the Project Manager. The Project Manager's decision on Contractor's proposal shall be final and binding.

- 5.1.4 ~~Complete propulsion system comprising of traction inverter, auxiliary inverter including auxiliary supply modules and traction motor shall be from/of a single approved vendor. The Train Control and Management System (TCMS) shall either be from the qualified propulsion system supplier (ref. ERTS 5.1.3) or from the carbody manufacturer/vehicle integrator provided the proposed TCMS is satisfactorily functioning in the metro cars.~~

~~The TCMS supplier shall have supplied the proposed TCMS hardware and software in functioning GOA4 lines since last more than three years and shall be compliant with international norms. The Contractor shall submit basic system architecture with hardware for approval at the concept design approval stage and establish 'proven design' as specified. Operational performance of the proposed TCMS system shall be submitted as per "Form EXP-2(c) (Specific Experience in Operational Performances) of Section: IV - Bidding Forms".~~

Addendum-1 dated 05.12.2022, Sl. No. 84

The Train Control and Management System (TCMS) shall either be from the qualified propulsion system supplier (ref. ERTS 5.1.3) or from the carbody manufacturer/vehicle integrator provided the proposed TCMS is satisfactorily functioning in the metro cars.

The TCMS supplier shall have supplied the proposed TCMS hardware and software in functioning GOA4 lines since last more than three years and shall be compliant with international norms. The Contractor shall submit basic system architecture with hardware for approval at the concept design approval stage and establish 'proven design' as specified. Operational performance of the proposed TCMS system shall be submitted as per "Form EXP-2(c) (Specific Experience in Operational Performances) of Section: IV - Bidding Forms".

5.1.5 Vendor Approval

~~It shall be obligatory for the Contractor to obtain Notice of No Objection from the Project Manager for the selection of the sub-contractor and vendors for all items of work, even if the name of the subcontractor and vendor is named in the Contractor's Proposal and the works to be done including purchase of materials and equipment's is in accordance with the Standards specified in the Contract. List of items for which Project Manager's approval of vendors is obligatory shall be proposed by the Contractor during preliminary design (well before finalising the vendors), which will be reviewed for approval by the Project Manager. On submission of the list by the Contractor, the Project Manager may direct the Contractor to include other items for which vendor approval shall be mandatory.~~

~~The request for vendor approval shall be comprehensive with all relevant references and details establishing their compliance to the specified conditions. Along with the vendor approval proposal, a commitment from the proposed vendor shall also be submitted that in case of any future procurement action by Employer, they shall quote directly to Employer.~~

Contractor shall also ensure that the technical support from Sub-Contractors/Vendors of following major equipment/subsystems shall be made available through permanent positioning of Sub-Contractor's/Vendor's staff at Depots for meeting DLP obligations:

- i) Propulsion system (including Traction Inverter, Traction motors)
- ii) Auxiliary Power Supply system
- iii) Brakes and Pneumatic system
- iv) Doors
- v) HVAC
- vi) Bogies

- vii) ~~TCMS~~
- viii) ~~GCTV~~
- ix) ~~PA/PIS~~

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Vendor Approval

It shall be obligatory for the Contractor to obtain Notice of No Objection from the Project Manager for the selection of the sub-contractor and vendors for all items of work, even if the name of the subcontractor and vendor is named in the Contractor's Proposal and the works to be done including purchase of materials and equipment's is in accordance with the Standards specified in the Contract. List of items for which Project Manager's approval of vendors is obligatory shall be proposed by the Contractor during preliminary design (well before finalising the vendors), which will be reviewed for approval by the Project Manager. On submission of the list by the Contractor, the Project Manager may direct the Contractor to include other items for which vendor approval shall be mandatory.

The request for vendor approval shall be comprehensive with all relevant references and details establishing their compliance to the specified conditions. Along with the vendor approval proposal, a commitment from the proposed vendor shall also be submitted that in case of any future procurement action by Employer, they shall quote directly to Employer.

For sourcing the equipment from indigenous manufacturing facilities, following conditions shall be complied:

- a) In case OEM wants to use manufacturing facilities in India (other than his own) for items for which the OEM has been approved, it shall enter into an agreement with such selected Indian equipment manufacturer and obtain prior approval from the Employer. No change in composition, rating, type, model no., manufacturing process, quality standards, design, etc. and make of the components used in assemblies/sub-assemblies of such equipment as manufactured by the approved parent vendor shall be made without specific approval of the Project Manager.
- b) In case the vendor uses his own facilities for indigenization after part supply of equipment from the approved manufacturing unit, Contractor shall obtain prior approval from Employer. No change in design, component type/make, quality standards, manufacture procedure, etc. shall be made without specific approval of the Project Manager.
- c) In case OEM wishes to change make/type/specifications, etc. of any sub-components for supplies to be sourced from Indian facility, specific prior approval of the Project Manager shall be obtained for changes made, model, specification, etc. Responsibility for obtaining such prior approval shall rest solely with the Contractor. If the prior approval as per above is not obtained by the Contractor and supplies are sourced from the un-approved local Indian source, then the Project Manager at his sole discretion may direct the Contractor to replace equivalent no. of such items with supplies from approved sources free of cost.

Format for submitting the vendor approval request shall be given to the Contractor during initial design stage and the same shall be followed throughout the Contract.

5.1.6 Approval for manufacturing plant(s) for Rolling Stock

It shall be obligatory for the Contractor to obtain Notice of No Objection from the Project Manager for manufacturing of bidded quantity of Rolling Stock in proposed plant(s). The plant(s) proposed by the Contractor shall have minimum five (5) years' experience of manufacturing similar type of Rolling Stock as proposed for this bid. The Rolling Stock supplied from proposed plant(s) shall have been in satisfactory commercial / revenue operation for at least three (3) years.

"In case Contractor proposes a new manufacturing plant(s) then the Contractor shall furnish sufficient information to prove the basic soundness and reliability of the proposal for review of the Project Manager. The Project Manager's decision in this regard on Contractor's proposal shall be final and binding".

5.2 Basic Design Philosophy & Requirements

5.2.1 The design philosophy should meet the following criteria:

- i) Application of state-of-the-art technology
- ii) Lightweight integral car body.
- iii) Service proven design.
- iv) Design life 35 years.
- v) Crashworthiness.
- vi) Minimum life cycle cost.
- vii) Low maintenance and overhaul cost.
- viii) Use of interchangeable, modular components
- ix) Extensive and prominent labelling of parts and wires.
- x) Use of unique serial numbers for traceability of components
- xi) High reliability.
- xii) Low energy consumption.
- xiii) System safety.
- xiv) Adequate redundancy in system
- xv) Fire smoke detection and protection.
- xvi) Use of fire retardant materials.
- xvii) High passenger comfort including low noise level.
- xviii) Environmentally friendly.
- xix) Adherence to operational performance requirements.
- xx) Safe passenger evacuation in emergency.
- xxi) Maximum possible commonality of structure, components, equipments, and sub-systems amongst different cars

- xxii) Maximum utilization of indigenous materials and skills, subject to quality conformity to performance requirements and quality standards.

5.3 Metro train architecture

- 5.3.1 The basic architecture of the metro train is to be determined by the Contractor according to operational requirements and shall consist of several motor coaches and trailers.
- 5.3.2 The metro train shall be a bi-directional train equipped with driving cab at each end.
- 5.3.3 Height of metro car floor shall be the same on all the length of the metro train and compatible with the station platform height and passenger access requirements.
- 5.3.4 The 6-car metro trains shall be with the following composition:
6-car train *DMC - TC - MC - MC - TC – DMC*
- Where:
- DMC : Driving Motor Car.
- MC : Motor car.
- TC : Trailer Car.
- * Automatic couplers
- Semi-Permanent couplers
- 5.3.5 All DMC, MC and TC supplied under this Contract shall be totally interchangeable with all other DMC, MC and TC respectively, supplied under this Contract, without modification.
- 5.3.6 In regard to the vehicle main dimensions, the following are given as indicatives:
- Total train length over body approximately for 6 car metro train is 130.3 meters.
 - Approximate distance between bogie centres 14700 +/- 250mm
 - Car min. Width: 2.88m within the limits of the Kinematic envelops given in Appendix-E.
 - Car floor height shall be >5mm and <50mm above the platform height compatible with the access conditions for disabled people.
 - ~~Nominal clear height inside the car: 2.1m~~

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Nominal clear height inside the car: 2.1m and minimum clear height shall not be less than 2.050m (2050mm)

- Car max. height (rail top to roof top) with Air-conditioning units and antenna: 3.88m and within the limits of the Kinematic envelops given in Appendix E.
- 5.3.7 The bidder/Contractor shall furnish static metro train profiles and cars with dimensions and typical cross sections of the vehicles. **(CDRL-5-1)**

5.4 Metro train weights

- 5.4.1 A strict system of weight analysis and management shall be implemented during all stages of design and manufacture of the Rolling Stock to ensure that each fully assembled metro train shall achieve the weight requirement restrictions as specified in this Section

- 5.4.2 To minimise energy costs, great importance will be placed on achieving practical designs of minimum car weight whilst meeting specified structural and performance requirements, wheel adhesion rate, acceleration.
- 5.4.3 The axle load shall not exceed **15.0 tonnes** in AW4 condition.
- 5.4.4 The gross weight of any type of coach should not exceed 60 tons under AW4 load condition. The tare weight of individual coach may be optimized accordingly, duly keeping in view the total expected passenger capacity under AW4 load.
- 5.4.5 Weight definitions are the following ones
- i) AW0: The weight of an empty, ready to run, vehicle,
 - ii) AW1: The weight of the vehicle with all seats occupied and one passenger in a wheelchair, the weight of each passenger is 65 kg,
 - iii) AW2: This weight is the sum of AW1 plus the weight of standees at 65 kg. each and 4 standees/m²,
 - iv) AW3: This weight is the sum of AW1, plus weight of standees at 65 kg. each and 6 standees/m².
 - v) AW4: This weight is the sum of AW 1, plus weight of standees at 65 kg. Each and 8 standees/m².
- 5.4.6 The bidder shall provide the weight distribution as defined in IEC 1133:1992.
- (i) 6 car metro train composition:

Kg	DMC	TC	MC	MC	TC	DMC	Train
Tare AW0							
Passenger weight AW1							
Passenger weight AW2							
Passenger weight AW3							
Passenger weight AW4							
Total							
Maximum axle load							

- 5.4.7 The layout of equipment, both on and within the vehicle body, shall minimise the difference in on-rail masses between the different types of car in the Train. The manner in which the equipment shall be distributed on a particular Vehicle shall be arranged to maintain a vehicle weight balance in the Tare Loading condition as follows:
- 5.4.8 Difference in weight measured from bogie pivot centre to bogie pivot centre shall be in accordance with IEC 1133-1992.
- 5.4.9 Estimated weight calculations, for each type of cars including all sub-components, shall be submitted as part of the design submissions prior to commencement of manufacture and updated at intervals to be determined between the Project Manager and the Contractor.

5.5 Deliverables

Contract deliverables required by this section of the technical provisions are

summarized below.

CDRL-5-1:	The Contractor shall furnish static metro train profiles and cars with dimensions and typical cross sections of the vehicles. (ref. ERTS 5.3.7)
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6 VEHICLE CAR BODY

6.1 General

6.1.1 Modern lightweight integrally structured rail passenger cars are required, using modular construction techniques for major components, such as roof, sides, floor and end modules.

6.1.2 The car body shall be designed and constructed for a service life of at least 35 years of normal usage without major rebuilding, strengthening and repair.

6.1.3 Common body shell structure shall be adopted for all types of car.

The car body consists of the following subassemblies:

- i) Under frame structure.
- ii) Side wall structure.
- iii) End wall structure.
- iv) Cab structure.
- v) Roof structure.

6.2 Aesthetics

6.2.1 The appearance of the car exterior must be of a modern and aesthetically pleasing profile. Emphasis is placed on the style on the car exterior as the metro wades through the most important part of the city. The car exterior finish with stainless steel body shall not require paint for protection.

6.2.2 Main requirements for aesthetic are:

- i) Modern look and must symbolize a modern transport means engaged toward in the future,
- ii) Rapid and robust appearance, two requirements which influence the shapes, the dynamic behaviour and reliability,
- iii) Nice, curvy and non-aggressive shape respecting the surrounding environment and contributing to the quality of life,
- iv) Accessible and protective at the same time, opened on the outside life with an impression of transparency, but protecting from the outside aggression,
- v) Comfortable, offering an impression of quietude to the passengers, by a tidy soundproofing, a relaxing brightness, soft and rounded shapes and a choice of suitable interior colours.

6.2.3 At least 5 aesthetic solutions shall be proposed by the Contractor including choices of colours, front face etc.

6.2.4 The Contractor shall submit his proposals in the form of drawings, renderings, isometric sketches, photographs, artist's impressions to convey the overall aesthetic appearance and image of his design. **(CDRL-6-1)**

- 6.2.5 The Contractor shall develop the exterior design of the Trains for the Project Manager's approval. A 3D motion video of a fully scale model of the Trains shall be developed. The video shall include the artistic impression of the Trains travelling through the open section of BMRCL. **(CDRL-6-2)**
- 6.2.6 The BMRCL logo (to be advised after contract award) shall be applied on both sides of the car and also at the both ends. The car number shall be applied on both sides of each car at both ends, both externally and internally and also inside the cab to be easily visible to the train driver and maintenance personnel.
- 6.2.7 The exterior style of the vehicle shall be subject to the Project Manager's acceptance. The final front cab end design, colour scheme shall be agreed upon during the preliminary design review of the cars.

6.3 Materials

- 6.3.1 The Car body structure material shall be manufactured of high tensile austenitic stainless steel with carbon content not more than 0.03% (JIS 4305 latest version or equivalent standard). Highly stressed components as head-stock, body bolster, may be manufactured with high tensile carbon steel quality preferable S355J2G3 according to EN 10025 or equivalent international standards.
- 6.3.2 Fibre-glass Reinforced Plastic (FRP) may be proposed for appropriate elements as driver cab front end. The Contractor shall show his offers are based upon their proven designs and experience.
- 6.3.3 Throughout the design life of 35 years, the car body material shall not corrode or be etched by the environmental conditions that exist in Bangalore and surrounding area and its tunnels to the extent that the original appearance of the car cannot be restored by normal washing. In particular, the cars shall withstand contamination from water dripping within the tunnel environment.
- 6.3.4 In the case of assemblies where metal parts with differing electrochemical dissolution potentials in water can be in contact, all necessary measures shall be taken to prevent the occurrence of galvanic corrosion.
- 6.3.5 In stainless steel cladding materials below 6mm in thickness, the side and end wall sections and under frame shall be manufactured from rolled sections, folded or pressed plates, or plain sheets.

6.4 Vehicle body construction

- 6.4.1 Welded construction shall be used to assemble the different elements of the vehicle body shell (side walls, front end car, cab structure, roof, under frame). The sections and plates shall be joined together by MIG/TIG type welding. For integration of roof with side wall and underframe, automatic continuous welding shall be preferred. For the remaining parts a semi-automatic/ automatic welding system may be used.
- 6.4.2 Full details of the technique/technology employed for joining the modular elements of shells shall be furnished, along with details of quantity and service records of vehicles assembled using such techniques. **[CDRL-6-3]**
- 6.4.3 Sealing of the car body shall be sufficient to satisfy the requirement of IEC 61133 or equivalent UIC standard.

- 6.4.4 The cars shall be completely watertight, without using any external sealing compound, and be able to withstand an agreed water test, simulating a train travelling at speed under severe climatic conditions of Bangalore as well as passage through automatic wash plants. If considered necessary, only weld-through sealants shall be provided.
- 6.4.5 During the all life of the vehicle, the original appearance of the car exterior shall not be deteriorated due to staining or streaking, including appropriate chemical cleaners, or environmental factors.
- 6.4.6 All Metallic conduit, tubing, piping, and fittings shall not require replacement for the design life of the car.
- 6.4.7 Design of carbody shall be such that sealants are not used as a primary protection for ingress of rain water.
- 6.4.8 The car body structure shall be constructed so that fixed or mobile jacks can be used to lift the car body, with or without bogies

6.5 Side Wall Structures

- 6.5.1 The exterior appearance of the side wall structure shall be unpainted metal without the use of filler. The maximum variation from the required car profile, over any one metre length, shall not exceed 1.5 mm. Any fluting, if offered, shall be shown to have advantages, and shall be subject to review by the Project Manager. Dents and other imperfections shall not be accepted.

6.6 End Wall Structure

- 6.6.1 The end wall structure consists of a frame connected together by fusion welding or by spot welding and covered by a flat sheet. The car end walls shall be designed in such a way, that the gangways can be mounted and dismounted easily.

6.7 Cab Structure

- 6.7.1 The cab structure consists of collision posts, corner posts and horizontal members (structural shelf, door header). Cladding shall be done by an FRP-mask.
- 6.7.2 Steps shall be provided to facilitate entry into the cab from rail or access level on both sides of the car. The steps of stainless steel shall have an anti-slip surface.

6.8 Under frame and equipment mounting

- 6.8.1 At both under frame ends it shall be provided anti-climbers located to prevent overriding and penetration into passenger compartment in the event of severe collision. The under frame end structure especially right behind the anti-climber shall be designed in a way to locally absorb collision energy exceeding the couplers energy absorption capacity at relatively low force levels and reduces the risk of passenger injury in case of an accident.
- 6.8.2 Equipment shall be mounted in accordance with IEC 1133:1992 regarding weight distributions.
- 6.8.3 Routine maintenance and inspection will be carried out from the sides and underneath of the car. The Contractor may mount propulsion and auxiliary equipment using an optimum number of pre-wired, piped and tested modules, to ensure ease of access to equipment.

- 6.8.4 Equipment box covers shall be provided with simple secure locking devices, with easily visible markings to indicate locked position. The size and weight of the cover shall permit removal and manipulation by one person. Covers shall be so designed that in the event of failure of a locking device in service, covers shall remain secured and shall not infringe the Kinematic Envelope in static as well as in dynamic condition. The Contractor shall submit the detailed calculations in design phase to validate this **(CDRL-6-4)**. Otherwise, cover retention shall be provided to prevent covers from accidentally falling off. Covers shall open in a manner that will prevent injury by contact with sharp edges or live electrical contacts. All the covers shall be provided with a safety chain to prevent falling off.
- 6.8.5 All the equipment mountings must be designed such that in the event of mal-operation or failure, equipment will remain secure and within Kinematic Envelope.
- 6.8.6 Equipment boxes and covers shall be of Stainless Steel/ Aluminium (anodized)/ Aluminium alloy.
- 6.8.7 Similarly, pneumatic and brake equipment shall be provided in a brake panel for easy access from the side.
- 6.8.8 All under-floor-mounted rotating machinery shall be fitted with resilient mountings to eliminate transmission of mechanical vibrations to the car body. Rotating parts should also be adequately guarded and protected against ejection under failure conditions.
- 6.8.9 Design of carbody underframe and equipment layout shall consider quick re-railing of the car specifically in case of derailment at points and crossings. Re-railing points shall be located at suitable locations and detail re-railing procedure with normal Lucas tools shall be advised and validated. It shall be possible to place the jack(s) beneath the coupler at agreed location for lifting and moving the car for re-railing purpose.

6.9 Roof structure and equipment mounting

- 6.9.1 The roof structure shall be designed to support the HVAC equipment, ducts, conduit, lighting fixtures, headlining, stanchions and other equipment, and shall, in addition, have sufficient strength to support, without permanent deformation, concentrated loads of 1000N, applied by personnel working on the roof at increments of 750mm apart. The minimum thickness of roof sheet shall not be less than 1.0mm.
- 6.9.2 In case of stainless steel, the roof welding line shall be 'passivated' involving chemical treatment with dilute acid solution for the purpose of removal of free iron or other foreign matter, before introduction of cars in commercial / revenue service. Alternative solution shall be proposed subjected to approval from the Project Manager.
- 6.9.3 The HVAC Equipment Package HVAC units shall be mounted at each end of the car roof, housed in suitable watertight wells in the car roof structure. The wells shall be provided with adequate, double sealed connections to the main conditioned air ducting, electrical supply and condensate drains. Conditioned air shall be fed into thermally insulated ducting. The duct shall be split diagonally from end to end to distribute air evenly throughout the length of the car.
- 6.9.4 Suitable arrangement shall be provided for providing sufficient quantity of conditioned air in the cab as well as in the front console and cubicles. The temperature in the cab shall be same as achieved in the saloon.

- 6.9.5 Gutters shall be provided to prevent rainwater from the roof flowing down the body sides particularly at doors and from water spouting as the train enters and leaves stations. The gutters shall be located at the top of the sidewalls, run the length of the car and have a valance to cover the door trolley mechanisms. The drainage shall be so designed to eliminate the requirement for unblocking of leaves and other debris. The drainage arrangement shall be suitable for use with, and not cause damage to the brushes of automatic train wash plants.
- 6.9.6 The roofs (to cant rail) shall be finished so that solar heat gain shall be minimized while not unduly increasing cleaning and other maintenance costs.
- 6.9.7 The roof, excluding the cant rail, may be either corrugated or smooth.

6.10 Car Body Strength

- 6.10.1 The mechanical strength of the car body structure shall comply with the requirements of EN 12663 P III category or equivalent UIC standards for metro trains.
- 6.10.2 The mechanical strength of the car body structure shall comply with the requirements of EN 12663 PIII or equivalent UIC 566 standard except for the compressive load, which shall be 1000kN applied at the end of the car body at the centreline of the coupler and shall be compatible in respect of crashworthiness. The tensile force shall be reduced in the same ratio as the compressive force EN 12663 PIII or equivalent UIC 566 standard.
- 6.10.3 EN 12663 for P-III category or equivalent UIC standards for metro trains (heavy metro train), defines also:
- i) Structural resistance (stationary and fatigue strength).
 - ii) Types of burden for design purposes.
 - iii) Maximum permissible stresses for materials.
 - iv) Requirements for resistance tests.
- 6.10.4 In addition, body structure shall be such as to withstand without damage buffing at low speed as well as particular stress generated by possible raising after derailling. Moreover, the deflection under the body as a result of the loads to which it is subjected shall not under any circumstances prevent the correct working of the doors.
- 6.10.5 The number of passengers seated shall be taken as one per seat and standing as 10 per square meter. The weight of each passenger shall be taken as 65kg, for the purpose of strength analysis.
- 6.10.6 For a welded construction, the camber on coach body under loaded condition with 10 persons/m² shall be such that the structure shall not sag below the horizontal plane throughout the vehicle's 35-year life. However, for shells fabricated with modular elements, the coach shall be built with a suitable camber under tare condition. It shall be ensured that the downward deflection of the coach with 10 person/m² loading shall be within the permitted deflection throughout the service life of 35 years to ensure proper operation of doors under all loading conditions. Detailed calculations shall be submitted by the Contractor for the expected deflection so as to confirm that the deflection is within permissible limits under all conditions throughout the life of the coach (**CDRL-6-5**). Tests for stresses etc. as well as other tests as per relevant standard for the method of construction deployed shall be carried out under specified loads.

- 6.10.7 The Contractor shall carry out a stress analysis of the car body (including torsion mode) as well as for important structural components that affect safety or availability, using the Finite Element Method [CDRL-6-6]. Separate analyses shall be demonstrated and submitted for car bodies having different basic structures. The analysis shall demonstrate that all static and fatigue strength requirements of the car body and equipment mounting are met.
- 6.10.8 All equipment, mountings and fasteners of components shall withstand the forces and impacts as specified in EN 12663 without any part of the equipment becoming detached, and without any permanent deformation to the car-body.
- 6.10.9 Assessment of fatigue load shall be in compliance with EN 12663 or comparable.

6.11 Crashworthiness

- 6.11.1 The car structure and its supplemental energy absorption devices shall be designed to EN 15227 Category C-II to give the driver and passengers' maximum practical protection in the event of an accident or collision whilst not permitting one vehicle to over-ride another, nor to telescope one into another. As specified in EN15227, crash worthiness validation shall be done at 25 Kmph for identical metro train units. Contractor shall analyse such scenarios during design phase and safety at survival space and structural integrity of the occupied areas shall be maintained in this scenario.
- Anti-Climber arrangements, that may include energy absorbing features, shall also be provided in the train to reduce the risk of overriding between the colliding trains after coupler failure. Anti-Climbers shall be preferred between all the coaches of the train also. Anti-Climber arrangements shall be fixed to the car body preferably by Bolt system.
- 6.11.2 The cab end of each cab shall have two corner posts, two collision posts and an anti-climbing device. The car structure shall be designed to limit any damage to the "Crumple Zone" of the car under the design collision scenario given in EN 15227 to minimise the cost and extent of repair after collision.
- 6.11.3 The car body design shall be suitable for a 6-Car metro train composition and shall be such that it is capable of absorbing collision energy in a manner so as to localize structural deformation at low energy levels.
- 6.11.4 A suitable proven energy absorption feature with associated collapse features shall be incorporated into the coupler draft gear. The coupler shall sustain no permanent damage when a fully loaded six-car train collides with an impact speed up to 10 kmph with another stationary fully loaded six-car train with braked (maximum parking brake) and un-braked conditions.
- 6.11.5 At high energy levels it shall be ensured that collision energy is absorbed by progressive deformation of the Coupler structure, Anti Climber with suitable energy absorption device (eg: collapsible tube) at cab end as well as in between the cars and vehicle end structure, thereby protecting the passengers and passenger area in the car. There shall be least deformation between the body bolsters.
- 6.11.6 An anti-climbing device shall be provided at the ends of all cars which shall prevent overriding of the vehicle ends in the event of a collision and it shall not be projected more than 40mm from cab-mask surface.

6.11.7 The bidder shall submit predicted values for the following in respect of fully loaded cars. The Contractor shall submit a detailed technical proposal and analysis (**CDRL-6-7**) to specify the following in respect of a 6-car train in AW4 condition colliding with another braked and un-braked stationary 6-car train in AW4 condition:

- i) The maximum collision speed at which there is no structural damage to the car body and the coupler.
- ii) The minimum collision speed at which the coupler energy absorption device fails.
- iii) The minimum speed at which actual structural damage commences.
- iv) The maximum speed at which the cab structural collapse features deform completely, without damage to the main car body structure.

6.12 Car Exteriors and Finish

6.12.1 The exterior of the car body shall be dull finish (non-directional) stainless steel left unpainted. The doors shall also to be made with stainless steel skin having same finish as the car body so that painting of the doors will also not be necessary.

6.12.2 Under frame member made of high tensile steel only, shall be painted which has been proven in modern metro cars body or similar applications. It shall provide durability and good resistance to abrasion, moisture, oils, and track work environment, to corrosion of coated metalwork and to car cleaning. Stainless steel member shall be left unpainted.

6.12.3 All painted surfaces shall match and display a uniformity of colour throughout its Service Life. The paint preparation and finish shall be such as to enable a satisfactory re-coat of part of the vehicle body in the event of localised repair.

6.12.4 The paint system shall include the Contractor's value of the paint materials such as smoke generated. Surface preparation requirements, number of coats and thickness with application instructions.

6.12.5 The performance of the paint finish including scratch resistance, impact resistance, chip resistance, abrasion resistance, and paint adhesion and paint elasticity shall be in accordance with recognised internationally approved standards.

6.12.6 The fittings and materials shall be easily cleanable (paint, graffiti, glue, etc.). They shall therefore withstand frequent use of various cleaning products (alkaline or acid detergents, petroleum solvents, mechanical action of brushes) without losing their colour or a noticeable deterioration of their surface aspect.

6.13 Lifting and jacking points

6.13.1 Lifting and jacking after derailment shall be taken into account in the Body car strength and strength calculations.

6.13.2 Lifting and jacking points shall be provided on the vehicle body to conform to the vehicle maintenance philosophy. The lifting and jacking points shall be easily accessible to facilitate re-railing in event of a derailment. The lifting and jacking points shall be clearly marked so that they are easily identifiable from the trackside

6.14 Automatic Couplers and Draft-gear

6.14.1 Automatic coupler without Electric head shall be provided as under:

- (i) In 6 car train composition (*DMC - TC - MC - MC - TC – DMC*), an automatic coupler **without electric head** shall be provided in the front of DMC car and semi-permanent coupler shall be provided between the cars.
- (ii) If Contractor doesn't wish to implement BP back-up brake system, then as specified in Clause 11.6.1 of Chapter-11 of ERTS, Contractor shall provide extension of EP brake and emergency brake lines from healthy train to defective train through small E-head connector with limited number of pins on the front automatic couplers of the trains to enable the application of service and emergency brake in the defective train from the healthy train.

6.14.2 Operation Requirement:

- (i) The automatic coupler shall be capable of gathering, engaging and coupling units on all track condition of BMRCL. The Contractor shall submit the design calculations/simulations to show that the coupler will be capable of gathering, engaging and coupling the trains standing on 120m radius of curve (**CDRL-6-8**). This shall be demonstrated through mainline tests.
- (ii) Coupling shall be achieved with the most adverse mismatch of car heights caused by wheel wear, passenger loading, air spring deflation and tolerances. The Contractor shall submit the required calculation and simulation in design phase for review of Project Manager. (**CDRL-6-9**)
- (iii) **Emergency Push-Out Requirements:**
 - a) A Trains end coupler shall be capable of mechanical and pneumatic coupling to the Trains end of another Train for emergency push out operation.
 - b) The Trains end coupler and all inter-car couplings shall be capable of transmitting the forces necessary to pull or push an unpowered Train in AW4 load condition up or down a 4.0% gradient at any speed up to 10 km/h along on all track condition of BMRCL.
 - c) All gangways shall be able to withstand the movement and forces induced during pulling or pushing of an immobilized Train in AW4 load condition up or down a 4.0% gradient at any speed up to 10km/h along on all track condition of BMRCL without damage

6.14.3 The **automatic** coupler shall, in conjunction with the draft-gear automatically effect mechanical and pneumatic coupling. It shall also permit separation of units either manually from the track side or remotely from the cab.

6.14.4 Coupling and Uncoupling Operation:

- a) Mechanical and pneumatic coupling shall be fully automatic without requiring any staff intervention.
- b) An electrical isolation switch shall be provided to isolate all the electrical connections of the coupler from the car wiring. Details shall be discussed during the Design Phase.
- c) An uncouple pushbutton shall be provided for uncoupling.

- d) Applicable Magnetic valve and shut off valves should be provided inside the driver cabin.
- 6.14.5 Height of the coupler shall be in the range of 740 mm to 815 mm in the same alignment of the under frame structure.
- 6.14.6 The automatic coupler shall be equipped with a self-centring device to prevent the coupler from swinging transversely when uncoupled. The couplers shall care for all suspension conditions and dynamic movements encountered during operation, including complete suspension failure.
- 6.14.7 When uncoupled, pneumatic connection shall be automatically protected against physical and mechanical damage and shall be sealed against ingress of water from rain and from washing plant and general dirt and detritus from the environment
- 6.14.8 Auto-couplers shall also incorporate provision for the selective isolation of air whilst remaining mechanically coupled. The electromagnetic valves used for actuation of coupling / uncoupling action shall have IP 65 and shall be proven in EMU metro operation for at least 2 years.
- 6.14.9 The couplers shall be easily replaceable in the event of becoming damaged and shall not impede the anti-climbing feature in the event of a collision.
- 6.14.10 The couplers shall incorporate longitudinal resilience sufficient to absorb shock loads during the transmission of traction and braking forces. The longitudinal stiffness characteristic of all similar type couplers shall be identical.
- 6.14.11 The automatic couplers shall provide positive indication to the TCMS to prove that they are correctly and fully coupled.
- 6.14.12 The coupler shall not generally require any maintenance up to intermediate overhaul. Any greasing if required shall be in-situ only.

6.15 Not Used.

6.16 Semi-Permanent Couplers and Draft-gear

- 6.16.1 ~~Except in the front end of the DMC, all the other car ends shall be provided with semi-permanent coupler. Between the cars, one end of the car shall be provided with semi-permanent coupler with gas filled hydraulic buffer and other end of the car shall be provided with semi-permanent coupler with deformation tube. A detailed simulation/calculation based on AW4 loading and other relevant parameters shall be submitted for Project Manager review during design phase. (CDRL-6-10).~~

Addendum-1 dated 05.12.2022, Sl. No. 87

Except in the front end of the DMC, all the other car ends shall be provided with semi-permanent coupler. Between the cars, one end of the car shall be provided with semi-permanent coupler with gas filled hydraulic buffer and other end of the car shall be provided with semi-permanent coupler with deformation tube **with suitable energy absorption device.**

A detailed simulation/calculation based on AW4 loading and other relevant parameters shall be submitted for Project Manager review during design phase. (CDRL-6-10).

- 6.16.2 Means shall be provided for vertically aligning the couplers, at the intermediate ends, to facilitate coupling. After coupling, such means shall not limit normal operating

movement of the coupler. This arrangement shall accommodate the full range of height variation between adjacent vehicles when being coupled.

- 6.16.3 ~~The semi-permanent coupler and draft-gear shall, in conjunction with the inter-car gangway, be capable of gathering, engaging and coupling units on all track conditions detailed in the environmental chapter. Under these track conditions, coupling shall be achieved with the most adverse mismatch of car heights, caused by wheel wear, passenger loading, air spring deflection, and service tolerances.~~

Addendum-1 dated 05.12.2022, Sl. No. 88

The coupler and draft-gear shall, in conjunction with the inter-car gangway, be capable of gathering, engaging and coupling units on all track conditions detailed in the environmental chapter. Under these track conditions, coupling shall be achieved with the most adverse mismatch of car heights, caused by wheel wear, passenger loading, air spring deflection, and service tolerances.

- 6.16.4 Electrical end connections shall be semi-permanent by means of jumpers or jumping cables. Uncoupling or re-coupling shall not damage these connections. It shall not be necessary to give preventative maintenance attention to these connections between vehicle overhauls. Electrical connections between cars shall be provided manually. Pneumatic continuity will be done by means of flexible hoses or through the semi-permanent coupler. Mechanical connection element between semi-permanent coupler shall provide durability and good resistance to corrosion.
- 6.16.5 The coupler shall be maintained horizontal by means of easily adjustable supports, which shall take care of loss of coupler height within the car body.
- 6.16.6 The weakest portion for parting shall be at the junction of the two coupler heads, interrupting electrical and pneumatic connections, and thus causing an instant emergency brake application.
- 6.16.7 ~~Time to couple and to uncouple cars including gangways support shall not exceed 30 min to 45 min in workshop.~~

Addendum-1 dated 05.12.2022, Sl. No. 89

Deleted.

- 6.16.8 ~~Semi-automatic coupler shall have the shear-off functionality. Except wearing plates, all other wearing parts of the coupler shall give life of minimum fifteen years. Wearing plates shall be of stainless steel.~~

Addendum-1 dated 05.12.2022, Sl. No. 90

Semi-permanent coupler shall have the shear-off functionality. Wearing parts/plates of couplers shall give a service life of minimum fifteen years. Wearing plates shall be of stainless steel. **Alternatively, Contractor may propose self-stabilizing deformation tube type semi-permanent coupler including anti-climbing functionality without shear-off functionality.**

6.17 Deliverables

The Contract deliverables required by this section of the Technical Provisions are listed below:

CDRL-6-1:	Overall Aesthetic appearance and image of proposed design (ref. ERTS 6.2.4)
CDRL-6-2:	A 3D motion video of a fully scale model of the Trains (ref. ERTS 6.2.5)
CDRL-6-3:	Full details of the technique/technology employed for joining the modular elements of shells (ref. ERTS 6.4.2)
CDRL-6-4:	Detailed calculations in design phase to validate in the event of failure of a locking device in service, covers shall remain secured and shall not infringe the Kinematic Envelope in static as well as in dynamic condition. (ERTS 6.8.4)
CDRL-6-5:	Detailed calculations for expected deflection on Carbody (ref. ERTS 6.10.6)
CDRL-6-6:	Stress Analysis Report for Carbody using Finite Element method (ref. ERTS 6.10.7)
CDRL-6-7:	Crashworthiness/energy absorption analysis (ref. ERTS 6.11.7)
CDRL-6-8:	Design calculations/simulations to show that the coupler will be capable of gathering, engaging and coupling the trains standing on 120m radius of curve (ref. ERTS 6.14.2 (i))
CDRL-6-9:	Detailed calculation and simulation for coupling height variation. (ref. ERTS 6.14.2.(ii))
CDRL-6-10:	Detailed simulation/calculation based on AW4 loading and other relevant parameters (ref. ERTS 6.16.1)

7 TRAIN DRIVER CAB

7.1 Train Driver Cab layout

- 7.1.1 Driving console layout and facilities shall be designed to meet all possible modes of operation including UTO, ATO, ATP, Manual Driving in line/depots/stabling yards etc.
- 7.1.2 In case the Employer does not engage UTO for any reason, the train operator will be on-board to drive the train under ATO or Manual Mode (under ATP). During such operations, the train operator shall be responsible for train safety and operation of the train as per the Employer's operating instructions and time tables.
- 7.1.3 Particular attention shall be given to the ergonomic design of the cab and its controls and instruments to achieve efficient working conditions. The cab design shall be demonstrated in the stage of Mock-up. The Contractor may propose a detailed arrangement during design review **(CDRL-7-1)**.
- 7.1.4 The Contractor shall submit the cab layout design with removable saloon to driving console partition for each Driving Motor (DM) Car in all trains irrespective of mode of operation. The removable partition shall be of the full width of the car with a provision of access door between saloon side and driving console side with a suitable arrangement of locking mechanism. **(CDRL-7-2)**

It shall be possible to remove these partitions and Driver's seat without disturbing the interior aesthetics. It shall also be possible to reinstall these partitions in the train, if required.

The details shall be discussed and finalized during design stage.

- 7.1.5 The Contractor shall ensure the following:
 - i) During UTO operation the driving console shall be concealed by an aesthetically matching cover (with car interiors). The cover shall have sufficient structural strength, vandalism proof, compatible with fire performance and suitably locked and secured. During the non UTO operation only authorized personnel can open the cover which shall be recorded and transmitted to the OCC.
 - ii) In order to release maximum space when the saloon to driving console partition is removed during UTO and also to enhance the effectiveness of operation, the control equipment shall be installed at distributed locations in the saloon area (near gangway area) without affecting the safety, maintainability and reliability of train operation. However, the equipment shall only be installed inside cubicles near the gangway area. Installation of equipment below passenger seats shall not be permitted. Contractor shall also ensure necessary IP protection for the equipment. During the design and in the physical mock-up it shall be demonstrated that the removal of the temporary partitions and other temporary fixtures shall be easily possible and space released for commuters giving good visibility of the driving console front.
- 7.1.6 The cab shall be the full width of the car with adequate depth to accommodate all specified equipment.
- 7.1.7 The cab driving position shall be in the centre of the cab front and will be designed to optimize UTO/ATO/ATP working, with the Operator seated.

7.1.8 Cab Layout. The main constraints for the design of the cabs shall be the following ergonomics and shall meet the following objectives for the driver comfort and possibly one other person:

- i) Visibility.
- ii) Be aesthetically pleasing.
- iii) Be comfortable for the operator.
- iv) Be able to withstand daily wear and tear.
- v) Interfaces with passengers.
- vi) Interfaces with the operational staff.
- vii) Fast exit of the driver in case of emergency.
- viii) Allow for efficient, safe and stress-reducing execution of operating tasks.
- ix) Provide efficient and safe detrainment facilities.
- x) Be easy to clean and maintain.

7.1.9 The train operator shall be seated in an optimal position to operate comfortably during a regular working day. Relevant standard is UIC 564-2.

7.1.10 The dimensions of the "standard" train operator are characterized by the anthropometric models of male and female persons, between 5 % to 95 % of the Indian population and take into consideration that 90% of operators are likely to be right-handed.

These dimensions shall be used to define the dimensions of the driving cab, the driving desk, the windscreen, seat (refer to standards NF X 35 002, UIC 651).

7.1.11 The driving commands and on driving desk shall be organized as follows:

- i) Primary zone including the most important commands and information related for the metro train driving, operation and safety. All these commands shall be used by the driver in a seating position and can be easily reached.
- ii) Secondary zone including the commands and information sporadically used, hand operated from the driver in seating position.
- iii) Tertiary zone including the commands and information the less important not generally used during the normal driving condition. To reach this command the driver may leave the seating position.
- iv) All buttons, switches and indicators shall have description tags in English language.

~~7.1.12 The cab shall allow the attendance of one occasional cab passenger (other staff, trainer) in sitting position. This passenger shall be able to see the desk panel equipment and the external signalling, and to reach the emergency braking control. This seat when closed (flipped up with the back wall) shall not provide any significant hindrance to the passageway between the centre of the cab and the side door~~

Addendum-1 dated 05.12.2022, Sl. No. 91

The cab shall allow the attendance of one occasional cab passenger (other staff, trainer) in sitting position. This passenger shall be able to see the desk panel equipment. This seat when closed (flipped up with the back wall) shall not provide any

significant hindrance to the passageway between the centre of the cab and the side door.

- 7.1.13 All edges and corners of the cab interior shall be designed to preclude injury to the operator.

7.2 Not Used.

7.3 Train Operator's Seat

- 7.3.1 The train operator's seat shall be cushioned, non-slippery, ergonomically designed with back/lumber support using non-flammable materials and filling, fully adjustable in the longitudinal/vertical directions and seat height adjustment shall be spring assisted. The complete seat assembly shall meet the flammability and smoke emission and toxicity as per EN 45545 part 1 to 7 (Hazard level HL3) latest editions or equivalent standard.

The Contractor may propose a detailed arrangement and seat adjustment during design review **(CDRL-7-3)**.

- 7.3.2 Assistant seat shall also be provided in each cab side. The seat back may be made integral with the back wall. The seat squab shall be arranged to flip up, when weight is removed from it, providing a narrow lateral passageway between the centre of the cab and the side door.

- 7.3.3 Adjustable footrest shall be provided for train operator. The seat and footrest shall be harmonized and shall be suitable for anthropology of Indians to ensure comfortable seating for Train Operator.

- 7.3.4 The seat shall be highest quality, heavy duty, long life, trouble free, maintenance free and easily cleaned (contain no dirt traps) and will have free space at front.

The seat position shall be located and positioned so that at the driver's eye level there will no obstructions from cab console equipment and full view across the front screen.

7.4 Windscreen

- 7.4.1 There shall be a single windscreen in each driving cab for the full width of the cab front. The Windscreen shall be constructed of toughened, laminated safety glass, and shall comply with the requirements of UIC 651, UIC 566 and EN 15152. The inner and outer surfaces of the windscreens shall be scratch resistant.

- 7.4.2 A 120° horizontal visibility in sitting position shall be allowed by the windscreen and the windows. The dead angle between the windscreen and the windows shall be reduced as much as possible. Horizontal and vertical angles visibility shall be described by the bid. The design will allow clear external sight lines such that all drivers can meet the vision requirements.

- 7.4.3 The front side of the metro train shall not have intermediate jamb.

- 7.4.4 The external facing surface of the windscreen shall be resistant to abrasion by the windscreen wipers or cleaning equipment, e.g. wash plant.

- 7.4.5 All windscreen surfaces shall resist attack by atmospheric pollution and cleaning solvents and shall be resistant to cracking and chipping.

- 7.4.6 All interfaces between the windscreen and the metro train body shall be sealed to prevent the ingress of draughts, water and foreign matter.

- 7.4.7 The colour of the windscreen shall ensure that correct observation of track-side signals is not affected. The windscreen shall not cause any visual distortion or reflection under any ambient lighting conditions and external vision shall not be affected by interior lighting conditions. If possible, the use of variable tinting pending on daylight may be proposed in order to limit solar radiation during daytime.

7.5 Windshield Wiper/Washer

- 7.5.1 Externally mounted windscreen wiper/washer units shall be provided, which shall accommodate intermittent operation in addition to a minimum of four positions: -

- i) Slow speed
- ii) High speed
- iii) Wash mode
- iv) OFF mode

The wipers shall sweep the largest possible arc and clear a windscreen area that shall enable the operator to meet all his external vision requirements.

- 7.5.2 Windscreen wiper shall be electrically operated.
- 7.5.3 The wipers shall not obstruct the operator's vision when in the parked position. Horizontal parked position of the wiper blades shall be preferred. The wipers shall provide efficient operation at all Metro Train speeds and environmental conditions.
- 7.5.4 The washer reservoir shall have an adequate capacity, refillable from the exterior of the metro train at track and station platform levels.
- 7.5.5 Wiper Switch, Wiper motor shall be simple & robust in design and shall be LRU and easily replaceable in less than 10 min.

7.6 Sun Protection Visors

- 7.6.1 Sun protection visors shall avoid the dazzling by sunbeam from the front and sides of the cab. This device shall be adjustable from the driver cab and the field of vision shall not be reduced.

7.7 Destination and Train No. Indicators

- 7.7.1 The Train Destination and Train No. indicator shall be located at the top of and immediately behind windscreen at appropriate location. (Refer ERTS Chapter 17)
- 7.7.2 The fixation of the Destination and Train No Indicators cover panels shall be with fasteners and sealed to prevent the ingress of draughts, water and foreign matter.

7.8 Cab Heating, Ventilation and Air Conditioning

- 7.8.1 The cab shall be ventilated by providing bleeding arrangement from the saloon air conditioning and be free from noise. (Refer ERTS Chapter 14)

7.9 Cab Floor

- 7.9.1 The cab floor shall be clear of all discontinuities and shall not incorporate access panels to under floor mounted equipment, junction boxes and cable ducts. It shall be possible to undertake water washing of the cab floor without damage to the floor or equipment. The cab floor material, the floor covering and general design shall be similar to the saloon interior floor.

7.10 Facilities

The following facilities will be provided in each driver cab:

- i) An emergency equipment cupboard shall be provided at suitable location beneath the non-driving side and equipped with first AID box, safety equipment including fire extinguisher (minimum 6 kg capacity) etc.
- ii) Suitable space / enclosure shall be provided in the cab for keeping train operator's kit, manuals and log books etc. located close to the train operator seat.
- iii) Cup holder shall be provided.
- iv) Suitable 15/16A and 5/6A socket with suitable protection device shall be provided in the cab and also in the cubicles at both ends of the car for charging emergency light, use of cleaning machines etc.
- v) Brush finished grab rails shall be provided at appropriate (more than one location) locations in the cab.

7.11 Saloon-to-Cab Door

7.11.1 Suitable designed door between the saloon and the cab to permit access to the passenger saloon shall be provided in the centre of the Saloon-to-cab partition. The clear door opening shall be approximately 650mm±50mm wide. In normal operation, opening the door from the saloon shall require the use of a special key.

7.11.2 The door shall not get jammed due to pressure exerted by passengers or distorted due to minor mishaps.

7.11.3 The finish of the door shall harmonize with that of the cab and the passenger saloon.

7.11.4 Opening the door from the cab shall not require any key.

7.11.5 The locking mechanism shall only use heavy duty locks, simple levers and actuating arms with proven record in metro applications.

7.11.6 The door shall not be possible to be bolted, wedged or otherwise locked, from either side of the door to prevent opening.

7.11.7 A visual and audible alarm shall be activated in the event that the saloon-to-cab door in the unoccupied cab is opened.

7.11.8 The open/close and lock/unlock status of the Saloon to cab door shall also be used to provide the status to TCMS and also to actuate the cab lights in the unoccupied cab is opened. Provision of two limit switch parallel to each other shall be installed. The details shall be furnished during design stage. **(CDRL-7-4)**

7.11.9 The assembly of the Saloon to Cab door shall not use any fasteners directly to FRP material.

7.12 Cab Side Doors

Cab Side Doors need not be provided. Suitable arrangement for train operator to board the train in depot (non-platform area) shall be provided. Detailed arrangement to be finalized during design stage. **(CDRL-7-5)**

In addition, a cab side window shall be provided on either side of the cab.

7.13 Lighting System

7.13.1 Head and Tail lights

- i) Power LED based Head and Tail lights in watertight sealed, vermin and insect proof integrated housings placed at approximately 2.2m center and 1.5m above top of rail datum, beneath the windscreens.
- ii) Two power LED based white lights, with provision for dipper shall be mounted at the front end of DMC car, to provide even illumination of the tunnel bore, track bed and track side signal posts. It shall be possible to read the various boards provided in the track side. The illumination level of the head light shall be as per EN 15153 -1. Replacement of individual cluster shall be possible in the depot without disturbing the functioning of the light. In case, the change of cluster requires readjustment of complete light or component, facility for the same shall be provided in each depot. Contractor shall submit the details during design Phase of entire Lighting system. **(CDRL-7-6)**
- iii) Each beam shall be separately adjustable both horizontally and vertically. The On/Off and Beam controls shall be switched from the train driver's console.
- iv) Two bi-colour power LED based marker lights (tail lights) shall be provided which may be lit in both active and non-active cab. The tail lights shall be LED type. Each LED shall be dual colour of white and red which shall be selectable from cab. Alternatively, white & red LEDs may be provided within the same block/fitting and be used accordingly. In active cab the marker lights shall be white and in non-active cab it should be of red colour. During the normal train operation, white front lights shall glow and rear shall be red. However, in case of a stationary train in siding or depot, both front and rear lights shall be red.
- v) The taillights shall be sufficiently large and bright, to enable the lamp to be seen and acted upon by a train driver within the stopping distance of the consist travelling at maximum speed
- vi) The control of Headlight and tail light shall be based upon the direction of train movement i.e. headlight and tail light (in white colour) should glow in the cab which is in moving direction and tail light (in red colour) should glow in the cab in the non-moving direction.
- vii) The headlights and taillights shall not be switched off when there will be any temporary disruption in 750 V D.C.
- viii) The Contractor shall propose to suitably indicate the front end of the train while parked at depot, or stabling sidings, by illuminating two white lights either by using dimmer position of head light or using dual colour LEDs in the tail light or by other appropriate means.
- ix) The IP protection shall be IP65, when fitted on the carbody. The failure of a circuit to an exterior lamp shall not result in the failure of any other exterior lamp.
- x) Bulbs or LED clusters used as exterior lights shall be able to be replaced easily from track level.
- xi) Access for cleaning and the replacement and adjustment shall be from the car exterior.

7.13.2 Flasher Light

- i) In order to attract the attention of the train operator of the following train or a train approaching from the opposite direction, in emergency, a powerful flashing amber light in addition to the tail lamps shall be provided in the front panel of each driving car. This light shall be switched ON by the train driver in case of emergency and shall not be switched OFF even while disconnection of DC supply.
- ii) Flasher light when lit and flashing shall be able to attract attention at a distance of 300m under clear sunny daylight.
- iii) The fixation of the Flasher Light cover panel shall be with fasteners and sealed to prevent the ingress of draughts, water and foreign matter.

7.13.3 Call-On Light Switch

- i) A Call-On Switch shall be provided in the train driver's cab, to cater for Emergency Push-Out situations. Operation of the switch on a failed train, with the Mode Selector in OFF, shall cause the tail lights at the front and rear of the failed train to flash on and off in red and white, indicating to the train driver of the rescuing train that he may proceed to affect coupling.

7.13.4 Cab Illumination

- i) The cab shall be provided with LED type ceiling lights, providing a sensibly constant level of illumination of 200lux at 1m above floor level. It shall be operated automatically by the opening of either cab door, and extinguished manually from within the cab.
- ii) Separate lighting of the train operator's console shall meet the requirements of UIC 651 OR which stipulates a minimum of 60 lumens/m² measured at the driving control desk. Driving console light shall be operated manually from within the cab.

7.13.5 Driving Console Lighting

LED based lighting of the train operator's console shall meet the requirements of UIC 651 OR which stipulates a minimum of 60 lumens/m² measured at the driving control desk.

7.13.6 UTO/RM Mode Indication Light

One indicating light visible from the side of the train indicating UTO or Restricted Manual mode status, shall be fitted on each side of both the cabs (four nos. of lights in total).

- i) The OFF status of the lights shall indicate that neither UTO mode nor RM mode is being used
- ii) The ON status of the lights shall indicate that the train is in UTO mode
- iii) The FLASHING status of the lights shall indicate that the train is in RM mode

7.14 Operator's Console

7.14.1 The console of the operator's cab shall include, but not necessarily be limited to the following controls: Design and layout of cab console shall be proposed by the Contractor for approval by BMRCL **(CDRL-7-7)**.

- i) ATO/UTO start controls (one either side of the cab);
- ii) passenger door open/close pushbuttons (one set either side of the cab);
- iii) two emergency brake stop pushbuttons (one either side of the cab);
- iv) master control switch, mode control selector;
- v) adjustable ventilation, which can be directed onto the operator's upper body;
- vi) warning horn controls (one on either side of the cab);
- vii) traction brake controller;
- viii) other cab system alarms and indicators;
- ix) auxiliary power supply controls;
- x) cab lighting;
- xi) air conditioning controls;
- xii) communication and radio controls;
- xiii) automatic voice announcement system controls;
- xiv) couple/uncouple controls for couplers;
- xv) override switches;
- xvi) windshield wiper controls
- xvii) miniature circuit breakers (MCB's)
- xviii) Video screen to display the view of in-training and de-training of the passenger from each saloon door during stoppage of train at platform.
- xix) Emergency controls and the controls requiring frequent/close monitoring by the train operator should be located within easy reach of the train operator.

7.14.2 In addition, adequate displays, such as pneumatic pressure gauges (self-illuminating LED based) and appropriate fault indicators shall be provided in the operator's cab.

7.14.3 Sufficient Hard-Wired fault indicators (self-illuminating LED based) shall be provided to facilitate fault identification and appropriate recovery action.

7.15 Console Annunciation

7.15.1 Each operator's cab shall be equipped with a console annunciation to perform all the functions (Refer ERTS Chapter 17).

7.16 Horn / Warning Devices

7.16.1 Each driving cab shall be provided with a warning horn.

7.16.2 The warning horn shall operate from the Train compressed air supply and shall maintain its performance over the full range of air working pressures.

7.16.3 ~~In addition to high decibel compressor air operated horn, one more pneumatic or electric horn of low decibel shall be provided for use during Yard movements in order to minimize noise pollution during night time movements in the Yard.~~

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7.16.4 The horn shall produce a loud warning tone when activated by means of a plunger or pushbutton located on the operator's desk.

7.16.5 The performance of the warning horn shall be in accordance with the requirements of UIC 644. The horn shall not generate a sound pressure level exceeding 90 dBA at the operator's cab with all cab doors closed.

7.17 Cab Mock-Up

7.17.1 The Contractor shall provide a full-scale mock-up of the operator cab at least six (6) months before manufacture of the cab area commences. **(CDRL-7-8).**

7.17.2 The mock-up shall be functional to the degree required to demonstrate and evaluate the maintainability and ergonomic aspects of the design and to serve subsequently as a training aid.

7.17.3 The Contractor shall submit the console and cab equipment design for the acceptance of the Employer prior to manufacture of the mock-up. The submission shall demonstrate the ergonomic suitability of the design and describe the logic behind the positioning of controls and instruments.

7.18 Deliverables

Contract deliverables required by this section of the Technical Provisions are summarized below:

CDRL-7-1:	Driver Cab Layout (ref. ERTS 7.1.3)
CDRL-7-2:	Driver cab layout with removable partition (ref. ERTS 7.1.4)
CDRL-7-3:	Train Operator's Seat (ref. ERTS 7.3.1)
CDRL-7-4:	Details for provision of two limit switch parallel to each other (ref. ERTS. 7.11.8)
CDRL-7-5:	Boarding arrangement for train operator (ref. ERTS 7.12.)
CDRL-7-6:	Lightning System (ref. ERTS 7.13.1)
CDRL-7-7:	Operator's console design, equipment (ref. ERTS 7.14.1)
CDRL-7-8:	Full Scale Mock-up of Operator's Cab (ref. ERTS 7.17.1)

8 PASSENGER SALOON DOORS**8.1 Number of doors and size**

- 8.1.1 Each car shall have necessary sets of electrically powered bi-parting, exterior sliding/plug type doors on each body side. It is expected to have a minimum of 4 double leaves doors on each side of each car with an approximate dimension of 1400 mm. The free passing through height of the open doors is at least 1900 mm in any point.
- 8.1.2 A maximum time of 30 seconds for dwell time (including opening and closing time) is required. The Contractor shall submit the calculations for boarding and detraining of the passengers as per international standards.
- 8.1.3 The passenger door pitch shall be equally spaced to the extent possible over the length of the Train. The Contractor shall submit the door layout design for approval by the Project Manager.

8.2 Door leaf

- 8.2.1 Not Used.
- 8.2.2 All saloon doors shall have the same durability as the vehicle body. The interior finish shall be compliant with the visual design and withstand severe wear and tear.
- 8.2.3 The inner and outer skin of the door leaf shall be formed in such a way as to be lightweight, of adequate strength, and internally reinforced and formed into an integral unit, in such a way as to prevent injury to passengers or staff.
- 8.2.4 Sheet metal shall be of ample gauge to provide adequate strength and rigidity. Joints and edges shall be thoroughly sealed against ingress of moisture with drain holes located at the bottom of the doors to allow drainage of condensate.
- 8.2.5 Doors shall be vibration free and sufficiently insulated against heat and sound transmission. Exterior and interior surfaces of the door leaves shall be finished to match the adjacent surfaces of car. The doors shall be free from dimples, warping, spot welding depressions and any other blemish.
- 8.2.6 When closed, door leaves shall be capable of withstanding loads imposed by passengers leaning on them under crush loading conditions. The doors shall be designed and tested such that the door leaves sustain such pressure with no permanent deformation. The Contractor shall submit test procedure based on best international practices.
- 8.2.7 It shall not be possible for a door to become detached from the vehicle under any operating conditions, including heavy side load from standing passengers or sudden pressure transients.
- 8.2.8 No single defect or failure of any part of any door system shall produce a situation capable of causing injury to any door user.
- 8.2.9 Door guides and supports shall be mounted within the section of doorway protected by the door seals and shall not allow ingress of dirt, debris, or any other foreign matter likely to result in excessive wear or incorrect operation of the door equipment.
- 8.2.10 The materials used for the door track rollers and seals shall take into account of hygroscopic effects in high humidity tropical environments.

8.2.11 Sealing arrangements on external sliding door leaf shall meet the following requirements:

- i) The doors shall be sealed against draughts, water and noise. In the event of ingress of water or dirt with the doors in the open position provision shall be made to ensure that rapid draining takes place and that no surrounding equipment or systems are affected in any way.
- ii) Positive sealing along entire saloon door opening and door leaf inner surfaces to eliminate in-rush of tunnel air due to the piston effect.
- iii) Door sealing shall also be such that the saloon interior noise specification is satisfied.
- iv) Door sealing arrangement shall be adequate to prevent water ingress due to torrential rain and car washing through automatic wash plant.
- v) The sealing arrangement shall take into consideration of car body manufacturing tolerance and deflections under fully loaded conditions.
- vi) Any seal shall not require regular cleaning (except lubrication). Seals and sensitive edges (if used) shall be effective under all operating conditions from tare to crush loading and particularly shall be resistant to atmospheric and chemical deterioration.
- vii) The door leaf edges shall be such that when the doors are closed, they form a weather tight seal extending the full height of the door.
- viii) Profile of center seal shall be discussed and finalized during design stage.

8.2.12 The Contractor shall indicate the amount of time required to replace a door leaf on the car, adjust it, and test it.

8.2.13 Adequate care shall be taken to ensure no part of door machinery is visible from inside / outside the saloon.

8.2.14 It shall be ensured that water does not enter / get trapped inside the door panels due to condensation or otherwise. The adhesives, if used, shall be type tested and certified for their performance under temperature cycles with 90% humidity & condensate.

8.2.15 Each door leaf shall have a window similar to the windows provided in the Cab door. In respect of solar gain, thermal insulation, replacement criteria, strength, resistance to pressure, and the transmission of light, and solar heat gain, these windows shall be identical with those of the saloon windows.

8.2.16 Specific measures shall be taken to maximize noise attenuation through doors. Door leaf shall be provided with honey comb sheets throughout. The doors assembly on the cars shall include carefully engineered sealing arrangement to reduce noise transmission into the cars.

8.3 Door windows

8.3.1 Please refer to ERTS clause 9.8 - "Body Side and Door Windows".

8.4 Door mechanism

- 8.4.1 The two door panels at each passenger doorway shall be synchronously controlled by a single electric actuator. The drive mechanism shall be a proven design in service. This mechanism shall provide symmetrical synchronous movement of both door leaf with respect to the door centre line.
- 8.4.2 During all door operations and under all power supply conditions, door movements shall be smooth, controlled and devoid of jerks or any violent motion. Doors shall not slam after removal of an obstruction or when the power supply is lost, removed or interrupted.
- 8.4.3 A belt driven type for door leaves is not acceptable.
- 8.4.4 Doors shall be electrically operated from 110V DC. supply through train line. The door operating mechanism shall be of a proven design in service.
- 8.4.5 The door system shall continue to operate correctly with the car battery voltage supply range between 77V to 137.5V DC.
- 8.4.6 The door operating mechanism shall be housed within the saloon above the doorway lintels. The design shall provide ease of access for maintenance. The complete mechanism shall be modular and mounted on a rigid frame so that it can be adjusted in situ for alignment and be removed as an integral unit from the car. The entire door mounting hardware and door actuation hardware must be readily accessible for adjustment and removal.

A microprocessor-based saloon Electronic Door Controller Unit (EDCU) shall control each pair of saloon door and shall be an integral part of door control assembly. The door controller unit of a proven design shall be equipped with self-diagnostic functions and shall communicate with TCMS. During the instant of any door fault, EDCU should record and store the fault history and background parameters in the memory. Each EDCU shall be connected to a dedicated TCMS port.

Power supply to EDCUs shall be in such a loop that the redundancy can be ensured in case of breakage of any one wire. The Contractor shall ensure that the system shall not be affected in single point failure. In case of EDCU transmission error, manual reset of EDCU shall be avoided and reset function shall be implemented through TCMS. Details shall be submitted for review of Project Manager. **(CDRL-8-1)**

8.4.7 EDCU Hardware and Software support:

- i) It shall be possible for the Maintenance Engineer to modify/change the parameters or closure/opening logic of door's circuit and implement the same as required by BMRCL based on their operational and maintenance requirements. Full access to the software for the purpose above shall be provided.
- ii) Any hardware/software tool required for this purpose shall also be provided free of cost (2 sets for each depot).
- iii) The documentation including but not restricted to flow charts (for complete software), signal flows, and interpretation of signal etc. shall be provided.
- iv) Training shall be provided by the OEM experts to BMRCL personnel to the complete satisfaction of the Project Manager.
- v) Single point uploading of software and downloading of faults/data on unit and train basis shall be ensured.

- 8.4.8 The minimum and maximum horizontal distance from centre of the track to the face of the passenger platform are specified in Chapter-2 para 2.2 of Schedules of Dimension (SOD). Design of doors and threshold plate shall be made to ensure the optimum minimum gap between the platform coping and edge of the car body floor threshold plate. The details shall be submitted and finalized at the design stage. **(CDRL-8-2)**
- 8.4.9 Limit switches used shall be of high reliability and with IP 65 protection. Life of the limit switches shall be at least 15 years. The Contactor shall furnish details during Pre-Final Design Stage. **(CDRL-8-3)**
- 8.4.10 The door position measurement and detection shall be accurate and real time measurement of the distance moved by each leaf. Details shall be discussed and finalized during design stage.
- Also, Door closed position shall be double checked through two independent arrangements. **(CDRL-8-4)**
- 8.4.11 Door System (software, hardware and control functionality etc.) shall be at least SIL 2 compliant at train level for all the safety related functions including the following:
- i) Door opening when train not at standstill.
 - ii) Door opening at standstill on track side,
 - iii) Train departure with an open door.
- The Contractor shall submit relevant certifications for the SIL levels as above. The SIL levels as above shall be validated and shall ensure that the train shall not move from a station unless the doors are closed and locked unless intentionally permitted by the Employer. Details shall be submitted for Project Manager's review during design phase. **(CDRL-8-5).**
- 8.4.12 The operation of saloon doors shall be under train operator control in the active driving console when the trains are driving in non-UTO mode. However, under UTO mode, the normal operation of saloon doors shall be under Signalling system.

8.5 Operation

- 8.5.1 Design, safety and testing of the passenger doors shall be compliant with EN 14752 standard
- 8.5.2 The force required for closing/opening of any door leaf, when fully connected with the driving gear shall not exceed as mentioned in EN 14752:2015 or latest.
- 8.5.3 Opening and closing time of the passenger doors shall be adjustable in the range of 1.5 to 3.5 seconds including response time.
- 8.5.4 The end of the closing stroke (say 100mm) shall be damped or cushioned to reduce impact and minimise possible injury to passengers.
- 8.5.5 All doors on the train shall fully open within 2.0 to 2.5 seconds from initiation of the open door command including response time.
- 8.5.6 All doors on the train shall fully close within 2.5 to 3.0 seconds from the initiation of the close door command including response time.

- 8.5.7 Close door actions shall be accompanied by audible chimes broadcasted to the passengers through Public Address system and saloon loudspeakers.
- 8.5.8 In case of short command received for door opening either from ATC or door open push buttons, EDCU should ignore the short command and doors shall open within the specified door opening time only and in synchronisation with other doors. A situation shall be avoided where some doors shall remain closed and some doors opened. The Contractor shall implement the same either through software or through hardwired circuit. The details shall be submitted for Project Manager's review during design phase. **(CDRL-8-6).**
- 8.5.9 Visible door status indications shall be provided to indicate door leaf failures or anomalies. These shall be located on both sides of every vehicle exterior and on the Driving Console. In addition, localized door status indicator light within the saloon shall also be provided for each saloon doors.
- 8.5.10 When a body side door is in the fully closed and locked position, it shall not be possible to be manually pushed open. A locking system for each pair of saloon door shall be provided.
- 8.5.11 While chime is played over the PA system, any existing auto announcement shall be aborted.

8.6 Safety

- 8.6.1 No part of any door, door installation, door control system or any other components for use with the door systems, shall be capable of causing injury to passengers or personnel as a result of door operation.
- 8.6.2 Particular attention shall be paid to detecting trapped obstacles in the passenger doors.
- 8.6.3 No spurious electrical signals shall cause any door to be released or opened unintentionally, particularly when the Train is in motion.
- 8.6.4 Each pair of saloon doors shall be provided with interlock switches incorporated in the Door Control Circuit to prove that doors are closed. When the Door Control Circuit is not proven closed, train movement shall be inhibited. Saloon door interlock status shall then be interfaced to the TCMS.
- 8.6.5 The body side doors are equipped with the following safety systems.
- i) Inform passengers that the doors are being closed by sound and visual devices.
 - ii) Mechanically lock the doors after closing.
 - iii) Authorize starting of the metro train only when the doors are closed and locked.
 - iv) Prevent a door from closing when a passenger is located between doors leaves, and order partial re-opening of doors when a passenger is blocked between leaves. Size of the obstacle and detection shall be the defined and proposed by the Contractor according to EN 14752 or more restrictive as per ERTS clause 8.6.6 below.

- 8.6.6 The doors shall not lock and permit a door-closed indication if an obstruction is detected. The obstruction detection feature shall not permit the doors to lock either when a 15 mm wide by 100 mm long flat plate is held between the door panels or when a 19 mm diameter bar is held between the door panels. If an obstruction is detected, the door shall stop. In case of detection of an obstruction the closing forces (dynamic and static) shall not be applied for longer than 1 sec. The door shall reopen by 50 mm (minimum 25 mm each door leaf) when an obstruction is detected. After a specified delay (adjustable between 0 and 5s), the door shall attempt to close again. If an obstruction persists, each door leaf shall stop again and the closing force of the obstructed door shall be removed. After the specified delay, the door shall attempt to close again. If the obstruction is still present the door shall reopen by 50 mm (minimum 25 mm each door leaf) and remain stationary, reporting a fault to the TCMS. The door shall not be indicated closed and locked with the obstacle dimensions as specified in clause 5.2.1.4.3 of EN 14752:2015.

In the event that the passenger door fails to close following the three attempts, further door movement shall cease on the affected passenger door and door will remain in full open position. Once such a passenger door has stopped movement, following this condition, further door closure shall require another activation of the corresponding "Door Close" command.

The details shall be submitted for Project Manager's review during design phase.
(CDRL-8-7)

- 8.6.7 ~~The push back feature shall be operative after the door leaves have been locked. It shall be possible to manually push back each closed door leaf to enable entrapped objects such as clothing and other articles, to be withdrawn, even after the mechanical lock has engaged. The force required to push back each door leaf shall not be less than 80N nor more than 150N as specified in clause 5.5.1.5 of EN 14752: 2015. However final value shall be decided during design. Expected door gap to be created by push back during intentional operation shall not exceed 30mm. During Push-back operation, it shall be ensured that door closing switch is not getting disengaged. The details shall be submitted for Project Manager's review during design phase. **(CDRL-8-8).**~~

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The push back feature shall be operative after the door leaves have been locked. It shall be possible to manually push back each closed-door leaf to enable entrapped objects such as clothing and other articles, to be withdrawn, even after the mechanical lock has engaged. The force required to push back each door leaf shall not be less than **100N nor more than 150N** as specified in clause 5.5.1.5 of EN 14752: 2015. However final value shall be decided during design. Expected door gap to be created by push back during intentional operation shall not exceed 30mm. During Push-back operation, it shall be ensured that door closing switch is not getting disengaged. The details shall be submitted for Project Manager's review during design phase. (CDRL-8-8).

- 8.6.8 Door closed and obstruction sensing information shall be recorded in TCMS.
- 8.6.9 The door system shall continue to operate correctly within the car battery voltage supply range of 77-137.5 Volt DC input.

- 8.6.10 The above gaps and timings are notional and shall be capable of being adjusted after experience in service has been gained. The initial settings shall be determined from an investigatory trial undertaken using the door mock-up, or the door test rig.
- 8.6.11 In case of unavailability/failure of door authorization signal from ATP system, adequate safeguards shall be provided and also incorporated in control circuit to eliminate the probability of error of opening of doors on wrong side (other than platform side) during commercial / revenue service. Manual opening/closing of the doors from the cab shall be possible by simultaneous operation of Two Push Buttons on door control panel on respective side using both hands.
- 8.6.12 Change-end Operation. The following sequential control functions shall be provided for use when the train arrived at the terminal station where changing the controlling cab is required:
- a) When the key switch is moved to the "off" position, all saloon doors shall stay in the previous condition either opened or closed;
 - b) Then the key switch of the other driving cab is moved away from "off" to take over the controls, all saloon door states shall remain unchanged;
 - c) Thereafter the door state shall follow the operation of the associated door control pushbutton of the active cab.

8.7 Door Failure

- 8.7.1 Failure of the door mechanism or door control circuitry shall not result in a saloon door unlocking or opening without a valid command. The door control shall fail in such a manner that the door leaves are both closed and locked.

Each saloon door shall be fitted with the means of isolating and locking both door leaves. The isolation shall require the use of a key at a location normally accessible from the platform. Maximum operating torque for lock-out device shall not exceed 10 Nm. The keyhole location shall be subject to review by the Project Manager. It shall be possible to isolate any closed and locked door from the driving console by the train operator using TCMS interface. It shall also be possible to isolate any closed and locked door remotely from OCC.

- 8.7.2 When the isolation is activated, the door shall be mechanically locked in the closed position. Manually isolated doors shall be indicated on the Train Operator's cab Visual Display Unit (VDU) and OCC.
- 8.7.3 The door leaves will need to be provided with the appropriate means of applying a locking device. Full details of the Bidder's proposal shall be provided.
- 8.7.4 During detailed design stage, all events that shall trigger recording of data in the EDCU shall be finalized. Various parameters that shall be available for display shall be selectable. For each event, the complete data for minimum previous 300 seconds shall be recorded & retrievable. The data shall include each input output & status of different parameters. Adequate memory shall be available for recording of at least 100 records. Complete diagnostic tools (software/hardware) shall be provided. Provision shall also exist to monitor all inputs / output ON LINE on a maintenance device. The event data shall be viewable on a laptop loaded with maintenance software (to be supplied by Contractor for each depot). The parameters to be monitored shall be finalized during the design phase. **(CDRL-8-9).**

8.7.5 No single defect or failure of any part of any door system shall produce a situation capable of causing injury to any door user.

8.7.6 Sealed type safety relay shall only be used for door system. All the relevant door relays shall be redundant for the door system.

8.8 Emergency Egress Devices

8.8.1 Passenger saloon doors shall be used to provide emergency egress for train crews and passengers

8.8.2 The following means of operating doors by staff, shall however be provided for emergency situations as described below:

- i) On each side of every car, two devices (Emergency Access Devices - EADs) shall be provided. This device shall be operable from outside the vehicle from platform level or track-side. Operation of this device shall release the "locking" mechanism; on the adjacent door. Manual emergency release device shall be unobtrusive, flushed with, or recessed into, the car side, but readily available in an emergency. The manual emergency release device shall be provided with spring loaded cover to ensure water tightness. This shall require a special key so that only authorized personnel can operate the same.
- ii) One device for each side shall be provided inside the operator's cab. This device shall be operable from inside the cab. Operation of this device shall release the "locking" mechanism on adjacent passenger saloon door of the DM car. This device shall be unobtrusive, flushed with, or recessed into the side wall / interior panel.

8.8.3 For emergency egress through the passenger saloon door, simplicity of operation is imperative. Instructions shall be displayed to enable passengers, unfamiliar with the equipment to operate the door, in emergency condition, when the train driver is incapacitated.

8.8.4 This manual opening device shall enable the doors to be manually opened without a specific key or electrical power. A latching device shall prevent door from opening when the train is in motion.

8.8.5 When the lever is activated and the train is stationary, electrical power to the door operator shall be disconnected and the door shall become unlocked, allowing the door to be pushed open, manually.

8.8.6 When the door leaves are unlocked, it shall not be possible to apply traction to the train and to release the brakes. To return the emergency lever to its normal position it shall be necessary to reset the emergency lever on the door operator assembly with a specific key.

8.8.7 The mechanism for emergency egress shall be provided with safe, simple and secure locking which shall though be unaffected by single point failure. Any operation of the Emergency Egress Device (EED) shall be indicated to train driver along with the position of the door(s) as open or close through TCMS. Any operation of the emergency egress devices shall also be indicated to OCC via Signalling System (ATC) along with the position of the door(s) as open or close.

- 8.8.8 All necessary ancillary equipment to enable emergency egress including equipment needed to return the passenger saloon doors to its normal position, as necessary, shall be provided as parts of the scope of equipment under this clause.
- 8.8.9 Full details of the arrangement shall be given. The Contractor shall interface with the relevant designated contractors to ensure safe and reliable emergency egress arrangement is developed.
- 8.8.10 The Contractor shall develop and implement suitable design to ensure safe and secure emergency egress (evacuation plan) at any of the elevated, at-grade and underground sections or at platform. Contractor shall furnish detail evacuation plan compatible with side evacuation. For side evacuation suitable arrangement for filling up the gap to the walkway (ramp) shall be designed considering the worst scenario of train standing at 120m inside curve or 120m outside curve. A suitable cubicle/box shall be provided in the train to accommodate the ramp. The details shall be submitted and finalised during design phase **(CDRL-8-10)**. The Evacuation Scenario will also cover the following conditions:
- a) Evacuation in Emergency, e.g. Fire, collision. The proposed car arrangements shall be compliant with the evacuation requirements specified in Railway Group Standard GM/RT2130 'Vehicle Fire, Safety and Evacuation' or better.
 - b) Controlled evacuation e.g. failed train or failed power supply. It will include study of evacuation time, the battery capacity calculation and other relevant documentation duly considering the side evacuation.

8.9 Reliability and Safety

- 8.9.1 The reliability and intrinsic safety of the doors of all high capacity metro trains are of paramount importance. One door failure often has the effect of disrupting the service, and usually by more than a two minute delay. It is of the utmost importance therefore that the door scheme shall be designed with all necessary safeguards against potential failure. The door operation shall remain reliable under all operating conditions from tare to crush loadings.

8.10 Interlocking

- 8.10.1 The interlocking plan as follow is indicative. The Contractor shall validate or improve this plan. The Contractor will be required to provide a comprehensive Safety Audit to the satisfaction of the Project Manager
- 8.10.2 No spurious electrical signals shall cause any door to be released or opened.
- 8.10.3 There shall be no single point failure of equipment or wiring, or two point failure with one failure undetected, which would cause a door to open without being commanded.
- 8.10.4 The door controls shall be interlocked with the train's zero speed circuitry so that the doors cannot be opened until the train is stopped. However, loss of ATC power at zero speed shall not inhibit door operation. Zero speed signal shall be hard wired.
- 8.10.5 Irrespective of the operating mode, the train shall not be able to move unless all the saloon doors are proved closed and locked. The train line circuit performing this interlock shall be a failsafe, double break circuit to provide maximum protection against erroneous door locked signal. A sealed cut out switch (Door Proving Loop Cut Out Switch) accessible to the train driver in each cab, shall be provided to bypass the

interlock, to enable a train to be taken to the next station prior to being taken out of service, to attend to the defective door. Operation of the cut-out switch shall be recorded by the Train Control Management System (TCMS).

8.10.6 At appropriate location near each door, (both exterior as well as interior) suitable indication shall be provided to indicate door status (including isolated state).

8.10.7 All door control circuits for one side of car shall be separate and distinct from those for the other side of the car. There shall be no shared component unless specifically called herein.

8.10.8 In ATP mode, it shall not be possible to energize the door open circuit if the train has not stopped in the correct location or if the car side adjacent to the platform has not been selected.

8.10.9 It shall be possible to operate any or both side doors in the maintenance depot or lines where ATP protection is not available. The details and schematic shall be provided for review of the Project Manager.

8.10.10 Both Door close and lock switches shall be hard wired.

8.11 Interfaces

8.11.1 With TCMS:

The door controller unit shall have communication link with TCMS. TCMS shall also be interfaced with the related circuits and interlocks so that all the door related status and commands are logged. See Appendix D for full details of the division of responsibility between the Contractor and Signalling & Train Controls.

8.11.2 With On-Train Public Address System:

The door control shall be suitably interfaced with On train Public Address System to achieve the following:

- a) A chime shall sound over the PA system as the doors are opening, as a signal to the visually impaired. The chime shall stop when the doors are fully open.
- b) A door close announcement shall be triggered each time the "Door Close Announcement" button is pressed. When door close command is initiated, the door close chime shall play till the Doors achieve locked position. Similarly, a chime shall be played during the door opening. During this time any existing auto announcement shall be aborted. The chime shall warn the passengers inside the train as well as those on the platform about the door operation. Selection of the type and adjustment of volume of the chime shall be independent of the volume of the announcements.
- c) While chime is played over the PA system, any existing auto announcement shall be aborted.

8.11.3 Interface with Platform Screen Doors (PSD)

The Contractor shall ensure compliance to the following interface requirements between Passenger Saloon Doors and Platform Screen Doors:

- (i) The two door leaves at each passenger doorway shall be synchronously controlled and shall provide a door clear opening width of equal spacing of not less than 1.4

- m. The location and size of the door panels are important for the PSD equipment supplier.
- (ii) The passenger door pitch shall be approximately equally spaced over the length of the rake. The Contractor shall submit the door layout design for approval by the Project Manager. **(CDRL-8-11)**.
- (iii) The Contractor is advised that platform screen doors (PSD) will be installed under a separate contract. The Rolling Stock Contractor shall coordinate with the designated contractors for PSD, Signalling & Train Control and Telecommunications to provide the necessary interface information data including but not limited to the following:
- ATP/ATO/UTO signals to synchronise the opening and closing of PSDs with opening and closing of train doors. The Rolling Stock door / PSD open/close synchronisation shall not exceed 0.5 sec. The Contractor shall provide all support necessary to Signalling & Train Control to achieve this target.
 - Station dwell times
 - Door opening and closing announcements
 - Signals for "Train Arriving" and Train Leaving" announcement
 - Any other information necessary for the proper design, interface, interface and operation of the PSDs.

Different failure scenarios of PSD as well train doors including information to passengers shall be considered. The details shall be submitted and finalised during design phase. **(CDRL-8-12)**.

8.12 Deliverables

Contract deliverables required by this section of the Technical Provisions are summarized below:

CDRL 8-1:	A microprocessor-based saloon Electronic Door Controller Unit (EDCU) control (ref. ERTS 8.4.6)
CDRL 8-2:	Design details of doors and threshold plate (ref. ERTS 8.4.9)
CDRL 8-3:	Limit switches (ref. ERTS 8.4.9)
CDRL 8-4:	Door closed position (ref. ERTS 8.4.10)
CDRL 8-5:	SIL level for door system (ref. ERTS 8.4.12)
CDRL-8-6:	Short command logic (ref. ERTS 8.5.8)
CDRL-8-7:	Door obstacle detection (ref. ERTS 8.6.6)
CDRL-8-8:	Push Back feature operation (ref. ERTS 8.6.7)
CDRL 8-9:	EDCU software for door failure (ref. ERTS 8.7.5)
CDRL 8-10:	Emergency Egress (evacuation plan) (ref. ERTS 8.8.10)
CDRL 8-11:	Door Layout Design (ref. ERTS-8.11.3 (ii))
CDRL 8-12:	Interface with Platform Screen Door (PSD) (ref. ERTS 8.11.3 (iii))

9 SALOON INTERIOR

9.1 General Considerations

- 9.1.1 The Contractor shall provide 3 proposals for the metro train layout and seat disposals which incorporate a modern aesthetic approach with considerations to optimise passenger comfort, safety and security as well as to minimise noise in the saloon. One of the layouts will be chosen by the Project Manager during the preliminary design phase. **(CDRL-9-1)**
- 9.1.2 The metro train interior layout is defined by wide double leaf automatic doors along each side, longitudinal seating, enclosed by stand-back areas and draught screens, grab-poles and rails, LED lighting, air conditioning outlet grilles, passenger information displays, public address loudspeakers, and passenger emergency alarm devices to permit passengers to make the train operator aware of problems.
- 9.1.3 The requirements include but are not limited to:
- i) Type of seats (width, comfort...) and supports.
 - ii) Number of seats.
 - iii) Distribution of seats and supports.
- 9.1.4 All passengers transported in the metro train, shall be able to move in the complete metro train without any fixed obstacle made up by car components or seats in their way.
- 9.1.5 Open gangways between metro cars are required.
- 9.1.6 This objective shall be met by:
- i) The surface of floor all at the same level, no step is authorized,
 - ii) Maintaining a minimum free passage in the area accessible to the passenger with wheel chairs (relevant standard UIC 565-3),
 - iii) Ensuring good visibility of all obstacles inside the metro train under any light condition,
 - iv) Ensuring any passenger holding points for at least one hand under any load condition (columns, handles...).
 - v) Ensuring more number of hands holds for standing passengers near to Gangways and also shall be able to move in the complete metro without any fixed obstacle.
- 9.1.7 The metro train shall be designed to transport all population, including valid people, children, passengers with luggage, senior citizens, slightly disabled people, blind or deaf people, handicapped persons, including non-ambulatory persons in wheelchairs.
- 9.1.8 The dimensions of the « standard » passengers are characterised by the anthropometric models of the male and female of the local population that will be agreed during design phase.
- 9.1.9 Design of the metro train shall be suitable for passengers from the 5th percentile of female population to the 95th percentile of male population. Average weight of each passenger is estimated to 65 kg.
- 9.1.10 Two 9 kg fire extinguishers of the dry powder type as per IS 15683 shall be installed in each saloon, readily accessible and flush mounted on panel diagonally.

- 9.1.11 The area between top of the body side windows and the ceiling shall be utilized for advertising displays. The details shall be finalized during design stage.
- 9.1.12 Each saloon shall have atleast two USB ports on both ends for mobile charging.

9.2 Habitability

- 9.2.1 ~~A height of 2100mm from floor to ceiling shall be provided in the saloon areas excepted at ends close to the gangways and in the gangways. The Contractor shall propose layouts that incorporate a modern aesthetic approach with considerations to optimise passenger comfort, safety and security as well as minimise noise in the saloon. The saloon layout design including the mock-up shall be subject to acceptance.~~

Addendum-1 dated 05.12.2022, Sl. No. 94

A nominal height of 2100mm from floor to ceiling shall be provided in the saloon areas excepted at ends close to the gangways and in the gangways. **However, the clear height from floor to ceiling shall not be less than 2050mm.** The Contractor shall propose layouts that incorporate a modern aesthetic approach with considerations to optimise passenger comfort, safety and security as well as minimise noise in the saloon. The saloon layout design including the mock-up shall be subject to acceptance.

9.3 Lining

- 9.3.1 ~~External panelling, including the under surface of the car roof, floor sheet and all interior surfaces of car body side panels shall be coated with suitable anti-drumming compound. Efficiency of the anti-drumming compound for noise suppression shall be demonstrated.~~

Addendum-1 dated 05.12.2022, Sl. No. 95

Anti-drumming compound shall be coated under surface of car floor and on Cab block of side structure. Efficiency of the anti-drumming compound for noise suppression shall be demonstrated.

- 9.3.2 The body side and roof outer skin shall have a suitable thickness of approved acoustic and thermal insulating material bonded to their interior surfaces. Suitable acoustic insulation shall be provided on the body side and roof sheet to minimize the effect of reflected noise into the saloon.

The carbody shall be designed to have high thermal insulation to reduce the heat loss and heat transfer coefficient (K value) of the carbody excluding glazing/windows shall be kept within 1.6W/(m²K). The calorific value of the insulation material used as well as the material used for fixing the insulation shall be bare minimum.

- 9.3.3 The design of interior fittings shall be safe under all conditions of passenger impact, during emergency braking and buffing under AW4 condition.
- 9.3.4 All non-metallic materials shall satisfy the fire property requirements of flammability, toxicity and smoke emission limitations, etc. specified in EN 45545 part 1 to 7 (Hazard level HL3) latest editions or better equivalent international norms/standards applicable for similar metro operations.
- 9.3.5 All interior surfaces must be finished with good blending and good slow ageing properties to provide a pleasant, high-quality interior and for ease of cleaning and maintenance. No material shall degrade or stain when exposed to food, drink, graffiti,

or any cleaners used by the Maintenance Personnel. No material shall produce any odour that would be noticeable or irritating to passengers.

- 9.3.6 ~~All internal panel surfaces shall be smooth finished with modern low flammability, low smoke emission, anti-graffiti and low toxicity material. All internal panels shall be resistant to graffiti, scuffing, vandalism and cleaning agents. (properties of cleaning agent shall comply with the Anti-graffiti Protection Standard NFF 31-112). Rounded corners or covings shall be provided wherever mutually perpendicular flat plane surface about. Metal kicking strips of 150 mm depth with radius coving are required on all exposed vertical surfaces above floor level.~~

~~All panels shall conform to ASTM standards (ASTM D2563 level 1) and NFF01-281. The colour shall not fade/discolour with time or due to rubbing. Interior panels shall be manufactured with Phenolic Nomex Honeycomb. Vacuum infusion process with in-mould heating, Non-Crimp Fabric with Nomex Phenolic (confirming to EN 45545-2 HL3), shall be used to get light weight panels having 60% or more fabric by volume. Gel coated panels shall not be accepted. The Contractor shall prepare detail plan during design and seek approval. Hand laying process shall not be acceptable unless inevitable due to shape etc. Contractor shall submit detail plan for approval.~~

~~Additives, fillers, monomers, catalysts, activators, pigments, fire retardants, and smoke inhibitors shall be added to the resin mixes to obtain finished products with the required strength requirements and the flammability requirements as mentioned in EN 45545 Part 2 (Hazard level HL3) latest editions. Antimony Trioxide shall not be used. Mineral filler shall not exceed 30 percent of the finished weight for any preformed matched die molding process.~~

~~Alternatively, Ceramic coated Aluminium panels preferably with Aluminium extrusion having suitable thickness, adequately stiffened may be considered. Ceramic coating shall be applied on both sides of Aluminium panels with thickness of 50 µm on front side and 20 µm on back side. The flatness of Aluminium side panels shall be controlled within 0.5 mm per 1m length. The panels shall have rubber packing on backside of the panel to prevent any bi-metallic corrosion. Details shall be discussed during design. (CDRL-9-2)~~

~~Contractor shall submit details of processes and raw materials proposed to be used in manufacturing of different panels such as side panels, driver's desk, ceiling panels, End ceiling panels, inspection cover panels, door coving panels, ceiling coving panels etc. for approval of the Project Manager during design stage.~~

~~Contractor must furnish details for different panels but not limited to properties such as Glass Content, Ultimate Tensile Strength, Tensile Modulus, Ultimate Flexural Strength, Flexural Modulus, Compression Strength, Compression Modulus and Impact Test complete with the test methods in compliance of relevant ISOs. Contractor shall also submit 200 mm x 250 mm samples of each proposed material, indicating material finishes.~~

Addendum-1 dated 05.12.2022, Sl. No. 96

All internal panel surfaces shall be smooth finished with modern low flammability, low smoke emission, anti-graffiti and low toxicity material. All internal panels shall be resistant to graffiti, scuffing, vandalism and cleaning agents. (properties of cleaning agent shall comply with the Anti-graffiti Protection Standard NFF 31-112). Rounded

corners or covings shall be provided wherever mutually perpendicular flat plane surface about. Metal kicking strips of 150 mm depth with radius coving are required on all exposed vertical surfaces above floor level. All panels shall conform to ASTM standards (ASTM D2563- level 1) and NFF01-281.

The colour shall not fade/discolour with time or due to rubbing. Interior panels shall be manufactured with Phenolic Nomex Honeycomb. Vacuum infusion process with inmould heating, Non-Crimp Fabric with Nomex Phenolic (confirming to EN 45545-2 HL3), shall be used to get light weight panels having 60% or more fabric by volume. Gel quoted panels shall not be accepted. The Contractor shall prepare detail plan during design and seek approval. Hand laying process shall not be acceptable unless inevitable due to shape etc. Contractor shall submit detail plan for approval.

Additives, fillers, monomers, catalysts, activators, pigments, fire retardants, and smoke inhibitors shall be added to the resin mixes to obtain finished products with the required strength requirements and the flammability requirements as mentioned in EN 45545 Part 2 (Hazard level HL3) latest editions. Antimony Trioxide shall not be used. Mineral filler shall not exceed 30 percent of the finished weight for any preformed matched die molding process.

Alternatively, Ceramic **or Powder** coated Aluminium panels preferably with Aluminium extrusion having suitable thickness, adequately stiffened may be considered. Ceramic coating shall be applied on both sides of Aluminium panels with thickness of 50 µm on front side and 20 µm on back side. The flatness of Aluminium side panels shall be controlled within 0.5 mm per 1m length. The panels shall have rubber packing on backside of the panel to prevent any bi-metallic corrosion. Details shall be discussed during design. **(CDRL-9-2)**

Contractor shall submit details of processes and raw materials proposed to be used in manufacturing of different panels such as side panels, driver's desk, ceiling panels, End ceiling panels, inspection cover panels, door coving panels, ceiling coving panels etc. for approval of the Project Manager during design stage.

Contractor must furnish details for different panels but not limited to properties such as Glass Content, Ultimate Tensile Strength, Tensile Modulus, Ultimate Flexural Strength, Flexural Modulus, Compression Strength, Compression Modulus and Impact Test complete with the test methods in compliance of relevant ISOs. Contractor shall also submit 200 mm x 250 mm samples of each proposed material, indicating material finishes.

- 9.3.7 All linings should be of modular design, easily and rapidly removed and replaced independently from each other by specialist personnel, but difficult to dismantle for non-specialists.
- 9.3.8 Since these measures cannot be totally effective, the fittings and materials shall be easily cleanable (paint, graffiti, glue, etc.). They shall therefore withstand frequent use of various cleaning products (alkaline or acid detergents, petroleum solvents, mechanical action of brushes) without losing their colour or a noticeable deterioration of their surface aspect.
- 9.3.9 As far as possible, fastening devices, fixings and securing screws shall not be visible from within the saloon.
- 9.3.10 Gaps between all interior linings, panels kick strips, seat shell, etc. and shall not exceed 2 mm. Suitable cushioning at panel joints shall be provided to suppress noise.

- 9.3.11 The area between top of body side windows and the ceiling shall be utilised for advertising displays. Ceiling shall be of honey comb panel to minimise noise transmission inside the saloon.
- 9.3.12 All non-metallic materials within the car saloon shall not give rise to generation of static charge on persons or equipment within the saloon.
- 9.3.13 The Contractor shall propose arrangements for Programmable Digital route maps, system route maps and advertisement holders in the saloon that are unobtrusive and easy to maintain, as specified in ERTS chapter 17 (Communication System)

9.4 Seats

- 9.4.1 Longitudinal banks of seats of stainless steel shall only be provided along the body-side between doorway draught-screens, and between draught-screens and body ends.
- 9.4.2 The seats shall provide an adequate level of comfortable with lumbar support, have a good aesthetically appearance and be scuff and vandal resistant and their mountings shall be capable of withstanding the loads arising in service conditions.
- 9.4.3 The seating arrangement with the size, colour, profile and shape of the individual seats shall be ergonomically designed. The seat shall be non-directional matte finish.
- 9.4.4 The seats shall provide some resistance to passenger movement longitudinally along the vehicle during acceleration and braking.
- 9.4.5 Seats shall not be upholstered and shall not have sharp edges or protrusions that could cause injury to passengers or staff.
- 9.4.6 Seat modules in similar situations in a vehicle shall be interchangeable. It is preferable that only one style of module be used throughout the train.
- 9.4.7 The seats shall be cantilevered out from the sidewall, to provide a clear unobstructed car width floor, for ease and speed of cleaning. The seating arrangement shall in itself be easy to keep clean and shall not impede the cleaning of any other part of the car interior. The seat fixtures shall be arranged so that no fixing or strut is visible. Permanent fixings shall form part of the floor and body sides.
- 9.4.8 The proposed minimum seat depth, measured from the seat's forward edge to the forward surface of the seat's back, minimum seat width and leg room shall be proposed by the Contractor for the approval of the Project Manager. **[CDRL-9-3]**
- 9.4.9 Seats shall meet the requirements of UIC 564-2 or equivalent standard.

9.5 Passenger access

- 9.5.1 The metro train floor height of the platform access shall allow passenger access with platforms described in the operation environment chapter and structural gauge.
- 9.5.2 ~~In order to provide good access conditions for all passengers including impaired persons and persons in wheelchair, the metro train floor height, doorways and access shall comply with the following criteria:~~
- i) ~~Vertical gap shall be ≥ 5 to ≤ 50 mm between station platform and metro train access in regardless of the passenger load and wheel wear condition.~~

- ii) ~~Maximum horizontal gap between platform on straight line and metro train access shall be ≤ 50 mm regardless the passenger load and wheel wear condition on straight track.~~

~~Specific information shall be provided by the bidder regarding these requirements.~~

Addendum-1 dated 05.12.2022, Sl. No. 97

In order to provide good access conditions for all passengers including impaired persons and persons in wheelchair, the metro train floor height, doorways and access shall comply with the following criteria:

- i) Vertical gap shall be ≥ 5 to ≤ 50 mm between station platform and metro train access in regardless of the passenger load and wheel wear condition
- ii) Maximum horizontal gap between platform on straight line and metro train access shall be ≤ 75 mm regardless the passenger load and wheel wear condition on straight track.

However, this shall be finalized during design stage.

- 9.5.3 The Contractor shall incorporate his proposals into the mock up, for consideration. Detailed arrangements shall be finalized and got approved from the Project Manager during the mock up finalization stage. The decision of the Project Manager shall be final and binding.

9.6 Stanchions and handholds

- 9.6.1 Stainless steel grab poles and rails shall be provided in the standing areas of the saloon including Gangway area for the comfort and safety of standing passengers.
- 9.6.2 Stanchions and handholds shall be seamless, corrosion resistant material tubing with satin finish. They shall be able to support the forces of the maximum number of passengers expected with 8 passengers/ m^2 loading under maximum emergency deceleration conditions. The design of any joints in the handrails or stanchions shall resist the effects of vibration, or of passengers moving or twisting them.
- 9.6.3 The stanchions and handholds shall suffer no permanent deformation when subject to loading conditions arising in service, in accordance with UIC 566/EN 12663.
- 9.6.4 Two rows of handholds and rails shall be positioned such that 95% of passengers can always access a pole or rail without having to reach more than 300 mm. The layout of stanchions and handholds shall be submitted and finalized during design phase.
(CDRL-9-4)

- 9.6.5 The completely assembled grab handles shall be subjected to "pull off test" to measure the maximum load they can withstand. A minimum load of 2500 N shall be achieved. The fully assembled grab handle shall be subjected to an endurance test with the following basic conditions:
 - i) Load: 35kg vertical
 - ii) Cycles: 300,000 cycles minimum
 - iii) Bending Angle: ± 45 degrees
 - iv) Frequency: Each cycle to consist of movement of the handle from one extreme to another extreme and back within one second.

Any other test considered essential for the grab handle test to be included in the test plan.

9.7 Disabled people

- 9.7.1 A dedicated space shall be provided in the Driving Motor car, near the first door of the DM car end, to accommodate a wheelchair, complete with its occupant. Detailed proposals, including the need for a doorway flap or ramp shall be submitted and may be reflected in the appropriate mock-up.
- 9.7.2 The wheelchair parking area shall be free of vertical stanchions and other obstructions and shall include equipment useable by a wheelchair occupant to restrain the wheelchair while the vehicle is in motion. Passengers shall be able to walk on and off the vehicle without being impeded by either the wheelchair and its restraint or the retracted restraint when a wheelchair is not on-board.
- 9.7.3 The wheel chair space and associated facilities shall be as per the latest European Railway Agency guide for the application of the Person with Reduced Mobility (PRM) Technical Specification for Interoperability (TSI).

9.8 Body side and door windows

- 9.8.1 The visual comfort depends on glass surfaces, light distribution and interior colours.
- 9.8.2 Window design must allow all passengers (sitting and standing position) to have a good vision on the outside and especially on the station information.
- 9.8.3 The body-side and door windows shall be designed to minimise solar gain and provide a level of thermal insulation consistent with the requirements of the air conditioning system.
- 9.8.4 All glass, except the cab windscreens, shall be tinted. The colour may be achieved by tinting the body of the glass. The tint shall not fade throughout the service life of the car.
- 9.8.5 Glazing shall be readily removed and replaced from outside the car without remove the interior linings. Contractor shall provide related repair procedure.
- 9.8.6 Saloon windows shall be provided and be flush mounted with the exterior of the car body.
- 9.8.7 All windows, including those in Passenger Saloon Doors shall consist of:
 - i) outer glass as double glazed laminated glass with PVB film pasted in between,
 - ii) Inner glass which should be of toughened variety,
 - iii) The gap between inner and outer glass shall be permanently sealed against ingress of moisture and to be filled with inert gas.
- 9.8.8 Each window, including glazing shall have sufficient strength to resist penetration of solid steel ball when tested as per Annexure 'A' of IS: 2553 Part-II.
- 9.8.9 Glazing shall imperatively be safety glass (compound or toughened) and the thickness shall be selected to withstand mechanical stress and contribute to sound and heat insulation.
- 9.8.10 All side windows shall transmit less than 5% of the incident ultra violet radiation.

- 9.8.11 All windows shall transmit between 50% and 55% of incident visible light.
- 9.8.12 Deflection at window and door openings under a compressive load of 1000KN and tensile load (reduced in the same ratio as the compressive load in UIC 566/EN 12663) shall not damage the window or door.
- 9.8.13 Glazing strength shall meet the requirements of UIC 564-1.
- 9.8.14 Glazing of windows, on body-side and doors, shall resist to an act of vandalism. The windows shall be high enough to prevent easy breakage.
- 9.8.15 Window seals shall be designed to prevent ingress of water to the inside of walls. The sealing material shall be so selected that it lasts at least the mid-life interval overhauls of car body.
- 9.8.16 Door windows shall have a window similar to the windows provided in the car body as far as possible in respect of solar gain, thermal insulation, replacement criteria, strength, resistance to pressure, and the transmission of light, and solar heat gain.
- 9.8.17 Door windows shall be replaceable without removal of the door leaf.

9.9 Draught Screens

- 9.9.1 Beside all passenger access body-side doorways, shall be provided a longitudinal space, providing a "stand-back" position for passengers to manoeuvre themselves into position when nearing their station.
- 9.9.2 Beyond the stand back area and at the end of the adjacent longitudinal seat a draught screen shall be installed.
- 9.9.3 The draught screens shall be formed from tubular metal grab poles, fitted with clear safety toughened glass, in such a way as to provide uninhibited hand holds to passengers within reach of the tubular metal sections.
- 9.9.4 The strength of the draught screens shall be such that passenger loadings shall not produce any permanent deformation, damage or displacement.
- 9.9.5 Draught Screen shall be adequately supported and the supporting part used shall not come out during the service life.

9.10 Floor

- 9.10.1 Flooring shall remain non-slip and not present a hazard to passengers when wet.
- 9.10.2 The transition between saloon floor, cab floor and gangway vestibule between cars shall be smooth and free from steps and unduly steep gradients, which would impede the flow of passengers between cars.
- 9.10.3 The non-skid floor structure shall be floating floor type comprising of glass wool insulation, stopper, rubber cushion and phenolic composite floor board and floor covering to achieve low noise level inside the cars and less weight. The phenolic composite floor board shall be with Reinforced Rigid Cell Foam Core or equivalent technology. The details shall be submitted and finalized during design phase. **(CDRL-9-5)**
- 9.10.4 The floor installation shall be continuous over the complete area of the saloon without floor traps, gaps, or holes. Either coving sections shall be provided between all floor and vertical sections or the floor coving should extend up into the side wall lining. At all

door openings, the floor shall make a weather-tight connection. No opening in the sub-floor is permitted.

- 9.10.5 ~~The floor covering shall have a proven record of successful use in comparable railway applications; a service life of 20 years should be provided.~~

Addendum-1 dated 05.12.2022, Sl. No. 98

Floor covering shall have a design life of not less than 20 years.

- 9.10.6 It shall be feasible to replace all, or sections of the floor covering and coving during the life of the train if necessary. The floor design shall allow the floor covering to be removed without damage to the floor sub-structure

- 9.10.7 ~~The floor board and its mounting structure, shall be designed to withstand any loads that may be applied over 35 years in normal operation of metro train. Floor shall resist to a load of $1.5 \times AW4$ (950 daN/m^2) and to a stamping effort of 35 daN on a surface of 25 mm^2 .~~

Addendum-1 dated 05.12.2022, Sl. No. 99

The floor board and its mounting structure, shall be designed to withstand any loads that may be applied over 35 years in normal operation of metro train. Floor shall resist to a load of $1.5 \times AW4$ and to a stamping effort of 35 daN on a surface of 25 mm^2 .

- 9.10.8 Floor covering material shall be laid with the minimum number of joints. Floor covering shall be so arranged to ensure that the bend radius required at the plinth base does not coincide with a joint in the covering that will affect the visual continuity between the plinth and floor. Where joints occur, they shall not coincide with those of the floor boards. Joints shall be sealed against the ingress of dirt, moisture and water. Any sealant used shall be coloured to match the background colour of the floor covering.

- 9.10.9 ~~The total floor structure shall provide an effective fire barrier for a minimum 30 minutes to be validated as per EN 45545 (part 1 to 7) latest edition or equivalent.~~

Addendum-1 dated 05.12.2022, Sl. No. 81

The train shall be designed to prevent fire propagation through the use of fire barriers in the floor, and in walls at the sides and ends and fire resistant equipment housings. **Flammable materials shall be well contained and protected. The vehicle floor shall provide a fire barrier of minutes duration tested in accordance with EN45545 Part 1 to 7(Hazard level HL3) latest editions or better equivalent standard.** There shall be no hatches in the floor of passenger areas. Floor hatches in the driving console shall be avoided.

The design and the materials used in the cars shall conform to fire safety requirements of EN45545 Part 1 to 7 (Hazard level HL3) latest editions or better international standards for similar metro operations, subject to the acceptance of the Project Manager

- 9.10.10 The sub-floor shall be insulated for anti-drumming and noise suppression.
- 9.10.11 Floor covering shall show no significant signs of wear. Test results for abrasion shall be submitted.

9.10.12 ~~Flooring shall remain colour fast under the following BS 1006: 1990 conditions specified below. Flooring with minimum colour fastness according to EN ISO 4892-2 or equivalent international standards.~~

- i) ~~Light~~
- ii) ~~Shampoo~~
- iii) ~~Dry cleaning~~
- iv) ~~Water spotting~~
- v) ~~Acid spotting~~
- vi) ~~Alkali spotting~~
- vii) ~~Rubbing~~

Addendum-1 dated 05.12.2022, Sl. No. 100

Flooring shall remain colour fast as specified in **ISO:105-B02 for the following minimum** conditions specified below. Flooring with minimum colour fastness according to EN ISO 4892-2 or equivalent international standards **shall be implemented for resistant to stain, the applicable standard is ISO-26987.**

- i) Light
- ii) Shampoo
- iii) Dry cleaning
- iv) Water spotting
- v) Acid spotting
- vi) Alkali spotting
- vii) Rubbing

9.10.13 Flooring shall be easily cleaned with the minimum of effort using readily available cleaning agents meeting the requirements.

9.10.14 Flooring shall not require glazing, polishing or any other post-production refinishing in short intervals to maintain its finish; the cleaning procedure shall be submitted.

9.10.15 Flooring shall suit regular cleaning schedules and during service and shall not appear dirty between scheduled cleaning.

9.10.16 The flooring shall not be damaged or discoloured by materials usually encountered in depot or service use.

9.11 Inter-Car Gangways

9.11.1 General:

- i) ~~Single piece, double skin gangway with suitable clamping and jointing arrangement on both ends with saloon end walls shall be provided within the unit. In case of separation of cars the gangways shall have securing arrangement and shall not get damaged or de-shaped. The details shall be submitted for Project Manager's review during design phase.~~

Addendum-1 dated 05.12.2022, Sl. No. 101

Single/double piece, double skin gangway with suitable clamping and jointing arrangement shall be provided between cars within the unit. **Double piece, double skin gangways shall be provided in between the 3 car units.** In case

of separation of cars the gangways shall have securing arrangement and shall not get damaged or de-shaped. The details shall be submitted for Project Manager's review during design phase.

- ii) All inter-car gangway structures shall be totally interchangeable with one another.
- iii) The gangway shall be suitable and compatible for Roll angles of 3 degrees and pitching angle of 2 degrees. The Contractor shall perform dynamic simulation (Roll Angle, Lateral displacement, Height Measurement, Yaw Angle, Pitch Angle, etc.) for Line-6, Phase 2A and Phase 2B to determine the relative movements of the vehicle end-faces before designing the gangway. The simulation results and analysis shall be submitted along with the gangway preliminary design. **(CDRL-9-6)**
- iv) The design of Gangway shall be validated with endurance test in real time test rig.
- v) After arriving of the prototype train, the supplier of the Gangway shall perform necessary tests on BMRCL main line to evaluate the performance of the Gangway.
- vi) A suitable draining arrangement shall be provided to prevent the water dripping during cleaning over couplers. The details shall be discussed during design phase.

9.11.2 Exterior

- i) The gangways, when coupled shall be completely weatherproof and draught proof.
- ii) The gap between the station platform edge and the exterior of the inter-car gangway shall be minimised.
- iii) The gangway structure shall lock securely at top and bottom. Locking and unlocking shall be by manual means with single operation levers one each for gathering and latching functionalities.
- iv) The means of uncoupling a semi-permanently coupled pair of cars, in workshop conditions shall be described by the bidder.
- v) To protect the interior of the vehicles when stabled from inclement weather, temporary gangway end covers shall be provided. The covers shall be sufficiently robust to provide good protection, but sufficiently light weight to permit fitting and removal by one person.
- vi) The covers shall be lockable in position to withstand high wind conditions.

9.11.3 Interior

- i) The inter-car gangways shall be arranged so that litter left in the gangway cannot accumulate, and is readily removable, without having to disconnect gangways or remove access covers.
- ii) The headroom in the inter-car gangway area shall be at least 1900mm, and the clear width at least 1400mm.
- iii) The interior design shall be fitted with smooth and aesthetically pleasing panelling and shall ensure that no potential finger or dirt traps exist. The design of panelling shall be made to avoid rubbing of the panels with car body on the track with 100 m radius of curve. The details shall be submitted to Project Manager for review. **[CDRL-9-7]**

- iv) It shall not be possible for a person to move apart parts of the gangway interior cladding in such a way as to gain access to the exterior of the vehicle between components of the gangway, under any circumstances.
- v) The centre line of the gangway shall be coincidental with the centre line of the Vehicles.
- vi) The gangway shall be provided with sufficient thermal and acoustic insulation to ensure that the overall air conditioning performance and noise performance of the Train are achieved.
- vii) ~~Gangway design should ensure noise attenuation of at least 40dB.~~

Addendum-1 dated 05.12.2022, Sl. No. 102

The attenuation of outside noise through the gangway shall not be less than 33dB.

- viii) The gangway shall maintain its performance and remain stable over the full range of relative vehicle movements encountered in normal operation.
- ix) Sealing of the gangway shall eliminate leakage of water into the saloon area.
- x) The elements of the gangway shall give a service life of fifteen years except those susceptible to wear and deterioration, such as gangway flexible elements, which may give a service life of 8 to 10 years.
- xi) The gangway shall withstand without permanent deformation the following loads:
 - A differential pressure between inside and outside of the gangway of $\pm 2.5 \text{ kN/m}^2$.
 - A concentrated perpendicular load, acting from within the gangway, of 1000N applied over an area of 0.1 m^2 anywhere on the surface of the side walls.

9.11.4 Gangway Floor

- i) The floor through the inter-car gangway shall be maintained as nearly as possible at the same height as the rest of the car floor. The height difference shall be kept to a minimum, and at no point shall it exceed 20mm difference from the remainder of the floor. Height changes shall be ramped so as not to cause inconvenience to passengers.
- ii) Vertical gaps between the hinged moving tread-plates of the inter-car gangway and the general floor level of the car shall not exceed 5mm. The means shall be provided to minimise wear of the floor by the sliding action of each moving tread plate.
- iii) The design of the floor shall be such that the relative movement between adjacent vehicle ends does not cause sliding floor plates to lift in such a way as could cause injury, in particular to sandal-clad or bare feet.
- iv) The gangway floor shall be designed to meet the same strength requirements as the rest of the car floor.
- v) Heat and sound insulation measures sufficient to meet internal noise levels and HVAC requirements of the car body shall be provided.
- vi) Sealing of the gangway shall eliminate leakage of any water into the saloon area. Also, the water from saloon shall not go and collect below the gangway floor.

9.12 Interior Illumination System

9.12.1 General:

The lighting system shall generally conform to EN13272. The system shall be based on power LEDs and should meet following requirements in general:

- i) The guaranteed life of the LEDs with their control system and optics/luminary shall not be less than 60000 burning hours.
- ii) The specified illumination level shall be met till at the end of the life of 60,000 hours when the illumination is not less than 70% of their original illumination level.
- iii) The colour of the LEDs shall be day light white (temperature 5000K-6500K). It shall be ensured that all LEDs are selected from same bin to avoid any difference in colour and performance.
- iv) The design of the heat dissipation arrangement shall submit in details with simulated results. **[CDRL-9-8]**
- v) Colour rendering index shall not be less than 80.
- vi) Complete light and energy simulation calculations shall be provided during design to prove validity of the proposed solution.
- vii) The system shall be designed to limit glare and ensure no glare by night time reflections in windows. Luminaries shall be designed to conform relevant international standards.
- viii) The change of chromaticity over the lifetime of the product shall be within 0.007 on CIE 1976 (u', v') diagram or equivalent.
- ix) Luminary efficiency inclusive of LEDs/control gears & optics etc. shall not be less than 100 lm/W at the working junction temperature; higher values shall be preferred.
- x) Design layout of LEDs & their strings/blocks should be such that the failure of one LED should not cause isolation of complete string/block. Similarly, failure of one controller on one string/block should not adversely affect other strings/blocks. Details shall be finalized during design stage.
- xi) Cars may remain unpowered in open sun and internal temperature may go upto 70°C. Suitable protection measures shall be taken to ensure that this does not adversely affect the performance, reliability or efficiency of the lighting system and its components. Verification/validation to the above shall be proposed by the Contractor during design phase.
- xii) Illumination within saloon with LED luminaries shall be designed so as to ensure that the desired maximum illumination level is achieved with LEDs operating at approximately 50% of its rated capacity. However, driver/control unit/optics etc. shall be designed for full rating of the LEDs.
- xiii) All luminaries shall be of LED type and fitting shall be protected and diffused. No exposed light sources will be accepted.
- xiv) LED luminaries and control gears shall be sealed to IP 52 and IP 54, BS EN 60529:1992, respectively to prevent the ingress of dirt and foreign objects.

- xv) ~~After one year, two year and 60,000 operation hours, the colour temperature shall be within $\pm 5\%$, $\pm 8\%$ and $\pm 10\%$ of the initial value respectively.~~

Addendum-1 dated 05.12.2022, Sl. No. 103

~~Deleted.~~

- xvi) LED luminaries shall be designed to withstand switch cycles of 100,000 and test shall be conducted to prove the compliance.
- xvii) ~~The Contractor shall replace all the LED lighting with a newly improved LED lighting if~~
- a) ~~The total cumulative failure rate of the LED luminaries and control gears within DLP exceeds 5% with 20% of LEDs failed in LED luminaries is constituted as a failure of the LED luminaries; or~~
- b) ~~The illumination level at floor level of any five trains drops below 90% of the initial values at the end of two-year operation of each train, by assuming 15 hours daily operation and 365 days of operations.~~

Addendum-1 dated 05.12.2022, Sl. No. 104

The Contractor shall replace all the LED lighting with a newly improved LED lighting if

a) ~~Deleted.~~

b) The illumination level at floor level of any five trains drops below 90% of the initial values at the end of two-year operation of each train, by assuming 15 hours daily operation and 365 days of operations.

- xviii) Since LED technology is fast evolving and the Rolling Stock supply is a long drawn process, sub-supplier shall commit to supply new generation of improved LEDs progressively and which should be compatible with the luminaries already supplied and installed. The Contractor shall regularly update the Project Manager on this aspect during the manufacture. **[CDRL-9-9]**
- xix) Noise generated by the energized LED lighting, fixtures and ballast/control gear installed in a car shall not exceed 50 dBA when measured 1m from the equipment.
- xx) LEDs manufactured by reputed manufacturers shall only be used after taking the prior approval of the Project Manager during Design Review.
- xxi) LED(s) shall have lumen rating as 100 lumen/LED or above.
- xxii) Maximum number of LEDs which a driver/power supply can feed shall not exceed 60 LEDs.
- xxiii) The PC-boards should be easily removed and exchanged, instead of screws and rivets are preferred to use a clip-type locking application for the PC-boards.
- xxiv) During commissioning and subsequently, it may be desirable to adjust the lux level to 250/200 in the saloon. Provision shall be made for adjustment of the lux level within saloon. At least three levels of adjustments i.e. 200 lux/250 lux/300 lux shall be provided in the saloon illumination design as a minimum. Details shall be discussed during design review.

- xxv) Emergency lighting circuits shall be designed to meet the emergency lighting requirement as specified in EN 13272. Dedicated separate circuit shall be implemented from the battery supply to meet the emergency lighting requirement as specified in EN 13272.

The selection of vendor shall be made so as to optimize the design criteria as above.

9.13 Saloon Illumination

- i) Energy efficient, power LED based lights, in luminaries for saloon & gangway meeting flame, smoke and toxicity requirements shall be recessed into the ceiling paneling. The light fittings shall be simple, and arranged not to trap dirt, moisture and insects. Suitable sealing protection shall be incorporated to prevent ingress of dust etc. from AC ducts. The luminaries shall ensure to minimize the glare. Modern state of the art lighting shall be arranged in such a way that it extends along the saloon ceiling.
- ii) All the saloon lights shall work on 110V DC.
- iii) The size and number of light fittings with diffuser shall be sufficient to provide a sensibly constant level of illumination of 300lux at a height of 1.0 m above floor level, along the entire length of saloon
- iv) Separately protected lighting circuits shall be used, such that in the event of one tripping, the others provide evenly distributed lighting throughout the saloon
- v) In the elevated corridors, during daytime, 25% of the lights, evenly distributed over the saloon area, shall remain illuminated. 100% saloon lights shall glow in tunnel in the day time. In night time, Saloon illumination shall be increased to 100%. The changeover shall be automatic as well as driver actuated. Saloon/Emergency lights shall be supervised by TCMS.
- vi) 100% of lamps, evenly distributed over the saloon area, shall remain illuminated, energized even when the train/car passes through non-bridgeable gap
- vii) The control logic shall ensure automatic selection, with manual over-ride, of the saloon light circuit(s) to maximize utilization of the natural light and maintain the desired illumination level. During daytime, the interior lights shall be controlled automatically through dimmer(s) so as to maintain illumination level within acceptable level and reduce the energy consumption. The Contractor shall submit details for review by the Project Manager. **[CDRL-9-10]**
- viii) The Contractor shall submit service life of LED lamp during the design stage which shall be as per the best international practices. **[CDRL-9-11]**
- ix) The Contractor shall submit layout of fittings and control circuit for review by the Employer. **[CDRL-9-12]**
- x) It shall be possible to replace defective LEDs/ block of LEDs with ease and minimum need for readjustments or otherwise.
- xi) The saloon illuminators are to be provided with metal rope of adequate strength such that it can withstand weight of the cover if the cover is opened accidentally. The Contractor may propose some improved arrangement for securing the cover. The details will be finalized during design phase.

- xii) The light units have to be made from aluminium profiles or aluminium sheet. Metal sheet should be avoided in order to save weight.
- xiii) In order to fast maintenance, the light unit has to have hinge for opening the diffuser. The locks of the diffuser have to be self-locking type.
- xiv) All cubicles and under frame boxes shall have sufficient lighting arrangement for facilitating their maintenance related works and it should be supplied from battery line, duly interlocked with door of that cubicle. Lighting in the cubicles for maintenance related works shall be made available even after isolation of control supply of the train. The details will be finalized during design phase.

9.14 Door Indicator Lights

- 9.14.1 An amber indication lamp (Power LED based) shall be located at an appropriate location near each door.
- 9.14.2 The lamp shall remain extinguished when respective door is fully closed and locked.
- 9.14.3 The lamp shall be illuminated when the door is opened, or when the locking mechanism has failed to register, preventing traction circuits from picking up.
- 9.14.4 The lamp shall flash whenever door open/close push button from the active cab is pressed. It shall continue to flash till such time the door is fully opened/closed.
- 9.14.5 When door is manually isolated, Door outside lamp (DOL) and Door inside lamp (DIL) of that door should flash and DOL's & DIL's of other doors should be "OFF" condition.
- 9.14.6 Door indicator lights and control gears shall be sealed to IP 55.

9.15 Maintainability

9.15.1 Cleaning Requirements

- a) The interior layout, materials, and detailed design of the car interior shall be such that one person can clean one car interior of all litter and clean up spillage of solids and liquids within 5 minutes.
- b) The design shall facilitate ease of cleaning and avoid trapping dirt.

9.15.2 Cleaning Philosophy

- a) The Contractor shall submit for approval the cleaning materials proposed for the cleaning of the interior, including graffiti remover.
- b) All materials selected by the Contractor shall facilitate easy cleaning. Materials shall all be capable of being cleaned without any deterioration in the material's appearance, shape or property.
- c) The interior design shall facilitate maintenance of a clean appearance.

9.16 Signage

- 9.16.1 Static signage appropriate to operating and maintenance staff (such as safety and procedural) and name plates (such as car number plates and gangway end identification plate) shall be provided

9.16.2 Static signage shall include:

- i) General regulations such as "Let's keep the air fresh" or "Let's keep the train clean".

- ii) Customer behaviour encouragement such as "Please offer your seat to the disabled" or "Please offer your seat to anyone in need".
 - iii) Operation instructions such as the emergency intercom device and the cab to saloon door.
 - iv) Warning labels such as "Mind the platform gap" and "Keep clear of doors".
 - v) Emergency signs such as the emergency exit signage and directions to emergency exits.
 - vi) Programmable Digital route map above each saloon door.
- 9.16.3 The design and supply of the signage described above shall be the responsibility of the Contractor.
- 9.16.4 All signs within the passenger areas shall either in Kannada/English or Kannada/Hindi/English.
- 9.16.5 The labels for the emergency signage/instructions shall be reflective types.
- 9.16.6 The Project Manager shall determine the position of that. The Contractor shall be responsible for the integration of all of the signage into the interior design such that it shall complement the interior styling.
- 9.16.7 Individual signs shall be fixed so as to enable easy replacement by authorized personnel.
- 9.16.8 The location of individual signs shall be suitably defined in the relevant drawings to enable them to be installed or replaced accurately and neatly by unskilled staff.
- 9.16.9 The door number identification sign shall be provided adjacent to each doorway.
- 9.16.10 Information and warning signs shall be located in the ceiling and door coving panels.
- 9.16.11 At each end of each car, a five-digit car number shall be provided. The number shall be bold style numerals 100mm high. BMRCL will furnish the specific numbering strategy. Numbers shall be on the exterior of both sides of the cars
- 9.16.12 Inside of the car, numbers shall be located at each Emergency Intercom and at each saloon end wall. A number shall also be located for quick reference to train driver in the cab.

9.17 Luggage Rack

- 9.17.1 ~~Suitable provision shall be provided for accommodating luggage of the airport bound passenger without affecting passenger capacity. Details shall be discussed and finalized during design stage. (CDRL-9-13)~~

Addendum-1 dated 05.12.2022, Sl. No. 105

Suitable provision shall be provided for accommodating luggage of the airport bound passenger without affecting passenger capacity **substantially**. Details shall be discussed and finalized during design stage. (CDRL-9-13)

9.18 Deliverables

The Contract deliverables required by this section of the Technical Provisions are listed below:

CDRL-9-1:	Proposals for the metro train layout and seat disposals (ref. ERTS. 9.1.1)
CDRL-9-2:	Details of panel lining (ref. ERTS 9.3.6)
CDRL-9-3:	Technical details of Passenger Seat design (ref. ERTS. 9.4.8)
CDRL-9-4:	Details of layout of stanchions and handholds (ref. ERTS 9.6.4)
CDRL-9-5:	Details of saloon floor (ref. ERTS 9.10.3)
CDRL-9-6:	Details of the recording of movement of gangway (ref. ERTS 9.11.1(iii))
CDRL-9-7:	Technical Interior details of Gangway design (ref. ERTS. 9.11.3 (iii))
CDRL-9-8:	Heat Dissipation Arrangement (ref. ERTS. 9.12.1 (iv))
CDRL-9-9:	Details of new generation of improved LEDs supplied to Rolling Stock (ref. ERTS. 9.12.1 (xviii))
CDRL-9-10:	Details of control logic to ensure automatic selection of desired illumination level (ref. ERTS. 9.13 (vii))
CDRL-9-11:	Details of Service Life of LED Lamp (ref. ERTS. 9.13 (viii))
CDRL-9-12:	Details regarding layout of fittings and control circuit of LED (ref. ERTS. 9.13 (ix))
CDRL-9-13:	Details of Luggage Rack Arrangement (ref. ERTS. 9.17.1)

10 BOGIES

10.1 General Requirements and Features

- 10.1.1 The bogies shall be of the two axle bolster less type incorporating a primary suspension system of proven steel-and-rubber or helical coil steel springs with vertical and lateral dampers, and a secondary pneumatic suspension system, and with axle bearings outboard of the wheels.
- 10.1.2 It shall be constructed to continue in service, under normal operating conditions for at least 35 years, assuming normal wear and tear, and maintenance. During that period, there shall be no major rebuild, repair or strengthening of any bogie structural members. However, the service life of rubber bonded metal components shall not be less than eight (8) years and shall be warranted for the same.
- 10.1.3 The bogie shall be track friendly and particularly suitable to negotiating small radius curvature up to 120 m in main line services and 100 m in the Depot. Axle shall negotiate the curves so that it takes radial position on the sharp curves. Bidder shall indicate the minimum radius of the curves on which axles will take the radial position.
- 10.1.4 The characteristics of the suspension shall give a low transmissibility of vibration to the car body and minimise both impact and vibration noise. The suspension frequencies shall be sufficiently separated from the fundamental bogie and body frequencies to ensure that resonance does not occur.
- 10.1.5 All bogies shall be subjected to Type and Routine testing in accordance with the requirements of ERTS clause 20.10.
- 10.1.6 All bogies shall comply with the dynamic performance requirements as specified in ERTS clause 10.2 and 20.5.
- 10.1.7 The maximum permissible static load per axle is 15.0 Tonnes (AW4) and to be designed for a maximum operational speed of 80 km/h. All vehicles shall be so designed and tested that no part of the car shall infringe the Kinematic Envelope for 90km/h.
- 10.1.8 ~~Bogie wheel base shall be 2200mm. Bidder may propose suitable bogie wheel base in order to limit the rail wear in small curve radius (120m with grade compensation on main line and 100m on depot) to achieve the stability performance.~~

Addendum-1 dated 05.12.2022, Sl. No. 106

Bogie wheel base shall be 2200mm. Bidder may propose suitable bogie wheel base **not exceeding 2300mm** in order to limit the rail wear in small curve radius (120m with grade compensation on main line and 100m on depot) to achieve the stability performance.

- 10.1.9 The bogies, body-bogie attachments and equipment attached to bogie frames and axle boxes must comply with the requirements of EN 12663.
- 10.1.10 Bogies shall be designed and manufactured to have as many items as possible to be interchangeable between motor bogies and trailer bogies.
- 10.1.11 Car body and bogie construction tolerances and distortions shall be controlled within the specified limited tolerances, if necessary suitable shims to be provided to maintain

the tolerances. If shims are required for permanent use, the same shall become a permanent fixture on the bogie and or car body

10.1.12 The design shall provide means for easy compensation for wheel wear and loss of height in the bogie resulting from other causes.

10.1.13 The bogie and bogie mounted equipments shall be designed to minimize unsprung mass.

10.1.14 Bogies proposed to be supplied against the bid shall be of proven design principles. Similar bogies as proposed for this bid, shall have been in use and have established their satisfactory performance and reliability on at least three (3) mass rapid transit systems in commercial / revenue service over a period of three years or more (in each MRTS) either outside the country of origin in three different countries or in Indian Metros. The bidder should submit performance certificate on the letter head of metro operator, confirming that the supplied bogies have completed satisfactory performance for more than three years. Bidders must submit following information with their offer:

- i) Statement indicating commissioning dates of bogies and numbers, duly certified by the metro operators.
- ii) Details of the designer and manufacturer (complete address) of the supplied bogies.
- iii) Following details of the metro systems where the bogies are in operation:
 - a) No of stations with details of inter-station distances
 - b) Average Annual kilometers earned
 - c) Details of sharp curve (Minimum radius) **(CDRL-10-1)**

10.1.15 In case, the bidder is not the manufacturer of bogies and intends to procure the bogies proposed to be supplied against the bid from a sub-contractor, the proposed sub-contractor for the bogie shall meet the eligibility requirements as stated in ERTS clause 10.1.14 above. Further, during contract execution, the manufacture of the bogies by the sub-contractor shall be required to be inspected and certified by a reputed Third Party Inspecting Agency engaged by the Contractor having sufficient previous experience of similar nature. The Contractor's proposal for engaging Third Party Inspecting Agency with detailed Terms of Reference (TOR) indicating detailed scope of work shall be submitted to Project Manager for the approval not later than six (06) months from the Effective Date. However, maintaining the quality standards, ensuring performance requirement and timely delivery shall be the sole responsibility of the Contractor.

10.2 Dynamic Requirements

10.2.1 Dynamic requirements shall be compliant with the specific Indian regulations and legislation.

10.2.2 ~~The bogie suspension, in conjunction with the car body, shall be designed to enable cars to operate satisfactorily on track with the maximum specified track twist. The maximum off loading of wheels 'AQ/Q' shall not exceed 50% of nominal wheel load in inflated up to maximum permissible speeds and shall not exceed 60% of nominal wheel in deflated conditions up to maximum permissible speeds.~~

[Addendum-1 dated 05.12.2022, Sl. No. 107](#)

The bogie suspension, in conjunction with the car body, shall be designed to enable cars to operate satisfactorily on track with the maximum specified track twist. The maximum off-loading of wheels ' $\Delta Q/Q$ ' shall not exceed 50% of nominal wheel load in inflated up to maximum permissible speeds and shall not exceed 60% of nominal wheel in deflated conditions up to maximum **safe** permissible speeds.

- 10.2.3 The axle yaw stiffness and the rotational resistance of the complete bogie shall be such that lateral flange forces generated when negotiating the track alignments for the route specified are not so high as to lead to excessive rail wear and wheel flange wear but shall be sufficient to obviate bogie or wheel set hunting.
- 10.2.4 The Contractor shall submit calculations to confirm that the derailment quotient Y/Q shall be less than 1 under the most adverse conditions, where Y & Q are the instantaneous lateral force on the wheel flange and the instantaneous vertical load on that wheel tread respectively under the most adverse conditions.
- ~~10.2.5 The Contractor shall submit calculations to confirm that ride index lateral and vertical shall not exceed 2.5 under all normal operating conditions for new vehicles and new track and shall not exceed 3 under all normal operating conditions for worn-out vehicles operated on rundown track conditions.~~

Addendum-1 dated 05.12.2022, Sl. No. 108

The Contractor shall submit calculations to confirm that ride index lateral and vertical shall not exceed **2.75** under all normal operating conditions for new vehicles and new track and shall not exceed 3 under all normal operating conditions for worn-out vehicles operated on rundown track conditions.

- 10.2.6 The bogie rotational resistance (X factor) test under inflated and deflated air spring conditions would be carried out at the manufacturer's works under AW0 and AW4 conditions, the value of which should not exceed 0.08 at rotational speed of 0.8 degrees/second. The rotational resistance shall neither cause excessive flange wear nor cause any possibility of flange climbing but shall be adequate to avoid bogie hunting on straight track. The Contractor shall show by analysis that no flange climbing occurs on any curve specified here when the car is in the new condition and on a worn condition and moving at all possible speeds.
- 10.2.7 A Dynamic Analysis, to evaluate the running behaviour of the vehicle with the proposed bogie design, shall be carried out by means of theoretical calculations applying multi-body simulation techniques. The following parameters, at the minimum, shall be evaluated /analysed.
- i) Natural frequencies of the suspension.
 - ii) Stability of the vehicle and any tendency to hunt.
 - iii) $\Delta Q/Q$ for the track twist.
 - iv) Bogie rotational resistance.
 - v) Wheel wear index at the tread and flange.
 - vi) Derailment quotient Y/Q .
 - vii) Carbody accelerations.
 - viii) Curving capability and any tendency to hunt

- ix) Ride index lateral and vertical
- x) Coefficient of flexibility

The Contractor shall submit a proposal covering the scope of the analysis for review by the Project Manager. **(CDRL-10-2)**

- 10.2.8 ~~The Contractor shall engage an experienced International Consultant who shall carry out validation of the design of the proposed bogie and shall also carry out/validate dynamic simulation as specified in ERTS clause 10.2.7 above. The Project Manager's decision in this regard shall be final. The consultant's report shall be discussed with the Contractor's design engineer and changes/improvements if required to be implemented shall be considered by the Contractor.~~

Addendum-1 dated 05.12.2022, Sl. No. 109

During design stage the Employer may engage an experienced International Consultant who shall also carry out validation of the design of the proposed bogie. The consultant's report shall be discussed with the contractor's design engineer and changes/improvements if required to be implemented shall be considered by the Contractor.

10.3 Bogie Construction: Bogie Frame

- 10.3.1 ~~The bogie frames shall as a minimum be of fabricated, robust construction, using weather resistant high tensile carbon steel compliant to EN 10025-1 to 5/ JIS G3114 capable of withstanding heavy duty, the design incorporating adequate safety margins. The bogie frame construction shall be consistent with good mechanical design, be as light as possible made of cold or hot rolled plates and forged and cast parts. Use of cast steel inserts of acceptable grade in fabrication of bogie is permissible with specific prior approval of the Project Manager.~~

Addendum-1 dated 05.12.2022, Sl. No. 110

The bogie frames shall as a minimum be of fabricated, robust construction, using high tensile carbon steel compliant to EN 10025-1 to 5/ JIS G3114 **or an approved international standard**, capable of withstanding heavy duty, the design incorporating adequate safety margins. The bogie frame construction shall be consistent with good mechanical design, be as light as possible made of cold or hot rolled plates and forged and cast parts. Use of cast steel inserts of acceptable grade in fabrication of bogie is permissible with specific prior approval of the Project Manager.

- 10.3.2 The welded design shall also be fully substantiated by the Contractor through analysis and test particularly regarding limitation of fatigue stresses in welded zones. Modified Goodman diagrams shall be submitted to Project Manager including calculated stress levels showing that fatigue stresses are within allowable limits and also critical weld drawings shall be submitted for approval. **(CDRL-10-3)**
- 10.3.3 The Contractor shall submit for review detailed calculations, including finite element analysis as per manufacturing drawings under different boundary conditions. Strain gauge and other bogie test results shall be correlated with the FEM results. (i.e. Making a comparison of bogie frame strain gauge test result and FEM analysis results). The bogie frames for all the cars shall be identical unless justified otherwise. **(CDRL-10-4)**

- 10.3.4 ~~All bogie frames shall be inspected by visual and magnetic particle methods as per inspection and testing plan. The visual and magnetic particle inspection procedures shall be verified by radiographic inspection. A full radiographic inspection shall be performed as per inspection and testing plan during series production.~~

Addendum-1 dated 05.12.2022, Sl. No. 113

All bogie frames shall be inspected by visual and magnetic particle methods as per Inspection and testing plan. The visual and magnetic particle inspection procedures shall be verified by radiographic inspection. A radiographic inspection **at critical joints on bogie frame** shall be performed as per inspection and testing plan.

- 10.3.5 The Contractor shall undertake full static load test, full fatigue test strain gauge and suitable non-destructive tests on a pre-production bogie frame and submit the report **(CDRL-10-5)**. The strain gauge fixing locations and the application of forces for static as well as for fatigue testing shall be reviewed by the Project Manager before start of testing. These tests have to be done as per EN 13749.
- 10.3.6 All fasteners for bogie mounted equipment or components shall be weather resistant and positively locked. The use of self-locking nuts alone is not acceptable.
- 10.3.7 Adequate corrosion protection shall be provided. Details shall be submitted. A corrosion protection control programme for the bogie shall be submitted. **(CDRL-10-6)**

10.4 Bogie Strength

- 10.4.1 ~~The mechanical strength of the bogie frame shall comply with the requirements of UIC 615-4 and UIC 515-4 for static test under exceptional loads and fatigue tests. The maximum stress developed under static load shall not exceed 85% of the yield strength of the material. The dynamic effects due to the inertia of the motors and transmission shall also be simulated along with traction and braking forces.~~

Addendum-1 dated 05.12.2022, Sl. No. 111

The mechanical strength of the bogie frame shall comply with the requirements of UIC 615-4, UIC 515-4, **EN 13749** for static tests including **service loads**, exceptional loads and for fatigue tests. The maximum stress developed under static load shall not exceed 85% of the yield strength of the material. The dynamic effects due to the inertia of the motors and transmission shall also be simulated along with traction and braking forces.

- 10.4.2 ~~The number of seated passengers shall be taken as one per seat and standing passengers as 10/m² (AW5) for all the above mentioned strength analyses. The passenger weight for this calculation shall be taken as 65kg/person.~~

Addendum-1 dated 05.12.2022, Sl. No. 112

The number of seated passengers shall be taken as one per seat and standing passengers as **10 passengers/m² (AW5)** for all the above-mentioned strength analyses **except for fatigue test**. The passenger weight for this calculation shall be taken as 65kg/person.

10.4.3 Loads:

- i) ~~Proof. The bogie structure shall withstand the following static load cases without permanent deformation or any form of damage or deterioration.~~

- ~~Vertical: 1.8 times of the sum of the maximum Structural Design Condition Weight (AW5) static pivot load and the bogie sprung mass. The load shall be applied vertically in equal parts at the secondary suspension points and reacted at the axles.~~
- ~~Lateral: The load equal to that applied to a bogie when the car is subjected to a load, applied at the car centre of gravity, which is sufficient to cause overturning of the car. The car shall be assumed to be in the condition of loading and air suspension inflation/deflation, which requires the greatest lateral load to cause overturning.~~
- ~~Longitudinal: 5g times the total bogie mass applied longitudinally in equal parts at the axles and reacted at the body/bogie connection. The maximum static pivot load shall be applied at the same time.~~
- ~~Twist: 10⁻⁶/₁₀₀ of track twist shall be sustained by bogie frame in the AW5 load.~~

Addendum-1 dated 05.12.2022, Sl. No. 114

Proof: The bogie structure shall withstand the following static load cases without permanent deformation or any form of damage or deterioration.

- Vertical: **1.4** times of the sum of the maximum Structural Design Condition Weight (AW5) static pivot load and the bogie sprung mass. The load shall be applied vertically in equal parts at the secondary suspension points and reacted at the axles.
- Lateral: The load equal to that applied to a bogie when the car is subjected to a load, applied at the car centre of gravity, which is sufficient to cause overturning of the car. The car shall be assumed to be in the condition of loading and air suspension inflation/deflation, which requires the greatest lateral load to cause overturning.
- Longitudinal: **3g** times the total bogie mass applied longitudinally in equal parts at the axles and reacted at the body/bogie connection. The maximum static pivot load shall be applied at the same time.
- Twist: 10⁻⁶/₁₀₀ of track twist shall be sustained by bogie frame in the AW5 load.

- ii) ~~Fatigue. Assessment of fatigue for fabricated steel structures shall be in accordance with UIC 515-4, a survival rate of 98.5%. The fatigue damage shall be assessed separately for each of the vertical, lateral and twist load cases given below, and also for any load cases arising from the requirements of the additional loads. The total damage resulting from the combination of the individual damages shall be provided for information.~~

- ~~Vertical: ±25% of the AW4 Weight applied vertically for 10 million cycles.~~
- ~~Lateral: ±15% of the AW4 Weight applied laterally for 10 million cycles.~~
- ~~Twist: 1 million complete reversals of the wheel off loading which results when a car with the air suspension normally inflated and in the AW4 condition passes over the track twist.~~
- ~~Traction/Braking: 10 million complete reversals of the loads applied to the bogie when a vehicle in AW4 condition accelerates and decelerates under its maximum tractive effort and decelerates at emergency brake rate.~~

Addendum-1 dated 05.12.2022, Sl. No. 115

Fatigue. Assessment of fatigue for fabricated steel structures shall be in accordance with UIC 515-4, **UIC 615-4 & EN 13749**, a survival rate of 98.5%. The fatigue damage shall be assessed separately for each of the vertical, lateral and twist load cases given below, and also for any load cases arising from the requirements of the additional loads. The total damage resulting from the combination of the individual damages shall be provided for information.

The fatigue load shall be decided based on actual loading which shall correspond to AW3 loading conditions. The loading cycles shall be as specified in respective standard. There shall not be any crack at the end of any stage of loading cycles. The passenger weight for this calculation shall be taken as 65 kg/person.

- iii) Additional Loads. The Contractor shall ensure that any other loads that may arise on the bogie due to the particular configuration chosen are adequately taken into account. These additional loads shall include, but not be confined to those caused by the effects of motor inertia, equipment inertial loads, damper loads, and the effects of passenger loading and unloading.

10.5 Primary and Secondary Suspension

- 10.5.1 All vehicles shall be so designed that no part of the car shall infringe the Kinematic Envelope at any speed up to 90 km/h.
- 10.5.2 Suspension characteristics shall be selected so as to avoid resonance between the various elements of the vehicle system including the car body. Bogie and body frequencies shall be suitably separated.
- 10.5.3 The primary suspension shall be designed to accommodate the appropriate vehicle weight. The secondary suspension shall be pneumatic in operation, with automatic vehicle body to bogie height adjustment functional for all vehicle loading conditions to ensure that the vehicle floor height is compliant with the requirements for passenger access as defined in Clause 9.5 of ERTS.
- 10.5.4 ~~The primary suspension shall be designed to ensure that the creep amount in 10 years later shall not exceed 5mm under worst condition.~~

Addendum-1 dated 05.12.2022, Sl. No. 116

The primary suspension shall be designed to ensure that the creep amount in 8 years later shall not exceed 5mm under worst condition.

- 10.5.5 Vehicle height variation due to wheel wear and re-profiling shall be adjusted by packing. Preferably, this shall be made possible without disconnection or removal of the car body from the bogie. Levelling of the car once adjusted, shall not get disturbed during operation or otherwise and shall not require any adjustment except for usual adjustments due to wheel wear and placement of shims. The maximum floor height reduction on this account shall be for review by the Project Manager.
- 10.5.6 Under the worst condition of track, along with deflated air springs & maximum deflection of primary springs and wheels with maximum tread wear, the minimum clearance of body mounted equipments from rail level shall not be less than 102mm under dynamic and static conditions of vehicle in AW4 condition.

- 10.5.7 Under the worst condition of track, along with deflated air springs & maximum deflection of primary springs and wheels with maximum tread wear, the minimum clearance of bogie mounted equipments from rail level shall not be less than 75mm under static condition and 65 mm under dynamic conditions of vehicle in AW4 condition.
- 10.5.8 In addition, the above conditions shall be satisfied when one of the following abnormal operating conditions occurs as well as any combination of the above normal operating and track conditions:
- i) Any one primary spring element failed and collapsed.
 - ii) Any combination of secondary air springs deflated.
 - iii) Wind forces gusting up to 125 km/h.
- 10.5.9 Drawings showing car extreme positions for each of the above conditions and a bogie envelope in relation to the car is required by Conceptual Design Stage, if all related information is available.
- 10.5.10 Particular attention shall be given to the limitation of car body roll. Under most extreme roll, car shall not violate the dynamic envelopes. The air spring shall have over inflation protection. The maximum permissible increase in height will be decided during design stage.
- 10.5.11 The car body of each car shall be supported by four air springs, i.e. two per bogie. Secondary suspension shall be provided by a pair of double stage emergency springs that are spatially flexible.
- 10.5.12 The secondary suspension shall be pneumatic in operation, with automatic vehicle body to bogie levelling height adjustment functional for all vehicle loading conditions to ensure that the vehicle floor height does not vary by maximum 5 mm at the four corners when the car standing on level track.
- 10.5.13 Secondary suspension emergency springs, which shall become operative in the event of full deflation of air springs, shall be fitted. The car shall remain dynamically stable throughout the full speed range (0 to 90km/h) of the train under all conditions when secondary air springs are functional. In the event of one air spring becoming wholly or partially deflated on any bogie, the complete air spring system of that bogie shall be correspondingly exhausted to ensure that the car body remains level laterally and can continue to operate safely. Safe speed to operate the train in this condition shall be calculated during design stage. The safe speed at which the train can operate will be verified through oscillation trials to the same safety and statutory limits with either complete (full coach) or partial deflation (one bogie) of the secondary springs.
- 10.5.14 All elements of the suspension shall be so chosen as to avoid resonance at operational speeds and to reduce oscillations (low frequency, high amplitude) and vibrations (high frequency, low amplitude) as perceived on the car body to a minimum and to meet the minimum requirements below.
- 10.5.15 ~~Hydraulic dampers of suitable capacity shall be provided symmetrically to control and limit the vertical and lateral oscillation of the car body. The damping factor in vertical mode, by wedge test, when tested using a wedge of 18mm thickness should be between 0.20 and 0.25. The damping factor in lateral mode when measured by "quick release side pull test" should be between 0.30 and 0.40. Suspension will not be considered acceptable if maximum acceleration and spring displacements do not~~

~~decay within 2-3 cycles. No leakages of any kind shall be permitted. The dampers overhaul shall not be required before 8,00,000 Kms.~~

Addendum-1 dated 05.12.2022, Sl. No. 117

Hydraulic dampers of suitable capacity shall be provided symmetrically to control and limit the vertical and lateral oscillation of the car body. The damping factor in vertical mode, by wedge test, when tested using a wedge of 18mm thickness should be between 0.20 and 0.25. The damping factor in lateral mode when measured by "quick release side pull test" should be between 0.30 and 0.40. Suspension will not be considered acceptable if maximum acceleration and spring displacements do not decay within 2-3 cycles. No leakages of any kind shall be permitted.

- 10.5.16 The air spring pressure shall also be used to provide an average signal input to the load weighing equipment for load compensation of the propulsion, brakes and air-conditioning systems. If the load signal fails, the system shall consider 'AW4' loading as default value. Air pressures of all the four air springs (per car) shall be taken accurately to determine the actual average load.
- 10.5.17 Pressure switch shall be fitted to monitor any fault with deflated air springs on each bogie. The status of the air suspension shall be reported to the TCMS and OCC.
- 10.5.18 Air suspension isolating cock shall be provided for each bogie to enable car levelling operation. The operation status of the air suspension isolating cock shall be reported to TCMS.
- 10.5.19 In case secondary suspension getting deflated during run, propulsion system shall automatically impose suitable speed restriction. The details shall be submitted to Project Manager for review. **(CDRL-10-7)**

10.6 Bogie to Body Connection

- 10.6.1 The car body bogie connection shall be capable of permitting the full range of bogie movements without excessive restraint.
- 10.6.2 Traction and braking forces shall be transmitted between bogie frame and carbody suitably by central pivot / traction linkage. Lateral forces between bogie and body shall be contained by a combination of components of the secondary suspension including air springs and progressive stops.
- 10.6.3 Traction linkage(s) / central pivot shall be provided and located such that the ride characteristic of the vehicle is devoid of any pronounced fore and aft and pitching motion.
- 10.6.4 Dampers shall be provided to control vertical and horizontal motion about the secondary springs if the air springs do not incorporate sufficient damping capacity.
- 10.6.5 There shall be stops of the bogie and/or car body to restrict the maximum angle of rotation, if required in service. The lateral stop shall be cushioned using a properly designed stiffness value. The lateral stops shall be sourced from Vendors having proven experience. Specific approval shall be obtained from the Project Manager.
- 10.6.6 Flexible cable and hose loops between the bogie and car body shall be adequate to allow the full range of bogie movement in service and maintenance. The loops shall be suitably clamped and shielded to prevent chafing. No tension loads must be taken by the termination.

10.6.7 Not Used.

10.6.8 Body to bogie connections shall be easily accessible to facilitate easy exchange of bogies. Flexible hose connections shall not be capable of being mismatched.

10.6.9 The bogie shall be attached to the car body in such a way as to permit lifting of car body and bogies as a complete unit. The Contractor shall indicate the minimum safety factor used, taking account of the yield stress for all support members.

10.6.10 The car body to bogie connection shall withstand the following loads without permanent deformation:

- (i) A vertical load of 0.75 times the AW4 weight of the carbody (excluding bogies).
- (ii) A lateral load of half AW4 body weight subjected to an acceleration of $\pm 1.1g$.
- (iii) A longitudinal load equivalent to the bogie mass subjected to an acceleration of $\pm 3.0g$.

10.6.11 Bogie and car body connection shall be designed to avoid the transmission of noise and vibration.

10.6.12 Longitudinal forces between car body and bogies shall be considered according to the rules in UIC 615-1, clause 4.2.

10.7 Bogie Mounted Equipment

10.7.1 Provisions, including mechanical and electrical interfaces, shall be made for the installation of the following bogie-mounted signalling equipment.

10.7.2 Provision shall be made to mount a current collector assembly on each side of all bogies. Provision shall be made to adjust the collector assembly vertically upward from tare position to account for wheel wear.

10.7.3 Bogie mounted components, requiring regular inspection and renewal shall be readily accessible for both inspection and replacements. A brake block/brake pad shall be easy to replace by one man working on a car where all air pressure has been removed.

10.7.4 The train equipment shall conform to IEC 61373 in respect of shocks and vibrations including the endurance limits both for fatigue and peak vibration levels. These shall be incorporated in the type test of the equipment.

10.7.5 The Contractor shall ensure that any other loads that may arise on the bogie due to the particular configuration chosen are adequately taken into account. These additional loads shall include, but not be confined to those caused by the effects of motor inertia, equipment inertial loads, damper loads, and the effects of passenger loading and unloading.

10.7.6 The accelerations and loads do not include the effects of locally generated loads or accelerations caused by the configuration of equipment or resonance. The Contractor shall ensure that any such conditions are adequately considered.

10.7.7 The Contractor shall submit detailed finite element calculations to demonstrate that the requirements have been achieved. **(CDRL-10-8)**

10.8 Motor Suspension

10.8.1 The traction motor shall be bogie frame mounted, complete with suitable drive and suspension.

10.8.2 Traction motors and drives shall be easily removable in a workshop, after disconnection of cables and fixings without the need to disturb the axle. Individual motors shall be removable by a vertical lift after the bogie has been removed from the vehicle body.

10.8.3 Calculations indicating the natural frequency of the motor suspension system shall be submitted and shall clearly indicate that resonance with the bogie frame is avoided.
(CDRL-10-9)

10.8.4 A gearbox suspension for frame-mounted motors shall be provided together with safety brackets to provide secondary support where appropriate. Attention is drawn to the need to provide adequate strength to accept forces due to solid track base. The clearance between wheel axle and motor should be enough preventing the wheel axle is scratched by the motor.

10.9 Gearbox and Coupling

10.9.1 Contractor shall provide flexible coupling between traction motor and drive gear.

10.9.2 The gearbox shall be compatible with the flexible coupling. Gear box movements shall be restrained by a torque reaction link between the gearbox and bogie frame. A safety device shall be incorporated to restrain gearbox rotation should the link fail in service.

10.9.3 The gears shall be splash oil lubricated and a sight glass shall be provided in the gear case for inspection. It shall not be necessary to change the oil earlier than 200,000km. Suitable arrangement shall be provided in the gear case to trap magnetic impurities in the gear case lubricant.

10.9.4 The gearbox shall be subjected to a test based on the actual duty cycle on a specified Corridor with the specified torque and speed conditions. Testing shall start with gearbox at temperature of at least 35°C and temperature shall be continuously monitored. The temperature shall not exceed the manufacturer's recommendations consistent with life between oil changes. Test shall be carried out in both the directions. Noise and vibration test shall also be performed along with this test.

10.9.5 The gears including bearings shall not require overhaul at least earlier than 1.0 million km. Comprehensive, flexible and fully automatic test bench(s) shall be provided (two sets, one for each depot) to test an overhauled/newly assembled gear case with transmission arrangement and duly mounted on the wheel set. The specification shall be got approved from the Project Manager.

10.10 Wheels, Wheelsets, Axles and Axle-boxes

10.10.1 The wheels shall be mono-block-forged steel, complying with the requirements of UIC Code 812-3/EN 13262, grade ER8 (for 1435 gauge). Grade of the material shall be decided during the design stage when rail details will be available. The technical approval procedures for wheels shall be in accordance with EN13979-1.

10.10.2 Based on type of rail, rail profile and rail inclination specified in ERTS clause 2.3.1 (track characteristics), the Contractor shall propose wheel tread profile for most optimal vehicle performances. The profile recommended in UIC 510-2 Appendix B can be considered.

10.10.3 Diameter of the wheels shall be 860 mm maximum or less when new. Optimal diameter in order to get maximum life span shall be proposed by the Contractor. Details of new wheel profile parameters and worn out wheel profile parameters with

relevant drawing and technical details shall be submitted. The maintenance limit for wheels shall be within limits recommended in UIC 510-2 OR and SOD adopted by BMRCL. **(CDRL-10-10)**

- 10.10.4 Efforts shall be made to reduce the squealing in curves by ensuring the correct alignment of wheel flange lubricator installed in the train. This must be confirmed by main line tests.
- 10.10.5 The wheel hubs shall be provided with a bore hole to ensure hydraulic assist wheel take-off. Wheels are balanced according to requirements of UIC.
- 10.10.6 Wheel sets shall be protected using a paint system, which will protect the wheel set from damage by corrosion for at least the period between bogie overhauls without maintenance.
- 10.10.7 The Contractor shall submit comprehensive details of his wheel set design. **[CDRL-10-11]** The submission shall include, as a minimum, axle detail drawings, axle design calculations, wheel detail drawings, wheel design calculations, details and description of any noise damping measures and wheel set assembly drawings and procedures.
- 10.10.8 Easy access shall be provided to both ends of all axles to allow ultrasonic testing of the axles. It shall be possible to carry out ultrasonic testing with the wheel set in site under the vehicles.
- 10.10.9 The Contractor shall submit procedures for testing of a free-standing assembled wheel set and for testing of a wheel set in site under a vehicle. It shall include location of testing and refer to test standards. **[CDRL-10-12]**
- 10.10.10 Wheel sets shall comply with requirements as per EN 13260/UIC Codes 811, 813-1.
- 10.10.11 The axle shall be designed in accordance with UIC 515-3/EN 13103-1 latest edition. Axle material shall conform to EN 13261 EA4T for motor axles and EA1N for trailer axles.
- 10.10.12 The powered and non-powered axles shall comply with UIC Code 811-1/EN 13261.
- 10.10.13 Wheels, axles, drive gears and axle bearings shall be assembled on axles by an interference fit method. Oil injection grooves shall be provided as appropriate.
- 10.10.14 The Contractor shall furnish the extreme maintenance limits for wheels according to UIC standard. **[CDRL-10-13]**
- 10.10.15 ~~Objective is that the cars shall achieve approximate of 3,00,000 kilometres before re-profiling of the wheels is necessary, whilst operating on the routes as specified in both corridors. The Contractor shall provide a reprofiling program in order to optimise the life span during the design stage and it shall be verified during the operation.~~

Addendum-1 dated 05.12.2022, Sl. No. 118

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- 10.10.16 Grease lubricated cartridge bearings shall be used. The bearing shall be such that no attention is required between bogie overhauls.
- 10.10.17 The front and rear seal shall prevent the ingress of water and/or cleaning fluids to the bearing both during normal running and during cleaning.

- 10.10.18 The Contractor shall carry out bearing life calculations to demonstrate that the selected size of bearing is adequate for L10 bearing life of 3,000,000 km under AW4 car loading (including dynamic force effects) in accordance with the method given in ISO 281/1. The Contractor shall provide adequate training to the Project Owner's Maintenance Personnel for overhauling of the axle bearings and shall also provide two sets of the special tools required for overhauling in each depot. The cost of such tools shall be deemed to be included in the quoted price. Details to be finalized during design stage
- 10.10.19 The housings shall incorporate seals to prevent leakage of grease and infiltration of water and dirt and maximize lubricant life. Bearing lubricant shall not, in any circumstances, be allowed to leak or discharge on to the wheel surface.
- 10.10.20 Natural frequencies of the wheels, axles, axle boxes and other un-sprung equipment shall have sufficient separation between natural frequencies with the track structure to avoid resonance.
- 10.10.21 Wide range of lubricants with different characteristics is already available in India. Use of any of these lubricants, especially those which have performed well in similar uses is preferred. In case the Contractor proposes to use other lubricants, he shall simultaneously evaluate the characteristics of lubricants available in India and indicate the equivalent lubricant that can be used for maintenance.
- 10.10.22 The wheel load deviation and axle load deviation shall conform to IEC 1133:1992.
- 10.10.23 Axle end covers shall consider the required axle end components, such as grounding, speed, sensors, etc.
- 10.10.24 Axle bearing boxes shall be isolated with respect to secure the bearing from electrical shocks.
- 10.10.25 Complete axle bearing assembly (axle bearings and bearing boxes) shall be from/of a single approved vendor.

10.11 Bogie Brake Equipment

- 10.11.1 Please refer to ERTS Chapter 11 - "Pneumatic Air Supply and Brake System".

10.12 Pipe work, Hoses and Miscellaneous

- 10.12.1 Braking pipes, hoses and conduits shall be installed such that risk of damage such as from flying ballast is minimized.
- 10.12.2 Braking pipes and conduits shall be supported with suitable cleats at intervals of not greater than 400 mm. Cleats shall be positioned so as to avoid high stressed areas of the bogie frame.
- 10.12.3 It shall be physically impossible for flexible hose connections to be mismatched.
- 10.12.4 Rigid pipes and fittings on bogies shall be stainless steel approved by Project Manager. Pipe work shall be designed in such a way as to prevent electrolysis, wear, fatigue or structural failure for the life of the car and that a minimum clearance to the bogie frame and unconnected equipment of 8mm is maintained.

10.13 Wheel Flange Lubrication (WFL) Equipment

- 10.13.1 Oil type Wheel flange lubricators (oil type) of a proven design in EMU/ metro application shall be provided only at both driving ends (front wheels) of each train. A

suitable mechanism shall be provided to ensure that lubricators operate only in the leading position on the train actuate suitably during traversing of the curves automatically and shall be effective for all wheels, the purpose of the WFL shall be to reduce wear of wheel and track/rail and reduce noise in the curves.

- 10.13.2 ~~The design of WFL system shall ensure precise & cyclic application of lubricant on the flange of the wheel(s) so that the lubrication application is uniformly distributed on the flange surface without any excess deposition on the contact surface. There shall be no flow of lubricant on the tread/braking surface under any circumstance. The system shall be designed to minimize oil and air consumption. Single tube system shall be preferred. The nozzles shall be designed to protect against choking /clogging due to dust. There shall be no movable part in the nozzle. The design shall permit optimized control of oil spray in curved track by suitably modulating the spraying cycles and quantity of oil in the spray. The spray cycle as above shall be programmable and shall be fine-tuned during field trials and performance of wheels during DLP. The programming tools shall be supplied to Employer (two sets, one set for each depot).~~

Addendum-1 dated 05.12.2022, Sl. No. 119

The design of WFL system shall ensure precise & cyclic application of lubricant on the flange of the wheel(s) so that the lubrication application is uniformly distributed on the flange surface without any excess deposition on the contact surface. There shall be no flow of lubricant on the tread/braking surface under any circumstance. The system shall be designed to minimize oil and air consumption. Single tube system shall be preferred. The nozzles shall be designed to protect against choking /clogging due to dust. There shall be no movable part in the nozzle. The design shall permit optimized control of oil spray in curved track by suitably modulating the spraying cycles and quantity of oil in the spray. The spray cycle as above shall be programmable and shall be fine-tuned during field trials. The programming tools shall be supplied to Employer (two sets, one set for each depot).

- 10.13.3 The actuation, spray cycle and quantity of lubrication shall be activated at a specific location in a curve or just before the curve by TCMS based on the coordinates and parameters of the curves communicated to TCMS by the ATC system or through GPS. WFL ON/OFF status and WFL system healthy status will be available in TCMS. It will be possible to isolate the equipment through TCMS in case of any defect/malfunctioning. It shall be the responsibility of Rolling Stock manufacturer to interface with Signalling & Train Control, TCMS supplier, Wheel Flange Lubrication supplier and Track contractor to finalize the same during design, manufacturing and commissioning phase. **(CDRL-10-14)**
- 10.13.4 Provision shall also be made in bogies to permit fitment of dry type flange lubricator on 50% axles in a train. The complete arrangement (including applicator) shall be installed by the Contractor, except the lubricator sticks. The cost of the sticks shall be borne by Project Owner/Employer. Details shall be submitted for Project Manager's review during design phase.

10.14 Maintainability

- 10.14.1 The bogie frame shall be fitted with suitable locations for lifting off the wheels and axles, for lifting the complete bogie frame during maintenance in the workshop and

- for re-railing a car or bogie. Jacking pad location shall be provided to match the shop equipment during the design stage.
- 10.14.2 In addition, the design of the bogie frame shall incorporate horizontal and vertical pads at diagonal positions for re-railing operations following derailments.
- 10.14.3 Turning in the pit with a wheel lathe shall be often performed in remote workshops without dismantling parts.
- 10.14.4 The bogies shall be capable of being cleaned using high-pressure hot water or steam jet cleaning equipment, with or without detergents. All closed sections and pockets shall be self-draining or sealed against water ingress. All bearings shall be adequately sealed to ensure that water and cleaning fluids do not enter during the cleaning process.
- 10.14.5 Bogies shall be capable of being disconnected and reconnected easily and with a minimum of operations by personnel working in pits or alongside the bogies. It shall be possible to easily inspect for correct reconnection without the need for special tools or instruments.
- 10.14.6 In case of axle being locked, it shall be possible to suitably lift the wheels of locked axle for placing the affected wheels on Emergency wheel skate. The Contractor shall interface with Track contractor of BMRCL and Emergency wheel skate supplier to ensure that during the towing movement, parts of the Emergency wheel skate are not infringed or obstructed by upstand or check rail or by any other way side equipments of BMRCL track. During design phase, it shall be ensured that lifting of the wheels of the locked axle for placing on towing equipment shall be possible without any infringement of bogie or body mounted equipments during the wheel lifting. Necessary calculation or documents shall be submitted to the Project Manager for review. **[CDRL-10-15]** Towing operation shall be demonstrated and validated on BMRCL main line. Three sets of Emergency wheel skate along with accessories shall be supplied.
- 10.14.7 The target interval between bogie overhauls shall be not less than 1.2 million kilometres of service operation. The Contractor shall furnish inspection, maintenance and operational schedule of the bogies along with the intervals.
- The bogie shall provide easy and safe access for all maintenance, including access for train operator to operate the isolating cocks for bogie-mounted equipment and parking brake manual release.
- 10.14.8 It shall be possible for personnel working in pits or alongside the bogie to visually inspect the condition of bogie components, such as brakes and wheel treads, easily and without the use of special tools.
- 10.14.9 Lubricated bearings shall be adequately sealed to ensure that water and cleaning fluids shall not enter during the cleaning process.
- 10.14.10 Arrangements shall be made to exchange wheel sets with the minimum dismantling of bogie components being required. The procedure for dismantling shall be furnished.
- 10.14.11 The arrangement should allow the bogie to be mechanically disconnected, permitting the body to be lifted sufficiently far to provide access between body and

bogie to disconnect traction motor cables, brake system flexible pipe connectors, and secondary suspension levelling valve linkages, etc.

10.14.12 Body to bogie connection shall be easily accessible to facilitate exchange of bogies.

10.14.13 The bogie shall provide easy and safe access for all maintenance, including access for train driver to operate the isolating cocks for bogie-mounted equipment and parking manual release.

10.14.14 The attachments between the body and the bogie shall be such that if the car is lifted without disconnecting the bogies, the bogies, traction drives and wheelsets shall be retained captive to the car without the need for additional restraints at the time of lifting. No damage shall result to any of the connections as a result of this action.

10.15 Obstruction Deflection/Detection and Derailment Detection Device (ODD)

10.15.1 At the front of the Driving Motor Car (DMC), an obstruction deflection/detection and derailment detection device shall be installed to push away objects/obstacles on track to avoid derailment. The actuation of the deflection device due to impact of the objects/obstacles shall initiate the emergency brake and shall be recorded by the TCMS. The design of obstacle deflection device and its mounting arrangement shall be proven and should be use in similar metro applications.

10.15.2 The Contractor shall submit the detailed calculation of design proof load, installation arrangement, safety against derailment, energy absorbing capabilities etc. during detail design. **[CDRL-10-16]**

10.16 Deliverables

The Contract deliverables required by this section of the Technical Provisions are listed below:

CDRL-10-1:	Proven design principles (ref. ERTS 10.1.14)
CDRL-10-2:	Dynamic Analysis of the vehicle (ref. ERTS 10.2.7)
CDRL-10-3:	Calculations of stress levels (ref. ERTS 10.3.2)
CDRL-10-4:	Review of detailed calculations & finite element analysis of Bogie Frame (ref. ERTS 10.3.3)
CDRL-10-5:	Review of full static load test, fatigue test strain gauge and suitable non-destructive tests of bogie frame (ref. ERTS 10.3.5)
CDRL-10-6:	Corrosion Protection Control Program (ref. ERTS 10.3.7)
CDRL-10-7:	Proposal for Automatically Impose of Suitable Speed Restriction on Propulsion system (ref. ERTS 10.5.19)
CDRL-10-8:	Finite element calculations for bogie mounted equipment (ref. ERTS 10.7.7)
CDRL-10-9:	Calculations indicating the natural frequency of the motor suspension system (ref. ERTS 10.8.3)
CDRL-10-10:	Proposal of maximum life span for Diameter of wheel. (ref ERTS 10.10.3)
CDRL-10-11:	Comprehensive details of wheel set design. (ref ERTS 10.10.7)
CDRL-10-12:	Testing procedure for free-standing assembled wheel set. (ref ERTS 10.10.9)

CDRL-10-13:	Maintenance limits for wheels according to UIC standard. (ref ERTS 10.10.14)
CDRL-10-14:	Details for Wheel Flange Lubrication (ref. ERTS 10.13.3)
CDRL-10-15:	Wheel towing operation (ref. ERTS 10.14.6)
CDRL-10-16:	Detailed design calculation of Obstruction Deflection Device. (ref ERTS 10.15.2)

11 PNEUMATICS, AIR SUPPLY AND BRAKE SYSTEM

11.1 General

- 11.1.1 Each 6-Car train set shall comprise of two 3-Car unit and each 3-car unit shall be fitted with a complete "stand alone" compressed air supply system with adequate provision for redundancy to meet the reliability requirements. A minimum of two air compressors shall be provided for 6-Car train set.
- 11.1.2 The working pressures (up to 10 bar) of the compressed air system shall be sufficient to meet all the requirements for the associated components that require the supply of compressed air.
- 11.1.3 The pneumatic brake isolation devices (Bogie Isolation cock- BIC and Electro-Pneumatic Isolation cock-EPIC) shall be provided and shall be located in the saloon area for brake isolation. Each brake isolation device shall only be capable of isolating the brakes on one bogie. Each brake isolation device shall be locked with a breakable seal and the appearance shall be distinguishable from other similar devices. The brake isolation devices located inside the saloon shall be operable from the doorway position, but inaccessible to passengers (duly protected by a lockable cover). Once operated, the isolation shall be readily discernible to operation and maintenance staff and shall be displayed on TCMS. The details shall be submitted and finalized during design phase. **(CDRL-11-1)**
- 11.1.4 The Pneumatic and Air Supply System shall consist of, but need not be limited to the following:
- i) Air compressor(s) unit and 3-phase 415V induction motor drive.
 - ii) Air dryer and filtration components.
 - iii) Reservoirs.
 - iv) Pressure governors and switches.
 - v) Pipe system.
 - vi) Air suspension equipment.
 - vii) Automatic coupling actuating equipment.
 - viii) Ancillary pneumatically driven devices.
 - ix) CCD actuating device.
- 11.1.5 The brake system and components shall be proven, state of art and widely used in modern metro Rolling Stock. The brake components, valves etc. shall have been in use and have established their satisfactory performance and reliability on at least three mass rapid transit systems in commercial / revenue service over a period of last three years or more (in each MRTS) outside the country of origin & in three different countries. The options for brake system have been specified in clause 11.4.6. Train braking performance shall be as specified in Chapter 3, Clause 3.7.2 and shall be designed for 90 KMPH. The operational speed shall be 80 kmph. The system shall generally conform to EN13452.
- 11.1.6 Complete brake system function description explanation should be submitted. **(CDRL-11-2)**

11.2 Brakes, principles and blending rules

- 11.2.1 Braking performance of 6-Car metro train shall be in accordance to ERTS clause 3.7.2 of Chapter -3.
- 11.2.2 The Contractor shall provide information regarding the braking application modes and performances (braking curves, wheel rail adhesion ratio, electro dynamic brakes, response time, blending rules...).
- 11.2.3 The Direct service brake application and release shall be smooth and step less from the maximum speed to 0 km/h.
- 11.2.4 The brake system of 6-Car train set consisting of two identical 3-Car unit shall consist of:
- i) Electro-pneumatic friction brake (EP): For inadequate dynamic brake capability, emergencies and failures, a pneumatic friction brake shall be provided. The friction brake shall be capable of sustaining the continuous full emergency braking requirements. It shall also be used during service braking to supplement and continuously blend with the Electro-Dynamic (ED) brake. The brake force shall be corrected automatically depending on the load in order to avoid too high deceleration with an empty metro train.
 - ii) The Electro-Dynamic (ED) brake: Instantaneous full-service deceleration as specified in ERTS clause 3.7.2 of Chapter-3 shall be achieved by Electro-Dynamic (ED) brake only in the speed range of 65 Kmph to 5 Kmph. ED brake shall take priority over the electro-pneumatic friction brake (EP) and full use of its capability shall be made in attaining any rate of service braking. The objective is to use the regenerative brake (ED) to the maximum degree possible in order to reduce wear on the friction brakes.
 - iii) Brake pipe control back up brake system.
 - iv) A spring applied air-release parking brake.
 - v) Wheel slip & slide protection.
- 11.2.5 The blending between Electro-Dynamics (ED) and Electro-Pneumatic (EP) friction brakes shall be done in the following way:
- i) doing an equitable sharing between all axles of the whole metro train;
 - ii) limiting the effort up to the normal adhesion request level (18% in tunnel, 16 % at grade and super-elevated sections), taking into account the effort produced by the electrodynamics brake. Consequently, if the adhesion limit is reached on an axle, the missing force is shared in the same way as before, on the axles being within the adhesion limit.
- 11.2.6 Brake blending logic shall ensure priority of Electro-Dynamic (ED) braking over Electro-Pneumatic (EP) braking. If the demanded brake effort is not achievable solely by the Electro-Dynamic (ED) brakes, the Electro-Pneumatic (EP) brake system shall supplement it. In case of failure of ED brake of any DMC or MC, missing braking effort shall be compensated by other healthy cars. Electric regenerative brake fade out shall start from 5 kmph only. For the given PWM Brake demand signal, the Brake effort achieved shall be same during the transition from ED to friction Brake. After the speed is reduced to a very low speed, holding brakes shall be applied to prevent the train from rolling backwards at station stops and gradient. The details shall be submitted and finalized during design phase. **(CDRL-11-3)**

- 11.2.7 Maximum brake operating timing including dead time, response time and measures in service and emergency braking modes shall be compliant with EN 13452-1 and EN 13452-2 (operation performances).
- 11.2.8 Jerk limits and measures in service and emergency braking modes shall be compliant with EN 13452-1 and EN 13452-2.
- 11.2.9 Any malfunction of the brake control system which can cause an unsafe operation shall result in an emergency brake application. In case of single point failure in brake control system, which can be automatically isolated and fully compensated without affecting the train performance, the application of emergency brake should be avoided. In case, full compensation is not available, the train control system shall impose a suitable speed restriction so that the braking distances are not exceeded.
- 11.2.10 All the pneumatic control equipment and valves shall be mounted in the enclosed lockable boxes, made of stainless steel.
- 11.2.11 The air supply and distribution systems shall be arranged such that any single type failure can be readily isolated such that full performance capabilities are maintained.

11.3 Emergency Braking

- 11.3.1 Emergency braking in normal mode is performed in friction brake only.
- 11.3.2 Emergency braking shall be caused by the train driver intentionally or by opening of contacts of safety devices in the brake loop, provided in the design, to avoid unsafe conditions. Two brake loops shall be provided; one normal and the other redundant.
- 11.3.3 Emergency brake is applied by friction brake system. Electro-dynamic regenerative brake shall be isolated during emergency braking. The Emergency braking shall be load weighed. Emergency braking rate as specified shall be achieved from 80 km/h to 0 km/h up to AW4 loading condition of the train on level tangent track.
- 11.3.4 Two emergency brake push-buttons shall be installed in each cab in the train. Activation of the buttons, including that of non-active cabs, shall apply the emergency brakes under all conditions.
- 11.3.5 Unintended parting of a metro train shall result in an emergency brake application on both halves of the train.
- 11.3.6 Wheel slide protection shall be available during emergency braking. Any failure in the wheel slide protection in emergency braking shall result in the application of full emergency brake force (load corrected) and deactivation of the slip/slide system.
- 11.3.7 Activation of the emergency brake by any means shall result in the propulsion system being disabled in a safe critical manner. The propulsion system shall not be re-enabled until the train is at zero speed and the emergency condition has been reset.
- 11.3.8 The Contractor shall furnish emergency braking distances to standstill, for a train in AW4 condition from speeds, starting from 10 km/h to 80 km/h in increments of 10 km/h and for 80 km/h including wheel rail adhesion ratio. **(CDRL-11-4)**
- 11.3.9 The friction brake system shall be rated to and have sufficient thermal capacity to safely complete two successive acceleration and emergency brake cycles, with no interval between each cycle. Each cycle shall comprise a full acceleration from standstill to 80 km/h followed by the application of emergency brake to standstill. On the completion of the two cycles, the brake system shall show no abnormalities. The requirement shall be demonstrated during testing.

11.3.10 ~~Following minimum SIL levels at train level shall be complied for the brake system:~~

~~Emergency Brake : SIL 4~~

~~Service Brake : SIL 2~~

~~Holding brake application and feedback: SIL 2~~

~~WSP (Watchdog/Safety Timer): SIL 4~~

~~The Contractor shall submit relevant certifications for the SIL levels as above.~~

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Following minimum SIL levels at train level shall be complied for the brake system:

Emergency Brake: SIL 4

Service Brake (excluding Electric Regenerative Braking): SIL 2

Holding brake application and feedback: SIL 2

WSP (Only Watchdog/Safety Timer): SIL 4

The Contractor shall submit relevant certifications for the SIL levels as above.

11.4 Electro-pneumatic friction braking

11.4.1 The friction brake system shall be provided for limited dynamic brake capability, emergencies and failures. The friction brake system shall be designed to supplement and continuously blend with the electro-dynamic braking.

11.4.2 When a train is at standstill, there shall be sufficient retention of brakes such that the train does not roll back on a 4% gradient. The brake application shall be retained while traction power is applied and the train takes forward movement.

11.4.3 ~~The friction brake system shall be proven and capable of independently achieving all performance requirements for a continuous round trip with maximum speed of 65 Kmph with AW3 load without the aid of electric braking.~~

Addendum-1 dated 05.12.2022, Sl. No. 121

The friction brake system shall be proven and capable of independently achieving all performance requirements for a continuous round trip with maximum speed of **50 Kmph** with AW3 load without the aid of electric braking.

11.4.4 The Contractor shall submit a detailed description and calculations of friction brake performance. **(CDRL-11-5)**

11.4.5 In the event of a failure of the dynamic brake, the friction brake shall be capable of carrying out two consecutive emergency brake applications from maximum speed down to standstill of a Train in AW4 Loading condition.

11.4.6 The metro train shall be provided with either wheel mounted disc brakes or tread brakes in all cars. However, for better maintainability or interchangeability only one type of brake shall be preferred.

11.4.7 Disc and brake pad/brake block wears are automatically compensated by an adjuster integrated to the actuator. If wheel mounted disc brake is provided, life of wheel disc shall be optimized and effort shall be taken to match the life of wheel disc with wheel life.

11.4.8 The friction brake actuation system shall be in accordance with the following general requirements:

- i) It shall be capable of reliable operation in service without the need for any routine attention between overhaul periods.
 - ii) It shall be capable of functioning satisfactorily without the need for routine lubrication between the overhaul periods.
 - iii) The design of the friction brake equipment shall permit the equipment to be removed from, and refitted to, the bogie from above (by crane) or below (using a lift table), without any need to disturb the axle or bogie.
- 11.4.9 Brake pad/brake block shall be of high-grade composite material and shall contain no toxic material and be compliant with the UIC standards. Heating by brake pad shall in no case cause the disc material to exceed its permissible temperature limits above which incipient thermal surface cracks appear. The brake pad/ brake block shall be proven in metro train operation. Brake friction materials shall not contaminate the wheels or rails adversely so as to affect train detection by the Signalling System.
- 11.4.10 The choice of friction braking material shall ensure the following requirements are met:
- i) The required braking power is provided under all conventional service conditions (dry and wet).
 - ii) The wear life shall be maximized to demand minimum maintenance.
 - iii) The performance of the friction braking material shall be consistent throughout its life.
- 11.4.11 The friction braking materials shall be able to be easily, quickly and safely changed by unskilled personnel without the need for special tools. It shall be possible to easily inspect brake block/brake pad and wheel mounted discs/wheel tread "in situ" without the need to remove or dismantle any components.
- 11.4.12 A common friction braking material shall be used for all bogie types and shall be interchangeable between all car types.
- 11.4.13 Due consideration shall be given to minimizing life costs of brake equipment and the generation of noise and odour when selecting friction braking material.
- 11.4.14 In case of problem of brake system of a bogie, the facilities shall be provided to isolate the affected bogie through Bogie Isolating Cock (BIC) provided in the passenger saloon area. The position of Bogie Isolating Cock (BIC) shall be monitored by TCMS. Isolation of any bogie shall popup an alarm in TCMS VDU and OCC for information and acknowledgement.
- In case of isolation of BIC, the control system shall automatically impose restriction on the maximum operating speed of the train based on number of BIC's isolated. The level of the speed restriction corresponding to isolation of BIC shall be proposed by the Contractor taking in to consideration of braking distance and other safety issues involved in mainline operation.
- If the no of bogies isolated is such that 1 more bogie isolation will result in GEBR violation, the speed restriction shall be imposed such that the braking distance is not exceeded upon isolation of one more bogie. If no. of bogies isolated is more than the minimum bogies required to achieve Guaranteed Emergency Brake Requirement (GEBR), then traction block shall be applied. However, it shall be possible to override

the traction block and a speed restriction of 10 kmph (configurable) shall be applied. Speed restrictions shall be finalized during design stage. RS contractor shall interface with Signaling contractor to implement the function in ATP/ATO/UTO mode of operation.

The details shall be submitted for Project Manager's review during the design stage.

11.5 Electro-dynamic braking

11.5.1 The principal service brake shall be dynamic (regenerative) to maximise the available energy. The Electro-Dynamic brake shall take priority over the pneumatic friction brake to utilise the regenerative energy to the maximum degree possible in order to reduce wear on the friction brakes, by ensuring that the dynamic brake provides full braking from maximum speed down to a minimal low speed. At this low speed, a blend of Electro-Dynamic braking and Electro-Pneumatic brake shall be used to stop the Train. During the blending process, a consistent overall braking effort with a seamless transition between the various types of brake shall be achieved.

11.5.2 The motor cars shall provide the dynamic brake that the regeneration is maximized and the wear of the friction brake equipment is minimized.

11.5.3 The braking effort shall be distributed among the trainset such that the maximum use of the available adhesion is achieved in meeting the demanded braking effort.

11.5.4 Response times during brake blending shall be minimized to facilitate a smooth and non-jerky operation.

11.5.5 Within the jerk limits specified, the electric brake shall be built up as rapidly as possible to maximize regeneration and minimize wear of the friction brake.

11.5.6 The Electro-Dynamic brake shall be continuously available from 80 Kmph down to around 5 Kmph for the purpose of minimizing the friction brake wears and maximizing the regeneration of energy within the limits of adhesion. Instantaneous full-service deceleration as specified in ERTS clause 3.7.2 of Chapter-3 shall be achieved by Electro-Dynamic (ED) brake only in the speed range of 65 Kmph to 5 Kmph. The friction brakes shall provide the final stopping force. Electro-Dynamic brake curves, speed/traction curves shall be provided by the bidder/Contractor for a 6-car metro train composition. **(CDRL-11-6)**

11.5.7 Regenerated energy during Electro-Dynamic braking (ED) shall be utilized as under:

- i) Under normal circumstances, Electro-Dynamic braking (ED) shall have the first priority in the braking process. The regenerated power shall be used either by the auxiliary system of the same train or will be utilized by the other trains on the line.
- ii) In case the Third Rail voltage transiently increases up to 900V DC due to injection of regenerated power and Third Rail is not able to receive the regenerated power, excess regenerated energy during braking shall be dissipated in brake resistor after being utilized by the same train. A suitable rated brake resistor shall be provided.
- iii) When the Third Rail system continues to be either partially or totally non-receptive, Electro-Dynamic braking shall still be maximized. This shall be done by means of a smooth transition from receptivity of regenerative to Third Rail system or partial

or full destroying of regenerated energy in to brake resistor and vice versa until the receptivity of the third rail system is resumed.

- iv) When there is no Electro-Dynamic brake available, the total required brake force shall be provided by the friction brake.

11.5.8 The braking system shall be automatically and continuously monitored to detect any equipment or control failures that could impair braking performance or compromise safety. Such failures shall be transmitted / announced to the operator's console.

11.5.9 The brake equipment shall be capable of withstanding surge and transient voltages, either induced or directly coupled, without damage or failure and without affecting the operation on the Vehicle. In the event that any protective device is used, it shall be automatically re-settable, once activated. The brake equipment shall also be capable of withstanding random transients or intermittent loss of the Traction Supply, without causing any malfunction or irregular operation of the braking system.

11.6 Brake Pipe (BP) Controlled Back-up Brake System

11.6.1 A BP controlled back-up system including a separate pneumatic control unit shall be provided in order to take over the control function in case of failure of electronic or electric control elements in the brake system. In case of such failure, the operator can continue to control braking by using the back-up brake. This system shall also be used to control brake system of dead train during rescue by a healthy train, transit of cars and shunting operation

OR

Alternatively, Contractor shall provide extension of EP brake and emergency brake lines from healthy train to defective train through small E-head connector with limited number of pins provided on the front automatic couplers of the trains to enable the application of service and emergency brake in the defective train from the healthy train. The E-head connector housing shall have protection level not less than IP65 and shall be designed to automatically protect the connector against dust and water. The cover shall harmonize with the external finish. The system shall ensure the integrity of these lines by built-in self-test and also their isolation in case of extension of feed to the faulty brake lines of the defective train. Detail shall be submitted for Project Manager's review during design phase. **(CDRL-11-7)**

11.6.2 The back-up brake control unit shall be ergonomically placed on operator's console and shall have three positions for application, charging and lap modes.

11.6.3 During the operation of this mode, the dynamic brakes shall be isolated and the pneumatic brake application shall be resorted to.

11.7 Parking brakes

11.7.1 Parking brake: a spring actuated brake with an emergency release device shall be provided as parking brake. The spring-actuated brake shall be designed in order to prevent the rolling-off of the metro train in standstill with the maximum passenger load AW4 (8 persons /m²) on the maximum gradient (4 %) and under the worst weather conditions and wind.

11.7.2 The parking brake can be applied and released manually through push-buttons installed on the driver's desk. The corresponding magnet valves should be housed

either inside the cab area or inside the saloon area. A means for manual release of each parking brake (at bogie) which can be accessed from track level without the need to reach underneath the car shall be provided.

- 11.7.3 The operation (apply or release) of Parking brake shall also be implemented through TCMS and it shall apply automatically when train is getting switched off. In case parking brake is applied then traction shall not be possible.
- 11.7.4 ~~The parking brake force on individual axles shall not be so large as to inhibit emergency train recovery or to give rise to locked wheels during recovery. The maximum wheel/rail adhesion level to be assumed for the "push-out" requirement shall be 0.1.~~

Addendum-1 dated 05.12.2022, Sl. No. 122

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- 11.7.5 In the case where the parking brake application is demanded by the train driver, the time for parking brake application shall not exceed 15 seconds.
- 11.7.6 Parking brake actuators shall incorporate automatic anti-compounding devices to prevent applied braking forces from exceeding the larger of the individual force produced by parking or full service brake applications.
- 11.7.7 The parking brake shall not give any additional frictional braking force when full service brake is applied.
- 11.7.8 Progressive application of the parking brake shall occur when the main reservoir air pressure falls below a specific pressure. The progressive application shall be nominally linear and shall be such that the parking brakes will take effect prior to fade off of friction brake and shall ensure that the combined brake effort of the friction brake and parking brake is never less than the full brake effort of the parking brake alone.
- 11.7.9 Subsequent application of air pressure shall automatically release and reinstate normal operation of the parking brake.
- 11.7.10 ~~Under conditions of a dragging parking brake for a minimum distance of 3 kilometres, no damage shall be caused to the braking system or any bogie component, with the exception of abnormal shoe wear. Detailed figures to be provided during preliminary design stage.~~

Addendum-1 dated 05.12.2022, Sl. No. 123

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- 11.7.11 The Contractor shall provide calculations to support his compliance with the performance requirements. **(CDRL-11-8)**

11.8 Braking control logic

- 11.8.1 The braking equipment shall not operate unless a direction signal and a braking demand signal are received, as well as receiving a signal representing the level of demand, transmitted via the same train highway as that for motoring. In the event of loss of the direction signal, the brake system shall revert to friction only. Changes in the level of brake demand shall result in an appropriate and corresponding change in brake retardation.

- 11.8.2 The brake control system shall be capable of receiving inputs from the combined traction brake controller in the controlling car and also the signal for the level of brake demand from the ATC system.
- 11.8.3 ~~The Contractor shall submit the details of the brake control system interfaces with the vehicle control circuits, The Propulsion system, the Master Controller, PWM generator/ Digital control and ATP/ATO etc. The brake control system logic shall have adequate redundancy and back up to meet the requirements as per ERTS 15.3.11. The details shall be submitted and finalized during design phase. (CDRL-11-9)~~

Addendum-1 dated 05.12.2022, Sl. No. 124

The Contractor shall submit the details of the brake control system interfaces with the vehicle control circuits, the Propulsion system, the Master Controller, Digital control and ATP/ATO etc. The brake control system logic shall have adequate redundancy and back up to meet the requirements as per ERTS 15.3.11. The details shall be submitted and finalized during design phase. (CDRL-11-9)

- 11.8.4 An emergency brake control system shall be provided by two independent Hard-Wired brake loops. Emergency braking shall be applied by de-energisation of an emergency magnet valve as a consequence of break in emergency brake loop. The break can be caused by the train operator intentionally or by opening of contacts of safety devices in the brake loop to avoid unsafe conditions. Two brake loops shall be provided; one normal and the other redundant. Both brake loops shall be controlled by separate feeder MCB. No electronic circuit components shall be directly coupled to this circuit. In the event of an emergency brake application, motoring and dynamic braking shall be inhibited and the emergency brakes shall remain applied until the metro train comes to a complete stop.
- 11.8.5 The system shall provide adequate protection against brake binding and give indication to the TCMS and OCC.

11.9 Brake Control

- 11.9.1 Each car shall be driven with fail safe Brake Electronics Control Unit (BECU) and an associated Electro-Pneumatic Brake Control Unit (BCU). The redundancy shall be provided at BECU level in each car. The BECU shall perform the following functions:
- i) on receipt of a brake demand, the service brake shall be applied at the correct and corresponding level having regard to the vehicle weight (from information provided by the pneumatic suspension system);
 - ii) when a change in braking effort is demanded, the BECU shall control the rate of change to be in accordance with the specified levels of jerk and response times;
 - iii) the BECU shall maximise the use of the Electro-Dynamic brake at all times by interfacing with the traction system with minimum time delay. Any shortfall in the effort provided by the dynamic brake shall be achieved using the friction brake;
 - iv) ~~during braking, if the Electro-Dynamic braking is operating and is providing all the required effort, the BECU shall maintain sufficient EP brake pressure to keep the shoes nearly in contact with the disc/wheel tread but shall not contribute to any braking effort or cause wear to the brake pad/brake block and discs/wheel tread;~~

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- v) All the BECU of the 6-Car train set shall be connected through Ethernet backbone with redundancy. It shall be possible to upload the software and download the fault records and trace data from all the BECUs through single point. Brake Electronic control unit shall have provision for logging of selectable parameters (by BMRCL) and faults with related data. The memory shall be extendable. Provision shall be available for continuous logging or logging triggered by a particular event of User selectable parameters (upto 4 at a time) for a period of upto 24 hrs. The memory shall be adequate to store the above data including additional minimum 20,000 incidents. Provision shall be available to download the stored data. Supply of any special tools complete with requisite software (one set for each depot) required for the above shall be included in the quoted cost. Training shall be organized by the OEM trainer for adequate duration before the commissioning of first 10 trains.
 - vi) the brake system shall have in-built self-diagnostic features compatible with the TCMS to enable fault log information to be accessed through the TCMS. A comprehensive set of indications shall be available on the BECU to display major faults. The fault indications shall be electrically latched when the faults are detected and shall illuminate whenever the supply to the electronics is switched on. The information contained within the fault log shall be stored on non-volatile memory.
 - vii) In case of failure/isolation of brake of any car, the missing brake force shall be compensated by the other cars automatically by the brake system. The details shall be submitted for Project Manager's review during design phase. **(CDRL-11-10)**
 - viii) The brake control circuits and logic shall be implemented in such a way that Isolation of brake of one bogie/car shall not affect the operation of the brake of the other bogies/cars. Similarly, in case of failure of BECU of one car, the function of this BECU shall be taken over by redundant BECU of the same car.
- 11.9.2 The associated EP brake unit (BCU) shall contain all the pneumatic items necessary to control all applications of the friction service brakes and emergency brakes on that Vehicle. The emergency brake control valves independent of the service brake control valves shall be controlled directly from the emergency brake train control lines. The friction emergency brake shall be fail safe and of "energise to release" type.
- 11.9.3 The emergency brake loop shall be a high integrity fail safe hard wired and fibre optic circuit and shall in no way be allowed to be bypassed due to an error in operation.
- 11.9.4 The mechanism of brake force/vehicle weight adjustment employed shall ensure a full proportional adjustment is achieved through the braking range between Tare Loading and Crush Loading conditions.
- 11.9.5 The method by which the passenger load-sensing signal is processed shall be arranged to ensure that absence of the signal, for any reason, shall result in a brake force being applied corresponding to a 'AW4' Loading condition on that Vehicle.
- 11.10 Brake Operating Timing**
- 11.10.1 The following maximum brake operating timing shall be achieved on all cars of a train. The maximum time for a brake application from full application to 90% of full Brake

Cylinder Pressure (BCP) and for brake release from full Brake Cylinder pressure to 10% shall not exceed the following:

- i) Service Brake Application : 2.0s
- ii) Emergency Brake Application : 1.5s (max.)
- iii) Service and Emergency Brake Release: 2.5s.

11.11 Air Compressor

11.11.1 Equipment using compressed air shall be grouped by function. Each function shall be capable of being isolated from the air supply.

11.11.2 Air compressor shall be of proven design in metro train operations for at least 5 years from pistons types. Oil free compressor type is required. However, Contractor is required to establish that its reliability, maintenance requirement and life of the components including bearings, cylinders, piston etc. shall not be inferior to oil lubricated compressor.

11.11.3 Minimum life of high-pressure piston ring shall be 4 years (6,000 operating hours) and overhauling shall be in 8 years (12,000 operating hours). The Contractor shall submit the details to prove that they will meet this requirement during design phase. **(CDRL-11-11)**

11.11.4 Two compressors shall have sufficient capacity to charge a completely empty six-car train including full air suspension inflation within 20 minutes. The average duty cycle of each compressor without electric braking shall not exceed 50% during operation. The Contractor shall submit calculations to show that the capacity of the compressor will meet the worst conditions. **(CDRL-11-12)**

11.11.5 An "intelligent air compressor management" shall be provided to ensure that the compressors on a 6-car train are operated during fill-up and both the compressors in the train are operated alternatively thereafter, to avoid moisture condensation in the compressor due to low duty cycle.

11.11.6 During normal operation, the leading car compressor is running and its duty cycle shall not be more than 50% of running time at a declared rate of leakage, based upon the brake and auxiliary air requirements of the metro train, where duty cycle is determined as:

$$\text{Duty Cycle} = \frac{\text{Total Compressor Running Time On Load} \times 100\%}{\text{Total Vehicle Service Time}}$$

11.11.7 The Contractor shall submit the Air consumption calculation, duty cycle calculations for review and approval. **(CDRL-11-13)**

11.11.8 The time required to charge up to full main reservoir line pressure of a metro train (with all reservoirs—and equipment at atmospheric pressure), including full air suspension inflation shall be less than 20 minutes.

11.11.9 In the event of total failure of electro-dynamic brakes and one air compressor on a fully loaded six-car train (6 car fixed composition), the remaining air compressors on the train shall have sufficient capacity to enable the train to remain in service for at least 3 hours and temperature rise in the motor while working continuously for 3-hours on load shall be within the safe limit. **(CDRL-11-14)**

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- 11.11.10 The Contractor shall by calculations or otherwise establish that the compressor will meet the above conditions.
- 11.11.11 The compressor shall be directly driven from an associated AC compressor motor. The drive motor shall conform to the requirement of IEC 60349-2 and the temperature rise of the windings of the motor shall be limited to temperature index of the insulation minus 70° C. The motor shall have at least IP 65 protection.
- 11.11.12 The compressor shall be designed to achieve a minimum of 12,000 hours of running time between overhauls. Routine maintenance shall not be required at a frequency more than once per year.
- 11.11.13 The compressor and all associated equipment shall be installed as an integrated independent module suspended beneath the under-body on resilient mountings. In the event of a failure of the resilient mounting arrangement, the compressor module shall remain secure and adequate safety stops shall be provided to prevent the compressor or the associated equipment from falling from the Vehicle. Rubber mounting pad shall be of proven design. The compressor and associated pneumatic equipment shall be so positioned as to facilitate access for maintenance and ensure freedom from noise, vibration and discomfort to passengers and train crew.
- 11.11.14 The motor-compressor unit is operated by means of the pressure switch set to cut-in within a range of 7.5 to 8 bar and to cut-out at 10 bar. Detailed figures shall be defined during design process to achieve the required number of subsequent emergency brake applications.
- 11.11.15 A pressure governor compressor shall be provided, which shall be capable of withstanding a pressure not less than the 'open' pressure of the safety valve without damage or deterioration. Safety valves shall be provided to protect the system from over pressure. A non-return valve shall be provided between the compressor and the main reservoir supply line. The compressor shall not be made to start against back pressure. If need be, a soft start feature shall be provided.
- 11.11.16 A pressure switch shall control the cutting in and out of the compressor. A time relay shall be provided to monitor` the state of health of the compressor and air delivery system which shall also be logged in TCMS.
- 11.11.17 Safety valves shall be provided to protect the system from over pressure.
- 11.11.18 A non-return valve shall be provided between the compressor and the main reservoir supply line.
- 11.11.19 The compressor shall not be made to start against back pressure. If need be, a soft start feature shall be provided.
- 11.11.20 Correct functioning and running hours of compressors shall be monitored and recorded by TCMS.
- 11.11.21 The Contractor shall convincingly establish that the reliability and maintainability of the compressor offered, has been established in actual metro train operation. The Contractor shall submit letters from actual users indicating experience with the compressors on their system.

11.11.22 The intake air shall be directed through a properly designed filter, suitable for the dusty atmospheric conditions prevailing in Bangalore. Filters shall be easy to clean and shall be easily accessible for cleaning and replacement.

11.11.23 The system shall be maintained within its service working pressure range when there is only one compressor functioning normally in trains.

11.12 Air Dryer and Filtration

11.12.1 Each compressor installation shall be fitted with a means of cooling the air produced prior to drying.

11.12.2 Each compressor shall be provided with an associated air dryer to provide a means of drying the air before distribution. The air leaving the dryer shall have a dew point sufficiently low to that there is no risk of condensation forming anywhere in the pneumatic system. The air dryer shall be preceded by an automatic drain valve which collects and discharge the bulk of the moisture in the compressed air before entering in the air dryer.

11.12.3 In the event of a failure of the air dryer, a means of isolation shall be provided disabling the supply of compressed air from the compressor. An alarm shall be sent to the TCMS and OCC (UTO mode) and information shall be displayed in the train driver's cab.

11.12.4 The air delivered to the pneumatic system shall be clean and dry. An air dryer and filtration unit proven on Rolling Stock application suitable for extremely hot, humid and dusty conditions prevailing in Bangalore shall be provided. The air dryer shall have IP65 protection.

11.12.5 The grade of filtration at rated pressure shall be provided by the Contractor.

11.12.6 The Contractor shall advise percentage relative humidity of outlet air. However, the relative humidity at the outlet of the air dryer shall not be more than 35%. Air dryer design shall ensure that under all ambient conditions prevailing in Bangalore, no condensation takes place.

11.12.7 A proven regenerative type of air dryer using desiccant and of a suitable capacity shall be provided between the air compressor and the main reservoir.

11.12.8 ~~Suitable means of oil and dust separation, along with automatic drain valve prior to the air dryer shall be provided. An inter-cooler and after-cooler of liberal capacity shall be supplied to ensure efficient operation of the air dryer. A humidity indicator showing the condition of the outlet air through change of colour shall be provided. Full technical details of the proposed air dryer shall be furnished by the Contractor for review by the Project Manager. Interval for replacement of desiccant in the dryer unit shall be furnished.~~

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Suitable means of dust separation, along with automatic drain valve prior to the air dryer shall be provided. An inter-cooler and after-cooler of liberal capacity shall be supplied to ensure efficient operation of the air dryer. A humidity indicator showing the condition of the outlet air through change of colour shall be provided. Full technical details of the proposed air dryer shall be furnished by the Contractor for

review by the Project Manager. Interval for replacement of desiccant in the dryer unit shall be furnished.

11.12.9 In case of continuous purging through air dryer, an isolating cock shall be provided to bypass air drier.

11.12.10 All failures of the air dryer shall be displayed in the TCMS and OCC.

11.13 Reservoirs

11.13.1 The dry air from the compressor shall be stored in main reservoirs and brake reservoirs by the pipe line, which shall be suitably sized to accommodate the air requirements and also to optimise the efficiency of the air production system.

11.13.2 Main reservoirs with adequate capacity shall be provided to distribute the air to various systems. The reservoirs shall incorporate a safety valve and an automatic drain valve. The Contractor shall provide calculations to substantiate correct sizing of the reservoirs. **(CDRL-11-15)**

11.13.3 Main reservoirs shall also have a manual device for venting/draining the contents of the reservoir.

11.13.4 A protected supply of air pressure for friction brake equipment shall be supplied by a separate brake supply reservoir. The brake supply reservoir shall be designed to ensure that when the brake supply reservoir is at the minimum operating pressure and the main reservoir pipe line is at atmospheric pressure, it shall be possible to make at least three emergency brake applications and releases with a train speed of 80 km/h in AW4 condition.

11.13.5 Reservoirs shall be manufactured from stainless steel. All reservoirs shall have a device for venting and draining of the contents of reservoirs. All Reservoirs shall conform to the requirements of EN 286-3 to 4 standards.

11.13.6 Separate reservoirs of suitable capacity shall be provided for satisfactory operation of other on-train pneumatic systems.

11.14 Piping System

11.14.1 A main reservoir pipe shall run continuously throughout the train.

11.14.2 All piping shall be of stainless steel conforming to the requirements of SUS316L JISG3459 or equivalent with flare less compression fittings. The pipe fittings shall conform to the requirements of DIN 2353. Brake system supplier shall provide the brake pipe diameters.

11.14.3 It is preferable that sizes of pipes are limited to a minimum. Sharp bends shall be avoided and standard connections shall be used as far as possible.

11.14.4 All branches from the main reservoir pipe or control system shall be fed via cocks with or without vent and electrical switches as appropriate. Magnet valves, reducing valves, check valves, silencer and drain plugs etc. shall be incorporated as required.

11.14.5 Quick release coupling test points made of stainless steel, with blanking plugs shall be provided. They shall be located in easily accessible positions.

11.14.6 Flexible hoses shall be kept to a minimum and be proven in metro train operation. The Contractor shall submit proposals to increase the integrity of the air supply system against rupturing of inter-car flexible hoses. Burst hose protection shall be

provided for hoses. All rubber hoses shall be steel wire braid reinforced conforming to ISO 11237- SAE-100 R-Type for better life and reliability. **(CDRL-11-16)**

- 11.14.7 Foreign matter shall be removed from all pipes prior to installation.
- 11.14.8 Suitable colour coding shall be applied to all pipe-work for identification. The proposed colour coding shall be reviewed during the under frame Equipment Layout Mock-up review.
- 11.14.9 All pipes shall be installed by means of clamps with integral, molded vibration damping inserts to prevent any rattling in service. Clamps shall not be welded to the pipe. The Contractor shall submit the colour coding scheme for pipe work. **(CDRL-11-17).**
- 11.14.10 Where piping passes through holes in the floor, the hole shall be sealed with EPDM modular based pipe sealing system with multi diameter technology. EPDM (ethylene – propylene diene monomer) should be low smoke index, halogen free cross-linkable rubber compound.
- 11.14.11 In the event of leakage from the Pneumatic circuit/system, it shall be possible to isolate the effected part of the circuit by train operator (remote isolation during UTO operation) and reach upto destination station. Isolation arrangement shall be simple and shall not require more than square key normally carried by Train Operator. Contractor shall submit detail plan during design for Project Manager's approval. The isolation arrangement shall preferably be in the saloon and shall be secured and monitored. The isolation arrangement shall be through remote isolation of magnet valves for isolation of service brake in affected bogie (s). This isolation shall not affect the emergency brake. The details shall be finalised during design stage.
- 11.14.12 All isolating valves that require operations by train crew in normal operation or in emergencies shall be easily accessible either from within the car or from track level as appropriate. The isolating valves shall be colour coded. The isolation of the cocks shall be monitored by TCMS.
- 11.14.13 Isolating cock handles shall lie parallel to the pipe in which it is installed, in the normal operational (Open) position, and perpendicular to the pipe in the isolated (Closed) position and shall operate in the horizontal plane only. Cable ties shall provide a ready means of identification of a cock, which has been operated. The cocks should be properly labelled for easy identification by the train operator.

11.15 Pressure Gauges, Governors and Switches

- 11.15.1 Each driving cabs shall be provided with analog pressure gauges with LED based illumination to monitor following:
 - i) The pressure in the main reservoir.
 - ii) The pressure in the brake cylinder pipe.
 - iii) The pressure in parking brake unit
 - iv) The pressure in the brake pipe
- 11.15.2 On all cars, test points, onto which test gauges may be connected, shall be provided in the vehicle brake and air supply system. The tests points shall be provided, at the minimum, to measure the pressure of the following:

- i) Compressor motor governor.
- ii) Brake cylinder pressure.
- iii) Main reservoir pressure.
- iv) Parking brake pressure.
- v) Brake pressure reservoir.
- vi) Brake pipe.
- vii) Overflow valve.
- viii) Air spring pressure.
- ix) Any other point, which in the opinion of Project Manager is required.

11.15.3 Pressure governors and switches proven in EMU metro applications shall be provided for various control and monitoring functions.

11.15.4 All pressure governors and switches will be monitored by TCMS.

11.16 Air Suspension Equipment

11.16.1 A levelling control system shall be provided to ensure longitudinal and transversal control of body height under all conditions of load. In each bogie, one levelling system shall be provided to adjust air pressure in the air springs gradually. In the case of failure of one air spring, the other should quickly bleed out so that the car body is lowered to its stable position. The air supply for the levelling system shall be taken from the main reservoir pipe and a separate reservoir shall be provided for the system. Load sensing valve shall be provided.

11.17 Automatic Coupling Actuating Equipment

11.17.1 Control of front auto coupler for rescue operation shall be from the driving console. The Isolating cocks for MR for extension of air supply through the coupler shall be located in the driving console. Any other operation required necessary for coupling shall be from the driving console only.

11.18 Wheel Slip and Slide Protection

11.18.1 Wheel slide protection with gradual slide correction shall be provided in all braking modes, on all cars. Slide detection shall be on axle basis and correction shall be on bogie basis. The slide protection scheme provided shall be capable of detecting the severity of the slide and provide the appropriate level of slide correction.

11.18.2 ~~The wheel slide system shall detect the onset of slide by either (a) an axle deceleration exceeding a pre-set parameter, or (b) detection of a difference between the relative speeds of the axles. A proven speed sensor mounted on the cover of each axle box shall be provided to detect the speed of associated wheel for implementing wheel slide protection scheme. Wheel slide indication shall be displayed through TCMS in the driving cab. The Contractor shall submit full details of wheel slide protection scheme and equipment. Dump valves shall be monitored for their correct functioning and status shall be monitored by TCMS. System shall ensure correct functioning of dump valves as pre-test before train is dispatched from depot or initialized.~~

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The wheel slide system shall detect the onset of slide by (a) an axle deceleration exceeding a pre-set parameter, and/or (b) detection of a difference between the relative speeds of the axles. A proven speed sensor mounted on each axle shall be provided to detect the speed of associated wheels for implementing wheel slide protection scheme. Wheel slide indication shall be displayed through TCMS in the driving console. The Contractor shall submit full details of wheel slide protection scheme and equipment. **Dump valves shall be monitored for their correct functioning by Brake electronic control and corresponding status shall be relayed to TCMS.** System shall ensure correct functioning of dump valves as pretest before train is dispatched from depot or initialized”.

- 11.18.3 Traction and brake control systems shall be designed to eliminate, by means of a reduction of short duration in the traction or braking power, the excessive slipping or sliding of axles occurring during acceleration or deceleration, and to prevent complete locking of the axles. In addition, the system shall make optimum use of the available adhesion between wheel and rail.
- 11.18.4 In the event of wheel-slip, the traction effort demand shall be reduced by the wheel-slip protection subsystem in order to adjust the effort to the available wheel-rail adhesion. The slip shall be detected by evaluation of each axle speed and acceleration and compared with a calculated speed reference for the train.
- 11.18.5 In the event of wheel slide detection, first the propulsion system shall attempt to correct the slide and in event of its inability to do so, BECU shall take over the control function and implement the corrective measures.
- i) Digital wheel slide protection with gradual slide correction shall be provided in all braking modes. Slide detection shall be on axle basis and correction shall be performed on bogie basis. The correction of slide shall operate independently on each vehicle. Automatic wheel wear compensation shall be incorporated in the wheel slip/slide protection sub-system.
 - ii) The sliding effect shall be maintained during a relevant period of time, in order to increase the available adhesion at the wheel-rail contact with permanent control, in minimising the air consumption and optimising stopping distance.
 - iii) The Contractor shall demonstrate that the correction process for wheel slip/slide shall not cause infringements of the signalling compatibility requirements.
 - iv) The performance of the wheel slide protection equipment shall satisfy the relevant requirements of UIC 541-05. Testing shall be carried out in accordance with Section 2 of the UIC 541- 05.
 - v) The wheel slide system shall detect the onset of slip/slide by either an axle deceleration exceeding a pre-set parameter, or detection of a difference between the relative speeds of the axles of any one axle of any bogie.
 - vi) The Contractor shall incorporate the complete compatibility for slip/slide with signalling system and interfaces. The Contractor shall submit full details of wheel slide/slip protection scheme and equipment.
 - vii) Wheel slip/slide indication shall be made available in the driving cab through TCMS system.

- 11.18.6 ~~Project Manager shall be able to adjust/change Brake cylinder pressure and other output parameters of Brake System as per specified values. One set of hardware/software tool required for this purpose shall also be provided to each depot. The documentation including but not restricted to flow charts (for complete software), signal flows, and interpretation of signal etc. shall be provided. Project Manager's Engineers shall be fully trained and made fully conversant by the Contractor for this purpose.~~

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Project Manager shall be able to adjust/change Brake cylinder pressure and other output parameters of Brake System as per specified values **with the authorization of Brake suppliers. The Brake suppliers shall submit necessary procedures.** One set of hardware/software tool required for this purpose shall also be provided to each depot. The documentation including but not restricted to flow charts (for complete software), signal flows, and interpretation of signal etc. shall be provided. Project Manager's Engineers shall be fully trained and made fully conversant by the Contractor for this purpose.

- 11.18.7 The Contractor shall incorporate the complete compatibility for slip/slide with signalling system and interfaces. The Contractor shall submit full details of wheel slide/slip protection scheme and equipment. **(CDRL-11-18)**

11.19 Monitoring

- 11.19.1 The performance of brake system shall be monitored by the train control management system (TCMS) and displayed in the train operator's cab.

11.20 Documentation

- 11.20.1 ~~Contractor shall supply exhaustive documentation on complete pneumatic system, its sub systems and components, Brake electronics (hardware and software), project software details, explanation and functionality at component and system level, coloured schemes of pneumatic system, brake system, valves with coloured cut sections under different operational states. It shall also include trouble shooting and diagnostic details explaining clearly (with coloured illustrations) the logics, transition states, algorithms, signal flow and software parameters etc.~~

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Contractor shall supply exhaustive documentation on complete pneumatic system, its sub systems and components, Brake electronics (hardware and software), project software details, explanation and functionality at component and system level, coloured schemes of pneumatic system, brake system, valves with coloured cut sections under different operational states. It shall also include trouble shooting and diagnostic details. explaining clearly (with coloured illustrations) the logics and software parameters etc.

11.21 Deliverables

Contract deliverables required by this section of the Technical Provisions are summarized below:

CDRL11-1:	Details for isolation of BIC and EPIC (ref. ERTS 11.1.3)
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CDRL-11-2:	Complete brake system function description explanation (ref. ERTS 11.1.6)
CDRL-11-3:	Detailed brake distribution and blending description (ref. ERTS 11.2.6)
CDRL-11-4:	Details of Emergency braking distances (ref. ERTS 11.3.8)
CDRL-11-5:	Detailed description and calculations of friction brake performance (ref. ERTS 11.4.4)
CDRL-11-6:	Electro-Dynamic brake curves, speed/traction curves (ref. ERTS 11.5.6)
CDRL-11-7:	Brake pipe controlled back-up brake system (ref. ERTS 11.6.1)
CDRL-11-8:	Detailed Parking brake description and calculations (ref. ERTS 11.7.11)
CDRL-11-9:	Details of switching over of VVVF to TCMS back-up PWM signal (ref. ERTS 11.8.3)
CDRL-11-10:	Details of brake control in case of isolation/failure of brake of one car (ref. ERTS 11.9.1 (vii))
CDRL-11-11:	Details of minimum life of High pressure piston ring (ref. ERTS 11.11.3)
CDRL-11-12:	Detailed calculations to show that the capacity of the compressor (ref. ERTS 11.11.4)
CDRL-11-13:	Air consumption calculation, duty cycle calculations of Air compressor (ref. ERTS 11.11.7)
CDRL-11-14:	Compressor management system when complete electro-dynamic brakes failure (ref. ERTS 11.11.9)
CDRL-11-15:	Calculations to substantiate correct sizing of the reservoirs (ref. ERTS 11.13.2)
CDRL-11-16:	Brake hose protection. (ref. ERTS 11.14.6)
CDRL-11-17:	Details for colour coding scheme for pipe work (ref. ERTS 11.14.9)
CDRL-11-18:	Full details of wheel slide/slip protection scheme and equipment. (ref. ERTS 11.18.7)

12 HIGH VOLTAGE ELECTRICAL EQUIPEMENT

12.1 General Requirement

- 12.1.1 All electrical equipment proposed shall comply with the relevant sections of IEC 60077 1 to 4, IEC 60349, IEC 61287-1, IEC 60571 and IEC 60850 or as otherwise specified. The standstill and line test requirements of IEC 61133 for Rolling Stock prior to handing over shall be complied with by the Contractor.
- 12.1.2 The High Voltage and Propulsion System shall be suitable for operation at 750 V DC third rail systems. The high voltage and propulsion system shall be configured such that it performs equally reliably for all consists, for all normal and abnormal duties defined herein.
- 12.1.3 The Train shall be propelled by a 3-phase AC asynchronous motor drive system with variable voltage and variable frequency (VVVF) Control. The VVVF inverter will be of pulse width modulation (PWM) type using insulated gate bipolar transistor (IGBT). Optimum regenerative braking shall be provided.
- 12.1.4 The propulsion and brake control system shall provide regenerative braking blended with pneumatic service braking as required. Regenerative braking shall be fully compatible with the power supply system under all train loading conditions. The principal highest priority service brake shall be regenerative and its capability shall be maximised.
- 12.1.5 There shall be a single Contractor for all propulsion equipment except TCMS. TCMS can be supplied either by qualified propulsion system supplier or from the car body manufacturer/vehicle integrator. The Contractor shall be responsible for the safe and correct transfer of interface information between the brakes and propulsion systems and also with other subsystems.
- 12.1.6 The Traction-braking system shall be predominantly controlled by micro-processor-based control systems inter-linked via Ethernet communication data bus system. Train propulsion, brakes, auxiliary control, on-board equipment status monitoring, fault data logging and first line diagnostics shall be integrated into the proposed train control management system (TCMS).
- 12.1.7 Constant torque zone in the braking shall be from 65 Kmph to 5 Kmph to maximize the regenerated energy. All the propulsion equipments including brake resistor, HSCB shall be rated accordingly. The details shall be submitted and finalized during design phase. **(CDRL-12-1)**
- 12.1.8 It will be necessary to operate trains manually in case of Automatic Train Control equipment failure. Hardware interlocking control for safety related circuits shall be provided. This shall include the safety interlock, emergency brake security control loop and saloon door and propulsion system interlock controls.
- 12.1.9 Contractor shall ensure that under no circumstances filter capacitor voltage pulsates during the operation of the train. Contractor shall submit the necessary calculation during design phase to show that under normal operating condition, resonance shall not occur in the circuit leading to the pulsation of filter capacitor voltage. Details shall be submitted and finalized during design phase. **(CDRL-12-2)**
- 12.1.10 During the negotiation of the train on cross overs, efforts shall be taken to reduce the motor current due to short break of 750 V DC supply to prevent over current in the

traction motors. The details shall be submitted and finalized during design phase.
(CDRL-12-3)

- 12.1.11 All under frame mounted electrical equipment shall be sealed to IP65 at the exception of the ventilated areas unless otherwise agreed. The enclosures shall not be affected by corrosion in the service life.
- 12.1.12 Separate push button shall be provided on driver's desk to open line circuit breaker(s) in the event of extreme emergency by Train Operator.
- 12.1.13 It shall be possible to operate working train till end of the service with one motor car (25% cutout) isolated without exceeding the specified temperature limits of propulsion equipment.
- 12.1.14 Low speed Cut-out mode of 25 kmph shall be provided for 6-Car Trainset.

12.2 Traction Equipment, overview

- 12.2.1 A traction control system shall be provided which is designed to ensure a high utilisation of available adhesion under all wheel/rail conditions and shall not cause any visible or measurable damage to the vehicle equipment, wheels or rail.
- 12.2.2 The Train shall be powered from a third rail supply via bogie mounted collector shoes. The main electrical protection of the nominal 750 V DC Traction Supply to each motor cars (DMC / MC) shall be achieved by means of a High Speed Circuit breaker (HSCB).
- 12.2.3 The HSCB shall be provided with latest technology and shall be rated considering the traction and braking characteristics of the train.
- 12.2.4 A surge arrestor shall protect the equipment and discharges any over-voltage to the car-body, which is connected to car-body grounding. Via a knife switch the main power can be switched off.
- 12.2.5 Brake resistors in charge to dissipate the brake energy during dynamic braking if regeneration energy is not receptive by third rail shall be provided.
- 12.2.6 The traction and braking equipment shall not suffer any damage in case of maximum traction and braking effort continuously and also in worst case of slip/slide condition.
- 12.2.7 The traction and braking system and associated equipment shall be fully integrated with control circuits, diagnostic and monitoring facilities, load-weighing and wheel-slip/slide systems. The integration shall be designed to minimise the time required to test the equipment and to diagnose faults. The electronics required for the control, diagnostics and monitoring facilities shall be designed and constructed in accordance with the requirements of IEC 60571.
- 12.2.8 The traction equipment shall be designed so that the tractive and braking effort of the metro train is dependent on the passenger load.
- 12.2.9 The manufacturing standards shall have already been proven widely in the railway traction industry.

12.2.10 The types of power semi-conductors used shall have had extensive use and experience in traction applications. The circuit breakers, contactors and conventional electromagnetic components used shall comply with the requirements of IEC 60077 1 and 2. The details including calculations for finalising the ratings of individual propulsion equipments shall be submitted and finalised during design phase. **(CDRL 12-4)**

~~12.2.11 The staggered closing of HSCBs of trains shall be suitably ensured under both normal and extended feeding scenarios arising after power supply restoration to avoid tripping of HSCB of substation due to high inrush current. Necessary command required for closing of HSCB(s) from OCC shall be ensured. Design shall be suitable for 90 sec headway. The details shall be submitted and finalized during design phase. **(CDRL-12-5).**~~

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The closing of HSCBs of trains shall be suitably ensured under both normal and extended feeding scenarios arising after power supply restoration to avoid tripping of HSCB of substation due to high inrush current. The details shall be submitted and finalised during design phase. (CDRL-12-5).

12.2.12 Not Used.

12.2.13 Staggered acceleration of the trains within the same power supply feeding zone shall be suitably ensured under UTO operation for both normal and extended feeding scenarios arising due to power supply disruption or bunching of trains within the same feeding zone as a part of interface design for avoiding tripping of HSCB of substation. Design shall be suitable for 90 sec headway. The details shall be submitted and finalised for Project Manager's review during design phase. **(CDRL-12-6)**

12.2.14 The traction inverter in a train shall be controlled such that the returned currents in the track in the ATP frequency range shall be below the specified level by Signalling & Train Control under the worst conditions. The Contractor shall interface with Signalling & Train control contractors for limiting values of the return current in track in ATP frequency range. Simulation for return current from complete 6-Car train sets shall be carried out under worst condition and propulsion supplier shall ensure that the total return current shall be within the limit specified by signalling and train control contractor. The same shall be verified/validated during joint tests along with main line EMC and EMI tests. **(CDRL-12-7).**

12.2.15 Any investigation/design documents required for the power supply authorities concerning the quality of the regenerated power shall be submitted.

12.3 DC / AC Traction Inverter

~~12.3.1 The box for the DC/AC traction inverter shall be of Stainless Steel/Anodized Aluminium/Aluminium Alloy so as to avoid any corrosion in service on any account and the box shall last for the lifetime of the traction inverter unit without needing any attention. The IP protection level of traction inverter box shall not be less than IP65. The connectors shall have IP67 protection. The cooling arrangement shall ensure no dust deposition on the component and associated electronics. The box cover which may have to be removed for maintenance shall be suitable secured against falling. Hinged opening cover arrangement shall be preferred.~~

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The box for the DC/AC traction inverter shall be of Stainless Steel/Anodized Aluminium/**Aluminium with paint** so as to avoid any corrosion in service on any account and the box shall last for the lifetime of the traction inverter unit without needing any attention. The IP protection level of traction inverter box shall not be less than IP65. The connectors shall have IP67 protection. The cooling arrangement shall ensure no dust deposition on the component and associated electronics. The box cover which may have to be removed for maintenance shall be suitable secured against falling. Hinged opening cover arrangement shall be preferred.

- 12.3.2 One traction inverter shall be provided for each traction bogie of motor car DMC and MC (8 inverters for a 6-Cars metro train). The inverter shall be proven, four quadrants IGBT (or later metro transit proven technology-based unit VVVF control). The equipment shall conform to IEC 61287-1.

- 12.3.3 The traction inverters with natural or forced air/water cooling shall be adopted. However, if forced air/water cooling is offered complete details of the arrangement including the method of dust filtration shall be furnished.

During design of cooling system, it shall be noted that Bangalore's ambient conditions are heavily dusty with abrasive dust, high humidity and environment pollutants. The cooling system, natural/forced air shall ensure that the devices/ components/ electronics is completely sealed against intrusion of dust/water. IP65 level of protection shall be ensured. The sealing arrangement shall be such that this protection level is ensured after normal maintenance and replacements of components. Gasket shall have minimum life of 12 years.

- 12.3.4 The system shall be designed to minimize switching losses, switching noise and weight and improve heat dissipation.

- 12.3.5 The current rating of the semiconductor shall be such that the junction temperature has the minimum thermal margin of 10°C in the worst loading conditions taking into account the extreme ambient conditions in Bangalore and surrounding.

- 12.3.6 The traction inverter system shall be capable of withstanding the maximum short circuit under fault conditions. Short circuit protection of IGBTs shall be implemented.

- 12.3.7 The continuous rating of the traction inverter shall meet all the normal, degraded, rescue condition in traction and braking modes.

- 12.3.8 Following special modes of operation shall be provided using VDU interface of TCMS:

- (i) Low speed control to operate the train during train washing.
- (ii) Low speed & low acceleration (settable parameters) during shunting operations.
- (iii) High Tractive Effort mode which may be used during isolation of any motorised car (DMC/MC) or rescue operation.
- (iv) Jog and Creep operation under Signalling control (as detailed in Appendix D)

- 12.3.9 Slip/slide control during powering and electrical braking may be provided using speed sensorless vector control subject to its provenness in Mass Transits. Uncontrolled slip/slide should be clearly recorded in TCMS as critical fault.

12.3.10 The Contractor shall demonstrate that the limits of electrical and thermal rating for all power components under all conditions of motoring and braking will not be exceeded.

12.3.11 Not Used.

12.3.12 Change-over of VVVF sequence from one mode to other mode shall be smooth and without any abnormalities. The details shall be submitted and finalized during design phase **(CDRL-12-8)**. The same shall be validated through mainline tests.

12.3.13 Protection and diagnostics:

- i) Control circuit logic shall permit testing/monitoring, operation and fault simulation of the traction inverter. Appropriate test equipment shall be supplied.
- ii) The traction inverter shall carry out self-tests to ensure the integrity of the equipment. Sufficiently detailed status, fault and diagnostic information shall be transmitted to TCMS, to enable protective or corrective action to be taken immediately, when necessary. It shall be possible to carry out the self-test of propulsion system from the cab only.
- iii) The traction inverter shall use a control scheme that contains extensive self-diagnostic logic, which shall be fully integrated with TCMS. At a minimum, the diagnostics system shall identify a range of credible faults, identify whether a Least Replaceable Unit (LRU) is responsible for the fault, and whether the LRUs (or non-LRUs) must be replaced or the system merely reset. The diagnostics system memory shall be retained when the train is powered down.
- iv) Software uploading and trace data downloading shall be done through TCMS and it shall not exceed 15 minutes for complete 6-Car train set.
- v) PWM input and output shall be recorded in TCMS.
- vi) The train operator from the cab/TCMS shall be able to isolate any defective traction inverter.
- vii) Reset function of VVVF shall be implemented from TCMS and OCC.
- viii) Current drawn by each motor shall be measured and recorded.
- ix) Redundant Temperature/Heat sensor/LHD location shall be in proximity of IGBTs and shall be linked to Local Control Panel and TCMS/Fire Detection (ERTS 3.14) so that their status is monitored.
- x) In case of faults in the traction motors, the defective VVVF group shall be automatically isolated. It shall be also possible to isolate the defective VVVF group manually through Miniature Circuit Breaker (MCB).

The details of the protection scheme shall be submitted and finalized for Project Manager's review during design phase. **(CDRL-12-9)**

12.3.14 Separate CTs shall be provided for each inverter for measurement and protection functions.

12.3.15 LED based lighting arrangement shall be provided in the inverter box for maintenance purpose. Its fail safe interlocking with the box cover shall be ensured. Contractor shall submit the details for Project Manager's review during design phase. **(CDRL-12-10)**

12.3.16 The propulsion equipment shall ensure the guaranteed performance for wheel diameter differences for at least up to 4mm within any bogie without any adverse effect on any equipment. If the wheel diameter tolerances exceed the above limit, there shall be no damage to any equipment.

- 12.3.17 Power system fluctuations within the specified voltage range or feed extensions shall not cause propulsion system shutdown leading to jerks in the train. Adequate capacity shall be built in the DC link and control parameters shall be selected and fine-tuned suitably so that in no case, system stability is adversely affected.
- 12.3.18 The component cooling system shall be designed to ensure the control electronics temperature inside traction inverter never exceeds 70°C under specified conditions after due consideration of proximity effect. The Contractor shall note that the air intake temperature for cooling can be appreciably higher than outside ambient temperature.
- 12.3.19 The type measurements shall be normalized for maximum specified temperature.
- 12.3.20 ~~During the design stage, Rolling Stock contractor, Propulsion supplier and Brakes supplier shall provide the brake block wear rate and consumption pattern for each line for each type of car considering various ATO patterns as provided by Signalling supplier as a part of joint interface design document which shall be duly validated during DLP/DLMP. In case the desired brake block consumption/ wear rate is not achieved, the Rolling Stock contractor, Propulsion supplier and Brake supplier shall take adequate measures to achieve the brake block consumption wear rate as decided during design stage. Rolling Stock contractor shall carry out necessary interface Signalling & Train Control contractor in case the problem is experienced at Signalling end.~~

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During the design stage, Rolling Stock contractor, Propulsion supplier and Brakes supplier shall provide the brake block wear rate and consumption pattern for each line for each type of car considering various ATO patterns as provided by Signalling supplier as a part of joint interface design document which shall be duly validated during DLMP. In case the desired brake block consumption/ wear rate is not achieved, the Rolling Stock contractor, Propulsion supplier and Brake supplier shall take adequate measures to achieve the brake block consumption wear rate as decided during design stage. Rolling Stock contractor shall carry out necessary interface Signalling & Train Control contractor in case the problem is experienced at Signalling end.

12.4 Traction Motors

- 12.4.1 The Train shall be propelled by a 3-phase AC asynchronous motor drive system with variable voltage and variable frequency (VVVF) Control. The motors shall be designed and manufactured in full accordance with the requirements of IEC 60349-2. Class 200 insulation shall be used for stationary and rotating windings.
- 12.4.2 Three phase asynchronous traction motors, suitable for the proposed inverter operation shall be offered. The motor shall have adequate built in margin to cater to the environmental conditions given in the specification. The motor shall be designed to suit ripples and harmonics from the inverter and shall have a high degree of reliability in service during motoring as well as regeneration.
- 12.4.3 The traction motor shall be self-ventilated and shall comply with the requirements of IEC60349-2- 'Electronic converter – fed alternating current motors'. An effective and efficient filtration system shall be provided to remove dirt and water from the self-ventilated traction motor cooling air. The air inlet openings shall include a protective screen designed in such a way as to preclude the accumulation of leaves and debris.

If installed, filters shall require cleaning no more frequent than once every two weeks. Contractor shall provide two numbers of dust blowing equipment in each depot to remove dust from traction motor stator core (cooling hole) in situ in the depot. The details shall be submitted and finalized during design phase. **(CDRL-12-11)**

12.4.4 A specific care shall be taken for the air cooling quality and sucking points to be particularly adapted for the operation in Bangalore. Cooling arrangements shall be defined during detailed design stage.

12.4.5 Evaluation of the insulation system for sealing against moisture shall be made in accordance with IEEE 429. The insulation system shall be evaluated for thermal endurance in accordance with the requirements of IEC 60505 (1975), its draft supplement and IEEE 304.

12.4.6 Various ageing parameters viz., thermal and electrical stresses, ambient temperature, humidity, dust and mechanical stresses, vibration etc., should be used in the evaluation and the temperature index of the insulation system corresponding to an extrapolated life of 20,000 hours shall be established. The Contractor shall submit the evaluation of the temperature index of the insulation system for review and approval. **(CDRL-12-12).**

12.4.7 Traction motor design shall be based on following premises:

The continuous current rating of the Traction Motor shall be based on RMS current calculated during All-out run with 25% motors cut out in the specified sections for a round trip without stoppage (dwell) time.

The temperature rise limit for the stator winding shall be the maximum temperature index of the insulation minus 70°C. The temperature rise and the RMS current of Traction Motor shall be calculated all out run in the specified sections without stoppage time.

Traction motor shall be subject to temperature rise tests as per IEC 60349-2 latest edition and combined propulsion system tests (including tests on BMRCL mainline) as per IEC 61287 and IEC 61377.

12.4.8 A temperature monitoring system of each traction motor through TCMS shall be implemented. Temperature rise shall be estimated by calculating the change in the rotor resistance based on measurement of voltage and current across the individual rotor winding. Initially, in case of abnormalities a message should be recorded in TCMS and even if affected VVVF group remains in service without any maintenance attention then the affected group shall be isolated automatically. No temperature sensor is permitted to be installed for this purpose. The details shall be discussed and finalized during design phase. **(CDRL-12-13)**

12.4.9 Simulations on a typical round trip for each corridor (Line-6, Phase 2A and Phase 2B) shall be provided by the Contractor in order to calculate the temperature curve of the traction motor in normal and downgraded conditions and in all the conditions of passenger load **(CDRL-12-14)**

12.4.10 The traction motor shall be suitably rated to meet the most severe service requirements as specified in design parameter Clauses 3.10.1 and 3.10.3 of technical specification.

- 12.4.11 The motor bearing maintenance inspection interval (excluding lubrication if required) shall exceed 1.0 million kilometers and the bearing shall have a design life of 2.1 million kilometers. Lubrication of motor and gearbox bearings shall be accessible without the need of equipment removal. Calculations supporting the choice of bearings shall be submitted for review. **(CDRL-12-15)**
- 12.4.12 Insulated bearing shall be used on both drive and non-drive end of traction motors to prevent current through the transmission to the axle.
- 12.4.13 Protection shall be provided to prevent current flow through the bearings in normal and under fault conditions.
- 12.4.14 The grease used for the traction motor bearings shall be selected so as to ensure the expected maintenance interval considering the maximum temperature estimated to be reached in the bearings, under the worst conditions. It should be provided to replenish the grease periodically *in situ* and overflow arrangement should be provided to avoid the possibility of the over greasing.
- 12.4.15 The motor shall be mounted on the bogie frame via flexible coupling and gear unit, which shall be totally enclosed and free from lubricant leakage. The coupling design and the motor to gear unit mounting arrangement shall minimize coupling dynamic angular displacement. The motor shall be dynamic balanced. The gaskets shall be of suitable material, compatible for use with gear case oil and service life shall be more than 1,000,000 kms. The details of the gear drive unit, gear performance, and coupling details shall be submitted to Employer for approval. **(CDRL 12-16).**
- 12.4.16 The traction motors shall be designed for a life of thirty five years with no need for major overhaul before 1000000 kms.
- 12.4.17 The mounting arrangement of the traction motor shall be designed to prevent the motor from dropping onto the track should the primary mounting arrangement become disconnected. All components shall have been already proven in previous railway service in similar operating and environmental conditions.
- 12.4.18 A.C. traction motors used for the traction drive shall comply with the requirements of Relevant standards are IEC 60349-1, 60349-2, IEC 60349-3 and shall, in particular, be fully compliant with the sections on motor characteristics, equipment marking, type and routine tests. Information on all the characteristics of the A.C. traction motor as stated in IEC 60349-2 shall be provided. **(CDRL-12-17)**
- 12.4.19 Rotor design shall be of copper alloy (copper-99.8% and Zirconium upto 0.2%) or of Die-cast Aluminium. However, rotor must have previous proven service record.
- 12.4.20 Any inspection covers shall be robust and designed for quick and easy removal/replacement and have secondary retention to prevent loss. Inspection openings shall be as large as possible to facilitate inspection and maintenance.
- 12.4.21 The gearbox case design shall give due consideration to minimizing weight.
- 12.4.22 The coupling of the gearbox shall accommodate all relative movements between the motor and the gearbox, including that caused by a free standing bogie, without damage to coupling.

- 12.4.23 The design of the motor installation shall permit the motor to be removed from, and refitted to, the bogie from above, without any need to disturb the axle and any bogie mounted equipment.
- 12.4.24 Where cables pass through holes in the traction motor frame, oil resistant resilient bushes suitably clamped shall be provided to prevent chafing of cables and to seal against the ingress of oil and water. The cables shall have sufficient freedom of movement to prevent stressing or fouling of other equipment during the full envelope movement of the bogie.
- 12.4.25 All the transits of traction motor cables through holes, cleats, etc. shall be sealed with a suitable EPDM (Ethylene Propylene Diene Monomer) based sealing system.
- 12.4.26 There shall not be any permanent flying lead attached to the motor. All connections to the motor shall be bolted, torque tightened and marked.
- 12.4.27 Traction motors shall be fully interchangeable. All components requiring periodic replacement, whether mechanical or electrical, shall be fully interchangeable unless approved by the Project Manager.
- 12.4.28 Motors shall be provided with noise mufflers or take alternative measures for minimising noise emission from motor.

12.5 Surge Arrestor

- 12.5.1 The surge arrestors shall be designed to give over-voltage protection from severe surges (such as lightning strikes) for electric urban transit and main line railway systems.
- 12.5.2 A surge arrestor shall be provided for each motor car and shall be mounted adjacent to the current collector.
- 12.5.3 Over-voltage protection shall be designed according to international standard IEC 61287-1.
- 12.5.4 The surge arrestor shall be free from moisture ingress, vandal proof, suitable for installation in polluted environments, high cantilever and torsion strength, non-explosive failure mode, low weight, small size and easy to install.
- 12.5.5 The arrestor shall consist of a non-linear metal oxide varistor fitted in a porcelain housing, which is sealed off by a flange. This contains a pressure relief device with gas diverter.
- 12.5.6 The arrestors shall be maintenance-free. A means of indication shall be provided for easy identification of a failed surge arrestor without dismantling it.
- 12.5.7 Under normal service duty, the minimum service life of the surge arrestor shall not less than 10 years.
- 12.5.8 The performance of surge arrestor shall be tested to EN 50124 – 2 / IEC 61992.

12.6 High Speed Circuit Breaker (HSCB)

- 12.6.1 The main circuit breaker shall reliably disconnect the traction equipment from the third rail in the event of severe disturbances, such as over-current, inverter fault or short-circuits in the line. One HSCB for each Driving Motor Car (DMC)/Motor Car (MC) shall be provided. The protection scheme from HSCB under various fault conditions shall be discussed and finalized during design phase. **(CDRL-12-18)**

- 12.6.2 The HSCB shall be capable of safely interrupting the maximum possible fault load current. With the exception of the fuses required for the current collection equipment, the use of fuses in the power circuit shall not be permitted.
- 12.6.3 The high speed circuit breaker shall be used for the following purposes:
- (i) fault rupturing;
 - (ii) fault isolation; and
 - (iii) protect the traction equipment against circuit faults, such as, traction power supply short circuit during regenerative braking.
- 12.6.4 The High Speed Circuit breaker (HSCB) shall comply with the requirements of IEC 60077-1 and 2 as applicable.
- 12.6.5 In the event that the fault is proved to be cleared, the high speed contact shall be either automatically reset or by the intervention of the train driver to re-close it.

12.7 Isolation Switch

- 12.7.1 A discharging function and an isolation switch shall be provided to facilitate the maintenance personnel with a simple means of isolating the traction equipment, discharging all high voltage capacitors to a safe voltage of 50V within 5 minutes and earthing all high voltage equipment.
- 12.7.2 The isolation shall be operable from outside the equipment case.
- 12.7.3 A means for locking the isolation switch in the isolated position shall be provided.
- 12.7.4 A knife switch shall be located in an under car position accessible from the side of the car. The switch shall, in the OPEN position, disconnect the current collector shoe power from all carborne systems. The knife switch shall be arranged so that the enclosure cover cannot be closed when the switch is in OPEN position.

12.8 Power Line Filter - Inductor and Capacitors

- 12.8.1 The filter-inductor shall comply fully with the requirements of IEC 60310 standard. The filter-inductor shall have minimum resistance to minimize the power loss and its efficiency shall be in the range of 96% to 97%.
- 12.8.2 The Capacitors shall comply with IEC 61881 standard.
- 12.8.3 The voltage of filter capacitor shall be monitored by TCMS.
- 12.8.4 For the commutation and power line filter capacitors, suitable sized and rated discharge resistors shall be fitted to ensure that the total capacitor terminal voltage shall be at a safe working level of 45 V within 5 minutes of removal of the voltage.

12.9 Brake resistors

- 12.9.1 The brake resistors shall comply with IEC 60322.
- 12.9.2 They shall be sized to perform without damaging the total electrical breakage in case of a non-receptive line.
- 12.9.3 The resistor shall be provided with over-temperature protection.
- 12.9.4 The resistor groups shall be double insulated and adequately protected against wheel splash, flying ballast/debris.

- 12.9.5 The braking resistor shall be installed so as to prevent over-heating of adjacent equipment, wiring or under frame structure.
- 12.9.6 An earthed cover shall be provided for the braking resistor bank.
- 12.9.7 Thermal insulation shall be provided between the resistor enclosure and the underframe.
- 12.9.8 "Brake resistor shall be under frame mounted. Adequate heat shields shall be provided to protect the car structure. Resistor design shall be based on a non-receptive line."
- 12.9.9 The temperature of resistor housing shall be defined and agreed during the design stage for safety concern under normal operating and emergency conditions.
- 12.9.10 Energy lost in the brake resistor shall be monitored by TCMS.

12.10 Protection

- 12.10.1 Protection shall be included in the power circuit to ensure that circulating currents through motor bearings or pinion cannot occur under any condition, for example, motoring, braking, coasting, wheel slip or towing a defective unit. Additionally, the Contractor shall ensure that circulating currents cannot occur between phases of equipment or between equipment.
- 12.10.2 Electronic and mechanical overload protection shall be provided in both motoring and braking. The overload protection shall also be capable of protecting the semiconductor devices against all foreseeable faults.
- 12.10.3 The misfiring of a traction inverter or short-circuit failure of a semiconductor device shall not cause consequential damage to other equipment outside the traction container.
- 12.10.4 Over and under voltage protection shall be provided such that the power circuit ceases to operate outside the limits.
- 12.10.5 Protection shall be provided to ensure that the equipment cannot be damaged in the event of line voltage transients. At the design stage the Contractor shall be required to match the protection with the power supply system.
- 12.10.6 A system shall be provided for detecting an earth fault. The design shall be of high integrity so as not to affect the availability of the train by nuisance tripping.
- 12.10.7 All high voltage capacitors shall be equipped with a separate discharge paths to ensure they are discharged to 50V within 15 minutes, even without operating the earth and isolation switch
- 12.10.8 Over temperature protection shall also be provided for any equipment which is short-time rated if these need additional protection, for example during emergency duties.
- 12.10.9 The transients from HV dc faults on one car shall not cause damage to other cars. The tripping of a substation breaker caused by bolted fault shall not cause reverse voltage damage to the input line filter capacitors or any other component or equipment on the cars.

12.11 Energy Measurement

- 12.11.1 The Contractor shall provide means to record usage of energy with an accuracy of $\pm 3\%$ for motoring and regeneration.
- 12.11.2 The record of cumulative energy shall be in units of kilowatt-hours.
- 12.11.3 The energy data shall be non-volatile, easily accessible and monitored by the train control management system. The details of energy measurements shall be submitted to Employer for approval. **(CDRL 12-19)**

12.12 Third rail current collector

- 12.12.1 The power to the Vehicles shall be supplied at nominal 750 V DC Traction Supply via conductor rails through current collection equipment. Each DMC/MC car shall be provided with four parallel-wired contact rail current collector shoes, with one shoe mounted on each side of each bogie.
- 12.12.2 The arrangement of the current collector shoes on the train shall ensure that there is no total loss of tractive effort or train borne auxiliary AC supply when any section of the Unit is positioned over any rail gap or insulated section on the Main Line or Depot track. The collector shoe equipment shall be able to cope with the current supply loading of both the auxiliary equipment and traction equipment, throughout the full range of speeds and operating conditions, as well as during emergency conditions.
- 12.12.3 The contact shoe of the current collectors shall be lower down by means of a pneumatic actuator. The design shall be based upon an "air-retract (lower down) spring applied" operating method.
- 12.12.4 When no air is available a mechanical means shall be provided to retract and latch the collector shoes. Additional manual retraction and raising by means of a mechanical, insulated lever, shall be provided. The manual control device shall be accessible from track level
- 12.12.5 It shall not be possible to retract the collector shoes with either traction or auxiliary circuits energized.
- 12.12.6 The current collectors shall be compatible with the characteristics of the specified bottom contact Traction Supply conductor rail. Each current collector shoe shall include an arm having a weak link device designed to break if an obstruction is encountered. The minimum impact energy to cause the weak link to break shall be specified by the Contractor.
- 12.12.7 The third rail current collectors and fuses shall be arranged to prevent any arcing to grounded metal parts of the car body and the bogie.
- 12.12.8 The third rail current collector shoe arrangement shall be mounted on the bogie frame such that it shall suit for the bottom current collector system. Suitable bottom cover shall be provided to prevent the damage of CCD part.
- 12.12.9 The current collector shoe arrangement shall be mounted such that it shall not infringe the kinematic envelope shown in Appendix E/1.
- 12.12.10 The current collectors shall be mounted to approved fibreglass or other dielectric bracket, with sufficient insulation and arc interruption capacity to allow mounting directly to a grounded portion of the bogie. Suitable arc shields of an approved material shall be used.

- 12.12.11 All car wiring downstream of each contact paddle shall be protected by a single, current-limiting, arc confining cartridge fuse capable of carrying the current for the entire car indefinitely.
- 12.12.12 The current collector shoe arrangement shall be suitable for Bogie pitching, rolling all dynamic requirements.
- 12.12.13 It shall have a suitable disconnection mechanism for isolating the power from the current collector rail.
- 12.12.14 The operation of the current collector shoe shall be through pneumatic and controlled from the Driver cab with proper interlocking with the traction control
- 12.12.15 The current collector shoe head shall be designed with suitable material to achieve minimum head mass and effective dynamic mass and friction to achieve optimum performance in all applications. The Contractor shall furnish the expected frequency for replacement of shoe in terms of kilometres (km) earned by the car.
- 12.12.16 The shoe head shall be capable for current carrying capacity according to the energy consumption.
- 12.12.17 All collector shoe equipment and mountings shall be identical, irrespective of the type of bogie on which they shall be mounted.
- 12.12.18 Individual Current collector status (up/down) shall be monitored by TCMS. If any CCD is not moving as per command, TCMS shall give pop-up message with alarm.
- 12.12.19 The rating of the fuse shall be decided based on the current collection though only one CCD per DMC/MC in all modes of operation. The rating and fuse mounting arrangement shall be finalized during design. The fuse of current collector device shall be visible through a transparent glass cover for ease of regular inspection and shall be supplied with micro-switch to monitor its position.
- 12.12.20 Middle wear mark and condemning limit mark shall be engraved on CCD shoe. Edges of CCD shoes shall be chamfered to avoid sharp edges.
- 12.12.21 ~~Contractor shall closely monitor the behaviour of shoe wear during DLP and suggest appropriate recommendations for maintenance.~~

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~~Contractor shall closely monitor the behaviour of shoe wear during DLP and suggest appropriate recommendations for maintenance.~~
Contractor shall closely monitor the behaviour of shoe wear during **DLMP** and suggest appropriate recommendations for maintenance.

- 12.12.22 The replacement of the collector shoes shall be easily achievable by unskilled maintenance personnel, in the minimum time, without the need of special tools. It shall also be possible to easily inspect the shoes in situ without the need to remove or dismantle any components.

12.13 Traction power supply (Stinger Supply) in workshop

- 12.13.1 Electrical receptacle located on each side of the vehicle, able to accept the same shop power as the knife switch, shall be provided. These receptacles shall be housed in a box constructed of an approved insulating material and be electrically connected to the test socket of the knife switch.
- 12.13.2 Electrical pick up terminals or receptacles on both sides of each DMC and MC shall be provided for stinger supply. While DMC or MC is energized through stinger supply,

supply from third rail through CCD shall be isolated and supply from stinger side shall not extend to CCD.

- 12.13.3 The Rolling Stock Contractor shall also supply (424 Nos.) the mating half of the connector, which shall include a full complement of female contacts.

12.14 Deliverables

Contract deliverables required by this section of these Technical specifications are summarized below:

CDRL-12-1:	Details of rating of propulsion equipments during constant braking zone (ref. ERTS 12.1.7)
CDRL-12-2:	Calculation to show that under normal operating condition, resonance shall not occur in the circuit leading to the pulsation of filter capacitor voltage. (ref. ERTS 12.1.9)
CDRL-12-3:	Negotiation of the train on cross overs to prevent over current in the traction motors (ref. ERTS 12.1.10)
CDRL-12-4:	Calculations for finalising the ratings of individual propulsion equipments (ref. ETS 12.2.10)
CDRL-12-5:	Closing of HSCBs of trains. (ref. ERTS 12.2.11)
CDRL-12-6:	Staggered acceleration of trains. (ref. ERTS 12.2.13)
CDRL-12-7:	Simulation for return current from complete 6-Car train sets (ref. ERS 12.2.14)
CDRL-12-8:	Change-over of VVVF sequence from one mode to other mode (ref. ERTS 12.3.12)
CDRL-12-9:	Protection and diagnostics of DC/AC Traction Inverter (ref. ERTS 12.3.13)
CDRL-12-10:	Details of LED based lighting arrangement in the inverter box. (ref. ERTS 12.3.15)
CDRL-12-11:	Details for ventilation system of traction motor (ref. ERTS 12.4.3)
CDRL-12-12:	Details for evaluation of the temperature index of the insulation system (ref. ERTS 12.4.6)
CDRL-12-13:	Traction motor temperature monitoring (ref. ERTS 12.4.8)
CDRL-12-14:	Calculate the temperature curve of the traction motor in normal and downgraded conditions (ref. ERTS 12.4.9)
CDRL-12-15:	Calculations supporting the choice of bearings (ref. ERTS 12.4.11)
CDRL-12-16:	Details of the gear drive unit, gear performance, and coupling details (ref. ERTS 12.4.15)
CDRL-12-17:	Characteristics of Traction Motor (ref. ERTS 12.4.18).
CDRL-12-18:	The protection scheme from HSCB under various fault conditions (ref. ERTS 12.6.1)
CDRL-12-19:	Energy Measurement Details (ref. ERTS 12.11.3)

13 AUXILIARY SUPPLY ELECTRICAL EQUIPMENT

13.1 Auxiliary Supply System

13.1.1 In 6-Car train set, auxiliary power supply shall be provided on a 3-car (*DMC-TC-MC) unit basis. The auxiliary power supply system shall be configured such that it performs reliably for all operating train consists. Each 3-Car unit shall consist of:

- (i) Auxiliary Power Supply (APS) unit / Static inverter.
- (ii) Battery charger.
- (iii) Back-up Battery.

13.1.2 ~~The auxiliary power distribution scheme shall be such configured that each 3-car unit (*DMC-TC-MC-) has at least one auxiliary power supply equipment. When any train operator's cab is activated, all the auxiliary power supply equipment in the train shall operate. It is preferred to operate all the auxiliary power system in synchronous mode of operation. In the event of failure of an auxiliary power supply equipment on one 3 car unit in 6 car train, the remaining auxiliary power supply equipment must be capable of supplying all auxiliary power to complete 6-car train except for HVAC load which shall be restricted to one HVAC per car. This transition shall be smooth and imperceptible for all the systems supplied by the Auxiliary Power Supply unit in failure. Details shall be submitted for Project Manager's review during design phase. (CDRL-13-1)~~

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The auxiliary power distribution scheme shall be such configured that each 3-car unit (*DMC -TC-MC-) has at least one auxiliary power supply equipment. When any train operator's cab is activated, all the auxiliary power supply equipment in the train shall operate. In the event of failure of an auxiliary power supply equipment on one 3 car unit in 6 car train, the remaining auxiliary power supply equipment must be capable of supplying all auxiliary power to complete 6-car train except for HVAC load which shall be restricted to one HVAC per car. This transition shall be smooth and imperceptible for all the systems supplied by the Auxiliary Power Supply unit in failure. Details shall be submitted for Project Manager's review during design phase. (CDRL-13-1)

13.2 Auxiliary inverters

13.2.1 Each Auxiliary Power Supply (APS) unit shall be mounted in individual box. The box for the auxiliary inverter shall be of Stainless Steel/Anodized Aluminium/Aluminium Alloy so as to avoid any corrosion in service on any account and the box shall last for the lifetime of the auxiliary inverter unit without needing any attention. The IP protection level of auxiliary inverter box shall not be less than IP65. The connectors shall have IP67 protection. The cooling arrangement shall ensure no dust deposition on the component and associated electronics. The box cover which may have to be removed for maintenance shall be suitable secured against falling. Hinged opening cover arrangement shall be preferred. The auxiliary inverters are protected by fuse, which are mounted in the auxiliary box. Via a knife switch the auxiliary inverter can be connected to the shop power supply.

- 13.2.2 The auxiliary inverters shall be independently supplied from the traction supply, via the line contactor. The auxiliary inverters shall receive its power from 3rd rail using current collector shoes mounted on the bogies of each motor car.
- 13.2.3 All auxiliary inverters shall be identical, interchangeable and under frame mounted. All internal items of the equipment shall be easily accessible and detachable, with the inverter "in situ", to facilitate maintenance.
- 13.2.4 Static inverters shall be provided with natural air ventilation system or forced cooling ventilation system.
- 13.2.5 Static type auxiliary inverters shall be of latest metro transit-proven technology (IGBT/SIC or latest) with microprocessor based, pulse width modulation control. The design of the auxiliary inverter shall comply with the IEC 61287 part 1. The three-output voltage shall be as follows:
- i) Output 1: 415V 50Hz 3 ϕ 3 wire
 - ii) Output 2: 230V 50Hz 1 ϕ
 - iii) Output 3: 110V D.C.
- None of the above shall be accessible by passengers.
- 13.2.6 The auxiliary inverter shall provide power supply to all auxiliaries including ventilation blower motor, air-conditioning units, air compressor, doors, light equipments, control units and low voltage loads.
- 13.2.7 The auxiliary inverter shall be capable of withstanding the full voltage range of the traction supply as specified, and still maintain the outputs as specified as per IEC 60085.
- 13.2.8 High voltage spikes or transients on the traction supply shall not be transmitted to the auxiliary inverter outputs. The auxiliary inverter shall not suffer any damage or malfunction, when subjected to surges and transients and the worst case surges, such as, the surge produced by the traction high speed circuit breaker when rupturing currents.
- 13.2.9 The supply shall be regulated within $\pm 5\%$ of the nominal voltage and total harmonic disturbance shall be limited to 8% under all operating conditions. Phase-to-phase voltage imbalance shall not exceed 1% between phases. The converter shall otherwise comply with the provisions of IEC 61287-1.
- 13.2.10 In the event of a failure of one auxiliary inverter the auxiliary equipments shall still continue to operate correctly by power automatically supplied from the other auxiliary inverter or degraded modes shall be proposed by the Contractor. The ac output provided by the auxiliary inverter shall be such that in the event of one auxiliary failure, it shall not cause the loss of more than 1/2 of the saloon lighting and 1/2 of the air conditioning system, in any one car.
- 13.2.11 Auxiliary inverters shall be designed to the same standards as those specified in traction system. The requirements specified therein in respect of limitation of interference shall apply also to static inverters.
- 13.2.12 Auxiliary inverters shall have safe protection against the possibility of high voltage dc component appearing on 110V or 415 V ac circuits. Voltages shall follow IEC 61287-1 standards.

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- 13.2.13 The dc output provided by the auxiliary inverters shall be arranged to ensure that the control supply is not lost in the event of a failure of an auxiliary converter.
- 13.2.14 The efficiency of the Auxiliary Inverters shall be a minimum of 92% at any voltage as defined in Chapter 2.5.1.
- 13.2.15 Power semiconductors shall be mounted on grounded heat sinks. Under all normal and emergency operating conditions, the peak junction temperatures shall not exceed 90% of their declared peak ratings.
- 13.2.16 The output circuits are galvanically isolated from the input and each other.
- 13.2.17 Staggered starting shall be provided on the Auxiliary Power Supply loads to minimize start up current.
- 13.2.18 Control Requirements. The following requirements shall be met:
- i) The auxiliaries of the whole train shall be switched 'off' from any cab by one operation only. Switching 'off' shall be possible from any control panel irrespective of that used to switch 'on'.
 - ii) Sequential starts or other means of limiting peak starting loads will be considered. Switching 'off' shall preferably be direct, but consideration will be given to delay circuits to allow air conditioning equipment to cycle off if this is shown to be essential. Under no circumstances, APS over current shall be detected during sequential start of auxiliary loads. The details shall be submitted and finalized during design phase. **(CDRL-13-2)**
- 13.2.19 **Protection and diagnostics:**
- i) Control circuit logic shall permit testing and monitoring of the operation of the auxiliary power supply system when running.
 - ii) Protection against single phasing and short-circuiting shall be incorporated into the auxiliary converter feeding 415V, 50Hz auxiliary drives.
 - iii) The auxiliary power control system shall carry out self-tests to ensure the integrity of the equipment. Sufficiently detailed status, fault and diagnostic information shall be transmitted to the Train Control Management System (TCMS), to enable protective or corrective action to be taken immediately, when necessary.
 - iv) The auxiliary inverter shall use a control scheme that contains extensive self-diagnostic logic, which shall be fully integrated with TCMS. At a minimum, the diagnostics system shall identify a range of credible faults, identify whether a Least Replaceable Unit (LRU) is responsible for the fault, and whether the LRUs (or non-LRUs) must be replaced or the system merely reset. The diagnostics system memory shall be retained for at least 200 events.
 - v) On the condition that the auxiliary inverter has been started previously, in the event of an interruption of the primary power supply including loss of contact of current collector and 3rd Rail, the auxiliary converter shall automatically re-start immediately once the input power has been re-established.
 - vi) The train operator from the cab/TCMS shall be able to isolate any defective auxiliary power supply equipment.

- vii) All auxiliary power equipment shall be easily accessible for inspection, testing and maintenance.
- viii) Contactors shall be rated for maximum current capacity and overload interruption capability.
- ix) During the negotiation of the train on cross overs, efforts shall be taken to reduce the APS current due to short break of 750 V DC supply to prevent over current in the APS unit.

The details of the protection scheme shall be submitted and finalized during design phase. **(CDRL-13-3)**

- 13.2.20 Heat detectors/LHD in SIV and battery charger shall be provided and status shall be linked to Local Control panel and TCMS/Fire detection (refer ERTS clause 3.14) so that their status is monitored.
- 13.2.21 LED based lighting arrangement shall be provided in the SIV box for maintenance purpose. Its fail safe interlocking with the box cover shall be ensured. Details shall be submitted for Project Manager's review during design phase. **(CDRL-13-4)**
- 13.2.22 Only in the event of critical fault conditions, such as, short circuit fault, shall the auxiliary inverter be automatically isolated from the traction supply line by rupturing of the fuse.
- 13.2.23 The box for auxiliary inverter shall be such that to avoid any corrosion throughout the service life on any account and the box shall last for the lifetime of the auxiliary converter unit without needing any attention.
- 13.2.24 Industrial 415V 50Hz 3 ϕ socket outlets with spring loaded covers, capable of accepting a shore supply shall be provided on each vehicle at sole-bar level, on both sides. Each shall be accompanied by a red lamp, to warn of live sockets, when a shore supply is plugged in. The control logic shall ensure that train motoring is not possible when shore supply is applied to the train. The design and type of the interface connector shall be submitted for Project Manager's review. Minimum 50 numbers of the mating connectors along with required cable length shall be supplied for installation in the depots.
- 13.2.25 The shore supply shall have sufficient capacity, rating and provision to enable Project Manager's maintenance personnel to test all electrical auxiliary equipment. The shore supply connector of adequate capacity shall be provided at diametrically opposite convenient locations on either side of each car.
- 13.2.26 The shore supply circuit shall be designed with isolation between AC circuit and 750V DC circuit to prevent two-point earth condition during charging through shore supply.
- 13.2.27 In case, neutral point of AC, 3phase power supply of the depot is earthed, neutral points of concerned transformer of APS box shall be disconnected from earth in shore supply mode to prevent two-point earthing in circuit after finishing pre-charging.
- 13.2.28 Additionally, internal 230V 50Hz 1 ϕ socket outlets for vacuum cleaners shall be provided in each car. The socket outlet shall be mounted within each saloon in a

position that is easily accessible to maintenance and cleaning staff but inaccessible to passengers.

- 13.2.29 The auxiliary power supply system shall be configured such that it performs reliably for all operating train consists. Full auxiliary power shall be available from 500 V DC to 1000 V DC.

13.3 Battery Charger

- 13.3.1 The battery shall be charged from the local (three-car unit) static battery charger. The battery charger with automatic control shall be capable of providing a temperature compensated high rate boost charge or float charge compatible with the characteristic of the Ni-Cd batteries.
- 13.3.2 The battery charger shall be capable of charging a discharged battery to 80% full charge within 4 hours. Once the battery is fully charged, float charge should exist. The Contractor shall submit for review and approval the design calculation for battery charger rating. **(CDRL 13-5)**
- 13.3.3 The battery charger setting in normal and float mode shall be finalized in interfaced with the battery supplier.
- 13.3.4 Batteries shall be connected to a common Battery Bus throughout the train.
- 13.3.5 Battery Charger health status and Battery Charger output (voltage and current) shall be displayed in TCMS VDU.

13.4 Back-up Batteries

- 13.4.1 Each three-car unit shall be equipped with one set of batteries consisting of nickel cadmium cells having a nominal voltage of 110V with cell casings of stainless steel or other alternative robust flame- retardant material. The battery shall be rated and tested in accordance with the requirements of IEC 60623 and shall also meet the requirements of IEC 60993 and EN 50547. Use of block battery shall not be preferred.
- 13.4.2 ~~The maximum charging and discharging current that the battery shall withstand without endangering its life and reliability shall not be less than 100A.~~

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- 13.4.3 The backup battery shall utilise a sufficient number of cells to ensure that it is capable to supply emergency load in case of failure of battery charger or its supply (no energy supply by the third rail) with the battery charged to 80% of its full capacity, before the voltage level at any device falls below 77V dc. Non-essential load shall be shed after 30 seconds of failure of battery charge supply. This feature shall be demonstrated during testing.

Design of battery shall be suitable for frequent discharge as per load cycle under sleep mode in GoA3/4 and at train start-up.

- 13.4.4 The proposed list of equipment of the emergency systems shall be submitted. Emergency loads shall include, but not be limited to:

1 hour supply emergency load with:

- (i) Emergency lighting.
 - (ii) All exterior lights.
 - (iii) Ventilation fans, but not air conditioning.
 - (iv) Communication systems including public address, passenger emergency alarm, surveillance system and train radio.
 - (v) Propulsion and brake controls.
 - (vi) Door controls.
 - (vii) TCMS.
 - (viii) Electric horn.
 - (ix) Cab console indicators, lighting and interlocking.
 - (x) HVAC controls,
 - (xi) ATP/ATO/UTO equipment (ATP/ATO/ATS).
 - (xii) Front Auto Coupler circuit.
 - (xiii) Fire detection system.
- 13.4.5 The design and control of the battery shall ensure that there is sufficient capacity left under all conditions to operate current collector's control system. Adequate circuit protection shall be provided to ensure the battery load shall be disconnected when the battery voltage has dropped below 70% of the nominal voltage and when the auxiliary load is re-connected, the initial battery load shall not cause the battery output to oscillate.
- 13.4.6 Battery electrolyte capacity shall be such that the batteries will require topping up not less than 8 months. Batteries shall be designed with integrated topping up provisions. Suitable interconnection shall be provided so that topping up of all the cells can be carried out using from a single point on battery box. The design shall be submitted for review of the Project Manager. **(CDRL-13-6)**
- 13.4.7 The battery terminal voltage shall float on the 110V DC output of the auxiliary power supply of which the output voltage shall have fine adjustments and good stability to avoid over or undercharging of the battery.
- 13.4.8 The control elements taking power from the battery shall be capable of operating between 77V and 138V DC. The instantaneous battery voltage shall be monitored and recorded through TCMS.
- 13.4.9 The battery shall be adequately protected using fuse and circuit breaker. These shall be mounted as close to the battery as possible. The status of fuse and circuit breakers shall be monitored by TCMS. The Contractor shall provide the detailed calculation to decide the rating of the battery fuse during design phase. **(CDRL-13-7)**
- 13.4.10 Battery temperature shall be displayed in TCMS.
- 13.4.11 Battery fuses are to mount such way that fuse blown indicator to be visible from outside at the time of maintenance work inspection.

- 13.4.12 Two sets of battery electrolyte automatic topping up devices shall be provided for each depot. Battery electrolyte automatic topping up devices shall be portable and easily operated by one person. They shall incorporate a feature to cut-off the electrolyte automatically when it has reached the correct level. The battery shall have a large capacity of electrolyte to allow topping-up intervals not less than 8 months. Contractor shall provide a single point topping-up system arrangement. Over topping-up of the battery shall be avoided. The details shall be submitted for Project Manager's review during design phase. **(CDRL-13-8)**
- 13.4.13 The hydraulic circuit arrangement of the batteries should not block by the battery box folding arm when it was locked and it should not touch with positive or negative terminal. the Contractor should demonstrate the hydraulic arrangement in first train set.
- 13.4.14 The cable routing inside the battery box shall maintain the sufficient length and electrical clearances (the gap between cable terminal Lug & battery cells terminal bolt) and it should not cause short circuit while carrying out maintenance work.
- 13.4.15 ~~Battery can be recharged 2000 times at least and follow UIC 854R requirement.~~
[Addendum-1 dated 05.12.2022, Sl. No. 136](#)
Deleted.
- 13.4.16 Not Used.
- 13.4.17 **Battery Protection and Isolation:**
- i) Protection of the battery shall be provided, with adequately rated fuses placed in both the positive and negative poles.
 - ii) Battery fuses shall be fitted in a separate box located adjacent to one of the battery boxes and shall enable easy access from track level.
 - iii) Back connected fuse holders shall be provided and the battery fuse enclosure shall be sealed to IP65 in accordance with IEC 60529.
 - iv) A battery switch operable from inside the saloon shall be provided to disconnect the battery from the car wiring electrically when required.
 - v) A low voltage earth bar shall be provided and located close to the negative fuse.
 - vi) The battery fuses shall be provided in the underframe area in a suitable independent enclosure or an integral part of the battery box and the battery isolation switch shall be provided in one of the electrical cubicles in the saloon area.
 - vii) The enclosure shall be located as close as possible to the battery and shall enable easy access to the isolation switch actuator from the track level.
 - viii) The switch shall be lockable by means of a personal lock with a removable key when the switch is in the isolated position.
 - ix) The Battery circuit shall be switch -off when battery voltage reaches 81V DC in case of Master controller key is removed condition and same shall be monitored through TCMS.

- x) All terminal bolts, inter connecting links between cells as well as battery blocks & terminal links to be insulated to avoid electrical short circuit risks by tools or any foreign metallic objects.
- 13.4.18 Two trains (one on each line) shall be fitted with Battery Control and Monitoring Unit (BCMU) both units to monitor the charging, discharging current, voltage etc. It shall be possible to install the BCMUs in any of the trainsets at later stage. RS contractor shall ensure necessary wiring in all the trains.
- 13.4.19 Battery supplier shall provide the quality control documents for ensuring the quality of installation of battery set including the requirement of crimping as per design, cable sizing and laying, torque requirements etc. RS contractor shall ensure the work at rolling stock manufacturer facility as per quality control documents provided by battery manufacturer.
- 13.4.20 Battery sizing calculation at high and low temperature, shall be submitted to Project Manager during detailed design stage.

13.5 Battery Box

- 13.5.1 Batteries box shall be designed by the battery supplier incorporating all the necessary clearances and safety precaution required to be taken. A 3D model of the battery box shall be prepared by the car builder and shall be validated by the battery supplier.
- 13.5.2 There shall be adequate clearance between rear hydraulic hose and the back metal frame of the battery so that in case of over flowing of electrolyte, adequate safety clearance shall be maintained between the hose and the back metal frame of the battery box. There shall be no rubbing of cable with battery hoses. The details shall be submitted and finalized during design phase. **(CDRL-13-9)**
- 13.5.3 Batteries box shall be removable as a single module with mechanical handling equipment. It should equip with sliding device to benefit the maintenance work.
- 13.5.4 The box for battery shall be such that to avoid any corrosion throughout the service life on any account and the box shall last for the lifetime of the cars. Within the battery box, the battery shall be mounted in roll out trays to allow for easy maintenance.
- 13.5.5 The roll out system shall be corrosion resistant and shall be provided with the necessary stops and locks to limit the travel of the battery box and retain it in both extreme positions. When rolled out, the entire top of the battery shall be exposed. All the battery terminals, including battery positive and negative main connections shall be easily accessible for maintenance work.
- 13.5.6 The box interior / the roll out trays shall be lined with a non-flammable, electrolyte proof, insulating material of suitable thickness. The box shall be ventilated to preclude the possibility of built-up of any gas. The vents shall be designed to prevent ingress of water or rubbish.
- 13.5.7 The battery box location shall be arranged to provide easy access for maintenance inspection and topping up of water.
- 13.5.8 The battery box floor shall be shaped to support and locate the battery and to assist drainage. A lip shall be provided at the front to prevent spillage from running down the front of the box. Ample drainage outlets shall be provided, which shall discharge clear of all equipment, and otherwise as low down as practicable.

- 13.5.9 The battery boxes shall be made of stainless steel lightweight construction suitably protected.
- 13.5.10 A lid, with top mounted lift off hinges shall be provided with safety straps.
- 13.5.11 With the lids removed, the whole front of the box shall be clear. Vents shall be provided in the top, ends and back of box.
- 13.5.12 The lid, in the closed position, shall be secured by spring clips.
- 13.5.13 The battery tray shall incorporate a secure quick release safety locking mechanism to keep the battery set in position, of which the locking and releasing position shall be easily identifiable.
- 13.5.14 Activation of the locking mechanism shall separate the battery tray from the battery box.
- 13.5.15 This battery tray shall be mounted on angles and, arranged so that a fork lift truck can lift the half battery out in its box as a unit once the cables and box fixings are released.
- 13.5.16 The battery compartment shall be naturally ventilated with the provision for dispersing any gas evolving from the battery without affecting the floor or the underframe in any way.
- 13.5.17 The battery cells shall be assembled in fire proof insulated crates and each cell shall be positively located within its crate/ Vibration proof automatic lock shall be provided to ensure absolutely no relative movement of the batteries inside the tray.
- 13.5.18 Battery box shall not de-shape /sag during lifetime of the car. Adequate strength shall be built in the battery box by providing suitable ribs etc. FEM & fatigue report of the battery box shall be submitted to establish the same. **(CDRL-13-10)**
- 13.5.19 Battery box shall be fitted with the flame arrester to arrest the fire in case of battery bursting.

13.6 Inverter for HVAC ventilation

- 13.6.1 Adequately sized battery voltage powered DC inverter shall be provided per HVAC unit in the under frame/inside saloon/inside HVAC units to feed the ventilation fans of HVAC in case of 750 V DC power loss.

13.7 Deliverables

Contract deliverables required by this section of the Technical Provisions are listed below.

CDRL-13-1:	HVAC operation logic when one APS fails (ref. ERTS.13.1.2)
CDRL-13-2:	Control requirements of auxiliary inverter (ref. ERTS 13.2.18 (ii))
CDRL-13-3:	The details of the protection scheme (ref. ERTS 13.2.19)
CDRL-13-4:	Details for LED based lighting arrangement in the SIV box (ref. ERTS 13.2.21)
CDRL-13-5:	Design calculation for battery charger rating (ref. ERTS 13.3.2)
CDRL-13-6:	Battery electrolyte capacity (ref. ERTS 13.4.6)
CDRL-13-7:	Calculation to decide the rating of the battery fuse (ref. ERTS 13.4.9)

CDRL-13-8:	Design of automatic electrolyte topping up device (ref. ERTS 13.4.12)
CDRL-13-9:	Details of clearance between rear hydraulic hose and the back metal frame of the battery (ref. ERTS 13.5.2)
CDRL-13-10:	FEM & fatigue report of the battery box (ref. ERTS 13.5.19)

14 HEATING VENTILATION AND AIR-CONDITIONING

14.1 HVAC for passenger saloon

- 14.1.1 The Heating, Ventilation and Air-conditioning (HVAC) System shall be installed on each car to provide full control of interior temperatures automatically, over the full range of heat loads associated with passengers, miscellaneous electrical equipment, lighting, heat transmission and solar gain as per seasonal changes.
- 14.1.2 HVAC units shall be roof mounted package type without interference with the Kinematic Envelope. Two identical units shall be suitably located to achieve specified conditions. The system shall be driven by AC motor.
- 14.1.3 Not Used.
- 14.1.4 The refrigerant used in the air-conditioning system shall be in accordance with the requirements of the Montreal Protocol. Environment-friendly refrigerant shall be provided and may include R134A or R407C or R410A
- 14.1.5 The Contractor shall submit the system design supported by schematic layouts, equipment sizing and selection, airflow distributions, cooling load estimation and psychometric charts to meet the saloon environmental requirements including, but not be limited to, temperature, relative humidity and noise requirements.
- 14.1.6 The air conditioning system shall be powered from the auxiliary electrical supplies for normal operation and from battery for emergency ventilation (1 hour).
- 14.1.7 In order to minimize energy consumption, load weight signal shall be used for controlling the performance of HVAC system.

14.2 Design Criteria – Cooling and Heating Capacity of the Unit

- 14.2.1 The HVAC unit shall be designed as per climatic data of ASHRAE 0.4% DB/MCWB respectively, 0.4% WB/MCDB conditions for rating of the HVAC equipment. However outside Design Data Condition for Bangalore is given in table below:

Table 14.2 External/internal conditions for HVAC

Weather Conditions	External temperatures	Internal Conditions
Summer	Dry Bulb 35.2°C Wet Bulb 19.6°C	Dry Bulb 25°C < 60 % RH
Monsoon	Dry Bulb 27.3°C Wet Bulb 23.0°C	Dry Bulb 25°C < 60 % RH

Heating is required for de-humidification only and not for saloon temperature control.

Provision of humidity control shall be there in the HVAC. Humidity control shall be done as per the comfort zone as specified in EN14750-1.

The above Data is taken from ASHRAE.

However, the bidder/Contractor may confirm from ASHRAE, outside design data conditions for Bangalore for the capacity calculation of HVAC. The design data conditions considered, and capacity calculations of HVAC shall be submitted for Project Manager's review during design phase. **(CDRL-14-1)**

- 14.2.2 Heat gains to be considered for each car shall be calculated according to ASHRAE Handbook fundamentals and/or any other acceptable guidelines but not limited to followings:
- i) Car lighting and electrical loads (including evaporator fan motors).
 - ii) Car body heat transmission with an assumed 10 km/h relative exterior velocity.
 - iii) Fresh air heat load.
 - iv) A solar load representing direct and diffused radiation, convection and radiation from window surfaces, and absorbed heat gain from the glazing, car body structure and passenger load.
- 14.2.3 The Contractor shall carry out cooling load estimates for all specified design conditions including equipment located inside saloon with the use of internationally recognized reference data. The estimated weight, power requirements and heat load calculations giving the parameters adopted, shall be submitted by the Contractor. The specific measures taken to minimise energy consumption of the HVAC unit shall be detailed in the bid.
- 14.2.4 The air conditioning units shall be sized to cater for AW4 condition with all equipment being operated. The Contractor shall take into consideration to allow the effects of door opening and closing at stations and the piston and infiltration effects for the train moving in tunnel.
- 14.2.5 The system shall automatically control the temperature and relative humidity throughout the passenger area up to 25°C and relative humidity within 60%RH respectively, for ambient temperatures of 27.3 °C 72% RH and 35.2°C 24% RH.
- 14.2.6 The air conditioning units shall be capable of cooling down an empty car, which has stabilized throughout the surface design temperature without sun radiation, to the control temperature of 25°C in the passenger saloon within 30 minutes.
- 14.2.7 ~~Employer expects that an energy efficient system comparable with the best available in the market shall be provided. Good energy efficiency shall be achieved in cooling and de-humidification operations of the HVAC. Contractor shall furnish Energy Efficiency Ratio (EER) for the offered system. In cooling mode, the Coefficient of Performance (COP) of HVAC shall be at least 2.5 in summer ambient conditions under all loading conditions from AW0 to AW4 which may be achieved by utilizing variable frequency control (if required) of compressors or any other control mechanism. The COP shall be validated as per IS8148, ASHRAE 37 or any other relevant standard, as agreed by the Project Manager. The Contractor shall submit the record of proven system already functional in any metros with the specified COP. The Contractor shall furnish expected power consumption of the HVACs per car for peak Summer, Monsoon and Winter ambient conditions for AW0, AW1, AW2, AW3 and AW4 passenger loads.~~

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Employer expects that an energy efficient system comparable with the best available in the market shall be provided. Good energy efficiency shall be achieved in cooling and de- humidification operations of the HVAC. Contractor shall furnish Energy Efficiency Ratio (EER) for the offered system. In cooling mode, the Coefficient of Performance (COP) of HVAC shall be at least 2.5 in summer ambient conditions

under **AW4 loading conditions** which may be achieved by utilizing variable frequency control (if required) of compressors or any other control mechanism. The COP shall be validated as per IS 8148, ASHRAE 37 or any other relevant standard, as agreed by the Project Manager. The Contractor shall submit the record of proven system already functional in any metros with the specified COP. The Contractor shall furnish expected **COP, cooling capacity and power consumption** of the HVACs per car for peak Summer, Monsoon and Winter ambient conditions for AW0, AW1, AW2, AW3 and AW4 passenger loads.”

- 14.2.8 The temperature variations inside saloon room shall follow EN -14750 (1/2) standards.
- 14.2.9 The air discharge velocities at any outlet grille, shall not exceed 1m/s measured 300mm below ceiling and shall vary progressively (EN13129/EN14750). The air velocity within ducts shall not exceed 8m/s, shall not cause noise or air movement discomfort to passengers, and shall generally follow internationally accepted practice. The air intake velocity at the re-circulation and exhaust grilles shall not exceed 3m/s. Details of the Contractor's proposals shall be submitted.
- 14.2.10 The minimum volume of fresh air supplied by the artificial ventilation shall be in the range of 2.22 litre/sec/passenger (AW4 load) and this air shall be filtered.
- 14.2.11 In the event of the failure of both HVAC on a car, an emergency ventilation system (1 hour with battery supply) shall operate automatically to admit fresh air directly into car to maintain the required oxygen level in the fully laden car, in accordance with ASHRAE. The outside fresh air shall not be less than 3.33 litres / sec /passenger (AW4 load) as per EN-14750. The emergency ventilation fan shall be fed from the 110V DC supply with. It shall be possible to stop the working of emergency ventilation system in the depot through TCMS when 750V DC supply is not available.
- 14.2.12 Saloon Pressure: the ventilation shall pressurize the car with all doors closed and car stationary. The proposed value of pressure and time it takes to achieve it, shall be submitted.
- 14.2.13 Provision shall be made to shut off the fresh air intake and re-circulate the internal air of the saloon, during an emergency condition, such as fire outside the train causing excessive heat and smoke to be drawn into the vehicle. Operation of such provision shall be made from the operative driving cab. The closing time of the fresh air damper shall preferably be less than 10 seconds from the receipt of smoke signal to avoid ingress of large quantity of smoke inside the car. Operation of such provision shall also be made from the operative driving cab through TCMS in Non UTO mode of operation and OCC in UTO mode. Provision shall be available to bypass the fire detection control unit though TCMS. Full details of the system proposed shall be discussed and finalized during design stage.

14.3 Emergency Ventilation System

- 14.3.1 The ventilation shall be provided in accordance with the following matrix

Mode	Cooling	Fresh Air	Return Air
Ventilation	Not required	Available	Available
Emergency	Not required	Full	Not required

Smoke	Available	Not required	Full
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14.3.2 Ventilation Mode

- i) In the event of failure of an air conditioning unit to provide cooling, the system shall provide ventilation with normal fresh air intake and return air circulation.
- ii) The failure shall be reported to and recorded by the TCMS.
- iii) Fresh air temperature, return air temperature and set temperature shall be monitored by TCMS. If the fresh air temperature is less than the set temperature (25°C normally) HVAC shall automatically go into ventilation mode. Also in TCMS, selection of ventilation option shall be provided through which all the HVAC can be run in ventilation mode.

14.3.3 Emergency Mode

- i) Provision shall be made to power the Supply fan blowers from the battery in the event of 750 V DC power to the car is lost. This provision shall automatically come in to operation 45 seconds after 750 V DC power is lost and be discontinued upon resumption of 750V DC Supply.
- ii) The emergency ventilation shall inhibit cooling and deliver full (100%) fresh air to the saloon without any re-circulation.
- iii) The fresh air intake rate shall be: Fresh air intake in saloon 3.33 (minimum.) l/sec/pas.
- iv) The air conditioning system shall automatically restore normal operation if power supply returns to normal.
- v) Operation of the emergency mode ventilation shall be reported to and recorded by the TCMS.
- vi) As emergency ventilation is a safety requirement, the battery shall be rated to provide power to the blowers for 1 hour in addition to that required for other emergency loads. At the end of this emergency period, the airflow shall not be less than 3.33 l/sec/pas.
- vii) In the depot, it shall be possible to override the operation of emergency ventilation mode through TCMS when 750V DC power supply is not available.

14.3.4 Smoke Mode

In the event of smoke being detected by smoke detector of HVAC, contractor shall submit the sequence of actions (status of dampers, air conditioning enable/disable, ventilation control etc.) which will be implemented.

14.4 Smoke Detection

14.4.1 The Contractor shall propose a smoke detection system suitable for railway application.

14.4.2 In 6-car train smoke detector shall be provided in all HVAC's as below:

DMC-1	2 Smoke detectors (One in each HVAC)
TC-1	2 Smoke detectors (One in each HVAC)

MC-1	2 Smoke detectors (One in each HVAC)
MC-2	2 Smoke detectors (One in each HVAC)
TC-2	2 Smoke detectors (One in each HVAC)
DMC-2	2 Smoke detectors (One in each HVAC)

- 14.4.3 The detection system shall be designed to give a fast and accurate response with minimized nuisance activation.
- 14.4.4 The detection system shall be activated if there is excessive dust or smoke in the tunnel. Smoke detection shall be reported to the TCMS and OCC.
- 14.4.5 The detection system shall be able to be checked and replaced from the saloon or from the roof including the sensitivity test.
- 14.4.6 The detection system shall be design to minimize the maintenance.

14.5 Roof Mounted HVAC Units

- 14.5.1 Two package type HVAC units per car, with all equipments required for satisfactory functioning of the system, shall be provided.
- 14.5.2 If one air conditioning unit is failed in any car, the other one unit in the same car shall be able to distribute conditioning air throughout the whole length of the saloon.
- 14.5.3 Package HVAC units shall be mounted on the roof, housed in suitable watertight wells in the car roof structure. The wells shall be provided with adequate, double sealed connections to the main conditioned air ducting, electrical supply and condensate drains. Conditioned air shall be fed into thermally insulated ducting. The wells to house air conditioning equipment shall have adequate strength and rigidity during operation in main line service with emergency braking applied.
- 14.5.4 Each unit shall be arranged on an integral frame, removable from the car as a single complete module. The integral frame housing of the unit shall be constructed such that to avoid any corrosion in service on any account and the box shall last for the lifetime of the HVAC unit without needing any attention.
- 14.5.5 The HVAC units shall have staggered starting in a sequence to reduce the inrush current load due to simultaneous starting of air-con motors. This may be achieved through Programmable Logical Controller of the units and TCMS. Failure of one of the HVAC units on a car shall not adversely affect operation of the other unit. The Contractor shall submit calculations for the inside conditions with one HVAC unit out of operation.
- 14.5.6 All electrical connections shall be fitted with quick disconnection fittings, at easily accessible locations.
- 14.5.7 The air conditioning unit shall be designed and constructed to meet the noise and vibration requirements.
- 14.5.8 All external grilles shall be constructed from stainless steel and designed to protected the coil face as well as prevent water ingress resulting from adverse weather or train washing.
- 14.5.9 Lifting lugs shall be provided at suitable positions to achieve balanced lifting.

- 14.5.10 The installation of unit shall be such that it shall be easily accessible for maintenance and removal. Filter elements shall be accessible from inside the car or via the roof.
- 14.5.11 The frame housing shall be designed and constructed so that access for inspection and routine maintenance is from roof hatches, hinged at one side, secured by captive bolts on the other, and provided with stops to retain them securely in the lifted position when opened.
- 14.5.12 The complete operation to remove and replace a unit should be simple. The Contractor shall declare the weight of the complete unit including specialized mechanical handling equipment.
- 14.5.13 ~~An electrical switchgear and control equipment for the system shall be located in a sealed cubicle, which shall be an integral part of the package. The cabinet shall be accessible from the inside the vehicle. The cubicle shall have IP55 protection. The electric switches, contactors and relays etc. should be proven in Metro application. The cables shall be halogen free compliant to EN45545 in respect of flammability, smoke emission and toxicity requirements.~~

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An electrical switchgear and control equipment for the system shall be located in a sealed cubicle, which shall be an integral part of the package. The cabinet shall be accessible from the inside the vehicle. The electric switches, contactors and relays etc. should be proven in Metro application. The cables shall be halogen free compliant to EN45545 in respect of flammability, smoke emission and toxicity requirements.

- 14.5.14 Air-conditioned unit shall have noise less compressors & condenser fans. Condenser fan assembly and evaporator motor-blower assembly shall be balanced in two planes, in-situ, as defined in ANSI/AMCA 204, and the residual unbalance should limit vibrations at motor end bells within 0.025 mm peak-to-peak displacement, or 2.3 mm/s RMS velocity, in any direction. However, any other balancing method may be proposed by the Contractor with the approval of Project Manager. This shall be a type test on prototype Unit.
- 14.5.15 The design shall ensure easy cleaning of the drains, evaporator coils, and condenser coils without need for lifting of HVAC unit from the car roof. Filter replacement, port for data downloading by PTU, electrical connection cubicle, control panel cubicle etc. shall be easily accessible from inside of saloon to the maintenance personnel, but not to the passengers.

14.6 HVAC Control and temperature setting

- 14.6.1 The saloon temperature setting shall be controllable through both the TCMS and the local communicating port to the control unit.
- 14.6.2 The temperature sensor control through programmable logic controller shall be easily accessible from saloon to facilitate maintenance.
- 14.6.3 Temperature sensors for the return air and other controls (Fresh Air, Humidity Sensor, Supply air Sensor) shall be solid state. The controls for the two air conditioning units shall be coordinated such that as the cooling load reduces, the unit can be unloaded in stages from full to half capacity to one unit being shut down except for the

ventilation blower. All the data shall be logged in TCMS and retrieval on demand from TCMS.

- 14.6.4 The Contractor shall propose the location to contain the control equipment for each air conditioner without affecting the interior styling of the saloon.
- 14.6.5 The control equipment shall be arranged to prevent overheating and ingress of water and dirt to meet the requirements.
- 14.6.6 Faults shall be reported to the TCMS to enable diagnosis via the TCMS or locally through a portable PC.
- 14.6.7 Not Used.
- 14.6.8 High and low pressure cut-out devices shall be provided to shut down operation if the refrigerant pressure exceeds the pre-set limits.
- 14.6.9 In the event of high pressure cut-out being activated by malfunction of the air conditioner, means shall be provided to inhibit further operation of the compressor and prevent self-reset of the cut-out device.
- 14.6.10 In the event of the high pressure being built up due to temporary abnormal high ambient temperature, the system shall unload without tripping the compressor miniature circuit breaker and permit the high-cut device to be self-reset when conditions resume normal.
- 14.6.11 The Contractor shall submit all pressure switch settings with the associated conditions.
- 14.6.12 ~~Compressor unloading device shall be provided to cater for part load conditions and relief of high refrigerant pressure due to the ambient temperature exceeding the tunnel temperature.~~

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- 14.6.13 ~~In the event that all conditions revert to normal without malfunction in the system, the unloading device shall be reset and the system shall load up automatically.~~

[Addendum-1 dated 05.12.2022, Sl. No. 140](#)

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- 14.6.14 The remote control shall be provided to operate the air conditioning control of the train from the cab.
- 14.6.15 Local Control: A control panel for each air conditioning (A/C) unit shall be provided.
 - i) The panel shall include a switch with "Automatic", "On" and "Off" positions; or a switch with "On" and "Off" positions where "On" position implies automatic operation. Further selection of mode of operation may be done through the PLC. Panel shall also include relays to motor circuit breakers for the compressor, fan and blower motors; and fault indicator lights for maintenance.
 - ii) Energizing an A/C unit shall include the compressor, condenser fan and ventilating blower. Shut down of an A/C unit shall initiate 'pump down' of the system before cut-out, if required for the used type of compressor.

- 14.6.16 Each HVAC unit shall be associated with its microprocessor control panel, installed in the electrical control cubicle within the car, or suitably provided within the unit, and including all necessary controls. The micro-processor based system, proven in railway service shall be provided with loading, scheduling, diagnostic and operational data interfaced with TCMS.
- 14.6.17 The microprocessor shall have extendable memory permitting logging of faults and system events in its memory for sufficiently long durations. The microprocessor shall have suitable interface with TCMS for data communication and display. Suitable communication shall be provided to permit logged events to be downloaded to a laptop computer.
- 14.6.18 The units shall be capable of being controlled from the driving cab. Facilities for remotely cutting-out and resetting of a faulty air-conditioning unit should be provided in the train operator's cab.
- 14.6.19 ~~High Pressure (HP) and Low Pressure (LP) values shall be monitored by TCMS.~~
- [Addendum-1 dated 05.12.2022, Sl. No. 141](#)
- High Pressure (HP) and Low Pressure (LP) faults shall be displayed by TCMS.**
- 14.6.20 A/C units in any car shall each be powered from different auxiliary power units.
- 14.6.21 All operator coils of relays and contactors shall be of the dc energized type.
- 14.6.22 The compressor motor shall be protected from overheating due to:
- i) Two phase operation.
 - ii) Low ac supply voltage.
 - iii) Overload
- 14.6.23 The following faults (as a minimum) shall be reported to TCMS. The faults list however is not exhaustive.
- i) Compressor overload thermal cut-out.
 - ii) Supply fan blower failure.
 - iii) Saloon over-temperature (rising at 33°C). A sensor shall be provided in each return air grille.
 - iv) High pressure failure circuit wise.
 - v) Low Pressure failure Circuit wise.
 - vi) HVAC compressor motor cut-off
- 14.6.24 The TCMS shall control the operation of HVAC through "OFF", "VENT" and "AUTO" mode.

14.7 Compressor/ Condenser Section

- 14.7.1 Compressor shall be scroll hermetic type of railway proven design.
- 14.7.2 The Contractor shall propose the overheating and overloading protection arrangement for the compressor motors. The compressor shall not suffer from any damage due to restarting after previously having shut down without a carry out pumping down cycle.

- 14.7.3 The compressor, unloading device, motors and pressure switches shall be weatherproof of IEC 60529 IP56.
- 14.7.4 The compressor shall be with unloading capability. It shall be directly driven and coupled by an ac induction motor (3ph 415 V ac) and rated for continuous duty at the design capacity. Motor overload protection shall be provided by a thermal cut-out embedded in the windings. The compressor/motor unit shall have a proven record in rail transit applications.
- 14.7.5 The condenser coil shall consist of copper refrigerant tubes with Aluminium/copper fins mechanically bonded to the tubes.
- 14.7.6 The condenser fan shall provide for adequate airflow over the coils at the design condition. The fan shall be direct driven by an ac induction motor (3ph 415V ac) rated for continuous duty, with two-stage speed.
- 14.7.7 Condenser shall be sized to be able to store 100% of the liquid in the system. A sight glass in the liquid line shall be provided to allow for check of refrigerant level.
- 14.7.8 The condenser coil shall be located so that it can be cleaned using water from the outside by removing the external covers only.
- 14.7.9 A filter/dryer and a refrigerant flow sight glass and system moisture indicator shall be provided.
- 14.7.10 Gauge Ports: High and low side gauge connections shall be provided. Each connection shall have a manual shut off valve and a self-sealing connection for a refrigeration service gauge set.
- 14.7.11 All the pressure control switches shall be adjustable type with calibration or pre-adjusted to fixed values.

14.8 Evaporator Section

- 14.8.1 The evaporator section unit shall be of adequate capacity to filter, cool, dehumidify and control the temperature of the air without condensate carry over or unacceptable noise level.
- 14.8.2 The blower and motor assembly shall be blow or draw the air from the mixing plenum through the evaporator and force it into the supply-air ducts from where it shall be discharge into the passenger areas. The blower and motor assembly shall be powered with 3 phase 415V AC. The motor and blower wheel assembly shall be dynamically balanced. The blower wheel and volute design shall ensure that, the airflow is stable so that the noise requirements can be achieved.
- 14.8.3 The evaporator shall be constructed of copper tubes with mechanically crimped pre-coated Aluminium/copper fins. There shall be a split feed requiring two coils and expansion valves to regulate the cooling capacity. The coils shall have copper alloy or stainless-steel end plates set in the casing to minimize stress from vibration, expansion and the external pipe couplings.
- 14.8.4 A condensate drain stainless steel pan shall be provided beneath the evaporator coil. Baffles shall be provided in the pan to prevent spillage. Suitable means shall be incorporate for cleaning of drainage system.

14.9 Refrigerant Circuit

14.9.1 Refrigerant of zero ozone depletion potential indexes in accordance with Montreal Protocol shall be used and the Contractor shall submit details of the proposed refrigerant.

14.9.2 ~~A sight glass shall be fitted in the refrigerant liquid line to show the refrigerant flow and be easy visible from the saloon area through an inspection hole or from the roof.~~

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14.9.3 The refrigerant piping shall be of copper with suitable non-ferrous fittings. All connections between the piping and equipment shall be made using either capillary fittings or brazed joints. There may be relative movement between the terminals of the compressor, condenser and evaporator coils resulting from vibration. The pipe layout shall take this aspect into consideration.

14.9.4 Screw couplings will be permitted only where necessary for disconnecting the refrigerant circuit for maintenance. Automatic shut off facilities shall be provided with the couplings to prevent loss of refrigerant for the disconnection. All other connections shall be of a permanent type.

14.9.5 The refrigeration piping system shall be effectively dehydrated prior to charging.

14.9.6 A dehydration device shall be installed in the refrigerant circuit and shall have sufficient capacity to absorb any moisture entering the system during operation. The dehydrator shall not require servicing between overhauls.

14.9.7 High sensitivity moisture indicator shall be provided with colour change to indicate the status.

14.9.8 Means shall be provided to avoid loss of refrigerant to atmosphere during charging and extraction.

14.9.9 Refrigerant storage in the condenser shall be provided to allow the refrigerant to be pumped down before shut down of the system to meet maintenance requirements.

14.10 Condensate Drainage

14.10.1 The Contractor shall submit the sizing and arrangement of condensate drainage to adequately collect and drain condensate without spillage.

14.10.2 The roof-mounted unit shall seat on a sealed pan on the roof with cut-outs for access from the saloon for maintenance purposes. The cut-outs shall be designed to avoid any water getting into the saloon area.

14.10.3 The floors of any wells shall be flat, and without obstruction which could lead to the collection of pools of water. The floors and sides of the wells shall be completely sealed against penetration of water into the saloon.

14.10.4 The drainage arrangement shall be integrated with the sealed pan design and shall avoid any blockage by debris. There shall be a condensate collector tray with drains under the evaporator units to prevent water dripping from the ceiling panels.

14.10.5 The plenum duct in the ceiling cavity shall be insulated to prevent forming condensation.

14.11 Ventilation and Condenser Fans

- 14.11.1 Fan and motor shall be directly coupled and rated for continuous duty.
- 14.11.2 No greasing shall be required for any part of the motor and fan coupling.
- 14.11.3 Each fan and motor assembly shall be dynamically balanced and constructed from stainless steel or material successfully proven for comparable applications and Approved by Project Manager. The assembly shall be tested to ISO 5801 or comparable national or international standards.

14.12 Air Ducts and Diffusers

- 14.12.1 Fresh air shall be drawn from grilles into the suction plenum. The grille shall be designed to prevent water ingress resulting from adverse weather or train washing.
- 14.12.2 Conditioned air from each unit shall be directly introduced into a duct running the full length of the car and be discharged into the car through ceiling outlets.
- 14.12.3 The duct shall be constructed from stainless steel or anodised aluminium and diagonally split so that each unit feeds one side of the car. The duct shall be fully lagged with non-combustible insulation material to prevent the formation of condensation.
- 14.12.4 The Contractor shall take into consideration the requirement of maintenance access for duct cleaning as and when required.
- 14.12.5 Two rows of air diffusers shall be mounted on each side of ceiling panel, blending well with the car interior design. It shall be possible to adjust the air quantity from the diffusers during testing and commissioning, to achieve uniform distribution of air, to the extent possible.
- 14.12.6 ~~A model of the proposed duct made of plywood or any other suitable material shall be prepared to evaluate the design parameters, including air velocity from the outlets and air distribution inside the car.~~

[Addendum-1 dated 05.12.2022, Sl. No. 143](#)

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14.13 Air Filter

- 14.13.1 All the air filter elements (fresh air and re-circulated air) shall be non-combustible and manufactured to comply weight arrest of 80% as per ASHRAE Standard 52.1 and 52.2 or EN 779.
- 14.13.2 Fresh air should be filtered for human comfort and safety, in accordance with internationally accepted norms. The filter element shall be provided before the fresh air damper and fixed in a metallic frame;
- 14.13.3 Even with extremely dusty and humid environment prevailing in Bangalore, the cleaning of the filters shall not be required before 6000 km of train run. The method for cleaning the filters and expected life of filter shall be furnished. Minimum expected life of filter provided shall be 100,000 km. Air-conditioned unit shall have noise less compressor & condenser.

14.13.4 The air filter shall provide effective filtering between scheduled maintenance without causing significant increase to airflow resistance. The air filter element shall be washable type. Disposable type filters will not be permitted.

14.13.5 Air filters to clean both fresh and re-circulated air shall be provided and located in such a manner that it (they) shall be easily replaced/installed from within the saloon or from the roof by maintenance staff. The air filter shall not be accessible to passengers.

14.14 Emergency Inverter

14.14.1 An inverter of adequate capacity shall be provided to supply 415 Volt power from 110 Volt DC battery to power the evaporator fan motor during emergency mode, when cooling is off, for supplying emergency fresh air. Inverter shall be IGBT based and tested in accordance with IEC 61287. The current rating of IGBT shall be such that the junction temperature has a minimum margin of 10 °C in the worst loading conditions.

Or

Alternately Contractor may use the existing APS/Battery charger to covert battery DC supply into 3 Phase supply.

14.14.2 In the depot, it shall be possible to override the operation of emergency inverter through TCMS when 750V DC power supply is not available.

14.15 Operator's Cab Air-conditioning

14.15.1 Separate cab AC unit is not envisaged. The cab, driving console and electrical cabinet in the cab shall be conditioned from the saloon HVAC. The ducts shall be suitably designed and dedicated ducts shall be provided for cooling of equipment housed in the driving console. Facility shall be available for independent air control in the cab. Separate air supply fan motor shall be provided for controlling the air supply in the cab. The temperature inside the driving console and cab shall be same as in the saloon i.e. 25°C under stipulated conditions. Necessary de-humidification arrangements shall be provided to prevent fogging of the windscreen.

14.15.2 The Contractor shall interface with Signalling & Train Control Contractor to ensure that temperature of the Signalling equipment provided in the cab are maintained as specified by Signalling & Train Control Contractor.

14.16 Deliverables

Contract deliverables required by this section of the Technical Provisions are listed below.

CDRL-14-1:	Heating and Cooling capacity of HVAC (ref. ERTS 14.2.1)
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15 ELECTRICAL AND CONTROL EQUIPMENTS**15.1 General**

15.1.1 On-train electrical equipment and control circuits, other than those for the propulsion system, shall use one or more of the following power sources:

- (i) 415V ac, 50 Hz, 3 ϕ , 3 wire
- (ii) 230V ac, 50Hz, 1 ϕ
- (iii) 110V D.C.
- (iv) 24 V D.C.

15.1.2 AC single phase levels at the load end shall be within $230 \pm 5\%$ V and $50 \pm 3\%$ Hz.

15.1.3 Vehicle Control Circuit (VCC) shall incorporate all the control requirements specified in this chapter. The details shall be submitted for Project Manager's review during design phase (**CDRL-15-1**). The same shall be sent to the concerned Designated Contractors for review from their end.

15.2 Train Control and Operational Principles**15.2.1 Modes of Operation**

For mode of operation please refer Chapter-4: Vehicle Driving modes

15.2.2 Unattended Train Operation (UTO)

- a) The Contractor shall list down all possible operational scenarios while designing the interface with Signalling & OCC (Telecom), the Contractor shall thoroughly examine all possible operating scenarios including those which may arise out of interface with designated Contractors. The Contractor shall prepare a detail document on possible implications of different failures and incidences that may occur during operations and responses to & from signalling and/or OCC. During such analysis the Contractor shall ensure that complete information has been transmitted to enable signalling /OCC to work correctly, safely & reliably as per interface design.
- b) The status of relevant equipment, MCBs etc. shall be relayed to Signalling/OCC and shall have remote control facility to reset the MCB's as decided by the Project Manager during design stage.
- c) It shall be possible to initialize the train from OCC/DCC when UTO command is being received by the train. Within depot premises, UTO mode shall be functional within specified area and it shall be possible to launch the train after self-checks including door operation and Brake dynamic test and preparatory works through OCC/DCC command. In case of failure of the train to pass its self-test, OCC/DCC shall get the message and train shall be operable by train operator.
- d) Similarly, train shut down shall be implementable from OCC/DCC and any failure shall be reported back.
- e) Built in safety measures, as applicable, shall be implemented during UTO initiation /failures.

- f) Signalling system shall control door operation with in-built safety provisions which shall be documented by the Contractor. In case of any defect in door operation, OCC shall be informed with door identity.
- g) The operation of the passenger train doors shall be under the control of signalling system. If the door system detects conflicting signals, the door status shall remain unchanged and a message shall be sent to the OCC. In the event that the door is unable to close after the predetermined number of times of re-close, a message shall be transmitted to the OCC giving the identity of the train and suitable message shall be broadcasted in the train.
- h) Interface of PA & PIS system with signalling system shall include display & route update, broadcast of messages etc. Failure of signalling system shall be recorded and fall back mode shall be resorted to.

Video analytic software shall detect any abnormal condition in the car which can be recorded as emergency case.

Contractor shall prepare detailed functional/ operation document. Similar document shall be prepared for interface with Signalling, Telecommunication and other systems.

- i) In case of short stop/over-run, OCC shall be able to issue jog/creep command for signalling system to send traction/brake command.

15.2.3 The control and operation shall be based on the optimized combination of the following principles:

- i) Maximum safety.
- ii) Maximum reliability and availability.
- iii) Operator convenience and ergonomic design.
- iv) Adequate redundancy.
- v) Energy efficiency.
- vi) Maintenance support.

15.2.4 The control logic shall ensure that the vital train control functions (such as Couplers, door system, brakes, propulsion power removal, PEA etc.) are executed using conventional relay control and dedicated hardwired train line signals. All vital circuits not totally within the system apparatus enclosure, shall be double wire, double break, with the exception of connections to non-vital circuits. The identified safety critical signals shall be carried using redundant train line pairs.

15.2.5 Warnings and indications that are necessary for safe operation of train shall be indicated by means of power LED lamps and shall also use hardwire system.

15.2.6 TCMS link shall be used to execute non-vital commands and controls of the train.

15.2.7 In addition, TCMS link shall be used for the identified non-vital control functions through VDU interface. TCMS link shall also be designed to provide back-up signals of certain identified vital commands.

15.2.8 The Contractor shall develop overall control logic for review of the Project Manager. The proposed equipment shall be service proven, reliable and safe.

- 15.2.9 The supply of the train control circuit shall have redundant and safety. The redundant design shall mean a second supply available in case of a failure of the normal supply. This function shall be verified during the vehicle system qualification test.
- 15.2.10 It is required that earth faults on the low voltage system shall not result in loss of control. The earthing of low voltage circuits at the operative controller only via isolating facilities shall be the preferred method of achieving this requirement. The low voltage circuits shall be negative pole earthed. A ground fault indication shall be required in the cab.
- 15.2.11 Unless specified, all control and operation circuits shall be 110V DC supplied. These systems/equipments shall function satisfactorily at battery supply voltages of 110 V DC (nominal) between 77 V DC and 138 V DC according to IEC 60077 -1 and 2.
- 15.2.12 ~~The Contractor shall submit details for inter-car and inter-unit connections to meet the necessary train operation requirement. Adequate number of spare connection pins (at least 10% of each type) shall also be provided at the end of DLP. Wiring from spare pins shall be brought till the nearest cubicle in the car/cab. Contractor shall keep an extra margin of 5% so that the same may be utilized by them during DLP for carrying out hardware modifications. The Contractor shall keep sufficient margin of additional spare connection pins at design stage so that, by the end of DLP, still 5% spare is available for carrying out any hardware modification in future.~~
- ~~As a minimum the following functions shall require train line controlled by 110 V dc signals~~
- ~~i) Brake Command and emergency circuits~~
 - ~~ii) Propulsion enabling circuits (direction, control mode, etc.);~~
 - ~~iii) Door enabling (each train side);~~
 - ~~iv) Safety related auxiliary commands;~~
 - ~~v) Train line integrity;~~
 - ~~vi) Air gauge;~~
 - ~~vii) Coupler control;~~
 - ~~viii) Door safety relevant controls and indications;~~
 - ~~ix) General fault indication for TCMS indicated with one lamp on driver's cab;~~
 - ~~x) Parking brake control;~~
 - ~~xi) Master controller;~~
 - ~~xii) CCTV and PA / PIS~~
 - ~~xiii) Additional train line circuits as required for train borne signalling and communications systems. Information shall be supplied and finalized at design stage.~~

Addendum-1 dated 05.12.2022, Sl. No. 144

The Contractor shall submit details for inter-car and inter-unit connections to meet the necessary train operation requirement. Adequate number of spare connection pins (at least 10% of each type) shall be provided.

As a minimum the following functions shall require train line controlled by 110 V dc signals

- i) Brake Command and emergency circuits
- ii) Propulsion enabling circuits (direction, control mode, etc.);
- iii) Door enabling (each train side);
- iv) Safety related auxiliary commands;
- v) Train line integrity;
- vi) Air gauge;
- vii) Coupler control;
- viii) Door safety relevant controls and indications;
- ix) General fault indication for TCMS indicated with one lamp on driver's cab;
- x) Parking brake control;
- xi) Master controller;
- xii) CCTV and PA / PIS
- xiii) Additional train line circuits as required for train borne Signalling and communications systems. Information shall be supplied and finalized at design stage.

15.2.13 Saloon light status shall be made available in VDU.

15.2.14 A minimum provision of spare 10% relays, contactors, MCBs terminal blocks and contacts shall be made in the respective circuits and at their locations. These shall be duly wired upto terminal blocks.

15.2.15 All such critical contacts which can lead to failure shall be duplicated to ensure the full redundancy. The Contractor shall specifically elaborate compliance to this clause during design. In case any such contacts are identified during commercial / revenue period by the Project Manager, the same shall be rectified by the Contractor at no extra cost.

15.2.16 Any isolation / failure shall be manageable from the working cab so that the train is not held up in main line and corrective action is taken with minimum loss of time.

15.2.17 Design of panels for push buttons, rotary switches, MCBs & relays etc. shall be such that future addition of these components is easily possible without any modification to the main panel. Each panel shall have at least one push button/rotary switch as spare duly mounted and wired up to the main electrical cubicle terminal block. Critical circuits which have possibility of having possibility of other circuit elements getting non-functional thereby leading to train detention on line, shall have independent MCBs.

15.2.18 ~~Relays shall have provision to add-on auxiliary contact blocks when mounted on the train. Contractor shall have provision to provide and mount the add-on blocks if required by the Project Manager during the DLP period.~~

Addendum-1 dated 05.12.2022, Sl. No. 145

Relays shall have provision to add-on auxiliary contact blocks when mounted on the train. Contractor shall have provision to provide and mount the add-on blocks for future requirement.

15.3 Cab Control

- 15.3.1 Ergonomic layout and design of the driver's desk shall include key switches, mode selection switches, master controller, TCMS display, ATO/UTO start button, horn buttons, portable radio handset holder, radio stand, lighting control switches, wiper-washer controls, pressure gauges, couple/uncouple controls, CCTV, PA/PIS and the interface items. All the ergonomic layout and controls in the cab shall be submitted.
- 15.3.2 The linear type mode selector switch and master controller shall be housed in a driver's control console. The master controller shall be of the vertical handle type and shall incorporate a driver's safety device "dead man" control (rotating type).
- 15.3.3 The master controller and the mode selector switch shall be interlocked in the manner to be agreed at the design stage and approved by the Project Manager. Provision shall be made for a driver's master key to activate the driving cab car. The Master Controller shall have adequate number of dedicated potential free interlocks solely for ATO and ATP system operation.
- 15.3.4 A control lock shall be provided in each control console (Master Controller), which shall be operated by the control key. The lock shall have two positions 'ON' and 'OFF'. The control key shall be removable in the 'OFF' position only.
- 15.3.5 The control lock shall be of fail-safe design. The control lock element shall use appropriate feature to ensure that contacts cannot possibly remain closed when lock or the switch position indicate that they should be open.
- 15.3.6 The control lock interlocking shall be of such strength that the mode selector handle and control key are sacrificial to the interlocking in the event either is subjected to excessive force.
- 15.3.7 The master controller step less type shall control both braking and propulsion efforts and provide as a minimum; service brake, emergency braking, coasting and propulsion. The centre position for the master controller shall put the train in the 'COASTING' mode. The master controller, when in manual mode, shall be move towards the driver to energize braking and move towards the cab front to energize motoring. The master controller positions proposed by the Contractor may be as follows.
- 15.3.8 The Master Controller shall include a mode selector to select the mode of operation of train.

The functionality of the master controller and mode selector are provided below. The details of Master controller will be discussed and finalized during design stage. **(CDRL 15-2)**

MODE	FUNCTION
POWER	Continuous Control between minimum and maximum tractive effort
COASTING	A notched position
BRAKE	Continuous control between minimum to full-service brake with the full service brake position as a notch
EM	Emergency brake (Notched position)

15.3.9 Not Used

15.3.10 The driving desk shall include a Mode Selector Switch, which has the following mode selection and stop position:

- i) **ATO:** Automatic Train Operation backed up by ATP.
- ii) **ATP:** Supervisory Manual Mode (or Manual Mode): Manual control backed up by ATP.
- iii) **RMF:** Restricted Manual Mode: Manual control backed up by Propulsion Logic ATP (max speed 25 km/h).
- iv) **"STANDBY" Mode:**
A fully initiated train in standstill condition. Traction control shall be inoperative, and brake shall be applied during this mode. This mode will be used for testing the door in depot. In Standby Mode, it shall be possible to operate the saloon doors without activating the Safety Cutout Switch. The Contractor shall submit the detail of mode during design stage. (CDRL-15-3).
- v) **RMR: Restricted manual Reverse Mode:** Max. 10 km/h limited to 10 meters.
- vi) **"OFF" Mode**

15.3.11 Powering/Braking command and demand: -

- i) The powering and brake commands shall be implemented through hardwired. However, powering and braking demands shall be implemented through TCMS interface. In case of UTO/ATO operation, powering/braking demands shall be implemented with safety data transmission protocol through ethernet interface between ATO/ATC and TCMS.
- ii) Redundant communication shall be available between TCMS & ATO/ATC (Dual Homing) and TCMS & master controller to implement the above functionality. TCMS shall also provide redundant communication network to transmit the powering and braking demand from ATO/ATC to traction inverters and BECU.
- iii) In case of failure of TCMS or failure of data transmission between ATO/ATC and TCMS, powering and brake demand shall be implemented through hardwired circuits under the supervision of ATC.

Details shall be discussed and finalised during design phase.

15.3.12 Train propulsion shall be disabled and emergency brake applied should both Driving desk on a train is switched off.

15.3.13 The position of the Mode Selector Switch shall be monitored by the TCMS.

15.3.14 The control console shall be arranged to allow access to all mechanisms by removal of a dust-proof cover. Also, Lockable cover for the control consoles shall be provided on trains during GoA4 operation to prevent unauthorized personnel from interrupting their correct operations.

15.4 Equipments cabinets

15.4.1 Contractor shall propose the details and locations of equipment cabinets/ cubicles. This shall be discussed and finalized during the design stage.

- 15.4.2 Each switch position shall be clearly identifiable with detent. The mode selector shall prevent any undefined states being achieved when changing mode. Permitted mode changes shall only be possible when Zero Speed is provided.

15.5 Brake control

- 15.5.1 The brake command circuit shall be comprised of two systems, emergency braking and service brake, which shall be functionally separate.
- 15.5.2 Emergency braking circuit shall operate based on the "fail safe" principle. It shall consist of a series loop circuit which through contacts in the ATP systems, master controller, driver's safety device (or "deadman" provision), low air pressure governors on each vehicle. The return circuit shall feed brake emergency valves on each vehicle and shall also feed a relay on each traction equipment to prevent application of power should the brake loop circuit be de-energized. The Project Manager will consider the brake circuit with two-loop design. A means of shortening-out the series contacts by a sealed switch shall be provided and when operated this shall prevent the train being driven other than restricted manual mode.
- 15.5.3 When this circuit is de-energized, an emergency brake application shall be made. Jerk control is required for emergency application.
- 15.5.4 The service brake system shall transmit the service brake commands to the vehicles.
- 15.5.5 The electric brake force or friction brake force shall be determined by load weighing signals.
- 15.5.6 A means of verifying the condition of the friction brake shall be provided and indicated in the cab.
- 15.5.7 Means shall be provided in the driver's cab by which the parking brakes could be applied.
- 15.5.8 There shall be a dead man safety device feature incorporated into the controller to protect the train in the event of the incapacity for the train driver, when driving in manual operating modes. Release of the dead man safety device for a preset value of time, except when the traction brake controller handle is placed in the full service braking or emergency position, shall stop the train by activating the emergency brake in all manual operating modes.
- 15.5.9 The dead man safety device shall be monitored by both the safety proving system and the Event Recorder.
- 15.5.10 The design of the traction brake controller shall ensure that it is impossible to override the specified safety features particularly the dead man safety device by using any easily available object.

15.6 ATP, Automatic Train Protection

- 15.6.1 ATP shall be supplied as per Appendix D - interface documents of Technical Specification
- 15.6.2 The ATP system will enforce safe train speed and will impose an emergency brake application if a potentially unsafe condition is detected.

15.7 ATO, Train Identification, Public Address and Radio Systems

- 15.7.1 This equipment shall be supplied as per Appendix D - interface documents of Technical Specification.
- 15.7.2 A separately protected 110 V dc supply shall be provided to operate the ATO, train identification and radio systems which will be supplied by Signalling or Communication Contractors.
- 15.7.3 The Contractor shall provide suitable housing for the equipment and shall provide and install all cabling external to the apparatus. A roof mounted antenna, and cab mounted loudspeakers, handsets, controls, ancillary radio communications equipment shall be supplied by the respective Contractors as per Appendix D, interface chapters.

15.8 Door Control

- 15.8.1 Each door leaf shall be detected by interlocks and a loop circuit shall be provided to detect the position of every passenger saloon door. These interlocks shall prevent the train from moving when any door is not closed and locked.
- 15.8.2 Separate door operator and door enable train lines shall be provided for each side of the train and both shall be cut-out when the door control is in the closed position.
- 15.8.3 A multi-note door chime shall be installed at each door and shall begin to chime for an adjustable period up to 2 seconds prior to door closing and cease when doors are closed. It shall be approved by the Project Manager.
- 15.8.4 The door unit shall be provided with fault monitor output and displayed in Train Management Systems (TCMS).
- 15.8.5 The normal operation of the saloon doors shall be controlled by the control of the train driver from the active cab, controls in the non-active shall be isolated.
- 15.8.6 In case of unavailability/failure of door authorization signal from ATP system, adequate safeguards shall be provided and also incorporated in control circuit to minimize the probability of error of opening of doors on wrong side (other than platform side) during commercial / revenue service.
- 15.8.7 The driving cab shall be equipped with buttons that shall operate the doors independently on each side of the train. Each side, i.e. left and right, shall be designed to be totally independent from each other ensuring that any failure of one side shall not affect the other.
- 15.8.8 Each circuit shall be designed to ensure that under no circumstances, on a moving train, shall it be possible for a train door to be opened due to an incorrect operation by the train operator or due to a single point failure.
- 15.8.9 Operation of the passenger doors shall only be possible when the key switch is moved away from the "off" position. In case of UTO mode of operation, door opening and closing shall be controlled by signalling system.
- 15.8.10 Only the correct side of the passenger door control circuit shall be operative according to the ATC Enable Signal provided by the ATC system to safeguard against wrong side activation.
- 15.8.11 The enable signals for the door control units shall be combined with the zero velocity signal. Only if Zero Speed is detected, the signal to enable the door control unit shall

be issued by the ATC. In case of faulty ATC the Zero Speed transmission shall be decided by the Contractor.

- 15.8.12 The ATC Enable signals shall be transmitted through a dedicated interface control hardwired train line between the ATC system and the door control circuits.

15.9 Fault Monitoring System

- 15.9.1 A comprehensive fault monitoring arrangement with microprocessor control unit shall be provided. As a minimum each major system shall display the presence of a fault in that system on a remote fault monitor panel to integrate with the Train Control Management System (TCMS) in the cab. The presence of a fault indication on any system will be combined to indicate a general fault on the driver's console.

- 15.9.2 Failure of essential equipment shall be indicated.

- 15.9.3 The specific content of the fault monitoring system will largely depend on the control scheme offered but the following functions are considered to be the minimum but not limited.

- 15.9.4 Comprehensive health monitoring of individual propulsion/brake units with indication of all significant malfunctions. (This may also require the use of depot based equipment to avoid over complexity on the vehicle.) Provision of cut-out facilities to isolate propulsion equipment shall require fault monitoring output. Monitoring of the propulsion/brake system shall also include positive confirmation of the response in the cab of the friction brake to a release of application command. The logic circuits associated with the propulsion and braking equipment shall include built-in checking equipment to ensure the correct functioning of the equipment.

- (i) Provision shall be made to monitor the air conditioning system. Air conditioning faults shall be indicated locally.
- (ii) The door control circuits shall be monitored to indicate as a minimum the "door open" status on each car. Door control faults shall be indicated locally
- (iii) Auxiliary equipment shall be monitored including inverters, battery chargers, and air compressors. Auxiliary equipment faults shall be indicated locally.
- (iv) Provision for routine checks shall be made of all major sub-systems to facilitate driver test procedures. This shall be associated with more comprehensive fault indications.

- 15.9.5 The monitoring equipment shall meet the objectives of facilitating preventative maintenance and reducing the incidence of on-line failures causing delays. Such equipment shall not result in a large increase in peripheral complexity.

15.10 Cab Equipments

- 15.10.1 Electrically operated Wind Screen Wiper

- i) The windscreen shall be equipped with wipers and washers. The area covered by the windscreen wipers shall be at least 80% of the foreseen visibility. Externally mounted windscreen washer/wiper units shall be provided. The wipers shall sweep the largest possible arc and clear a windscreen area that shall enable, when manual mode, the driver to meet all external vision requirements. The wipers shall not obstruct the driver's vision when in the parked position. The

wipers shall provide efficient operation at all metro train speeds and environmental conditions. The washer reservoir shall have an adequate capacity, refillable from the exterior of the Metro train at track and station platform levels.

- ii) Windscreen wiper shall be provided at appropriate location for operable from the train driver's control panel.
- iii) Windscreen wiper shall be electrically operated.
- iv) The Contractor shall submit details of the system configuration and components like screen wiper blades, washer nozzle, the washing media, reservoir etc.
- v) Wiper control shall have the following modes of operation:
 - Slow speed.
 - High speed.
 - Wash mode.
 - Off mode.
- vi) It shall be possible to operate one or both of the wipers in the operating cab.

15.10.2 ~~Electric Horn~~

~~Two electric horns, one having high tone and other low tone, operable from the train driver's console shall be provided, located at the front end of the cab, facing forwards. Technical details of the horns shall be submitted for review by the Project Manager.~~

[Addendum-1 dated 05.12.2022, Sl. No. 146](#)

[Electric Horn](#)

[Two electrically operated pneumatic horns](#), one having high tone and other low tone, operable from the train operator's console shall be provided, located at the front end of the cab, facing forwards. The system shall comply to the requirements of EN 15153-4. Technical details of the horns shall be submitted for review by the Project Manager. Horn failure to be monitored and same shall be tested as part of UTO self test.

15.11 Deliverables

Contract deliverables required by this section of the technical provisions are summarized below:

CDRL 15-1:	Details of Vehicle Control Circuit (ref. ERTS 15.1.3)
CDRL-15-2:	Data on Master Controller Design (ref. ERTS 15.3.8)
CDRL-15-3:	Standby Mode (ref. ERTS 15.3.10 (iv))

16 TRAIN CONTROL MANAGEMENT SYSTEM (TCMS)**16.1 General**

16.1.1 All the trains shall be equipped with microprocessor-based Train Control Management System (TCMS) providing real-time distributed control and modular processing of all sub-systems in fully redundant manner with high reliability and availability required in adverse operating environment experienced in MRTS system.

TCMS shall be a completely integrated system equipped with

- i) data acquisition,
- ii) monitoring,
- iii) control,
- iv) record,
- v) display,
- vi) self-diagnostic,
- vii) fault diagnostic,
- viii) remote diagnostic,
- ix) configuration editing,
- x) troubleshooting-guidance

features/functions for the train, its systems and subsystems. Contractor shall submit a comprehensive list of capabilities for each of the above listed features.

16.1.2 Proven Design

Basic architecture and hardware of TCMS proposed to be implemented/used by the Contractor should already be functioning in Metros and shall be compliant with international norms. In addition, the TCMS supplier shall have supplied the proposed TCMS hardware and software in functioning GOA4 lines since last more than three years. The Contractor shall submit basic system architecture with hardware for approval at the concept design approval stage and establish 'proven design' as specified.

16.1.3 Maximise Controls & Monitoring via TCMS

It is desirable that the control and monitoring functions are implemented by software, to the extent possible, so as to reduce hardware and cables. All functionalities that can be implemented by software shall be provided via TCMS unless specifically desired otherwise by the Project Manager.

16.1.4 SIL Compliance

TCMS shall be SIL2 compliant for all vital and safety related control and monitoring functions including but not limited to the following hardware, software and control functions:

- i) ATC (Vehicle Automatic Train Control) operation mode (ATP, ATO and UTO etc.),
- ii) Door Proving loop cut-out,

- iii) Traction/braking command/demand/authorization transmission (communication),
- iv) Traction/braking command/demand/authorization signal failure,
- v) Door Open, Door Close command,
- vi) Direction control of train operation,
- vii) Holding brake release,
- viii) Speed transmission,
- ix) Fire alarm transmission via ATC,
- x) ED (Electro Dynamic) brake cut-out signal transmission,
- xi) Actual ED brake effort signal transmission
- xii) Sliding signal transmission,
- xiii) ED brake effective signal transmission,
- xiv) Brake demand/applied signal transmission,
- xv) Speed restriction in degraded modes:
 - (a) Bogie brake isolation,
 - (b) Secondary Suspension failure,
 - (c) Uncontrolled excessive slip/slide,
 - (d) Rescue/Wash mode,
- xvi) Electropneumatic brake isolation in bogie(s),
- xvii) Request and reset of Passenger Emergency Activation.

at all levels including but not limited to hardware, software and control functionality etc. Any change in SIL level shall be subject to the hazard analysis and acceptance or otherwise of the same by the Project Manager, whose decision shall be final and binding.

16.1.5 UTO Compatibility

The TCMS architecture, functionality and redundancy level shall be compatible with the UTO mode of operation. Contractor shall submit details of all UTO specific design functionalities for Project Manager's review. **(CDRL-16-1)**

16.1.6 Signalling Interface

TCMS shall have adequate facility and interfaces to communicate with wayside signalling for both UTO and non-UTO modes. It shall be possible to simultaneously operate different trains in a section in GoA2/GoA4 without any safety/reliability issue as per IEC 62290-1:2006.

16.1.7 TCMS Configuration Details

The Contractor shall submit the complete TCMS configuration details including but not limited to Application Software Logic, Data Acquisition Routines, Control logic, Fault Detection Algorithms, Data Storage Logic etc. Graphical interface for editing and configuring the same shall be provided and submitted for Project Manager's approval during design stage.

16.1.8 Applicable Norms and Standards

All communication protocols, architecture and data acquisition concepts shall be of the latest state of the art technology and compliant to international and railway industry standards. The Bidder/Contractor shall advise the proposed applicable standards for review.

16.1.9 Conceptual Approval Only

Design approval of proposed TCMS shall imply only conceptual approval. Further changes as required by Project Manager based on operational, maintenance and functionality considerations shall be discussed during the Contract and solution be implemented to the satisfaction of Project Manager without additional cost. This will include finalization of event list, fault priorities, diagnostics and others.

16.1.10 ~~The cables which are intended to be used in emergency circuit for alarms and communication shall have intrinsic fire-resistant property in compliance with EN 50200 for PH120 and EN 50289.~~

Addendum-1 dated 05.12.2022, Sl. No. 147

The cables which are intended to be used in emergency circuit for alarms and communication shall have intrinsic fire-resistant property in compliance with EN 50200 for **PH60** and EN 50289.

16.2 TCMS Architecture

16.2.1 Data Communication Link

i) Ethernet based

The network communication technology to be adopted for all TCMS data communication links and subsystem communication interfaces shall be based on Ethernet (100 Base TX or better).

ii) EMI Immune

Proven train data communication links that are immune to EMI and harmonics generated by traction equipment shall be provided between the cars. Suitable physical bus interfaces, to ensure error-free and high speed data transmission shall be provided.

16.2.2 Not Used.

16.2.3 Ethernet Consist Network (ECN)

Ethernet Consist Network with dual-homing ladder-type topology/dual-homing ring type topology (compliant with IEC 61375-3-4) shall be adopted.

All the End Devices shall support dual-homing type Ethernet connections to ECN via physically independent ports to increase system reliability and availability.

All digital and analog IOs interfacing with TCMS (directly or via an interface unit) shall also be fully redundant.

16.2.4 Redundant Processors

The processors running the TCMS application software for control, monitoring etc. shall be duplicated with a hot standby redundancy provision. Details for the

switchover and recovery times shall be submitted by the Contractor for Project Manager's review. **(CDRL-16-2)**

16.2.5 Single Point Failure Tolerant

The TCMS shall be of fault tolerant distributed control system architecture. A single point failure of any individual equipment/ component/ board/ communication link etc. shall not affect data acquisition & processing or cause any adverse performance impact on train performance or loss of data.

Contractor shall submit the failure redundancy matrix for entire TCMS indicating the various failure modes, available redundancies and the effect on train performance.

16.2.6 ~~Spares Provision~~

~~The TCMS components shall be modular in design at all levels (i.e. hardware, functional, communication etc.) with at least 10% spare capacity in each car for expansion at the end of DLP. The spare provision shall exist for all different equipment's pins, terminals, connectors, ports, train lines, communication packets bits, digital/analog IOs etc. and the same shall be available for after DLP. The hardware spares shall be duly wired to the nearest terminal box.~~

~~Considering that some changes/modifications would be required during DLP, at least 12.5% spares capacity shall be initially ensured by Contractor.~~

~~Contractor shall submit a detailed proposal for Project Manager's review and approval during design stage.~~

Addendum-1 dated 05.12.2022, Sl. No. 148

Spares Provision

The TCMS components shall be modular in design at all levels (i.e. hardware, functional, communication etc.) with at least 10% spare capacity in each car for expansion **for future use**. The spare provision shall exist for all different equipment's pins, terminals, connectors, ports, train lines, communication packets bits, digital/ analog IOs etc. and the same shall be available for **future use**. The hardware spares shall be duly wired to the nearest terminal box.

Contractor shall submit a detailed proposal for Project Manager's review and approval during design stage.

16.2.7 ~~Expandability Provision~~

~~The Contractor shall also provide 10% expandability provision (i.e. expansion of capacity by adding of additional hardware) for pins, connectors, network ports, train lines etc. over and above the spares available at the end of DLP. Contractor shall demonstrate to the Project Manager that adequate space has been reserved to exercise this option.~~

Addendum-1 dated 05.12.2022, Sl. No. 149

Deleted.

16.2.8 IEC 60571/EN 50155 Compliant

The hardware system shall conform to IEC 60571/ EN 50155.

16.2.9 IP Rating

Minimum IP level of all TCMS cubicles/equipment shall be IP53 or higher and the same shall be declared by the Bidder.

16.2.10 Labelling

The type, location and identification of all hardware, software interconnections, cabling and terminals shall be determined on a coherent hierarchical system basis. Labelling or identification shall use appropriate English language based mnemonics or abbreviations. The Contractor shall submit proposal for review.

16.2.11 ~~Maximum CPU Loading~~

~~Contractor shall demonstrate to the Project Manager's satisfaction that none of the TCMS CPUs/processors are loaded to more than 50% of their processing capacity. The Contractor shall keep adequate margins in the design to allow for addition of functionalities to TCMS during DLP period. A verification report for the same shall be submitted.~~

Addendum-1 dated 05.12.2022, Sl. No. 150

Maximum CPU Loading

Contractor shall demonstrate to the Project Manager's satisfaction that none of the TCMS CPUs/processors are loaded to more than 50% of their processing capacity. The Contractor shall keep adequate margins in the design to allow for addition of functionalities to TCMS **for future use**. A verification report for the same shall be submitted.

16.3 Data Acquisition

16.3.1 Network Interfaced Systems

TCMS shall schedule, initiate and control data acquisition, processing and analysis by interfacing with all microprocessor/ microcontroller based on-board systems. These systems shall include, as a minimum:

- i) ATP/ATO/UTO
- ii) HVAC System
- iii) Auxiliary Power Supply System
- iv) Brake System
- v) On-Board Communication System
- vi) Doors
- vii) Propulsion System
- viii) Train Radio
- ix) PSSS (Passenger Saloon Surveillance System)/CCTV
- x) Lighting System
- xi) Depot Wireless Communication
- xii) Fire Detection Unit
- xiii) Wheel Flange Lubricator

All interface signals with ATP/ATO/UTO and selected interface signals with other on-board systems shall be monitored and recorded with time stamp. The Contractor shall submit the details for Project Manager's review. **(CDRL-16-3)**

16.3.2 Hardwire Inputs

In addition to above, TCMS will also acquire status data via hardwire from the various identified vehicle control circuit nodes, train lines, ATP/ATO/UTO, or any other subsystems. This data acquisition shall be fully redundant, bus monitored and duly recorded in TCMS. The interface units provided for this purpose shall be dual homing compliant.

16.3.3 Communication Protocol Details

The software and communication protocols used throughout the TCMS and the interfaces to subsystems shall be compliant to a common standard or standards. Contractor shall submit details of the communication protocols used in their design (at all different levels of the OSI model) clearly indicating how the requirements of monitoring and control are complied with. The Contractor shall also define the dual homing compliant communication protocols for all EDs. Further details along with any hardware/software tools required shall be submitted during design stage. **(CDRL-16-4)**

16.3.4 Signal List Modification

It shall be possible for authorized maintenance personnel to update and modify the list of data acquisition signals and its associated parameters like periodicity, task cycle, data acquisition routine etc. Suitable graphical configuration editors shall be provided for this purpose. Data protocols and standards should be to international and railway industry standards.

16.3.5 Clock Synchronisation

TCMS shall synchronize its clock with the system master clock through the ATP/ATO/UTO interface. All the microprocessor/microcontroller based on-board systems shall synchronize respective clocks with TCMS clock. Detailed clock synchronisation proposal shall be submitted for Project Manager's approval. **(CDRL-16-5)**

16.4 Control Features

16.4.1 Non-Vital Controls

TCMS shall be used to execute all non-vital commands and controls of the train.

16.4.2 Vital Controls

TCMS shall be designed to provide back-up controls of certain identified vital commands. Unless otherwise indicated specifically in these specifications, hardwire back up shall be provided for each safety related control functions.

16.4.3 Control Strategy

The Contractor shall submit technical details of the TCMS control system with full explanation of control methods and strategy adopted in the design. The proposal shall also clearly discriminate between the implementation of vital & non-vital controls as well as manually triggered/operator based & automatically executed controls.

16.4.4 OCC Remote Controls

TCMS shall have provision for receiving and implementing remote control commands from OCC/BCC/DCC through Signalling interface. Necessary interfaces with Signalling and Train Control/Telecommunication Contractors shall be ensured.

16.4.5 List of Operator Control Functions

Control features available for the Train Operator's control via on-board HMI or for the OCC/BCC/DCC's control via remote HMI shall include, but not be limited to, the following:

- i) Train start up and Sleep Mode.
- ii) Control of various saloon and cab air conditioner parameters such as selective and/or collective starting and switching off, car temperature control, provide override control of operating mode etc.
- iii) Isolation of any particular passenger side door that has been detected as closed and locked.
- iv) Override control over automatic selection of the saloon light circuit(s).
- v) Resetting of minor faults in sub-systems
- vi) Parking brake control (apply & release)
- vii) Train Horn control including its isolation
- viii) Isolation of only service brake (per bogie) in conditions of brakes fail to release subject to proper hazard mitigation
- ix) Any other item as desired by the Project Manager

The Contractor shall submit detailed list of functions /features proposed to be controlled through TCMS for Project Manager's review and approval. **(CDRL-16-6)**

16.4.6 Protective Controls

TCMS shall appropriately shut down or reset equipment in response to self-diagnostic test results or occurrence of specified faults. Detailed scheme for protective controls shall be submitted for Project Manager's review and approval.

16.4.7 Speed Calibration Control

Provision for Speed calibration after wheel turning shall be provided.

16.4.8 Speed Sensor Redundancy

Adequate redundancy shall be built in for correct train speed measurements in case of failure of any of the speed sensors. System shall also counter check the speed recorded by the ATP/ATO. For the purpose, the Contractor shall suitably interface with Signalling & Train Control Contractor.

16.4.9 ATC Interfaced Controls

- i) Remote Initialisation

TCMS shall interface with ATC for remote initialization of train at siding, stabling lines or in depot for commercial / revenue operation. The "wake-up" command from OCC shall be implemented by TCMS after performing self-tests of different train borne systems. TCMS shall send "Train Ready" / "Train Ready with Fault" / "Train Not Ready" signal to train ATC else a corresponding fault code shall be sent to OCC. Suitable interface to correlate Auto wakeup tests (Rolling Stock and Signaling) shall be suitably interfaced to be displayed at OCC. Details for "Train Ready" / "Train Ready with Fault" / "Train Not Ready" shall be discussed during design stage.

ii) Sleep Control

ATC may initiate automatic train sleep function at designated locations when trains are not required. Whenever sleep command is initiated by Train Operator, TCMS shall shutdown the relevant equipment except for control supply to necessary equipment.

iii) Standby Control

Train Standby function may be actuated by ATC system when train is in stabling siding. TCMS on receipt of such command shall switch off auxiliary equipment except compressor, battery charger etc. and shall maintain train in a "Ready" state.

iv) Shunting Control

Initially Shunting Operation in Depot shall be as per GoA2 and it shall be changed subsequently to GOA4.

16.4.10 UTO/ATO Interface

TCMS shall be fully compatible and interface with signalling system to ensure safe ATO/UTO operation.

For UTO/ATO operation, the necessary train command digital inputs signals shall be provided by the Signalling & Train Control Contractor. The ATP/ATO/UTO initiated signal demands shall be redundant. The redundancy shall also be provided on TCMS side by RS Contractor. The form of these inputs shall be coordinated between RS and Signalling & Train Control Contractors.

The Contractor shall also liaise with the Signalling & Train Control contractor to harmonise their system with the energy saving modes under ATO/UTO.

16.5 Equipment Monitoring

16.5.1 Traction and braking system

The TCMS shall provide the following functions of:

- i) Facilitating the train driver to initiate the traction test, any fault detected shall be logged and recorded by the TCMS.
- ii) Recording and displaying any fault status of the wheel slip/slide protection system.
- iii) Recording and displaying any identified permanently locked axle.
- iv) Facilitating to isolate defective VVVF group and dynamic brake system isolation functions and failed friction brake on a bogie basis.
- v) Recording and displaying any brake rate deviation.
- vi) Recording the accumulative mileage run of each train for maintenance scheduling.
- vii) Recording and displaying the train speed on the TCMS display terminal.
- viii) Conveying all logical commands generated by the associated mode selector, traction brake controller, which are activated by the train operator into the associated, hardwire train lines and transmit to the required circuits.

- ix) Interface with each traction inverter and brake control unit to receive traction and braking system operational monitoring signals and detected faults.
- x) Monitoring the conditions of the above train line signals and response. For any conflicting logical commands, such as, both forward and reverse wires are energized, and both motoring and braking wires are energized, the train system shall be responded safety orientated. This fault shall be reported to train driver and logged into the Event Recorder.
- xi) Monitoring the integrity of the speed detection circuit and report when fault is detected.
- xii) TCMS shall provide fake motoring signal from TCMS VDU to release holding brake in case of all VVVF's are faulty.
- xiii) Operation and monitoring of CCD up and down operation from TCMS VDU.
- xiv) Monitoring of HSCB isolation and reset through TCMS VDU.
- xv) Monitoring of CCD fuse status in TCMS VDU
- xvi) Monitoring the control commands received from the ATO/UTO. The train system shall be operated through the TCMS. For any illegal logic state i.e. the faulty state occurred shall be reported to the train driver and logged into the Event Recorder.

16.5.2 Door System

The TCMS shall provide a signal processing function to:

- i) Monitor and record the by-pass command activated by the train driver to control the train door by isolating the UTO/ATO/ATP safety signals when the UTO/ATO/ATP system failed.
- ii) Monitor the healthiness status of each door pair, such as, the operating time, the fully closed signal provided by the door proving device.
- iii) Monitor any operation of the manual emergency release device.
- iv) Monitor the status of mechanical lock and manual door isolation device.
- v) Facilitate maintenance adjustment of train door operation profile parameters by using a monitor programmer at the local door control unit.
- vi) The TCMS shall continuously monitor the conditions of the train line door commands of open and close. For any conflicting logical commands, such as, both open and close wires train lines are energized, the train system shall be responded. This fault shall be reported to train driver, logged into the Event Recorder and shall also be reported to OCC.

16.5.3 Air conditioning system

In order to ensure the passenger comfort and optimize the energy consumption of the air conditioning units, an automatic control of the air conditioning systems shall be provided according to the following conditions:

- Hour basis: It shall be possible to pre-set period of time in different slots in a day by selecting an option of "Hour Basis" soft key. By selecting an option of "Hour Basis", 1st month wise option will come and through that particular day of the month

can be selected. On the selected day, 6 different soft key shall be provided for different slots. This shall facilitate to set temperature of the saloon interior through TCMS in different time slots in a day.

- Seasonal basis. It shall be possible for a pre-defined period of months, the target saloon temperature setting to be regulated by the TCMS.
- For backup purpose, an overriding function shall be provided to override the above commands of shutdown/re-start and temperature setting either by means of the individual local control of the air conditioning unit or via the train drivers input device through the TCMS.
- All the above setting of time/periods shall be easily adjustable by the maintenance personnel via the TCMS.
- The saloon temperature of each car shall be monitored in real time and reported to the TCMS.
- HVAC shall remain same as last set temperature even after AUXON/AUXOFF of the train.
- In order to reduce the inrush current due to simultaneous starts of the air conditioning units, a staggering start arrangement shall be provided to control the starting sequence of the air conditioning units of the train via the TCMS.
- The TCMS shall monitor and record when there is a fault detected. In the event that the smoke detector detects smoke, the train driver shall be informed and the damper system shall close automatically to prevent outside smoke entry in to the saloon interior.
- Interface with each air conditioning unit to receive air conditioning unit operational monitoring signals and faults including:
 - a) Cooling failure and operation of only mechanical ventilation.
 - b) Operation of emergency mode ventilation.
 - c) Operation of smoke mode ventilation.
 - d) Faulty or dirty smoke detector.
 - e) Operation of high pressure cut-out device, low pressure cut-out device and compressor unloading device.
 - f) Operation of compressor motor overheating and overloading protection device.

16.5.4 Auxiliary Power Supply System

- i) The TCMS shall monitor the status of the auxiliary inverter and record any failure.
- ii) Interface with each auxiliary converter to receive auxiliary converter operational monitoring signals and faults.
- iii) TCMS detects the number of Auxiliary failure according to the Digital input from Auxiliary inverter units. Auxiliary load reduction control is required. HVAC can provide the load reduction mode by changing the mode from Cooling to Ventilation mode based on the Auxiliary status information from TCMS.

- iv) The ac and dc supply shall be monitored by the TCMS particularly the battery charger output.
- v) In order to reduce the inrush current due to simultaneous starts of the auxiliary inverters, a staggering start arrangement shall be provided to control the starting sequence of the auxiliary inverters of the train via the TCMS.

16.5.5 Suspension System

- i) Passenger loading on a car basis shall be measured and fed back to the TCMS in real time for the controls of train systems, such as, traction and braking systems. This passenger loading data shall be sent to the OCC upon request by the OCC and recorded on the data log at predefined intervals to be confirmed during design stage.
- ii) In case of deflated secondary suspension during run, TCMS will detect the same and shall interface with VVVF to impose pre-defined speed restriction in different mode of operation.
- iii) The TCMS shall monitor the passenger loading feedback signal, the TCMS shall record and display when any abnormal passenger loading is detected.

16.5.6 Pneumatic System

- i) The run time and duty cycle of each air compressor of a train shall be recorded for maintenance scheduling
- ii) Monitor the Main Reservoir pressure, Brake pipe and brake cylinder pressure of each car. These pressures shall also be recorded by the Event Recorder.
- iii) The position of Bogie Isolating Cock (BIC) shall be monitored by TCMS. In case of isolation of BIC, the control system shall automatically impose restriction on the maximum operating speed of the train based on number of BIC's isolated. The level of the speed restriction corresponding to isolation of BIC shall be proposed by the Contractor taking in to consideration of braking distance and other safety issues involved in mainline operation. In case of isolation of 50% or more than 50% BIC in the train, it shall not be possible by train operator to move the train on its own power.
- iv) TCMS will provide fake motoring signal from TCMS VDU to release holding brake in case of all VVVF's are faulty.

16.5.7 Interface with Automatic Train Control System:

Contractor shall interface with Signalling & Train Control contractor to record and monitor various signals from ATC side. Contractor shall submit the details for Project Manager's review. **(CDRL-16-7)**

16.5.8 Train Communication and Passenger Information :

- i) Broadcasting of pre-recorded announcements shall be triggered by the real time information received via the interface with TCMS.
- ii) The Passenger Information System shall receive the required information from TCMS to display.
- iii) Any operation of the Emergency Intercom shall be report to the Event Recorder

- iv) Monitor Station Announcement bits from ATC.
- v) The healthiness status of Passenger Announcement and Passenger Information System shall be monitored

16.5.9 Coupler:

Monitor and display the positive indication from the automatic couplers for proving that they are correctly and fully coupled with other train's coupler.

16.5.10 Lighting Control:

- i) Monitoring of healthy status of interior light controller (ILC)
- ii) Switch on and switch off saloon lighting on a car /train basis (25%, 50%,75% and 100% lighting)

16.5.11 Wheel Flange Lubricator

Wheel flange lubricator ON/OFF status and WFL system healthy status will be monitored by TCMS (refer ERTS clause 10.13.3). TCMS shall receive identification of sharp curve on the route from ATC or GPS and based on this shall provide ON and OFF signal to the wheel flange lubricator.

16.6 Fault Diagnostic Features

16.6.1 Fault Diagnostic Function

TCMS shall perform the task of fault diagnostics, in addition to performing the control/monitoring tasks. The design shall consider the train as a complete system and diagnostic capability incorporated in the system shall detect any node section failure rapidly to ensure no impairment of normal control and monitoring functions. The Contractor shall submit proposed scheme and fault detection logic for Project Manager's review and approval.

The fault diagnostic functionality of TCMS shall include, but not be limited to, the following features:

- i) continuously monitor the status and determine health of all connected equipment and subsystems,
- ii) detect and log events and fault occurrences,
- iii) perform fault analyses and perform failure management actions by causing appropriate action to be taken, and wherever necessary shut down affected equipment, present alarms & conditions/guidance to the train operator.

16.6.2 Fault Detection

Degraded performance condition monitoring shall be provided as an integral part of TCMS wherein on-board CPU shall process the inputs from on-board subsystems and be able to determine car level, unit level or train level faults based upon the defined fault parameters/detection logic.

The various important parameters/signals of the equipment/subsystems (i.e. associated trace/environment data) shall also be recorded for pre-determined period before and after of occurrence of associated events/faults with a view to enable proper fault analysis.

The key indicators of degraded performance, fault parameters/detection logic and trace data signals for all principal car systems shall be defined by the Contractor and reviewed by the Project Manager.

Authorized maintenance personnel shall have facility to select and edit:

- i) event details (e.g., displayed fault text, fault level etc.),
 - ii) list of associated parameters/trace data,
 - iii) periodicity of the parameters/trace data,
 - iv) time interval for pre and post event capture of parameters /trace data.
 - v) fault detection algorithms and fault management logic,
- Complete facilities to implement the same shall be supplied.

16.6.3 Fault Analysis and Management

Appropriate corrective actions shall be taken to reset critical faults and guidance shall also be provided to operator in the form of Troubleshooting Directory (as defined in clause 16.11). Details of failure management actions shall be submitted during design stage for Project Manager's review and approval.

16.6.4 Fault Info Display

Real-time diagnostic information shall be made accessible on the train VDU and the OCC GUI to assist the operator to operate the train safely, quickly, efficiently, and to rectify resettable faults or failures.

16.6.5 Fault Levels

The scheme proposed shall differentiate between faults which are not potentially life threatening (e.g. air conditioning failure) and other system faults which could be life threatening (e.g. failure of the brake system).

The faults/events shall be at three or more levels with Level 1 events displayed on HMI with buzzer, Level 2 events displayed on HMI without buzzer and Level 3 being events recorded in the memory.

Provision shall exist to temporarily upgrade the level of the fault/event automatically in case of its being experienced for predetermined number of times (settable by the authorized maintenance personnel) in pre-determined time period (settable by the authorized maintenance personnel). Detailed proposal for the same shall be submitted for Project Manager's review and approval.

16.6.6 Specific Fault Provisions

The following are some faults that shall necessarily be included in fault detection logic:

- i) Popping up and acknowledgement of the status of each safety switches not in normal state at the time of taking traction and cab activation.
- ii) Loss of redundancy of equipment and subsystems.

16.7 Recording Features

16.7.1 Operator Commands Log

TCMS shall retain a non-volatile record of all train operator and ATP/ATO/UTO initiated commands and system responses for a minimum of 240 hours before overwriting. Overwriting shall be such that the latest information is retained.

16.7.2 Event/Fault Information Log

Adequate redundancy shall be built into TCMS. The size of On-Board Database memory for fault records shall be sufficient to hold all car level and train level events between normal downloading intervals of 30 days through hardware download. In case of overwriting, Level 3 events/faults only may be overwritten.

16.7.3 Data Recorder Log

Separate adequately sized memory shall be available in TCMS for keeping user defined data recording (DR) log files for extensive continuous data logging and fault analysis for more than 200 parameters/signals. The list of parameters/signals and trigger conditions for recording start/stop shall be fully editable.

16.7.4 S&T Interface Signals Logs

TCMS shall also log information/signals as received/delivered from/to ATP/ATO/UTO and Train Radio equipment supplied by the Signalling & Train Control Contractor and Telecommunications Contractor respectively. Please see Appendix 'D' for details.

The Contractor shall also enable Signalling & Train Control Contractor to record similar data/signal interfaced between Rolling Stock and Signalling. During design and interface additional signals may have to be interfaced with Signalling & Train Control Contractor to improve train performance. The same shall be implemented by the Contractor.

16.7.5 Memory Capacity Limit

For the functionalities specified in these specifications, not more than 70% of the provided memory capacity shall be utilized. Further all the memories used in TCMS shall be expandable further as required by the Employer.

16.7.6 Files Format

The file format of all recorded data log files as above shall be submitted along with the tools required for reading and processing the same in batch mode via third party tools.

Naming convention for all different data file types shall be submitted for Project Manager's review. Suitable placeholders for time, car ID, equipment ID, trip ID, train ID etc. shall be incorporated.

16.8 Event Recorder

16.8.1 Each DMC shall be fitted with an event recorder in addition to the on-board TCMS memory for the requirements as specified in sub-clause 16.7.2 and 16.7.3 above.

16.8.2 ~~The event recorder shall have a minimum storage capacity to store 30 days of recording for 300 digital channels and 36 analog channels continuous recording at a minimum sampling rate of 10 samples per second.~~

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The event recorder shall have a minimum storage capacity to store 30 days of recording for **the signals combination of discrete digital and analog inputs as per the requirement specified in GM/RT 2472:2002. Details shall be finalized during design phase.**

16.8.3 The event recorder shall be placed at a location where the risk of damage during a Trains collision is low.

- 16.8.4 The event recorder shall record the Trains status information according to GM/RT 2472 Issue 1.
- 16.8.5 The event recorder shall comply with the crashworthiness and fire protection requirements as per IEEE Std 1482.1 – 1999 and GM/RT 2472.
- 16.8.6 This device shall monitor and flag any operation of critical function such as emergency brake applied by the Trains operator via the activation of emergency stop push buttons or deadman safety device. In addition, any abnormal operation shall be recorded including wrong side saloon door operation. Details of monitoring arrangement shall be submitted for Project Manager's review.
- 16.8.7 The Event Recorder shall incorporate playback function for signals recorded and shall be supplied with a diagnostic software for analysing the recorded data. The diagnostic software shall allow the selection of which data to be displayed / viewed.
- 16.8.8 The memory module used for the storage of data shall be removable to allow playback on other common commercially available Windows 7 or higher operating system computer.
- 16.8.9 The data recorded on the memory module shall be well protected and facilities shall be provided to prevent:
 - i) Unauthorized access and accidental erasure of the recorded data.
 - ii) Removal of the memory module from the Trains by unauthorized person.
- 16.8.10 Both local and remote download of the data in the event recorder shall be possible.
- 16.8.11 The event recorders shall have sufficient capacity to retain information for a period of 120 minutes on rolling memory (first in first out basis) at a higher data sampling rate. The proposed number of signals monitored and the signal sampling rate shall be submitted for Project Manager's review.
- 16.8.12 Data recorded shall be non-volatile type. In case of loss of Trains power supply, the recorded data shall be retained for a minimum of 4 weeks with no external power supply present.
- 16.8.13 The status of the event recorders shall be monitored by the TCMS and the OCC. Any failure of the event recorders shall be notified to the TCMS and the OCC.

16.9 Single Point Upload/Download Provision

- i) Single point uploading of software and downloading of faults shall be possible from TCMS nodes and/or via wireless mode in each train. In-case of sub-supplier's equipment like doors, PIS, HVAC etc. also, single point uploading of software and down loading of faults on unit/car/train basis shall be ensured.
- ii) The overall time required for uploading the software and downloading fault data for all Subsystems shall not be more than 15 minutes each and the same shall be demonstrated. The individual Electronic Door Control unit (EDCU) shall be connected with dedicated port of TCMS to minimize the time taken for data downloading and uploading of door software.
- iii) Contractor to ensure that all fault and associated data residing in the subsystem's internal memory shall be retrievable on specific request from the TCMS nodes/wireless terminal.

- iv) If fault data downloading is interrupted somehow, it should resume from the same point, at which it was interrupted.

16.10 Driving Console Interface

16.10.1 Video Display Unit (VDU)

Each Driving Console shall be provided with a VDU to display real time information to the train operator. Capacitive touch screen-based VDU or better shall be provided as approved by the Project Manager. The display screen shall be of the colour Light Emitting Diode (LED) type, suitable for use in rugged railcar environment. VDU shall be equipped with brightness, sharpness, intensity and contrast controls etc. The VDU shall support both text and graphic presentation of information. Commands shall be entered by the train operator via touch screen. The TCMS VDU shall have the provision to display CCTV images on demand or event generated and shall be capable of displaying multiple screens as per the requirements. Contractor shall provide a robust hardware with adequate memory, RAM, etc. and optimize the software interface in order to cater to the requirements of both TCMS and CCTV. Suitable protection features for the safety of the VDU shall be provided.

16.10.2 The VDU shall display the following information but not limited to

- Equipment operating status
- Faults and Failure of both auxiliary and control functions.
- Time and Date
- Approximate number of passengers
- A Six-digit odometer display
- Energy Consumption data
- Train Identification number
- Train Speed
- Push buttons for start of subsystem test
- Software versions of subsystems
- control of HVAC mode and temperature change
- Powering/Braking mode and demand
- Status of safety switches shall be displayed on VDU and shall be acknowledged by the incoming train operator. The status shall be relayed to OCC/BCC via ATC.

16.10.3 All operations of Train operator including pressing of push buttons etc. shall be recorded with time stamp.

16.10.4 VDU shall recommend remedial actions in the event of alarms or faults occurring on the train.

16.10.5 The level of access to distinct screens shall be controlled for the train operator and maintenance personnel. At least three levels shall be defined which shall be user name and password protected. The Contractor shall submit the details for Project Manager's review. (CDRL-16-8).

16.10.6 Provide distinct screens for different functionality or subsystems. The information shall be divided among screens and presented in a logical and orderly manner.

16.10.7 The screen layout including the selection of default screen, abbreviations etc. shall be reviewed and approved by the Project Manager.

16.10.8 Editing VDU Screens

The format/contents/graphics of VDU screens shall be proposed by the Contractor during design and may have to be changed during the Contract based on operational/maintenance requirements. The Contractor shall make such changes as and when required by the Project Manager during the Contract and shall also train Employer's engineers to design, review and execute the changes in VDU screens in post Contract period. Necessary hardware and software tools with manual shall be provided for each Depot.

16.10.9 Test Mode Extension of VDU

The TCMS VDU shall be connected to the Ethernet Train Bus and it shall be possible to simultaneously plug-in multiple laptops at any point on the train bus and replicate the TCMS VDU display. Suitable application software shall be developed to enable replication of TCMS VDU along with touch and/or mouse-based interaction. In such additional VDUs shall login as "Test Mode" that shall be provided to access the "Operator and "Maintainer" modes of the TCMS.

16.10.10 VDU Response Time

The response time for most complex VDU screen change from one TCMS screen to other TCMS screen, TCMS to CCTV screens, manoeuvring from one camera image to other under full VDU loading shall not exceed 0.5 second. Contactor shall submit compliance details during design stage which shall be got validated during static test.

16.11 Troubleshooting Directory

16.11.1 For quick guidance of Train operator and Maintenance staff, a summarised menu driven, user friendly Trouble Shooting Directory (TSD) shall be made available in the HMI. The TSD shall have separate login modes for operators and maintainers. Extensive use of graphics shall be made TSD for better understanding of the T.O.'s. Details shall be decided during design & commercial / revenue service period.

16.11.2 Maintainer Mode

i) Highlighted FBD

The maintainer mode of TSD shall display detailed functional block diagram (as per IEC 61131) for the fault detection software logic wherein the relevant pathways of the logic diagram tree that triggered the fault shall be highlighted.

ii) Input Output Signal State

The TSD shall also display the real-time states of the various input and output signals related to fault detection logic in tabular form.

iii) Action Items

Detailed action item text containing description of fault logic, possible failed device(s) info, troubleshooting instructions and corrective action as collapsible

blocks of text shall be included on TSD screen. This text shall be colour coded so as to indicate the most pertinent points for any particular failure.

- iv) Mode Switch
- v) It shall be possible to switch from maintainer mode to operator mode of TSD without logging out of TCMS maintainer mode but not vice-versa.

16.11.3 Operator Mode

- i) Graphics and Animations

The operator mode of TSD must include graphics and animations that shall be developed corresponding to all the failed devices, all the failure cause identifications and all the proposed corrective actions for each of the faults. These graphics shall be submitted for review of Project Manager and shall be promptly updated as per his decision.

The detailed proposal for the same shall be submitted during design phase and shall include a listing of all media files being provided in the TSD library.

- ii) Locational mapping

The locational mapping of these graphics files with various train equipment and various fault codes shall also be submitted. The colour highlights and transition effects possible with the graphics shall also be made part of the proposal.

16.11.4 Intelligent Analysis

The TSD shall be smart enough to group together related faults (i.e. faults that have the same root cause) and provide guidance in a combined view for such faults. The various FBD logical pathways as requested above shall be distinguished in this case with different colours.

16.11.5 Editing of TSD

Based on the operational requirements, the directory shall be regularly upgraded during the Contract period. The TSD shall be editable by authorised maintenance personnel. Necessary training for the operator and maintenance personnel shall be provided.

16.12 Maintenance Tools

16.12.1 Scope of Supply

A minimum of fifteen notebook computers as approved by the Project Manager, together with all associated accessories and preinstalled software necessary for all diagnostic and configuration editing functions for all train-borne equipment shall be provided. Two copies of all the software uploaded in the notebook computers shall also be provided separately in approved non-volatile memory.

The notebook computers shall be of rugged design, high performance having sufficiently large storage capacity, high battery backup, sufficient no. of ports required generally (like USB, LAN, serial, VGA, HDMI etc.), a DVD drive (inbuilt or separate) etc. with latest generation Processor and Operating System.

16.12.2 On-board Connectivity

A high-speed suitable communication port shall be provided in each car to interface with a notebook computer and all information on the TCMS shall be made accessible on the notebook computer. It shall be possible to download the desired data for the entire train including data logged in its subsystems through any one of these ports (single point downloading of train's faults/data).

Additionally, it shall also be possible to connect with TCMS remotely via wireless network access and download faults from any train in depots.

16.12.3 Levels of Access

The level of access to distinct functionalities shall be controlled for the maintenance personnel. Atleast three levels shall be defined which shall be user name and password protected. The details shall be reviewed by the Project Manager.

16.12.4 Required Features

The notebook computer shall provide full testing of and interaction with the on-board TCMS at both train and car level. The following minimum capabilities shall be provided:

- i) System monitoring, fault data retrieval and analysis.
- ii) Viewing and processing of logged TCMS data
- iii) Uploading new operating software and parameters for all the on-train subsystems
- iv) Uploading new train configuration data (e.g. wheel diameters, etc.)
- v) Downloading of fault and usage information
- vi) Initiating self-test and Downloading self-test reports
- vii) Exercising and checking of digital inputs and outputs
- viii) Checking of train and subsystem serial links
- ix) Checking of train data bus set-up and configuration
- x) Retrieval of equipment identification numbers
- xi) Initiating function testing of on-board equipment
- xii) Force various inputs/outputs interfacing with VCC
- xiii) Forcing internal signals of TCMS as a tool for simulation
- xiv) Editing of fault logic (ERTS 16.6.2)
- xv) Editing data acquisition signal list (ERTS 16.3.4)
- xvi) TCMS configuration editing (ERTS 16.1.7)
- xvii) Editing DR data signals list (ERTS 16.7.3)
- xviii) Running Energy Saving mode analytical tools (ERTS 16.14.4)

16.12.5 OS Compatibility and Upgradability

All the software(s) used in train, diagnostics, monitoring or analysis purpose shall be compatible with latest Windows version and upgradable for higher versions of Windows. The Contractor shall either commit to supply upgraded versions to match

with higher version of Windows, as and when available or the software(s) shall be so developed to have automatic upgradability with Windows.

16.13 Depot Wireless Communication System

16.13.1 General

~~The Contractor shall provide equipment and install the complete system to enable~~

- ~~i) remote access of TCMS data and subsystem trace data on trains present in depot(s)~~
- ~~ii) remote downloading of TCMS data and subsystem trace data (data recorder logs, events logs stored on on-board TCMS memory, subsystem trace data, event data stored in event recorder, etc.) to depot server through wireless communication (Wi-Fi) network using a dedicated port on the On-board TCMS. The Contractor shall interface with the supplier of Asset and Maintenance management system for data integration. The Contractor shall be responsible for complete set up, commissioning and satisfactory working of the system during DLP.~~

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General

The Contractor shall provide equipment and install the complete system to enable

- i. remote access of TCMS data and subsystem trace data on trains present in depot(s)
- ii. remote downloading of TCMS data and subsystem trace data (data recorder logs, events logs stored on on-board TCMS memory, subsystem trace data, event data stored in event recorder, etc.) to depot server through wireless communication (Wi-Fi) network using a dedicated port on the On-board TCMS.

The Contractor shall interface with the supplier of Asset and Maintenance management system for data integration. The Contractor shall be responsible for complete set up, commissioning and satisfactory working of the system.

The data which shall be possible to be downloaded remotely via the depot wireless communication system shall include but not be limited to the following:

- a) Event data and fault data necessary for fault diagnostics and troubleshooting
- b) Trace data stored in subsystems and TCMS
- c) Energy data stored in TCMS
- d) Equipment performance data
- e) On-board test results
- f) Event recorder data
- g) Any other data as decided during design

The facilities of remote downloading shall be in addition to the hardwire downloading.

16.13.2 Scope of Supply

Contractor shall supply:

i) Depot server

The data as above shall be downloaded on the depot servers. Two Depot server sets, each consisting of server, server racks, UPS, Switch hub, User console, in-rack networking etc., shall be provided by Rolling Stock Contractor for two depots (i.e. one set for each depot). Communication link with the on-board TCMS to the depot server shall be provided by the Contractor. A dedicated port shall be made available in the On-board TCMS to cater for depot wireless downloading. Necessary interfacing devices shall also be provided by the Contractor.

ii) Depot Equipment

Within the depot(s) areas, the Contractor shall install and configure wireless network for accessing the diagnostic data, both directly from on-board TCMS memory and from the depot server via maintenance notebook computers.

All equipment required within depot(s) shall be supplied by the Rolling Stock Contractor for three depots. Any other networking equipments as defined in Appendix-D shall also be in the scope of Rolling Stock Contractor. Further details shall be worked out as approved by the Project Manager during design stage.

iii) On-board equipment

Any on-board equipment/access point/switches/router/antenna etc. shall be provided by Rolling Stock Contractor. On availability of train in the depot, the recorded data in TCMS shall be transferred to the depot server and subsequently to the Asset and Maintenance management system automatically. The data to be recorded in the depot server and to be integrated with the Asset and Maintenance management system shall be discussed and finalized in interface with Asset Management system supplier. The details shall be submitted for Project Manager's review. **(CDRL-16-9)**

16.13.3 Required Features

i) Download Triggers

The remote downloading to depot server shall be initiated automatically when the train is in Wi-Fi zone in depot and it shall be possible to force downloading remotely by authorized metro personnel.

ii) High-Integrity data transfer

Integrity of the data shall not be affected during remote download and in case of any interruption or otherwise the data shall be suitably secured and retrievable.

iii) Auto resume of downloading

If the downloading of On-board TCMS data to depot server is interrupted or fails due to any reason, the next download attempt should start where the previous attempt was interrupted.

- iv) Duplication of data in depot server shall be avoided. When availability of train is detected in the wireless zone, depot server should trigger the download and download only that data from On-board TCMS which has not been downloaded earlier to the depot server.
- v) Asset and Maintenance management system, issue of work orders etc. shall be linked with this software.
- vi) The Contractor shall supply the multiuser software(s) required for analysis of the faults and predictions/judgments on likely faults/failures. The specification of the software shall be got approved from the Project Manager.

16.14 Energy Consumption Measurements

16.14.1 General

The Vehicle Control Circuit shall be suitably designed to ensure that Energy Consumption values at specified points are measured, recorded and made easily retrievable. The accuracy and integrity of these measurements shall be specifically ensured as the Employer intends to use the data for getting carbon credits.

The measurements shall be:

- i) made independently at CCD, VVVF inverter and APS levels,
- ii) made separately for traction, coasting and regeneration modes for each train,
- iii) linked with Crew IDs,
- iv) segregable between mainline and depot consumptions,
- v) time stamped every 5 seconds,
- vi) stored in TCMS memory for 60-day period,
- vii) retrievable on VDU as cumulative/integrated values with advanced filtering option.

16.14.2 Reporting of Measurements

i) Display on VDU

The cumulative energy values at CCD, VVVF inverter and, APS levels with both the components viz. motoring (including coasting) & regeneration, shall be displayed on VDU. It shall also be possible to apply time and trip filters to the energy values.

ii) Relaying to OCC

Complete energy data shall be transmitted to control centre at assigned times which shall be advised during design. The data shall be stored for one week and shall be downloadable as and when required. Further details including reporting format shall be discussed and finalized during design.

iii) File Format

The Energy Consumption data shall be exportable to Microsoft Excel in the following format:

Parameter	Time ₀	Time ₅	Time ₁₀	Time ₁₅	...
Energy Consumed @ CCD (Powering)					
Energy Consumed @ CCD(Coasting)					
Energy Consumed @ CCD (Braking)					
Energy Regenerated @ CCD (Braking)					
Energy Dissipated @Brake Resistor (Braking)					
Energy Consumed @ VVVF (Powering)					
Energy Regenerated @ VVVF (Braking)					
Energy Consumed @ APS (Powering)					
Energy Consumed @ APS (Coasting)					
Energy Consumed @ APS (Braking)					
State (Powering/Braking/Coasting)					
Crew ID					
Train ID					
Trip Number					
Last Station ID					
Mainline/Depot					
Train Speed					

In above format the values in blank cells shall only correspond to the recordings made during the 5 second interval between successive time stamps and shall not be accumulated.

16.14.3 Measurement Accuracy

i) Accuracy

All energy measurements shall have accuracy within $\pm 3\%$ of the measurements made with Standard Wattmeter and Standard Instrument Transformers connected at appropriate test point in the Vehicle Control Circuit. This shall be validated during type tests.

ii) Verification

The Contractor shall be required to submit the detailed arrangement for connecting the standard Instrument Transformers and Standard Wattmeter at the test points for measurement of Energy Consumption for all above defined parameters during the Type Test. Further details shall be discussed during design stage.

iii) Least Count

The least count for recording data shall be 0.01 kWhr at all levels of measurement.

16.14.4 Analytical Software Tools

~~The Contractor shall also provide suitable analytical tools to screen and analyse the energy data for:~~

- i) ~~optimization of energy regeneration, coasting~~
- ii) ~~right manner/energy saving manner of driving,~~
- iii) ~~educating train operators,~~
- iv) ~~identifying the areas where energy can be saved,~~
- v) ~~calculating efficiency values, Traction inverter, auxiliary inverter etc.~~

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Analytical Software Tools

The Contractor shall also provide suitable analytical tools to screen and analyse the energy data in **“ATP mode”** for:

- i) optimization of energy regeneration, coasting
- ii) right manner/energy saving manner of driving,
- iii) educating train operators,
- iv) identifying the areas where energy can be saved,
- v) calculating efficiency values, Traction inverter, auxiliary inverter etc.

16.15 TCMS-OCC Interface

16.15.1 Key Alarms

The Contractor shall propose a list of critical/key alarms to be communicated to the OCC in real-time through the signalling network. This list shall include all alarms that are required for maintaining safe train operation.

Any repetitive, hierarchical or cascading type faults shall be suitably masked or combined together to ensure brevity of the information being presented to OCC operator. The key alarms shall also have well defined actionable procedures associated with them as finalised in the OMPD document.

16.15.2 OCC GUI for Rolling Stock Controller

The Rolling Stock Controller (RSC) in OCC shall have facility of full TCMS functionality of any train on his workstation on demand through signalling network. Development of the GUI application in RSC workstation shall be responsibility of Rolling Stock Contractor. Contractor shall provide detailed information of the Rolling Stock - Signaling interface as implemented for the function of OCC GUI in at least two recently executed UTO Projects for reference during design stage.

16.16 Deliverables

Contract deliverables required by this section of these Technical specifications are summarized below:

CDRL-16-1:	UTO Compatibility (ref. ERTS 16.1.5)
CDRL-16-2:	Details for the switchover and recovery times of redundant processors of TCMS (ref. ERTS 16.2.4)
CDRL-16-3:	Network Interfaced Systems (ref. ERTS 16.3.1)
CDRL-16-4:	Communication protocols used in their design at different levels (ref. ERTS 16.3.3)
CDRL-16-5:	Detailed clock synchronisation proposal (ref. ERTS 16.3.5)
CDRL-16-6:	Detailed list of functions /features proposed to be controlled through TCMS (ref. ERTS 16.4.5)
CDRL-16-7:	Interface with Automatic Train Control System (ref. ERTS 16.5.7)
CDRL-16-8:	Driving Console Interface (ref. ERTS 16.10.5)
CDRL-16-9:	Depot Wireless Communication System (ref. ERTS 16.13.2 (iii))

17. COMMUNICATION SYSTEM

17.1 Train Communication Equipment

17.1.1 The following on-train communications requirements shall be provided:

- i) Two-way Communication between the Operations Control Centre (OCC) and train operator, via train radio equipment (Supplied by Communication Contractor).
- ii) Emergency passenger announcements (PA) on the train by OCC via train radio system (Supplied by Communication Contractor).
- iii) Means for the train operator to address passengers throughout the train from the driving cab.
- iv) Means for the train operator & OCC to address passengers including announcements etc.
- v) Not Used.
- vi) Facilities to permit duplex conversation between a passenger who has operated a Passenger Alarm Emergency Handle (PAEH), and the train operator or OCC.
- vii) A Digital Voice Announcement Unit (DVAU) based on ATC bits.
- viii) A Passenger Information System (PIS).
- ix) Passenger saloon surveillance system (PSSS) using CCTV
- x) Door opening / closing chime.
- xi) Complete tools including Software, Hardware, equipment etc. for configuring, editing and creating route /station data, announcements, messages & fonts, audio speech and interface of the system with other sub systems etc. shall be supplied. It shall be possible for the Project Manager to configure the PIS/PSSS software for implementing operational & maintenance related modifications. Software tools and portable maintenance terminal for each depot for recording and analysing interface signals shall also be provided. It shall be possible to modify/add any pre-recorded announcements in the Digital Voice Announcement Unit through portable maintenance terminal.

Full access to the software for the above purpose shall be provided. Any hardware/software tool (two sets, one for each depot) required for this purpose shall also be provided. The documentation including but not restricted to flow charts (for complete software), signal flows, and interpretation of signal etc. shall be provided. Project Manager shall be fully trained and made fully conversant by the Contractor for this purpose.

Necessary set-up including Software, Hardware, Equipment etc. to realise the change/modification shall also be ensured by the Contractor. Contractor shall submit the details for Project Manager's review. **(CDRL-17-1)**

- xii) PA & PIS system shall have full flexibility and dynamic compatibility with any number of short loops/route changes which may be enforced during operation. In short loop operation, all the announcement should be based on ATC bits. Necessary interface with signalling system shall be ensured.

- xiii) All the interface signals relevant for PA & PIS system shall be recorded with time stamp.
- xiv) PA/PIS & PSSS System shall be designed to cater any single point of failure. Functionality at car/train level (as applicable) shall not be affected due to any type of single point of failure. Adequate redundancy shall be built in the proposed system architecture. Contractor shall submit the details for Project Manager's review. **(CDRL-17-2)**
- xv) PA/PIS & PSSS shall have state of the art communication protocol. Provenness of the system shall be ensured by the Contractor. Contractor shall submit the details for Project Manager's review.

Single point upload and download of data, software etc. for all PA/PIS & PSSS system shall be provided by the Contractor along with the provision of remote upload/download. Full details shall be submitted for review by the Project Manager during detailed design stage. **(CDRL-17-3)**
- xvi) PA/PIS & PSSS equipment shall be of at least IP53 or better class. Complete details of available IP protection of all PA/PIS & PSSS system's equipments shall be submitted and get approved by the Project Manager.

Exterior equipment shall be of at least IP67. Any degradation based on technical difficulty or recommendation by OEM shall be reviewed by the Project Manager during the design.
- xvii) Suitable interface of PA/PIS & PSSS for synchronizing time with TCMS shall be ensured by RS Contractor.
- xviii) Any other equipment required on-board for interfacing with the other designated Contractors viz. Signalling, Telecom and others for operation of trains shall be provided by the Contractor.
- xix) Provision of self-checking & its result for all PA/PIS & PSSS equipment shall be ensured. Contractor shall submit the details for Project Manager's review. **(CDRL-17-4).**

17.2 OCC to Train driver and On-train Public Address Communication Link

A Train-to-OCC radio communications link (supplied by the Communication Contractor) shall be provided to enable:

- i) Voice communication from OCC to passengers, and between the OCC and the train driver.
- ii) Vehicle health data communication from TCMS to OCC at designated times and locations shall be provided. The data required to be transferred from the train to the OCC shall be finalized by the Contractor at the preliminary design stage and submitted for review by the Project Manager. **(CDRL-17-5)**
- iii) The interface between the radio link and TCMS shall be provided by the Contractor.
- iv) Voice shall have priority over data communication.
- v) When the OCC to passenger communication occurs, any other system set at that time shall be overridden.

- vi) A radio control head, which shall be integrated with the driving console, shall be supplied by Communication Contractor. The mounting location shall be carefully planned as the equipment is frequently used by the train operators.

17.2.1 A suitable interface shall be provided by the Contractor to enable the OCC-to-Passengers announcements to be transmitted over the train public address system.

17.2.2 Adequate space and reliable battery backed power supply shall be provided to communication Contractor for the on-board radio system.

17.2.3 Facilities to permit announcement in the train along with the provision for communication with OCC by Roving Attendant through train radio shall be provided. Contractor shall submit the details for Project Manager's review. **(CDRL-17-6)**

17.3 Automatic Digital Voice Announcement Unit and Public Address (DVAU and PA)

17.3.1 General

- i) The Contractor shall provide the DVAU and PA equipment including Cab-to- Cab Intercom and Emergency Intercom System
- ii) All Cables, connectors, interfacing plugs and sockets, earthing connections and all associated mounting materials shall be provided by the Contractor.
- iii) The Contractor shall provide accommodation including mountings, equipment cabinets and cable access for installation of all the DVAU and PA equipment.

17.3.2 The DVAU and PA system shall consist of:

- i) The following equipment, as minimum, in each cab:
 - A Master Control Panel (MCP) with loudspeaker and microphone.
 - An Auxiliary Control Panel (ACP) with microphone.
 - A Digital Voice Announcement Unit (DVAU).
 - A DC Voltage Regulator Unit.
- ii) The following equipment, as a minimum, in each car of the unit:
 - 8 loudspeakers in the saloon interior and 4 loudspeakers in the saloon exterior.
 - 4 Emergency Intercom units.
 - A Public-Address Unit with Public Address amplifier.

17.3.3 The following modes of communication shall be provided by the DVAU and PA:

- i) Public Address (PA) to passengers including:
 - Radio broadcasting in which traffic controller in OCC can make live announcements to all passengers via Train Radio.
- ii) Cab-to-Cab Intercom which provides intercom function between the two driving cabs.
- iii) Emergency Intercom system which enable communication between the train driver and passenger who has operated the push button via the loudspeakers and microphone situated adjacent to the push button.
- iv) Communication between the train driver and the traffic controller in OCC via train borne radio system.

17.3.4 The availability of the different modes of communication in active and non-active cab shall be:

Table 17.3.4

Driving Cab	Public Address (PA)	Cab-to-Cab Intercom	Emergency Intercom	Cab – OCC intercom
Active Cab	Y	Y	Y	Y
Non-active Cab	N	Y	N	N

17.3.5 The different modes of communication (Public Address, Cab-to-Cab Intercom and Passenger Alarm System) shall have different priority as tabulated below. Details shall be finalized during design stage for conditions and response of the loudspeakers.

Table 17.3.5

Priority	Communication Mode
1	PA – Manual Broadcasting by train driver
2	Cab-to-Cab Intercom
3	Cab-to-OCC Intercom
4	Passenger Alarm system
5	PA – Radio Broadcasting by train traffic controller
6	PA – Broadcasting of pre-recorded announcements based on real time information received via interface with TCMS

17.3.6 The first priority communication mode has the highest priority while the sixth priority communication has the lowest priority. Higher priority communication mode shall interrupt and stop the lower priorities.

17.3.7 The DVAU and PA shall be designed and supplied to meet the constructional and workmanship standard and electrical and electronic design standard.

17.3.8 The stability and operation of the DVAU and PA equipment shall not be affected by the driving cab EMI environment. All DVAU and PA equipment shall conform to the EMC requirements.

17.3.9 The DVAU and PA shall have a self-test function on power up that checks the system healthiness. The result of the self-test shall be reported to the TCMS via the interface unit.

17.3.10 The DVAU and PA shall be equipped with automatic sensing and adjustment devices to sample and detect the ambient noise in each saloon and automatically adjust the output level of PA amplifiers in order to maintain the threshold sound level of broadcast messages above that of the ambient noise. A sound level adjustable between 6 dB(A) and 10 dB(A) above background noise level is required throughout the train.

Apart from this, independent volume adjustment facilities shall be provided through Software/Hardware configuration to enable the Employer's personnel carry out the volume adjustment. The Hardware/Software required for this shall be supplied by the Contractor. Full details shall be submitted for review to the Project Manager.

17.3.11 Manual Broadcasting

The train driver shall be able to make live announcements to passengers via either of the microphone on the Master Control panel or Auxiliary Control Panel. The 'Press-To-Talk' (PTT) button on the microphone shall be pressed during the announcement to enable the broadcast to passengers.

17.3.12 Radio Broadcasting

- i) The interfaces of the DVAU and PA system to the train radio equipment shall be designed to enable the traffic controller in OCC to make announcements to passengers via Train Radio.
- ii) A separate indicator in the MCP shall be illuminated during the course of radio broadcasting.

17.3.13 On-train public address shall be capable of being initiated from the OCC, the driving cab or the automatic digital voice announcement system. The Automatic Voice System shall be the default public address mode (default mode).

17.3.14 The microphone to be used for public address / announcements should have high dynamic noise cancelling feature.

17.3.15 The Public Address System together with its main components shall comply with internationally accepted standards.

17.3.16 Power amplifiers are required for the PA system and shall cater for the requirements of a 6-car metro train composition. One power amplifier in each car shall be provided.

17.3.17 Power amplifiers are required for the PA system and shall be provided in each car. Each power amplifier shall feed 50% of the speakers in the same car and 50% in the adjoining car, to ensure that in the event of a single power amplifier failure, at least half of the speakers are still operative in the car.

17.3.18 ~~The number, positioning and output of each loudspeaker and power amplifier shall be designed such that an even sound coverage in all areas of the passenger saloon is achieved. The sound pressure level when measured at a height of 1.5m above the floor shall not vary by more than 1dB(A) along the entire length of the consist. Details shall be submitted for Project Manager's review during design phase. (CDRL-17-7)~~

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The number, positioning and output of each loudspeaker and power amplifier shall be designed such that an even sound coverage in all areas of the passenger saloon is achieved. The sound pressure level when measured at a height of 1.5m above the floor shall not vary by more than **3dB(A)** along the entire length of the consist. Details shall be submitted for Project Manager's review during design phase. (CDRL-17-7)

17.3.19 The public address amplifiers shall be protected against short circuit at the outputs of the amplifier.

17.3.20 The through line cable inside the car shall be suitably insulated, screened, armoured and overall outer sheathed. The cable shall be of the fire survival type.

17.3.21 The Contractor shall submit for the approval an audibility analysis for the PA system, including the location of each speaker in the car. The minimum acceptable speech transmission index must be better than 0.5. **(CDRL 17-8)**

17.4 Broadcasting of Pre-recorded Announcements

- 17.4.1 All the pre-recorded announcements shall be stored in the Digital Voice Announcement System Unit and shall be able to be selected for broadcasting.
- 17.4.2 The DVAU and PA shall store, select and broadcast all the required messages for Line-6, Phase 2A and Phase 2B trains.
- 17.4.3 There shall be three types of pre-recorded announcements in either the Kannada, Hindi and English languages or a combination of two or three of languages stored in the DVAU:
- a) Door messages for all stations, for example "Please stand clear of the doors"
 - b) Station messages for particular stations, for example "The next station is K. R. Puram".
 - c) Special messages, for example "Attention please, there will be a short delay because of train service regulation. Please accept our apologies for any inconvenience caused".
 - d) Emergency messages, for example "Attention please. This train is unable to move because of a technical problem. Please walk to the front of the train. The train driver will escort you to the next station. Please accept our apologies for any inconvenience caused."
- 17.4.4 The broadcast of pre-recorded announcements shall be able to be triggered by:
- a) Automatic station announcement including information regarding side of door opening based on announcement bits received from ATC.
 - b) Station announcement including information regarding side of door opening through TCMS manually in case of failure from ATC side.
- 17.4.5 All the special and emergency messages shall be selected and initiated by the train driver via TCMS. Different indicators shall be provided to indicate the broadcast of special and emergency messages.
- 17.4.6 Emergency messages shall be broadcast repeatedly to the passengers. A 'reset' button shall be provided to terminate the broadcast of emergency messages. The repeating broadcast of emergency message shall also be terminated if a higher priority communication mode is activated.
- 17.4.7 The PIS display panels shall be pre-loaded with all three types of pre-recorded announcements in the DVAU in the corresponding textual format. Synchronization of audio and textual announcements (in Kannada, Hindi and English) shall be achieved such that the message broadcast (either triggered by the train driver or by ATC via TCMS) by the DVAU and PA is also displayed by all the PIS display panels in the corresponding textual format at the same time. This shall be applicable to all types of messages i.e. door, station, special and emergency messages except for those emergency messages requiring detrainment.
- 17.4.8 In case detrainment of passengers is required, an emergency message informing such arrangement shall be able to be selected by the train driver and broadcast to passengers. At the same time, a command shall be sent via the TCMS interface to all the PIS display panels to stop the display of all other information and show a big

arrow directing passengers. "EMERGENCY EXIT" in Kannada Hindi and English shall also be displayed. This message information shall be displayed from power to be made available from Auxiliary Inverter or battery. In the display, also the door selected for Emergency egress shall be shown in Green colour.

17.4.9 Automatic Station announcement (arrival, departure and platform announcement) shall be based on bits provided by ATC. Rolling Stock contractor shall interface with Signalling & Train Control contractor to finalize the interface. In the event of failure of ATC, station announcement shall be switched over to TCMS mode.

17.4.10 In the event of failure of the automatic broadcast of announcements triggered by train borne ATO/ATP equipment, it shall be possible to switch to TCMS mode, where messages are triggered by driver over TCMS.

17.4.11 Via the TCMS the train driver shall be able to repeat the broadcast of the previous announcement in ATO/ATP failure mode.

17.5 Automatic Digital Voice Announcement System Unit

17.5.1 An automatic Digital voice announcing unit shall be provided in each cab by the Rolling Stock Contractor. Functions and features of this system shall be as follows: -

- i) The Automatic Digital Voice Announcement System shall be fully integrated with the On-train PA system. Any failure of component which can adversely affect functionality shall be logged by the system itself and also be communicated to TCMS for reporting to the train driver and data logging. Contractor shall submit the details for Project Manager's review. **(CDRL-17-9)**
- ii) Fail safe mode with full functionality (for both DVAU/MCP)- In case of failure of master DVAU of driving cab, DVAU of the other cab shall become master automatically and normal announcement will not be affected. The Contractor shall submit the details for Project Manager's review.
- iii) The pre-determined messages (voice announcements and text messages) shall be automatically triggered by train events and / or the ATC system to make an announcement. Close liaison is required between the Contractor and the Signalling & Train Control Contractor in this regard. Contractor shall submit the details for Project Manager's review. **(CDRL-17-10)**
- iv) All the hardware requirements to achieve interfaces between the automatic voice announcement system and the ATP/ATO system shall be provided by the Contractor.
- v) The Automatic Digital Voice Announcement System shall also be equipped with display and announcement of computer-generated messages.
- vi) The comprehensive details (their format, frequency, use etc.) of message and special messages (to be triggered manually) shall be subject to review by the Project Manager.
- vii) A door close announcement shall be triggered each time the "Door Close Announcement" button is pressed. When door close command is initiated, the door close chime shall play till the Doors achieve locked position. Similarly, a chime shall be played during the door opening. During this time any existing auto announcement shall be aborted. The chime shall warn the passengers inside the

train as well as those on the platform about the door operation. In case of obstruction/non closure in particular door(s), the chime on the corresponding car/door(s) shall only be broadcasted. Selection of the type and adjustment of volume of the chime shall be independent of the volume of the announcements.

- viii) It is proposed to provide commercial / general audio/video and/or visual messages in between the announcements or during the available journey time/between the station(s). The system shall be capable of playing / displaying (both manually & automatically) of such advertisements. Programming flexibility to assign/nominate the announcements etc during the journey time or between the stations shall also be ensured by the Rolling Stock Contractor. Contractor shall submit the details for Project Manager's review. **(CDRL-17-11)**
- ix) Voice announcements and text messages for the displays shall be pre-recorded and configured into the system using the "off line" speech and route database editor. Messages, audio or visual or both shall be in the Kannada, Hindi and English languages. Messages shall be recorded in the voice of professionals Announcers to be approved by the Project Manager. The hardware and dedicated software etc. for editing and modifying the speech and route database shall be handed over to BMRCL at an appropriate time, during the Contract period, to be decided during the design stage. The Project Manager's staff shall be associated during the editing activity. Messages shall be digitally stored. Provision for adding /expunging / editing any type of message shall also be ensured. Necessary tools (two sets, one for each depot) shall also be handed over at an appropriate time.
- x) The time taken from the confirmation of any selected message to the resulting message being broadcasted in the saloon shall be 500 msec maximum. This shall be applicable for all four types of message, i.e. door, station, special and emergency messages.
- xi) The system shall be capable of storing 230 minutes of pre-recorded messages preferably in digital MP3 format or a latest format. The memory shall be able to store Route Database for at least 200 stations. However, it shall be possible to enhance the memory by expansion using commercially available memory devices. Full details shall be submitted for review by the Project Manager.
 - a) Door and station message : 200 min.
 - b) Special message : 15 min.
 - c) Emergency message : 15 min.
- xii) The stored messages of the DVAU shall be delivered naturally in speech tones and shall meet the following performance:
 - a) Bandwidth : 300 – 7000 Hz (-3dB).
 - b) Distortion at 1 kHz : < 1%.
 - c) Dynamic range : 80 dB minimum.
- xiii) The DVAU shall not at any time generate any incorrect message and shall not interfere with station PA broadcasts under any circumstances.
- xiv) A portable maintenance terminal including software and portable PCs with latest specifications shall be provided in each depot that enables a technician to

customize the DVAU and manage the stored messages. The interface to the DVAU shall employ state of art interface or other standard industrial interface. It shall also enable the upload/download of digitized messages to the train borne DVAU. The location of the interface port shall be readily accessible.

- xv) The following functions shall be provided as a minimum:
 - a) System configuration and programming.
 - b) Fault diagnosis of the DVAU.
 - c) Downloading/uploading of digitized messages via state of art interface with the portable maintenance terminal.
 - d) The recorded messages in three different languages of Kannada, Hindi and English shall be provided.
 - e) The digital voice recording file shall be .WAV, MP3 or other approved format.
- xvi) In case of train parting, both cab's automatic digital voice announcement system shall become active and it shall be possible to make an announcement from either of the Cab and from OCC.

17.5.2 Audio Recorder

An automatic recorder shall be provided to record all automatic announcements made by PA system in saloon, manual announcements through MCP in saloon, announcements made by OCC in saloon (train), conversation between cab to cab and conversation between passenger (recorded PEA wise with time stamp) & train operator/OCC when Passenger emergency alarm is activated in MP3 format or any other superior format. It shall be possible to download the recorded data without using any special tool/equipment directly from the recorder. The recorder shall have expandable memory to store the data for at least three days in revenue service.

17.6 Cab to Cab Intercom

- 17.6.1 In the cab-to-cab mode, the train operator shall be able to communicate with a person at the other end of the train. Two way communications shall be established in this mode.
- 17.6.2 The train operator on either driving cab shall be able to initiate the Cab-to-Cab Intercom function.
- 17.6.3 Not used.
- 17.6.4 The cab-to-cab communication system shall be able to operate independently of, and simultaneously with, automatic announcements.
- 17.6.5 Simplex mode operation between two trains while in proximity shall be possible, via OCC on the radio communication system (supplied by Communications Contractor).
- 17.6.6 Duplex mode operation between two trains while in proximity shall be possible, via OCC on the radio communication system (supplied by Communications Contractor).
- 17.6.7 It shall be possible for Train operator to adjust the volume in the cab.

17.7 Passenger Emergency Alarm (PEA)

17.7.1 There shall be four Passenger Emergency Alarm (PEA) in each car.

17.7.2 When a passenger emergency alarm device is operated, a warning sonic device shall sound in the driving console, an indication shall be given to the train operator of the location of the operated device, automatic views from surveillance cameras provided near the location of activated PEA shall be displayed in the monitors inside cab/OCC and a visual indication on the exterior of the car shall advise station staff which is the affected car.

Full details of automatic view available at driving console/OCC upon actuation of certain critical events like fire detection, opening of driving console, door obstacle detection, operation of obstruction deflection device (ODD), track/third rail/infrastructure related event etc. shall be submitted for review and approval by the Project Manager.

The train operator/OCC shall be able to acknowledge the alarm by operation of an override device in non UTO/UTO operation respectively, which shall terminate the cab sonic alarm, and simultaneously cause an indicator to illuminate at the emergency device location. It shall be feasible for train operator/ OCC to acknowledge and isolate/reset the specific PEA from the driving console/ OCC after verifying the conditions in the saloon to his satisfaction through CCTV images which shall be recorded with date, time, train ID/No., rake ID, Camera Name/Camera ID and event stamping.

Recording of image upon certain critical events shall be as per ERTS 17.13.3.

Passenger communication shall be train operator/ OCC initiated. This will render the local microphone and loudspeaker adjacent to the activated emergency device active, thereby enabling bi-directional inter-communication between the train operator/ OCC and the passenger. Once pressed/operated, it shall be possible for the commuter to communicate with the Train Operator/ OCC unless inhibited by the Train Operator/ OCC.

A fall back system shall be provided to enable the communication between Train Operator/ OCC & passengers with PEA in case of failure of normal communication channel. If more than one emergency device has been operated, each demand shall be independently acknowledged, and alarms shall be stored, displayed and answered sequentially.

Contractor shall submit the details for Project Manager's review. **(CDRL-17-12)**.

17.7.3 Whilst the communications system is in the passenger alarm mode it shall be possible for the train operator/ OCC to move between passenger alarm, train operator/ OCC PA and cab-to-cab communication.

In the event that the train operator/ OCC fails to acknowledge a passenger alarm call, within a specified time, the call shall be logged by TCMS. TCMS shall be provided with following data relating to the passenger emergency alarm:

- Current status of each passenger alarm button.
- Alarm event for each passenger alarm button, clearing when acknowledged by the train operator/ OCC.

- Once the doors have been opened, it shall not be possible to restart the train until all the passenger alarms have been reset from OCC/driver's cab. Once this has occurred the system shall revert to its normal form of operation.
Provision of bypass for enabling traction if required or as decided by the Project Manager shall also be provided. Full details shall be submitted for review and shall be discussed during design stage.
 - Screened cable pairs of fire survival type shall be provided for the passenger alarm system.
- 17.7.4 Under no circumstances shall cab-to-cab conversation or train operator to OCC conversation be relayed to any passenger.
- 17.7.5 The PEA push button once pressed should be resettable from remote from the operating console or OCC. When train is operating in UTO mode, two-way communication shall be established with OCC.
- 17.7.6 The activation of any PEA shall interface with the saloon CCTV such that images of concerned area are automatically displayed on train-borne display unit inside the cab.
- 17.7.7 The activation of any PEA shall interface with the saloon CCTV such that images of concerned area are automatically displayed on train-borne display unit inside the cab and transmitted to OCC. It shall be possible to OCC to identify which PEA has been activated so that the communication with the passengers can be initiated.
- Automatic transmission of CCTV images for live streaming at OCC and creation of historic data (from the occurrence to 15 min after the event) shall be as per ERTS 17.13.3. Historic data period shall be customizable. Contractor shall submit the details for Project Manager's review. **(CDRL-17-13)**
- 17.7.8 Multilingual (Kannada, Hindi and English) indication of indicators shall be provided on PEA speaker panel (like wait, call, talk etc.). The indication shall be separate from Labels & Signage provided for the operation & function of PEA. Necessary indication to commuters shall also be made available in case of faulty PEA.
- 17.7.9 PEA communication system shall be SIL2 compliant except for voice signals.
- Speaker/mic panel provided for PEA shall be flushed with carbody wall to have good aesthetic. PEA shall be such design as to avoid accidental activation by passengers. Contractor shall submit the details for Project Manager's review. **(CDRL-17-14)**
- 17.8 Master Control Panel (MCP) with Loudspeaker and Microphone**
- 17.8.1 The MCP of proper size shall be located on the driving console.
- 17.8.2 It shall be equipped with the following, as a minimum:
- i) 'Emergency message' selected- initiates and indicates the broadcast of emergency message.
 - ii) 'Cab-to-cab intercom' selected – initiates and indicates a cab-to-cab intercom request.
 - iii) 'Passenger emergency intercom' indicator – indicates emergency button(s) operated.
 - iv) 'Radio broadcasting' indicator – indicates radio broadcasting is active.
 - v) Loudspeaker with volume adjustment device.

- vi) Microphone that can be unplugged and replaced easily.

17.8.3 Auxiliary Control Panel (ACP) with Microphone:

- i) The ACP of proper size shall be located on the auxiliary console.
- ii) It shall be equipped with the Microphone and Press to talk (PTT) button.
- iii) The Microphone shall be unplugged and replace easily.

17.8.4 Public Address Unit and Public Address Amplifier provided in each car of the Train

- i) The Public Address Unit shall accept the audio signal from either the DVAU or the microphone and broadcast it to the saloon loudspeakers (except for passenger alarm talkback in which it shall only be transmitted to the selected loudspeaker).
- ii) The following performance shall be met:
 - a) Sound Pressure Level
 - b) The sound pressure level measured in all areas where the train driver or passengers can sit or stand in the driving cab or saloon at height between 1 meter and 2 meters above the floor level shall be $9\text{ dB} \pm 1\text{ dB}$ above the ambient noise measured at the same area and height range. This Sound Pressure Level parameter shall be able to be adjusted by means of the portable maintenance terminal.
 - c) Differential Sound Pressure Level
 - d) The Sound Pressure Level between maximum and minimum along the length of each saloon measured as in (b) above shall not be greater than 3 dB within each saloon.
 - e) Bandwidth: 50 Hz to 7 kHz (-3 dB)
 - f) Total Harmonic Distortion: less than 1% at 1 kHz at rated output.
 - g) Signal to noise ratio: greater than 60 dB.
 - h) Hum level: -80 dB at full rated output.
- iii) The PA system shall exhibit no oscillation, acoustical feedback or other instabilities at any combination of input level, gain or speaker volume control settings under all test and operational conditions.

17.8.5 Interface Description

Following interfaces shall be provided in 6-car train set with TCMS, DI & TNI and Train Radio:

- i) An interface with TCMS shall be provided to allow:
 - a) the transfer of system status, message displayed in the PIB display boards;
 - b) the receipt of ATO/ATP/UTO information;
 - c) the receipt of door open/close status;
 - d) the reporting of activated Emergency Intercom button as stipulated.
- ii) An interface with DI & TNI shall be provided to allow:

- a) the transfer of route, station and message information;
 - b) reception of message displayed in the DI&TNI display boards and DI&TNI system fault data.
 - iii) An interface shall be provided with Train Radio for radio broadcasting. A balanced audio output and a dry contact closure will be provided to the DVAU and PA system for broadcasting the PA message to the passengers by the Train Radio.
- 17.8.6 The Contractor shall submit functional descriptions and block diagram of the MCP and the associate communication component's **(CDRL 17-15)**
- 17.8.7 The Contractor shall submit for approval, during design review, detailed information on radio equipment interfaces, mounting, and wiring. **(CDRL 17-16)**

17.9 Passenger Information System

17.9.1 General

- i) The passenger information system (PIS) shall comprise of the below four sub-systems:
 - a) Passenger Information board (PIB),
 - b) Electronic Destination Indicator (DI) and Train Number Indicator (TNI),
 - c) Electronic External Side Destination Indicator,
 - d) Programmable Digital Route Map (DRM) - Dynamic.
- ii) Several PIBs per car shall be provided. The general arrangements of these displays shall be submitted.
- iii) For each driving cab, one DI & TNI shall be provided behind operator cabs' wind screen.
- iv) PIB and DI & TNI shall be capable of displaying the requisite information in Kannada, Hindi and English language.
- v) The Destination Indicator, External Side Destination Indicator and Train Number Indicator shall have pixel diameter of 3 mm and pixel per pitch shall not be greater than 4 mm. Alternative displays panel configurations may also be considered for better resolution. The Contractor shall submit the proposal for review of the Project Manager.
- vi) Size and location of Destination Indicator, External side Destination indicator and Train number indicator shall be optimized as much as possible with reference to mounting location. Details shall be submitted for review by the Project Manager. Location & size of all the displays shall be reviewed during mock-up review.
- vii) Full facilities including any hardware/software tools for programming the displays and system shall be supplied to the depots (one for each depot).. Employer's engineers shall be fully trained to programme, edit and interface the display panels with the system.

17.9.2 Passenger Information board (PIB):

- i) The Passenger Information Board (PIB) may be with split screen which include a high-resolution multi- colour graphic display suitable for the remote displaying of moving messages (i.e. destination station, present station, approaching station, time for reaching next station, real time clock, continuous advertisement, special and emergency messages) in multilingual (Kannada, Hindi and English), on board the train, in the passenger area. The colour of multilingual (Kannada, Hindi and English) character shall be approved by the Project Manager. Emergency announcements may be displayed in red. In case the train arrives at the platform then station display will be automatically resume on full screen. The storage capacity for video file should display video for minimum 30 sec between stations for the complete Line-6, Phase 2A and Phase 2B including stations.

Minimum 8 nos. of LCD with LED backlit programmable displays (approximate size 450mm or more) with adequate protection from vandalism shall be provided in each saloon interior (location shall be decided during mock-up review). Contractor shall submit different schemes of display of digital advertisement and passenger information to have continuous advertisement display without affecting the station announcement. Details of available size of displays shall be submitted for review by the Project Manager. These displays shall be used for messages/ advertisements (incl. video) etc. which shall be downloadable from one end of the car/unit and/or from the cab. The displays shall be commercially available and work on open/commercial protocols. The colour combination of the display content should be such that these may be distinguished by colour blind person. The Contractor shall submit the details for Project Manager's review during design phase. **(CDRL-17-17).**

- ii) The location and number of the display units shall be proposed by the Contractor taking into consideration the need for all-round good visibility by passengers within the saloon/platform both for advertisement and station announcement. The Contractor shall submit proposal, including diagrammatic representation of the angle of visibility of the display units.

iii) Mechanical Requirements:

- The panel shall be designed to flush mounted with the coving panels of the saloon interior after installation.
- The design of the panel enclosure shall be tamper resistant and shall not allow passenger to disassemble the unit from the front.
- All equipment of the panel shall be sealed to IEC 60529 IP41.
- The LED screens shall be protected against vandalism by passengers.
- The front shield shall be non-reflective, glare less and with light transmission of not less than 95%. The front shield shall not affect the colour quality of the display.

iv) Electrical Requirement of PIB:

- a) The PIB shall be equipped with a highly efficient and reliable internal power supply converter to supply power for control and displaying functions.

- b) The noise power level generated by the converter shall be limited below 30dB in the audible frequency ranged from 20Hz to 20kHz

17.9.3 Destination Indicator and Train Number Indicator:

- i) Destination Indicator and Train Number Indicator may be merged into a single display. The Contractor shall submit the details for Project Manager's review. **(CDRL-17-18)**
- ii) The method of mounting the DI&TNI indicator behind the windscreen in the driving cab shall allow easy installation and removal. All the cable connections to DI&TNI shall be of plug and socket type, and the female connector shall be mounted on the car body side. Removal and installation of one DI&TNI shall be easily by maintenance staff.
- iii) There shall be a Destination Indicator behind operator cabs' wind screen. The destination indicator shall be capable of displaying two lines of messages. The top line shall display Kannada characters of at least 90 mm height while the second line shall display English characters of at least 45mm height with yellow LEDs. Contractor shall submit the details for Project Manager's review. **(CDRL-17-19)**
- iv) There shall be a Train Number Indicator similar to the 'Destination Indicator' behind operator cabs' wind screen. The Train Number Indicator shall be capable of displaying up to 6-digit alpha-numeric train ID and destination station.
- v) The Destination Indicators and Train Identification Indicator shall be able to be set via the route setting control unit. The route setting control shall be either through the manual control on the TCMS or be automatically set by the Automatic Train Supervision (ATS) system.
- vi) The Train Number indicator and Destination Indicator shall have a view angle of not less than 120 degrees in the horizontal plane and shall be legible under direct sunlight, artificial light and darkness. Light sensors shall be equipped to vary the intensity of the LEDs based on the level of ambient light.

17.9.4 External Side Destination Indicator:

- i) There shall be an External Side Destination Indicator on each side of every car, at an appropriate location close to mid-point of the vehicle but beyond the sweep of the passenger saloon doors. The destination Indicator shall display the destination name to the passengers standing on the platform and it shall also display "Reserved for Lady Passengers" in case the coach is reserved for lady passengers. The details shall be submitted for Project Manager's review. **(CDRL-17-20)**. It shall be capable of displaying the requisite information in single line alternating between in Kannada, Hindi and English language. The device shall be flush mounted with the exterior of the car body. The display shall automatically change as per short loop operation as the case may be. The destination indicator shall be set either through the manual control on the TCMS or be automatically set by the Automatic Train Supervision (ATS) system.
- ii) The external displays shall have adequate brightness which shall have auto adjustment with the outside ambient light. The characters of External Side

Destination Indicator shall be legible from the station platform on either side of the train at a minimum distance of 5 m and at an angle of up to 45 degree, by a person with normal eyesight. The characters of External Side Destination shall be legible in direct sunlight when the train is running in open section, and in artificial light and darkness in underground section. Interface with designated PSD Contractor shall be ensured to finalize the location of external displays in order to get clear view of displays by Passengers on platform.

17.9.5 **Programmable Digital Route Maps (DRM):**

Programmable coloured LCD with LED backlit based route maps for the respective lines shall be provided above each saloon door, gangway ends etc. and shall have following provisions as minimum. Details shall be decided during design:

- a) Display of destination station, present station, approaching station, distance for reaching next stations, real time clock and door indications etc. Necessary interface shall be ensured by the Contractor.

Route-map of respective lines in different colours, point of inter-change or any other important information, flashing of emergency messages, important train messages, scrolling of routes, adding/ expunging of stations, selectable display of route.

- b) The size of the letter on LCD with LED backlit displays panel and resolution shall be programmable and have adequate clarity and visibility for a seating passenger. Further details shall be decided during design.
- c) Direction of movement of displays, positioning of destination station on DRM shall match with the geographical direction of destination station/train direction.
- d) The station names shall be displayed in multi-languages (Kannada, Hindi and English) alternatively.
- e) DRM display size has to be much longer to give comfortable view of the complete line(s) and additional information as already described above. DRM display shall fully use the available space in the door coving where the same shall be mounted.

Provision shall also be made to install equal number of LCD with LED backlit display in future by the Employer by simply connecting it to the system. Size and location of the provisional displays shall be decided during design.

Detail specification shall be drawn and screens shall be got approved during design. Additional changes if required shall be incorporated during design phase.

- f) Door indication on DRM shall be discussed during the design stage and is likely to be different on each DRM due to its mounting location. Details shall be submitted for review by the Project Manager.
- g) Routes map, arrows, lines etc. shall be dynamically updated based on the train location.

- 17.9.6 The Contractor shall submit for approval information on the design, specification and location of the interior and exterior displays at PDR. **(CDRL 17-21)**

17.10 Operation of Passenger Information and Automatic Announcement System

- 17.10.1 The system shall be capable of automatic operation throughout. At train set up, the train number provided by ATP/ATO/UTO (i.e. arriving bit, departure bit, door authorization etc.) shall automatically select the route to initialize the passenger information system by selecting the appropriate information from the train equipment and transmitting it to speakers and displays. The train operator shall be able to override the automatically supplied train number and when no automatic route selection is given shall be able to enter the train route
- 17.10.2 All arrival, departure, station announcement in ATP/ATO/UTO mode shall be automatic and shall be based on bits provided by "ATC". In case of delocalization or fault of front ATC, automatic announcement information from rear cab "ATC" will be shared to rear TCMS and rear TCMS will share data to front TCMS and information from front TCMS shall be shared to PA system for announcement. In other modes, station arrival/departure announcement shall be made through PA/PIS/ TCMS.
- 17.10.3 The system shall be capable of receiving real time information from the control center relating to delays and other relevant information. The system shall be capable of automatically updating the information being presented at the time to include the real time information received without the train operator's intervention.
- 17.10.4 Skip station operation and announcements at appropriate location and station shall also be available. Necessary interface with the signalling & train control contractor shall be ensured by the Rolling Stock Contractor to ensure correct announcement in case of skip station. Full details shall be submitted for review by the Project Manager. **(CDRL 17-22).**
- 17.10.5 **Manual System:**

- i) In addition to automatic operation, visual and audio information shall be capable of being originated from the train operator's cab. The system shall be capable of making pre-recorded announcements (both audio and visual) by manual triggering from main communications panel in the event that the ATO/ATP positional information is not available. Under such circumstances, messages shall operate automatically for the route from the TCMS information. Messages and announcements shall be triggered based on distance travelled and door operations. Manual override shall be provided to allow for station skipping. The train operator shall be able to override the automatic system and select message to be broadcasted randomly. All activation criteria shall be submitted for review by the Project Manager.
- ii) In case of system degradation, train operator shall be able to make manual announcements through microphone from the cab.

17.11 Interface with TCMS.

The PIS shall meet the following interface requirement with the TCMS

- i) To transmit and receive the required information from TCMS.
- ii) To display advertisements.
- iii) To display the real time, name of route and names of next and destination stations in the display terminal.

- iv) During the normal circumstances, the station code shall be updated according to the station information provided by the ATC system. In the event that the data transmission link between the ATC system and the TCMS fails, this fault shall be reported to the train driver and the TCMS shall automatically perform the update of the station codes according to the following sequential control logic:
 - a) the train speed is decreased to 0 km/h; and
 - b) the passenger doors of the train have been commanded to open and close once, then
 - c) the station code of the next station shall be updated and displayed in all display units according to the system routes specified.

17.11.1 The following control functions shall be provided to facilitate the train driver to control the PIS:

- i) remotely power on or off of the display boards of the PIS;
- ii) manually change the name of route and names of next and destination stations through the TCMS; and
- iii) Manually reset the PIS to the default state for re-initialization purpose.

17.11.2 Automatic Fault Diagnosis Test:

- i) The PIS shall be able to detect, at any time when the PIS is in operation, the relevant hardware and software fault. The faults shall be monitored by the TCMS.
- ii) The PIS shall be able to carry out a LED test when the LED test command is received from the TCMS.

17.12 Passenger Saloon Surveillance System (PSSS)

17.12.1 The Passenger Saloon Surveillance System (PSSS) includes the following:

- i) Network Video Recorder (NVR): Storage device that receives video via Ethernet backbone. Each DMC shall have one NVR.
- ii) Internet protocol (IP) based Cameras, 4 internal cameras per car, 4 external cameras each side of the train and 1 forward facing camera per driver cab.
- iii) Routers, PoE, cables, monitors and other accessories.

17.13 Network Video Recorder (NVR)

17.13.1 The Network Video Recorder (NVR) shall record the images from each camera in non-volatile memory with Solid State Drive (SSD). The NVR shall have recording capacity for at least 7 days to record all the on-board cameras. The NVR shall have at least 2 USB 3.0 port and should have the facility to save the selected video to the pen drive.

17.13.2 The NVR memory shall be expandable by simple plug in of commercially available memory media. The NVR should incorporate removable solid state drive (SSD), minimum 2 SSD per NVR, each SSD of minimum 1 TB. To provide protection for the solid state drives they should be mounted in modules / caddies. The design of the modules / caddies should allow them to be docked, undocked and secured to the NVR. Solid state drives that have been removed from the NVR should be playable in a different machine and not electronically tied to the original recorder. Consideration

should be given to the provision of spare modules / caddies so that any solid state drives can be replaced after an incident thus enabling the NVR to continue functioning.

- 17.13.3 The visual images from each camera shall be recorded in non-volatile SSD memory in a video recorder without any limitation of repetitive writing of the data. The capacity of the recorder shall be of at least 7 days and shall have the provision of First In First Out (FIFO). The memory shall be expandable by simple plug in of commercially available memory media. The records shall be easily downloadable. The Contractor shall provide equipment and means for the same. At least one set of such equipment shall be provided to each depot
- 17.13.4 Provision shall be made and tested to store relayed CCTV images to dedicated server at OCC and BCC in case of emergency or on demand. Storage device shall be of SSD type. CCTV server for this purpose shall be provided by the Signalling & Train Control Contractor. The radio communication used for CBTC/CCTV may be used for relaying the images as above. As a minimum, the images should be selectable for a time or time interval as required. Final scheme shall be worked out during design. The Contractor shall provide the on-board equipment and commission the system based on the communication link provided by the Employer.

Contractor shall submit the details for Project Manager's review. **(CDRL-17-23)**

- 17.13.5 It shall be possible to view the images of saloon interior through OCC. Contractor shall interface with the Signalling & Train Control contractor to finalize the interface during design phase.
- 17.13.6 The clocks of all NVR shall be synchronised with the clock of ATC/TCMS.
- 17.13.7 All recording shall have the vehicle's identity, associated camera unique identifier time and date information stamped and super imposed onto the video image. Facilities to recover any recordings using time, date and/or location request shall be implemented. The operator shall be able to retrieve, monitor and playback videos (including fast forward and rewind and frame by frame forward and reverse viewing) from the system based on time, date and/or location without affecting any of the recording functions. The Contractor shall provide equipment and means for the same. At least one set of such equipment shall be provided to each depot.
- 17.13.8 Routers shall be intelligent layer – 3 switch and shall transmit the required packet only to NVR and shall not malfunction in case of weak Signal, and in case if Power Over Ethernet (PoE) is used then the PoE shall have DHCP server port –based address allocation facility. The system shall be based on open environment / protocol like Ethernet for ensuring interchangeability of cameras. IP address of NVR, Camera and routers of one train shall not be changed from other train signals. The Contractor shall submit details of IP plan in interface with Telecommunication Contractor during implementation phase. **(CDRL-17-24).**
- 17.13.9 Redundancy shall be provided between NVR's. all recorded images shall be stored in two separate cars on a set to provide redundancy of storage in the event of equipment failure and incidents

17.14 Internal Cameras

- 17.14.1 Each car shall be provided with at least four surveillance IP based camera devices at appropriate location to cover the maximum passenger saloon area for surveillance. The wiring and end connector to mount camera in cab(s) and mounting arrangement complete in all respect, but masked, shall be provided. Employer's Engineers shall be trained for interfacing and commission the same.

The design of camera shall be finalized during design stage. Mounting of camera shall be unobtrusive, flushed with, or recessed into the interior panel. The system shall be based on open environment/protocol like Ethernet for ensuring interchangeability of cameras. Camera cover support structure (inside of train) shall match aesthetically to the interior of the car.

- 17.14.2 The system shall have self-diagnostics and communicate the same suitably to the NVR and TCMS. The system should switch ON when the driving cab is energised and remain active during operation. The Video Surveillance System (CCTV) power supplies should be compatible with the railway vehicles' power supplies and transient conditions. These should be derived from the rail vehicle's emergency power supplies. The CCTV system should also incorporate a circuit breaker to protect the power supply.

- 17.14.3 CCTV shall be designed for minimum 25 fps with dual stream capability such that the viewing & recording at different resolutions & frames per second are possible in MPEG4 or better standard. The minimum angle of view shall not be less than 80° (horizontal) & 50° (vertical). The picture quality will be level E as minimum at 100% Rotakin measured according to EN50132-7. The CCTV shall compliance to EN50155, EN61373 and IP 65. The communication of CCTV shall compliance to IEEE 802.3af and it should have following supported protocols Telnet, FTP, TCP/IP, UDP/IP (Unicast, Multicast IGMP), IPv4/v6, SNMP, SNT, RSTP, ONVIF etc.

- 17.14.4 All CCTV camera shall be colour CCD/CMOS, IP based full HD (at least 1080p) type with low light capability to produce clear and detailed picture quality as well as under high lighting contrast conditions. CCTV camera shall have wide dynamic range (WDR) for excellent image quality in different lighting condition. The camera shall be capable to provide different streams/resolutions/bitrate/ fps etc. (as decided during the design) to CCTV HMI/VDU, In-built storage, Network Video Storage (NVR), OCC, BCC, Servers etc. The Rolling stock contractor shall also choose the lens size appropriately depending upon the desired coverage/ field of view / target.

- 17.14.5 In case of activation of Passenger Emergency Alarm (PEA) in any of the cars, the views from camera provided near the location of activated PEA shall be displayed in the monitors. However, the train operator/OCC shall be able to select any other camera, as required. The images shall be with time stamping and it shall be possible to link them with respective location of train. Similarly, in case of door obstruction / obstacle the camera(s) shall focus on door way and alert the train operator by flashing the image.

Provision of handling multiple emergency calls (on one train and different trains) shall also be provided.

- 17.14.6 In case of certain events like Fire & Smoke, opening of driver console desk, Obstacle detected by saloon door or by obstruction deflection device etc. the camera(s) shall

focus and alert the train operator/OCC by automatically flashing the image. Contractor shall submit the details for Project Manager's review. **(CDRL-17-25).**

17.15 External cameras

- 17.15.1 The Rear-View Video Monitoring System (RVVMS) – Four cameras shall be installed on the exterior of each side of the train as minimum for gathering rear view of the platform and shall ensure clear view of passengers on platform, provide visual assurance to the driver that the coach passenger side doors are clear for departure before start at each station till train leaves the platform completely. The system shall automatically switch to rear view when the train stops and will go back to default mode after the train leaves the platform. Train operator shall have full flexibility in selection of cameras as per his/her need. Interface with designated contractor for PSD shall be ensured to finalize the location of outside camera in order to get clear view of passenger on platform to train operator. Camera cover support structure (outside of train) shall match aesthetically to the exterior of the car.
- 17.15.2 The cameras shall be displayed on the CCTV HMI in an automatic sequence stepping through the cameras on the platform side along the complete train. The time each camera shall be displayed on the CCTV HMI shall be adjustable as a system parameter, default 2 seconds. it shall be possible to manually select a camera to be displayed on the CCTV monitor. The CCTV HMI shall display which car and camera is selected.
- 17.15.3 It shall be the responsibility of the Contractor to interface with the designated Telecom contractor, Signalling & Train Control contractor to get the station stop information, including platform side, station approach event and leaving station event. During station stop time it shall be possible to view the RVVMS camera images streams live on the CCTV HMI in the cabs. The images from the RVVMS cameras shall only be made available on the CCTV HMI during station stop. The frame rate and resolution of streams shall as a maximum be equal to the highest recording frame rate and resolution. The RVVMS camera video stream shall be available from NVR and not demand any further processing by the CCTV HMI or Train Operator.
- 17.15.4 Forward Facing Closed Circuit Television (FFCCTV) – One Camera shall be positioned forward facing and behind the windscreen or externally in an enclosure in each vehicle cab. The FFCCTV camera and lens assembly should be orientated to record landscape views. As a minimum, the camera and the lens assembly should be capable of recording images that include the viewing envelope for the seated driver (i.e. the track; third rail; wayside signals & equipment's;) Detail shall be finalised during design phase.
- 17.15.5 The FFCCTV camera system should have two modes of operation, colour (day) mode and black / white (night) mode. The colour (day) mode should be capable of operating over the light range of 1 Lux to 10,000 Lux. The black / white (night) mode light range should extend into the colour mode light range and operate down to 0.05 Lux. The FFCCTV camera system should automatically switch between day and night modes of operation and also occur during entry and exit of tunnels. The FFCCTV camera system should be fitted with a lens that has an automatic gain control or electronic iris with a fast dynamic response to deal with rapid changes between sunlight and dark conditions.

- 17.15.6 The IP camera should get the same IP address automatically whenever the camera is replaced/malfunction or the CCTV system is restarted and all the other functions required for change of IP address of camera, NVR shall be performed through TCMS. Also resetting function of NVR and camera shall be performed through TCMS. CCTV supplier shall interface with TCMS supplier for the provision of control and monitoring function of CCTV through TCMS. Detail shall be finalised during design phase.
- 17.15.7 Additional camera(s) for gathering front end view, track, ODD (Obstruction Deflection Device) conditions and detrainment process view camera shall be provided by the Contractor. Suitable high sensitive camera(s) capable to record at low light shall be ensured. Full details shall be submitted for review by the Project Manager. Selection and type/number of camera shall be finalized during design stage
- 17.15.8 The Rolling Stock contractor shall interface with Telecom contractor for IP address for each camera. In case of camera replacement, IP address shall remain the same.
- 17.15.9 Outside camera shall comply to IK09 level of EN 62262 standard with scratch resistant glass and its enclosure material shall be better grade to avoid any corrosion effect. Suitable dust & water/moisture protection (at least IP 68) shall also be ensured by the Contractor.
- 17.15.10 Details of storage module used for PA/PIS & PSSS and its capacity, limitation (if any) shall be submitted for review by the Project Manager. Storage module/USB version used shall be of latest version & State of the art of technology.
- 17.15.11 ~~Automatic Track Monitoring System using high resolution Digital Line Scan Camera shall be installed in two trains (4 Cameras, 2 in each train) of Line-6 and 4 trains (8 Cameras, 2 in each train) of Silk Board – Kempegowda International Airport corridor i.e. 12 Cameras in total. The proposed track monitoring system shall be proven for similar metro rail applications. Track monitoring system shall detect track conditions such as rail fractures, running edge defects, rail head surface defects, corrosion, missing fasteners etc. in real time using artificial intelligence up to 90 kmph of train speed. An on-board module shall be provided in the train to analyse and process the images/video stream received from the Digital Line Scan Camera and detect defects in the track. Critical defects along with exact location of the defects shall be communicated to OCC in real time through the CCTV network to be supplied by Signalling and Train Control Contractor. The list of critical defects to be communicated to OCC shall be finalized during design phase. Necessary interface shall be ensured between the Rolling Stock, Signaling & Train Control and Track monitoring system contractor to achieve the required functionality. The Rolling Stock Contractor shall supply, install and commission the track monitoring system at the time of delivery of two trains nominated by the Project Manager. The Automatic Track Monitoring system shall be compliant to IEC 62290 and IEC 62267. Contractor shall submit the details for Project Manager's review at design stage (CDRL-17-26).~~

Addendum-1 dated 05.12.2022, Sl. No. 155

Automatic Track Monitoring System using high resolution Digital Line Scan Camera shall be installed in two trains (4 Cameras, 2 in each train) of **Reach-6** and 4 trains

(8 Cameras, 2 in each train) of **Phase 2A & 2B** (Silk Board – Kempegowda International Airport corridor) i.e. 12 Cameras in total. The proposed track monitoring system shall be proven for similar metro rail applications. Track monitoring system shall detect track conditions such as rail fractures, running edge defects, rail head surface defects, corrosion, missing fasteners etc. in real time using artificial intelligence up to 90 kmph of train speed. An on-board module shall be provided in the train to analyse and process the images/video stream received from the Digital Line Scan Camera and detect defects in the track. Critical defects along with exact location of the defects **with image** shall be communicated to OCC in real time through the CCTV network to be supplied by Signalling and Train Control Contractor. The list of critical defects to be communicated to OCC shall be finalized during design phase. Necessary interface shall be ensured between the Rolling Stock, Signaling & Train Control and Track monitoring system contractor to achieve the required functionality. The Rolling Stock Contractor shall supply, install and commission the track monitoring system at the time of delivery of trains nominated by the Project Manager. The Automatic Track Monitoring system shall be compliant to IEC 62290 and IEC 62267. Contractor shall submit the details for Project Manager's review at design stage (CDRL-17-26).

- 17.15.12 Hot axle box detection system for monitoring of axle box temperature shall be provided by Rolling Stock Contractor. On-board temperature sensors for detecting axle box temperature shall be provided and installed on all axle boxes of 318 cars. The wayside equipment for gathering and processing the data from on-board sensors shall be provided in 3 stations of each line (Line-6 and Silk Board – Kempegowda International Airport corridor) i.e. 6 stations in total on both UP and DOWN track separately. Two data base servers with workstations (one in each OCC), required software and communication network from way side equipment up to station Telecom Equipment Room (TER) shall be provided by Rolling Stock Contractor. The Telecom Contractor shall provide Ethernet/Fibre Optic channel from station TER (Telecom Equipment Room) to CER (Central Equipment Room) of OCC. Data processing, interface equipment on both ends i.e. at wayside station and OCC shall be the responsibility of Rolling Stock Contractor. The Hot Axle Box Detection system shall compliant to EN-50212-3-2.

17.16 CCTV Touch Monitor (HMI)

A dedicated CCTV HMI shall be provided on the driving console. However, the TCMS VDU shall act as a backup for the CCTV HMI and shall have provision to show simultaneous multiple views of CCTV/TCMS/PA/PIS. CCTV images can be display on the TCMS VDU on demand or event generated. The TCMS VDU shall have provision of displaying multiple screens as per the requirements. The Contractor shall submit the details for Project Manager's review. **(CDRL-17-27)**

17.17 Software & hardware tools

Contractor shall provide adequate tools (two sets, one set for each depot) and also impart training to Employer's Engineers for modifying/adding etc. the station names as well as audio visual announcements without changing the complete software and hardware.

17.18 Interface.

- 17.18.1 Appropriate interfacing with TCMS shall be developed to carry out the above mentioned functionality. The interface shall include provision of single point downloading the data logs stored in the memory of all train-based Communication Equipment using TCMS interface.
- 17.18.2 Wi-Fi internet facility in train shall be installed by Designated Contractor. Rolling Stock Contractor shall install CAT 7 standard communication cable or latest standard cable. Complete cabling to access points, router, Gateways and internet antennae etc. shall be carried out by Rolling Stock Contractor. Provisioning of space and power plug point arrangements for accommodating Wi-Fi access points, routers, gateways and antennae etc. shall be made by Rolling Stock contractor in such a way that maximum coverage is achieved when train is carrying the passengers to its full capacity. Provision of dynamic bandwidth and its optimization for different uses shall be ensured suitably. Details shall be submitted for Project Manager' review during design phase. **(CDRL-17-28)**

17.19 Deliverables

Contract deliverables required by this section of the Technical Provisions are summarized below: -

CDRL-17-1:	Details of necessary set-up including Software, Hardware, Equipment etc. to realise the change/modification (ref. ERTS 17.1.1 (xi))
CDRL-17-2:	Adequate redundancy of PA/PIS and PSSS system (ref. ERTS 17.1.1 (xiv))
CDRL-17-3:	Provenness of PA/PIS & PSSS system and single point upload/download of PAPIS/PSSS software (ref. ERTS 17.1.1 (xv))
CDRL-17-4:	Provision of self-checking & its result for all PA/PIS & PSSS equipment (ref. ERTS 17.1.1 (xix))
CDRL-17-5:	Vehicle health data communication from TCMS to OCC (ref. ERTS 17.2 (ii))
CDRL-17-6:	Announcement in the train along with the provision for communication with OCC by Roving Attendant through train radio (ref. ERTS 17.2.3)
CDRL-17-7:	Positioning and output of Loudspeakers (ref. ERTS 17.3.18)
CDRL-17-8:	The Contractor shall submit for approval an audibility analysis for the PA system, including the location of each speaker in the car. (ref. ERTS 17.3.21)
CDRL-17-9:	Details for functionality failure data logging monitoring in DVAS system (ref. ERTS 17.5.1 (i))
CDRL-17-10:	Pre-determined messages shall be automatically triggered by train events and / or the ATC system to make an announcement (ref. ERTS 17.5.1 (iii))
CDRL-17-11:	Detailed proposal to provide commercial/ general audio and/or visual messages. (ref. ERTS 17.5.1 (viii))
CDRL-17-12:	Passenger Emergency Alarm operation (ref. ERTS 17.7.2)
CDRL-17-13:	Passenger Emergency Alarm operation (ref. ERTS 17.7.7)
CDRL-17-14:	Speaker/mic panel provided for PEA shall be flushed with car body wall to have good aesthetic (ref. ERTS 17.7.9)

CDRL-17-15:	Functional descriptions and block diagram of the MCP and the associate communication component's (ref. ERTS 17.8.6)
CDRL-17-16:	Detailed information on radio equipment interfaces, mounting, wiring and power requirements. (ref. ERTS 17.8.7)
CDRL-17-17:	Passenger Information board (PIB) (ref. ERTS 17.9.2 (i))
CDRL-17-18:	Details for display of Destination Indicator and Train Number Indicator (ref. ERTS 17.9.3 (i))
CDRL-17-19:	Details for Destination Indicator behind operator cabs' wind screen (ref. ERTS 17.9.3 (iii))
CDRL-17-20:	External Side Destination Indicator (ref. ERTS 17.9.4 (i))
CDRL-17-21:	Design and location of the interior and exterior displays. (ref. ERTS 17.9.6)
CDRL-17-22:	Skip station operation and announcements (ref. ERTS 17.10.4)
CDRL-17-23:	Transfer of CCTV images to the dedicated server. (ref. ERTS 17.13.4)
CDRL-17-24:	Details of IP plan in interface with Telecommunication Contractor during implementation phase (ref. ERTS 17.13.8)
CDRL-17-25:	Internal cameras (ref. ERTS 17.14.6)
CDRL-17-26:	Details of Track Monitoring system (ref. ERTS 17.15.11)
CDRL-17-27:	Functionality details of CCTV touch monitor (HMI) (ref. ERTS 17.16)
CDRL-17-28:	Wi-Fi internet facility in train (ref. ERTS 17.18.2)

18 MATERIAL AND WORKMANSHIP**18.1 General**

- 18.1.1 This chapter covers constructional details and workmanship requirements for the train system.
- 18.1.2 The standards and practices detailed shall be observed as the minimum standards.
- 18.1.3 The Contractor shall adopt the up-to-date best practice and workmanship to execute the Works to specified standard.
- 18.1.4 The Contractor shall take the prior approval of Project Manager / Employer for Makes and manufacturers in respect of various equipments, components, materials etc. proposed to be used in the manufacturing of car, during preliminary / pre-final design stage.

18.2 Standards/Reference

- 18.2.1 Equipment shall comply with the relevant International Electro-Technical Commission Recommendations (IEC) and cited national standards.
- 18.2.2 Reference to any standard implies reference to the latest issue as of date of Award of Contract.
- 18.2.3 Electrical Equipment shall comply with either IEC 60349 or with IEC 60077 1 and 2 as appropriate. Where Approved by the Project Manager, ac machines may comply with IEC 60034 or IEC 60349.
- 18.2.4 Complete vehicles shall comply with International Electro-Technical Recommendation IEC 61133.
- 18.2.5 The offer of equipment to alternative standards will be considered prior to Vehicle Design Meeting but shall be accompanied by copies of the proposed alternative specifications, in English, and the Project Manager will advise whether such alternative(s) can be applied in whole or in part.

18.3 Definitions

- 18.3.1 The following definitions shall apply:
 - Heavy Current: Currents in excess of 30A.
 - Light Current: Currents of 30A or less.
 - High Voltage (HV): In excess of 300V, to earth.
 - Low Voltage (LV): 300V or less, to earth.
 - Auxiliary Contact: A contact in a low voltage circuit.
 - Power Contact: A contact which is not covered by the definition of auxiliary contact.
 - Enclosure: A closed space in which equipment is mounted.
 - Contact Enclosure: A small enclosure in which auxiliary contacts only are mounted.
 - Terminal: A fixed point to which a conductor can be attached to from a connection.
 - Termination: A device fixed to a cable or other conductor to enable it to be attached to a terminal.

18.4 General Requirements

- 18.4.1 All equipment shall be constructed in a sufficiently robust manner, and arranged so as not to suffer deterioration, apart from functional wear or damage due to vibration or shock loads encountered in traction service.
- 18.4.2 Equipment shall be arranged into groups where practicable, the items of any one group being mounted on a common frame or the equivalent, complete with such as wiring and piping.
- 18.4.3 All equipment shall be protected against damage such as those caused by dirt, dust and moisture etc. including during transportation.
- 18.4.4 The use of asbestos, lead based pigment paints, lead, urethane foam, polystyrene and viton rubber shall not be allowed.
- 18.4.5 Welding, painting and crimping are considered as special processes. Contractor shall ensure process qualification and validation for these processes and records of the same shall be maintained for scrutiny and review by the Project Manager.
- 18.4.6 All relays/MCBs/equipment etc. shall be suitably de-rated for specified temperatures including the proximity effect.

18.5 Corrosion Protection

- 18.5.1 The Contractor shall address corrosion protection in the design review process and intergraded into the maintenance manual. Also, Contractor shall submit a corrosion protection plan during the design phase for the review of Project Manager. **[CDRL-18-1]**
- 18.5.2 Contractor shall take into consideration that all equipment shall be operated under a prevailing tropical weather and corrosive ambient conditions.
- 18.5.3 The Contractor shall take adequate precautions at each stage of processing of stainless steel materials to avoid contamination from harmful materials which can affect corrosion and/or rust resistance properties. Precautions shall also be taken to avoid deep rolling marks, which can potentially affect corrosion resistance properties or enhance stress
- 18.5.4 Closed or inaccessible areas made of materials suspect to corrosion, shall be internally covered with an adequate corrosion protection coating immediately after completion of fabrication.
- 18.5.5 All corrosion protection measures shall be permanent without contamination and follow recognized standard.

18.6 Equipment and components mounted on car body and bogies

- 18.6.1 Fixing for mounted on car body shall be adequately locked to prevent loosening in service. Under frame equipment mountings shall be able to withstand, without deformation, equipment accelerations of 60m/sec^2 in the longitudinal horizontal direction 30m/sec^2 in the vertical direction and 20m/sec^2 in the transverse horizontal direction or according to the requirement of EN 12663 or IEC 61373.
- 18.6.2 Items and equipment on the Bogie and axle box including their mountings shall be designed to withstand the forces associated with the acceleration according to IEC 61373.

18.7 Interchangeability

- 18.7.1 The Contractor shall minimize the number of different equipment models on the train. As far as practicable, the same model of equipment shall be used to fulfil similar functions at different applications. For example, the same relay model may be employed to fulfil similar switching functions in different circuits.
- 18.7.2 Equipment items or components of the exactly same model shall be readily interchangeable. They shall be designed and manufactured so that no additional fitting, machining, adjustment or modification, other than those Approved by the Project Manager, would be necessary during replacement.
- 18.7.3 This is particularly important, such as in the case of covers, bearing caps, equipment mountings and door leaves, cameras, amplifiers, speakers, door outside lamp and door inside lamp etc. which will be replaced or interchanged frequently among different locations after maintenance work. At the request of the Project Manager, the Contractor shall provide demonstration on any specified equipment to shown that such requirement is satisfied.
- 18.7.4 In cases where the same mounting arrangement, such as an electrical plug or pneumatic valve, is provided on different equipment which are not interchangeable, the Contractor shall design the mountings so that the equipment will not be mixed up during installation.
- 18.7.5 This shall be achieved by providing suitable identification devices such as colour-coding or special markings. If the Project Manager consider such devices inadequate, the Contractor shall provide a non-interchangeable design to make wrong installation impossible.
- 18.7.6 The requirement above shall also apply to cases where it is possible to install or assemble an equipment item in a number of different orientations, such as mating halves of housing, non-symmetrical cams on a shaft.

18.8 Bolted Joints and Fasteners

- 18.8.1 All fasteners shall be in ISO Metric size. The applied standards shall be in accordance with this document.
- 18.8.2 Due considerations shall be given in the design stage to the tolerance of components to ensure inter changeability of components.
- 18.8.3 For fixings connections, which will be dismantled for maintenance, the following methods shall be used:
- i) Structural bolted connection shall use documented torque tightening procedures. Hexagon head bolts and nuts of a grade compliant with strength requirements shall be used. Where secondary locking is required, which include all structural bolted joints and bolted joints subjected to high levels of vibration, prevailing torque nuts to BS 4929 or a comparable DIN or EN standard shall be used.
 - ii) Setscrews (Grade 8.8) and stud connections (Grade 8.8) studs with grade 8 prevailing torque nuts shall only be used where it is not practicable to make a bolted connection. The use and the proposed method of locking shall be mutually agreed.
- 18.8.4 Washers shall be used where the nut is tightened onto a soft surface.

- 18.8.5 Mating surfaces shall be machined flat if applicable and shall be clean and free from paint, primer or rust.
- 18.8.6 Suitable precautions shall be taken to prevent corrosion in joints involving dissimilar metals.
- 18.8.7 Tapped holes in aluminium shall, in all cases, be provided with suitable thread inserts. Items of proprietary equipment, which are normally supplied without, wire thread inserts may be exempted from this requirement.
- 18.8.8 Where tab washers are proposed the material chosen shall be sufficiently hard to prevent settlement of the joint and consequent loss of bolt preload. Mild steel tab washers shall not be used.
- 18.8.9 The Contractors torque tightening procedure shall include provision for marking torque-tightened fasteners with coloured paint to indicate that the torque tightening procedure has been correctly carried out.
- 18.8.10 Screws, bolts, nuts and plain washers shall be suitably treated by an Approved method to avoid corrosion. Screws, bolts, nuts and plain washers shall be suitably treated by an Approved method to avoid corrosion and Contractor shall consider priority to adopt stainless steel. Proprietary makes of high tensile or other types of screw may be used unprotected provided the Project Manager is satisfied that a standard screw is not suitable and that corrosion will not be a problem, and provided that the above specified screw thread requirements are adhered to.
- 18.8.11 In all other areas the favoured method shall be by means of the use of an Approved form of single turn spring washer.
- 18.8.12 The use of nuts with nylon inserts or similar self locking nuts which can be removed and replaced for a limited number of occasions is not favoured where frequent use is required and shall not be used for electrical connections. Whatever method of locking is employed the number of loose items shall be kept to a minimum.
- 18.8.13 Whenever possible, tapped holes shall be drilled and tapped for the full thickness of the material. Blind holes shall be used only where unavoidable and must be Approved by the Project Manager.
- 18.8.14 Tapped holes shall be provided with suitable thread inserts where necessary, and in all cases in aluminium or copper except as Approved by the Project Manager. The use of loose nuts and bolts will only be Approved where it is possible to reach easily both parts of the fixing simultaneously.
- 18.8.15 Fixings for covers which may have to be removed for maintenance shall be captive and, where visible to the public, shall be of stainless steel (preferred) or chromium plated. Items of electrical equipment shall be fitted to panels so that all fixings can be made from the front only, except where specially Approved.
- 18.8.16 Exposed heads of rivets shall be free from rings, fins, pits or burrs.
- 18.8.17 The use of blind rivets shall be mutually agreed to.
- 18.8.18 Holes shall be accurately located and aligned and, where necessary, reamed round to specified size and position. They shall be drilled where necessary due to functional requirements, and of minimum size necessary. Rounding out of holes is not acceptable other than as above.

- 18.8.19 Rivet holes for metal fabrication shall be de-burred before assembly.
- 18.8.20 Hand driven steel rivets shall be driven hot and shall completely fill the hole. Cold rivets shall only be used where structural strength is not required. They shall be driven using mechanical equipment.
- 18.8.21 Normally, screw threads smaller than M5 size shall not be used. Screw and bolt heads shall be of hexagonal form on all M5 and larger screws. Screws smaller than M10 shall be of high tensile material.
- 18.8.22 All steel fasteners used in electrical equipment and/or exterior applications shall be of stainless steel, hot dip galvanised or cadmium plated.
- i) Jointing on members requiring structural strength shall be carried out with aluminium alloy rivets, cold squeezed or by stainless steel fasteners suitably protected against corrosion.
 - ii) Aluminium shall be riveted to stainless steel by stainless steel rivets or by Approved fasteners.
- 18.8.23 Corrosion Protection of Metals Other than Stainless Steel:
- i) Contacting surfaces of dissimilar metals assembled by means other than welding shall be treated with an appropriate anti-corrosion agent, if corrosion is not prevented by other method of protection surface treatment of the material, before assembly (e.g. anodizing or similar method).
 - ii) When jointing aluminium or its alloys to other metals, mating surfaces shall be treated with zinc chromate anti-corrosion agent, or an Approved equivalent, before riveting if corrosion is not prevented by surface treatment of the materials, (e.g. anodizing). Rivets shall be driven wet if applicable.

18.9 Welding

18.9.1 General:

- i) Welding, unless specified or approved otherwise, shall conform to EN, DIN, or European Railway Authorities Standards applicable for Rolling Stock manufacturing.
- ii) Welding rod, wire, or filler material shall be chosen with respect to size, type, manufacture, composition, and suitability to the application.
- iii) The edges and surfaces of all materials to be joined by welding shall be thoroughly prepared as required by flame cutting, grinding, machining, chipping, or other recognized means. When materials are to be welded, they shall be clean and completely free of coatings such as dust, oil, grease, oxide, mill scale, corrosion products, and all other substances likely to affect the welding process or ultimate weld strength or finish.
- iv) Where welding defects such as undercutting, porosity, incomplete penetration, lack of fusion, slag inclusion, or others not permitted according to the agreed standard occur, the Project Manager reserves the right to reject or request either non-destructive or destructive inspection and testing to be carried out by the Contractor. In such cases, the Contractor shall be responsible for all costs, both

labour and materials, involved in the testing and replacement requested by the Project Manager.

- v) All welding work shall be under the control of a suitably qualified welding engineer nominated by the Contractor as his representative.
- vi) All welding equipment shall conform to relevant national or international standards.
- vii) Permanent backing strips shall not be used unless otherwise Approved.
- viii) Welding of stainless or high tensile steels, of aluminium or its alloys, or of components carrying structural stresses, as may be Approved.
- ix) Complete and adequate fusion with the base material shall be obtained, without loss of structural thickness (undercutting); testing shall be done in accordance with DIN 6700. The Project Manager may demand radiographic examination of critical areas to verify this point.
- x) Arc Welding: Such welds shall be made by an Approved gas shielded arc method.
- xi) Spot Welding: Spot welding of components carrying structural stresses shall be performed using equipment fitted with time, current, and pressure control.
- xii) Hand Welding: Where hand welding of components carrying structural stresses is mutually agreed to, the Project Manager reserves the right to inspect the qualifications of the welders and the welding procedures involved. Use of hand welding of such components will only be Approved where the Project Manager is satisfied that alternatives are impracticable or mutually agreed to.

18.9.2 Standards:

- i) Welding of carbon and carbon/manganese steel shall be to the requirements of EN 1011-1, EN 1011-2, or European Railway Authorities Standards applicable for Rolling Stock manufacturing.
- ii) Welding of aluminium and aluminium alloys shall be to the requirements of EN, 1011-4 or European Railway Authorities Standards applicable for Rolling Stock manufacturing.

18.9.3 Materials:

- i) All materials used for carbody structure and safety or functional critical items shall be clearly identified and shall have certificates of chemical composition and mechanical properties, which shall be held by the Contractor.
- ii) Materials shall be free from laminations and lamellar defects.
- iii) Fusion faces in the areas to be welded shall be prepared according the relevant welding standards and shall be free from paint, rust and other contaminants. Any solvents used to achieve this shall be thoroughly dried off prior to welding.

18.9.4 Critical Welds:

All welds which fall into any of the categories defined (i), (ii), and (iii), below, shall be designated as Critical Welds:

- i) Welded joints from which failure would represent a risk to safety of the car.

- ii) ~~Welded joints which are designed with a Miner's Summation, evaluated in accordance with 'Miners Rule' (BS 7608 or BS 8118) and the relevant fatigue load cases from the car Particular Specification, greater than 0.7 or in accordance with the agreed welding standard.~~

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Welded joints which are designed with a Miner's Summation, evaluated in accordance with 'Miners Rule' (BS 7608 or BS 8118) and the relevant fatigue load cases from the car Particular Specification, greater than 0.7 or in accordance with the agreed welding standard. **Alternatively, Contractor may propose assessment of Critical welds based on FKM guideline strength assessment.**

- iii) Welds in load bearing members subject to a stress level exceeding a figure to be agreed to. Which are not readily accessible for inspection during maintenance or overhaul.

18.9.5 Critical Welds shall be clearly identified on manufacturing drawings.

18.9.6 Welding Procedures:

- i) All welding shall be carried out in accordance with documented welding procedures. If there will be a new welding procedure developed, the suitability of the welding procedure shall be established by testing of test specimens in accordance with either AWS / EN288-3 standards or other equivalent standard. Following satisfactory completion of testing the procedure shall be mutually agreed to.
- ii) Welding consumable shall be such that the mechanical properties of the completed joint shall not be less than those specified for the parent materials.
- iii) The requirements shall apply to procedures for rectification of defects in welds.

18.9.7 Welder Approvals:

- i) All welders shall be Approved in accordance with the relevant parts of either DIN 6700 (1 to 6) or EN 287-1, EN 287-2 and EN 288-9. Destructive testing of the test pieces is required.
- ii) The Contractor shall maintain records of welder Approvals, together with full supporting evidence. This information shall be made available on request.

18.9.8 Approval Testing and Witnessing:

- i) Witnessing of weld procedure, testing of welds and Approval of the results shall be carried out by a nationally or internationally qualified welding engineer independent of the Contractor and subject to Approval.
- ii) An independent nationally accredited test house shall carry out all testing associated with welding procedure and welder tests following the agreed standard.

18.9.9 Non-Destructive Testing (NDT):

- i) Visual inspection of all welded joints before, during and after welding, together with any additional examinations required by the welding procedures, shall be carried out.

- ii) The Contractors NDT program and procedures shall be subject to Approval before the commencement of any testing.
- iii) NDT procedure writers and NDT operators shall hold an appropriate valid certificate of competency from a recognized national or international organization, which shall be subject to Approval.
- iv) Detailed procedures, which shall include definitive acceptance standards, for all NDT examinations shall be prepared in accordance with the requirements of the agreed standard.
- v) Procedures for the examination of welds in steel shall conform to EN, DIN, or European Railway Authorities Standards applicable for Rolling Stock manufacturing or relevant AWS Standards.

18.10 Labels and Rating Plates

- 18.10.1 Items of apparatus shall be labelled with the maker's name and the type and/or form of the piece of apparatus or numbering to allow identification.
- 18.10.2 The position in which apparatus is nearly mounted and the apparatus itself shall be labelled clearly with the circuit designation. Such labels shall be clear and easy to be read and securely fixed adjacent to the mounting position.
- 18.10.3 Covers, arc-chutes, and similar removable interchangeable items shall not be labelled.
- 18.10.4 All enclosures containing equipment where voltage to earth exceeds 200V shall be clearly marked.
- 18.10.5 All labels fitted to the exterior of equipment cases, and all warning labels shall be consistent in content.
- 18.10.6 In addition, a connection diagram shall be provided inside or adjacent to the terminal box, where provided. Unidirectional rotating machines shall carry an arrow showing the correct direction of rotation and, in the case of axial fans, of the air flow.
- 18.10.7 Labels, rating plates, and the arrows required for fans shall be mounted in such a position that they can be seen from the usual point of access. The labels shall be clearly stamped, cast, or engraved and securely attached to the machine.
- 18.10.8 The Project Manager may require certain equipment other than machines to carry serial numbers and information on rating.
- 18.10.9 All labels shall be in English the maker's name and the type and form of the piece or item, discrete serial number and rating data, and the date of manufacture of the particular piece of equipment. It is desirable that the labels used for different equipments/ sub-systems / systems on the train are of a standard pattern.
- 18.10.10 All cables and busbars shall be provided with durable and legible cable identification markers at each end, corresponding exactly with those on circuit diagrams.
- 18.10.11 The labels shall be clearly stamped, cast or engraved and securely attached to the equipment. Where appropriate, equipment shall be labelled with warnings of high temperature and electric shock risk. Warning labels shall be written in both Kannada and English to be confirmed during design stage.

18.10.12 Warning Signs. Where any hazardous situation could arise due to voltage level, air pressure, maladjustment, disoperation, etc., then prominent warning labels shall be provided to denote this. Warning label shall be written in both Kannada and English to be confirmed during design stage.

18.10.13 Assistance of Kannada translation from the Project Manager will be provided upon.

18.10.14 Submission: The Contractor shall submit the design of equipment identification labels during design stage.

18.11 Mountings and Enclosures

18.11.1 General:

All inside mounted equipment shall be arranged in self-contained groups and enclosed to protect them from the effects of dirt, dust and moisture. Unless otherwise specified, all equipment mounted in the saloon area shall be sealed to IEC 60529 IP54 and all equipment mounted in the external area, such as under frame and roof, shall be sealed to IEC 60529 IP65 and shall pass the specified water tightness test

18.11.2 Ventilation of Enclosures:

- i) Air inlets, outlets and vents shall be fitted with louvers or otherwise designed so that ingress of rain or rubbish is prevented, irrespective of whether the car is moving or stationary and independent of the wind direction. In the case of forced ventilation, the filter (if provided) or a suitable settling chamber may be relied on to remove any rain which passes the louvers provided that the complete system meets the requirement of efficient filtration. Any louver or guard intended to prevent the ingress of rubbish should not reduce the enclosure ventilation to a critical extent with guard or louver 75% blanked off. The battery enclosures shall be prevented from the accumulation of explosive gases during charging.
- ii) The term filter, in the context of this Clause, covers any device to remove dust, dirt, and rain drops from the air. Where filters are proposed, they shall be of the dry type and shall not require cleaning more frequently than at 12 monthly intervals. Such cleaning shall be by knocking or blowing off the dirt. If washing of the filters is required, this shall not be at more frequent intervals than six months, and easy access for removal of the filter shall be provided.
- iii) Inertial separators are permitted for traction equipment and other 750 V machines and shall be maintenance free between 5 years overhauls.
- iv) Oil wetted air filters shall not be used.
- v) For equipment cases containing power equipment, which could possibly produce electric arcing during operation means shall be provided to reduce the production to a minimum and prevent the accumulation of corrosive gases.
- vi) Equipment with moving parts shall be so arranged that the movement is accessible for inspection and cleaning if it is needed.

18.11.3 Mounting of Groups:

- i) An equipment group may be mounted in a box or case, or on a frame or panel. The individual items of equipment shall be so arranged that they can be removed separately, or in sub-groups as appropriate. Any group mounting shall be self-

supporting when out of the car and sufficiently strong to be lifted out complete under normal workshop conditions.

- ii) Anti-vibration resilient mounts shall be incorporated on the fixings of the rotating machines where necessary to avoid the transmission of vibration onto the car body or its structure.
- iii) Under frame equipment mountings shall be designed such that, in the event of failure of any of the fixings, the equipment case or module shall be prevented from falling onto the track.

18.11.4 Wiring and Piping of Groups:

- i) All groups shall be complete with internal wiring and pipe work.
- ii) The connections to the group shall be taken to suitable terminal bars.
- iii) Where suitable cable runs can be arranged, the Project Manager may approve the running of heavy current cables direct to equipment and not via the group terminal bars, provided he is satisfied that the work of disconnection and reconnection is not thereby increased.
- iv) Groups containing equipment, which may produce arcs, such as heavy duty contactors or circuit breakers, shall have the low voltage terminals mounted in such a position that arcing to the terminals is prevented.
- v) Consideration shall be given to mounting such terminals in a separate enclosure.
- vi) Cables entering equipment cases shall be limited to those connecting to equipment within that case, such case shall not be used as terminal boxes.

18.11.5 Type of Enclosure:

- i) Inside and under frame-mounted equipment shall be in sealed enclosures.
- ii) Equipment mounted in such enclosures shall be treated as mounted in clean conditions as specified in IEC 60077 1 and 2. Where enclosures, as described above cannot be adopted, ventilation of enclosures, naturally or forced air, shall be considered. Equipment mounted in such enclosures shall be treated as mounted in dirty conditions as specified in IEC 60077 1 and 2, except that enclosure pressure ventilated with filtered air shall be designated as clean areas.
- iii) In the case of machines, the machine frame forms the enclosure.
- iv) Machines shall be regarded as inside mounted and shall comply with this Clause.
- v) Enclosure doors and covers shall be securely attached, and wherever possible with quick release latches. These shall include safety devices and keyed access to prevent accidental unlatching.

18.11.6 Under frame Enclosures:

- i) Clipped covers shall be used where regular access to equipment is necessary, and bolted covers elsewhere on the under frame. Covers shall be lightweight, shall be fully compliant with the requirements of fire performance as specified, shall be designed to prevent distortion and damage, and shall be fitted with lifting handles and safety chains. Clipped covers shall be provided with location guides to facilitate location and correct fitting by one man. Particular care shall be

exercised in ensuring a good seal against the ingress of dust and water for the life of the equipment. Furthermore, water shall be prevented from accumulating on seals and gaskets.

- ii) Covers, which are substantially flat, may be lightweight metal pressings otherwise meeting the above requirements.

18.11.7 Enclosures Inside the Car:

- i) In the case of body-mounted equipment other than in the passenger area, suitably stiffened lift-off hinged doors may be used. Doors hung on "piano" hinges made of stainless steel or other corrosion resistant material shall be used in passenger areas. Doors shall be secured by mutually agreed locks in cabs or passenger compartments.
- ii) Bolts shall only be used to secure doors or covers where access is infrequent. Where bolts are used for hinged doors or covers they shall be captive to the door or panel.
- iii) Enclosures in which excessive heat or arcs may be generated shall be lined with barriers of insulating material. These materials shall also be used for vents, where required. The design of such vents in the case of heavy duty equipment shall be such that the arc has a clear path to the outside of the enclosure and such that the vents do not tend to impede the emerging gas.
- iv) Enclosures, including the frames of electrical machines, shall be effectively earthed by bolting solidly to the vehicle frame, or by using an earth connection where the equipment is otherwise mounted. Apparatus using two stages of insulation shall also be totally enclosed in an earthed metal case or case made from insulating material.
- v) In the case of body-mounted equipment other than in the passenger area, suitably stiffened lift-off hinged doors may be used. Bolted doors will be considered where appropriate. The number of fixing bolts for bolted doors or covers shall be kept to a minimum.

18.11.8 Enclosures/cubicles shall be provided with Linear Heat Detectors (LHD) or heat detectors (refer ERTS clause 3.14) to protect against any abnormal increase of temperature within the enclosed cubicles which may lead to risk of fire.

18.11.9 Access to Equipment:

- i) Equipment with moving parts shall be so arranged that the moving parts are easily accessible for inspection and maintenance. The location of any item requiring adjustment shall be mutually agreed to.
- ii) In the case of contactors, relays and cam-operated switch groups it shall be possible, without breaking any pipe joints, or any electrical connections except those to the item concerned and without disturbing any other equipment, to change the following:
 - All contact tips and flexible copper braids.
 - All arc chutes and arcing horns.
 - All contactors and relays.
 - All magnet valves.

- All auxiliary contact enclosures complete.
- All plug-in cards.
- iii) This requirement may be extended to other equipment as mutually agreed to.

18.11.10 Openings:

In the case of air inlets, outlets or vents accessible from the platforms or areas to which passengers have access, it shall not be possible to touch, or to insert any object with diameter over 4mm into any moving or electrically energized equipment, including blower or fan rotors. Any such inlet, outlet or vent, which is, mounted other than in such an area shall be covered with a mesh or grille so that it is impossible to insert a hand or finger to a dangerous extent.

18.11.11 Roof Mounted Equipment:

Roof mounted equipment may be mounted externally in a recessed area of the roof, or inside the roof cavity. Outside mounted equipment shall be water tested before assembly and, if repair is required, it shall be completely removed from the car. The design shall ensure that penetration of water cannot occur, either at sealing surfaces or at fixing points.

18.11.12 Outside Mounted Equipment:

Where outside mounted equipment on the underframe except for current collectors includes bare conductors energized at high voltage, an earthed screen (solid or mesh) shall be provided to prevent accidental contact with staff walking beside the car. Detailed arrangement to be mutually agreed during design stage based on safety considerations.

18.12 General Material Specification

18.12.1 Ferrous Materials:

- i) Steel Castings – BS 3100 (grade 592) or equivalent international standard
- ii) Stainless Steel other than body-shell- chromium content not less than 17%, carbon content not more than 0.03% -JIS 4305 or equivalent standard.
- iii) Steel (other than stainless steel) used in welded structures shall be corrosion and weather resistant and not inferior to ASTM A36/A36M. The amount of such steel shall be kept to a minimum and shall not be used at all in structural assemblies above the under frames of vehicles constructed substantially of stainless steel, of aluminium, or in exposed areas of passenger compartments.

18.12.2 Aluminium Based Material:

- i) Aluminium: Aluminium alloys shall conform to the composition, strength, quality requirements, and corrosion resistance requirements of EN 458, EN 573 and EN 755 1 to 9. Any exposed unpainted aluminium surfaces in the interior of the vehicle shall have a clear anodic coating thickness of 0.02mm and a minimum coating weight of 0.054 mg/sq.mm.. Proper allowance shall be made for the effects of fatigue, and for column and plate stability effects. Aluminium alloys used for structural purposes shall be limited to the 5000 and 6000 series of alloys.

- ii) Castings Aluminium alloy castings shall conform to the requirements of EN 573 or equivalent. Castings shall be free from blowholes, cracks, shrinkage, and other defects that will prevent the attainment of the required life.
- iii) Forgings Aluminium alloy forgings shall conform to the requirements of ASTM B-247 and shall use 6061-T6 alloy or equivalent.
- iv) The other grade of aluminium alloy material should be Approved by the Project Manager.

18.12.3 Rubbers:

Synthetic rubber, conforming to International Standards, shall be used for components exposed to sunlight or lubricants during Operation & Maintenance. All rubber hoses, connecting pipes etc. used in pneumatic circuit and bushings in antiroll bar shall not be required to be replaced before 5 years or major overhaul whichever ever later. All rubber hoses shall be steel wire braid reinforced conforming to ISO 11237-SAE-100 R-Type for better life and reliability. Complete purchase technical specifications with drawings of all rubber components shall be submitted.

18.12.4 Fibreglass Reinforced Plastics:

Fibreglass reinforced plastics (FRP) may be used for non-structural parts, and applications as accepted by the Project Manager. They shall be manufactured to an approved process and satisfy the flammability, toxicity and smoke generation limitations of EN 45545 Part 1 to 7 (Hazard level HL3) latest editions.

18.12.5 Finishes:

- i) Stainless steel and aluminium, or their alloys, shall not be painted except as required by the colour scheme. Stainless steel or aluminium visible to the public shall be finished by an Approved method. Soft metals subject to creep (aluminium, zinc, etc.), shall not be used in applications requiring them to carry current, stress or operate in high temperatures. In exceptional cases, such applications shall be submitted to the Project Manager for review.
- ii) Steel (other than stainless steel) framing structural sub-assemblies including bogies shall be surface prepared, primed and painted. Steel parts of the bogies and underside of the vehicle, (including equipment boxes where use of steel is Approved) shall be prepared and painted in accordance with this Clause.
- iii) Panels inside the car shall have smooth easily cleanable surfaces suitably coloured, and metal fittings shall have stainless steel or anodized aluminium surfaces or Approved finish. Use of chromium plating will only be Approved where stainless steel cannot be used. Welding shall not be carried out on parts on which surfaces have already been treated.
- iv) The wheel, bearing, and driven gear seats of each axle shall be finished smooth and within drawing tolerances using either a machining process, or if cold rolling is applied the surface shall be grinded.

18.13 Cable

- 18.13.1 All wires and cables shall be adequately protected for the maximum design and fault currents and designed for minimum voltage drop.

- 18.13.2 The insulation of all wires and cables including those used within equipment / subsystem shall be halogen-free flame- retardant and formulated to minimise generation of smoke, noxious emissions and corrosive fumes, in the case of overheating or fire in compliance with EN 45545 (Hazard level HL3) latest edition. Cables shall all comply NF F 63-808 (for low voltages, and NF F 63-826 (for high voltages), EN 50306 (Part 1 to 4), EN 50264 (Part 1 to 3) and EN 50382 as approved by the Project Manager.
- 18.13.3 Fire resistant cables shall be proposed for circuits, which should survive for long periods during fire, as per applicable international standards. As a minimum, the cables and wires for Public Address System, emergency lighting, door opening and warning systems shall be fire resistant in compliant to EN 50200.
- 18.13.4 The system adopted to rate cable shall be fully specified for review. All de-rating factors shall be applied, together with the maximum permissible conductor temperature for the particular insulation type. In no case shall the conductor continuous temperature exceed 90°C. The maximum short circuit temperature shall not exceed 250°C. The cable insulation shall be capable of withstanding these temperatures.
- 18.13.5 The minimum cross-sectional area of control cables for connections between equipment shall be 1.5 mm². Smaller cable sizes may be used inside equipment cases. Any deviation from this requirement, in exceptional cases, will be subject to review by Project Manager in design stage.
- 18.13.6 The proposed cables shall be proven on metro Rolling Stock. The Contractor shall submit the voltage grade, size and type of cable for different applications along with the proposed specification for the cables for review by the Project Manager.
- 18.13.7 The voltage grades shall be compliant according to IEC 60502 (1/2/4).

18.14 Cable Joints and Connections

- 18.14.1 All connection at a cable termination or joint shall:
- i) Be mechanically and electrically sound;
 - ii) Be protected against moisture, mechanical damage and any vibration liable to occur;
 - iii) Not impose any appreciable mechanical strain on the fixings of the connection;
 - iv) Not cause any harmful damage to the cable conductor;
 - v) Be appropriate to the size and type of conductors with which they are to be used;
 - vi) Be suitably insulated for the voltage of the circuits in which they are situated.
- 18.14.2 No strand of a stranded conductor in a cable core shall be cut away in making a cable joint or termination.
- 18.14.3 Unless otherwise approved, all cables termination shall be crimped with ferrules.
- 18.14.4 All mechanical clamps and compression-type sockets shall securely retain all the wires of the conductor.
- 18.14.5 For the purposes of Approval, samples of types of crimped lugs, or other terminations shall be submitted with the following information:
- (a) Maker, Maker's Mark and Type Number.

- (b) Cable size and stranding for which the cable lug is suitable.
- 18.14.6 The Project Manager may require tests before Approval and will require to be satisfied that the quality of crimping will be maintained by the carrying out of regular tests on all equipment under the supervision of his representative.
- 18.14.7 High voltage cables, of conductor sizes up to 6 mm² shall be crimped with a lug which grips the insulation as well as the conductor, or other arrangements made to prevent excessive flexing of the core where it emerges from the lug.
- 18.14.8 The insulation need not be crimped where the conductor size exceeds 6 mm² irrespective of the insulation grade, however if the cable is in a position where movement occurs, such as earth brush, then suitable crimping shall be provided to prevent stress of the conductor at the point of connection to the crimp.
- 18.14.9 Lugs shall be closed-end type unless otherwise Approved.
- 18.14.10 Terminals shall be of the steel screwed post type securely moulded into an insulating base. All power terminations on one stud shall be assembled together without intervening, such as nuts and washers. Studs or bolts shall not be used to carry current.
- 18.14.11 Alternative forms of terminals will be considered where appropriate but post terminals are mandatory for safety circuits.
- 18.14.12 Terminal posts or the equivalent shall be mounted horizontally or vertically downwards. Vertical posts shall only be used if the posts are completely shielded from the possibility of being bridged by a conducting object dropped onto or lying across the terminals. Horizontal posts shall be so arranged that there is little possibility of an object lying across two posts. Failure of a fixed terminal shall not result in scrapping of a complete piece of equipment.
- 18.14.13 Terminals and terminal boxes shall be so arranged that water collecting in ducts and conduits cannot reach live parts.
- 18.14.14 Terminals for circuits of different voltages shall be kept in separate groups.
- 18.14.15 Negative and neutral terminals shall be grouped separately.
- 18.14.16 Cable glands shall securely retain without damaging the outer sheath of the cables.
- 18.14.17 Electrical connections shall not be used as the sole means of mechanical support for components other than those mounted on printed circuit boards. Contactors and other equipment, which are specifically designed to be mounted via its electrical connections, is exempt from this requirement provided that the appropriate manufacturers data sheets are submitted for information to the Project Manager.
- 18.14.18 Low voltage cables up to 6.0 mm² conductor cross sectional area shall preferably be fitted with terminals conforming to BS4579 Pt.1 or equivalent. Alternatives shall be submitted for review.
- 18.14.19 All cable sockets and busbar contact faces shall be tinned. In printed circuit boards contact faces of connectors shall be gold plated. Any deviation from this requirement in exceptional cases will be subject to review by Project Manager in design stage.

18.15 Cable Enclosure

- 18.15.1 Cable enclosures as protective conductors:

- i) Types of protective conductors, such as circuit protective conductors, earthing conductors, of which shall be formed by rigid steel conduits, trunking or ducting.
 - ii) Metallic enclosures where used as protective conductors shall
 - Have a cross-sectional area according to BS 7671 or equivalent;
 - Have an electrical continuity achieved and maintained to afford protection against mechanical, chemical or electrochemical deterioration; and
 - Permit the connection of other protective conductors at every predetermined tap-off point.
 - iii) All cable enclosures shall be properly supported and of a type suitable for any risk of mechanical damage to which they may be liable in normal conditions of service or adequately protected against such damage.
 - iv) Where cable enclosures pass through fire barriers, the opening made shall be sealed according to the appropriate degree of fire resistance specification.
- 18.15.2 Where cable enclosures are not used as protective conductors, the non-metallic enclosures can be used provided that the material used shall comply with the fire performance as specified.

18.16 Conduit, Trunking and Ducting

18.16.1 Conduit:

- i) Conduit and fittings shall be to standards ISO metric dimensions.
- ii) Conduit shall be of an Approved rigid non-metallic grade except where high mechanical strength or electrical continuity is a requirement.
- iii) Metallic conduit where Approved shall be of solid drawn seamless zinc coated steel.
- iv) The conduit and fittings shall comply with EN 50 286 / EN 61 386.
- v) The nominal minimum outside diameter of any rigid conduit to be used shall be 16mm with a minimum wall thickness of 1.4mm.
- vi) The outlets of all metallic conduits shall be protected by suitable bushes.
- vii) All steel conduits, conduit fittings and the associated metallic boxes for the enclosure of electrical accessories shall be protected against corrosion on both the inside and outside surfaces. Non-metallic conduit ends shall be suitably protected by a nylon bushing or as Approved.
- viii) An adequate number of suitably sized adaptable boxes shall be provided in conduit installation to enable cables to be drawn in easily and without damage.
- ix) Conduits in exposed locations shall be provided with an effective means of sealing the cable entry to prevent the ingress of water and condensed moisture.
- x) The use of flexible conduits will not be accepted except where compensation for movement (incl. mounting and dismounting), vibration and possible thermal expansion will be required.
- xi) Flexible steel conduits shall comply with EN 61 386.

- xii) Fittings for metallic conduit shall be screwed to suit the conduit size. The fittings shall be of the same class of materials as the conduit.
- xiii) The use of conduit bushings or fittings of moulded phenolic or similar brittle resins will not be acceptable.
- xiv) Inspection fittings shall not be used. Draw-in boxes shall only be used where specially approved.
- xv) Workmanship:
 - Conduits shall not be bent in such a manner, which appreciably distorts their original cross-sectional shape or causes damage to the conduits.
 - Burrs, sharp edges and projections shall be removed from the internal surfaces and ends of conduits, ducting or other enclosures when installed.
 - Where the protective coating on a metallic enclosure has been damaged after installation, such surface shall be effectively restored by paint or other suitable coating to prevent corrosion.

18.16.2 Trunking:

- i) Steel trunking and fitting shall comply with the requirements specified in EN 50 285 or equivalent.
- ii) Steel trunking installations shall be constructed using manufacturer's standard fittings such as tee or angle pieces, throughout as far as practicable.
- iii) All steel trunking and fittings shall be protected against corrosion.
- iv) The steel trunking installation shall be made mechanically and electrically continuous throughout and be effectively earthed.
- v) Electrical continuity shall be achieved by means of connecting a protective conductor of adequate size across the two adjacent ends of the trunking.
- vi) Every entry to the trunking installation shall be provided with smooth bore bushes or grommets and the return edge of the lid of the trunking shall be left intact in order to prevent and/or to be protected against the ingress of water.

18.16.3 Ducting:

- i) Ducts under frame shall be closed type, including any removable lids or covers, against ingress of moisture and dirt.
- ii) Lids shall be provided to enable the cables to be introduced easily into the duct.
- iii) The cables and cable loom shall be cleated or otherwise secured into the duct sufficiently frequently to prevent movement.
- iv) Ducting with top access lids shall be avoided whenever possible and will not be accepted for under floor mounting.
- v) Duct lids shall not be used for cable support.

18.16.4 Space Factor:

Space factor of at least 20% shall be provided for all cable conduits, trunkings and ductings.

18.17 Cable Runs**18.17.1 General:**

- i) All cables shall be run in a vertical or horizontal direction, where practicable and shall be secured flat or in a bundle, such as on the surface of body panels, columns, partitions or ceilings, throughout the entire route.
- ii) Where cables run as a span, such as between beams, trusses, and rigid support throughout their entire length shall be used.
- iii) Cables crossing an expansion joint shall be formed into a loop such that any movement in the joint shall not stress the cables.
- iv) The minimum bend radius in cables shall not be less than twice that required in breakdown tests used in the applicable cable standards. Any deviation from this requirement in exceptional cases will be subject to review by Project Manager in design stage.
- v) All cables external to equipment cases or ducts must be protected by conduits, trunking or ducts, except for high voltage and grounding cables for a short distance that has to be mutually agreed to.
- vi) Wiring arrangement and layout shall be for Approved by the Project Manager.

18.17.2 Heavy Current Connections:

- i) Heavy current connections may be by cable.
- ii) Heavy current cables run in ducts shall be adequately cleated or secured against chafing or movement. Power cables, suitably sheathed, shall be cleated at not more than 400 mm centres. For the smaller cable size cleat distances less than this may be necessary. Such cables may be run bundled together as necessary to give additional support.
- iii) Cable runs shall not cross a horizontal floor or surface except where unavoidable, and then a clearance of at least 25 mm shall be left beneath the cables, and where the likelihood exists of the cables being damaged they shall be protected by a removable tread plate.
- iv) Where cables pass through holes in the traction motor frame, oil resistant resilient bushes suitably clamped shall be provided to prevent chafing of cables and to seal against the ingress of oil and water.
- v) Adequate length of cable shall be available from terminals to avoid straining in all service conditions and in Depot.

18.17.3 Light Current Connections:

- i) Light current connections outside enclosures shall be by cables protected by conduits or ducts, or unprotected where so Approved.
- ii) Cables inside enclosures may be run unprotected, and, where more than one cable, made up into cable looms.
- iii) Cable looms shall be made up by fastening them together to form a neat bundle. The individual cables shall be laid parallel and pulled straight and shall have a

neat appearance. Particular care to obtain parallel lays shall be taken where looms go round corners.

- iv) The looms shall be fastened at not more than 150 mm intervals.
- v) Fastenings shall also be applied at the start and finish of any bend, and at the point at which one or more cables leave the loom so as to secure the leaving cables. The term fastening includes the application of flame retardant lacing cord or of Approved, non-metallic, proprietary fasteners to secure the bundle. The use of self-adhesive tape or lacing cord will not be accepted. Care shall be taken that the fastenings are not tightened excessively. Fastenings shall only be applied using the manufacturers recommended tool to obtain the tightening force appropriate to the cable.
- vi) As far as practicable cables shall leave looms at right angles, to give a neat appearance. Sufficient slack shall be allowed to prevent a constraint being placed on cable terminations.
- vii) The use of proprietary cable ducting and support systems inside enclosures as an alternative to the foregoing requirements shall be submitted for Approval.
- viii) High and low voltage cables shall be kept separate. Where cables of greater than 200V between conductors as being carried in the same jumper as other cables they may be run together as far as the adjacent junction box. Alternating current cables shall not be run so as to result in eddy current heating of conduits.
- ix) Electrostatic and magnetic electrical shielding methods shall be employed to minimize the effects of stray signals and transient voltages on low-level interconnecting cables. Power and signal cables shall be physically separated where practical and magnetically shielded where necessary. Transient suppression devices shall be used on electromagnetic components to protect low-level circuits.
- x) All cables of voltage less than 50V shall be kept separated from high and low voltage cables.
- xi) Cable looms for case or enclosure internal wiring shall not be cleated to incoming cable looms.
- xii) Light current cables or cable looms shall be adequately secured to supports. Cables or cable looms shall be supported sufficiently frequently to prevent movement chafing or vibration in service.

18.17.4 Location of Cables and Looms:

- i) Cables and looms shall be run in such positions that they are clear of apparatus and do not impede access for maintenance. They shall be clear of high temperature and electric arc areas. Arc or heat barriers to protect the cable runs shall be provided where it is not possible to avoid such areas, in such a way as to allow circulation of air around the cables.
- ii) Sharp edges over or near which cables or looms may run shall be protected. The possibility of displacement in service shall be duly considered. Where cables pass through metallic partitions suitable grommets shall be provided.

18.17.5 Cable Identification:

- i) Cable markers, respectively cable marking, shall be located so that they can be read easily.
- ii) They shall be an Approved non-metallic type with clear markings, and of a type that does not come loose, age nor deteriorate due to UV Light, dirt, grease or contact with other contaminants, which may be encountered in a railway environment. Neoprene rubber markers will not be accepted.
- iii) Markers requiring dilating fluid will not be accepted. Cables markers displaying numerals shall be coloured in accordance with the international colour code. The numerals shall be embossed or otherwise permanently marked to the satisfaction of the Project Manager. Other methods of cable marking may be used subject to mutual agreement.
- iv) All cables, both within and outside enclosures and equipment cases shall be identified with cable markers, respectively cable marking. Wire looms within electronic racks are excluded from this requirement.

18.17.6 Conduit Runs:

Conduit shall be adequately secured and supported by clips or otherwise. Welding of conduit will not be accepted. Metallic conduit shall be used on bogies, in exposed positions on the underframe, and to protect the cables between the shoe gear and line switch for the traction and auxiliary supplies. Non-metallic conduit shall be used elsewhere except as Approved. The jointing of cables within a cable run will not be accepted. The only accepted way to join a cable is at a terminal.

18.17.7 Safety Circuits:

- i) Insofar as is practicable safety circuits shall be run direct to apparatus and not to terminal bars. Where it is essential that intermediate terminals be used, (for example, circuits which pass through inter-car jumpers) the terminals shall be covered and separated from others terminals. All safety circuit cables shall be coloured yellow.
- ii) The Project Manager will direct which circuits or sub-circuits shall be designated safety circuits within the meaning of this clause.

18.17.8 Inter-car Connections:

- i) Inter-car connection shall be by an Approved form of multi-core cable taken to contact boxes integral with the couplers.
- ii) 750 V connections shall be by bolted cables.
- iii) Care shall be taken that the cables run in easy bends without undue flexing.

18.17.9 Train Wires:

All multi-core train wires, with spare wires, shall be run from coupler to coupler, irrespective of whether required by the circuit, except where the circuits demand otherwise.

18.17.10 Spare Wire:

- i) Spare wires shall be provided and terminated in the same way as other wires.

- ii) The spare wires shall be shown on the wiring diagram and labelled with cable markers in the same way as all other wires.
- iii) Minimum quantity and requirements will be decided during the detailed design stage.
- iv) All spare wires shall be properly secured and insulated by capsulate.

18.18 Electrical Creepage and Clearance

- 18.18.1 Surface creepage and clearance distances between voltage potentials and car body earth shall be as defined in IEC 60077 Specification for Electric Traction Equipment, for all electrical circuits, equipment and associated cabling. Voltages less than 250V shall be treated as 250V.
- 18.18.2 Creepage or clearance where arcs are present, or along the outside or clearance where arcs are present, or along the outside of a cable sheath, shall be 200% of that defined in IEC 60077: Specification for Electric Traction Equipment. Any deviation from this requirement in exceptional cases will be subject to review by Project Manager in design stage.
- 18.18.3 Terminal boards and panel surfaces between terminals and live posts shall as far as possible be vertical to minimise the build-up of tracking paths.

18.19 Protection & Earthing

- 18.19.1 Except as specifically required otherwise, D.C. and single-phase A.C. circuits shall be such that one pole of each device shall be connected directly to the negative or neutral line, i.e. without switches, fuses or contacts on the negative or earthy side.
- 18.19.2 High voltage traction circuits shall be protected in accordance with the requirements of IEC 60077: Rules for Electric Traction Equipment, by an approved fault-interrupting device.
- 18.19.3 In all cases, the fault discriminating characteristics of the system shall be submitted for review.
- 18.19.4 Low voltage fuses and associated fuse carriers shall comply with IEC 60269-1: Low Voltage Fuses. Protection and isolation of low voltage circuits shall be in accordance with IEC 60947-2: Low Voltage Switch Gear and Control Gear: Pt.2 Circuit Breakers or approved equivalent.
- 18.19.5 Grounding connections shall be made through copper or bronze pads of adequate area, to the car body. Any deviation from this requirement in exceptional cases will be subject to review by Project Manager in design stage.
- 18.19.6 High voltage circuits and low voltage circuits should not be earthed together and separate earthing shall be arranged. All earthing pads shall be readily visible and accessible for inspection and trouble-shooting.
- 18.19.7 The Contractor shall produce a complete earthing scheme, which shall prevent traction return current passing through motor and axle bearings, gearboxes, bogie centre bearings, couplers, or any path other than the designed path. The earthing scheme shall be submitted to the Project Manager for review.

- 18.19.8 Miniature circuit breakers (MCB's) shall be used only for the protection and isolation of the D.C. control voltage and A.C. auxiliary circuits. MCB's shall be of a robust design suitable for use in the railway environment as detailed in IEC 61133.
- 18.19.9 All grounding and bonding jumpers and straps shall either be with copper cables or copper braids of adequate size to handle fault currents and lightning discharge currents, for which the voltage drop shall not exceed 25V. All earthing connections shall be colour coded as per relevant International Standards.
- 18.19.10 The bonding method employed shall not produce a D.C. resistance in excess of 0.0025Ω; or more than 0.025Ω at 150kHz for any applied A.C. voltage.
- 18.19.11 Electrical equipments like capacitors and transformers which can develop internal faults shall be provided with effective devices to isolate at once the defective equipment from the source of power such that there is no fire or explosion at any time.
- 18.19.12 Liquid dielectric materials used in capacitors, transformers and similar equipment shall be of the non-inflammable type.

18.20 Circuit Diagrams

- 18.20.1 Circuit diagrams shall be clear and easy to interpret and shall comply with IEC 61082 and IEC 60617-1 to 13.
- 18.20.2 Apparatus coding and cable and wire designations shall be Approved by the Project Manager.
- 18.20.3 The version of all Circuit diagrams & TCMS sheets shall be inter-linked for smooth and seamless tracing of signals and wiring.

18.21 Auxiliary Contacts

- 18.21.1 Auxiliary contacts shall be of the silver butt type. They shall be contained in a separate dust proof contact enclosure under an Approved type of cover. In the case of small relays and the like the whole relay may be contained in the enclosure. The contact enclosure is required irrespective of the type of enclosure of the main equipment. The cover shall be transparent plastic and all fixings shall be captive. Acrylic resin will not be accepted.
- 18.21.2 The Project Manager shall be satisfied that condensation of moisture inside the contact enclosure will be prevented. Contacts shall be adequately protected against corrosion.
- 18.21.3 The above requirements also apply to the contact section of master controllers, but the enclosure may be formed by the controller case and need not be of transparent plastic.
- 18.21.4 The connections shall be made outside the contact enclosure. It shall be possible, as far as practicable, to remove a contact enclosure complete and substitute another of the same type without removing the contact cover.
- 18.21.5 Notwithstanding the above, the use of an Approved type of small contactor for several applications, either as a relay or as a contactor shall be considered, even if it does not fully comply with the foregoing, to economize on equipment types.

18.22 Power Contacts

- 18.22.1 All power contacts shall be fitted with contact tips, securely fixed to their support and arranged for easy removal without further dismantling. Contact screws of size M8 or larger shall not be provided with screwdriver slots. Current shall be taken from moving contacts by flexible copper braids, amply proportioned and having end connections secured by crimping only, with flared ends to avoid abrasion of the shunt. Braids shall be supported and restrained so as to prevent damage due to excessive movement or vibration. Passage of current through springs or bearings shall be positively prevented.
- 18.22.2 Contacts shall be rated for inductive loads. The electrical contact material and sizing shall be appropriate for the use intended and Approved by the Project Manager and be normally a break-before-make type. Push buttons or switches interfacing with the ATC system shall have double-break contacts unless otherwise Approved.
- 18.22.3 Blowout coils shall be connected on the positive side of the contacts.
- 18.22.4 Arc horns, which are removed with the arc chute, are not permitted. Where used, the associated flexible lead shall be sleeved.
- 18.22.5 The Contractor shall satisfy the Project Manager that all arc chute components have adequate resistance to erosion and burning from the arcs to which they may be subjected.
- 18.22.6 Arc chutes shall be of a manageable size. Arc chutes that weigh more than 5 kg shall include an inner replaceable arc box to avoid changing the whole assembly when cheek wear occurs.

18.23 Rotating Electrical Machines

- 18.23.1 The design of all rotating electrical machines used for the train shall be complied with IEC60349.
- 18.23.2 All rotating electrical machines, particularly those are under floor mounted shall be fitted with resilient mountings, if necessary to achieve the specified noise and vibration limits, to eliminate transmission of mechanical vibrations to the car body.
- 18.23.3 Rotating parts shall also be adequately guarded and protected against ejection under failure conditions. Suitable protection shall be put in place to guard against the ejection of rotating parts under failure conditions.
- 18.23.4 The rotating electrical machines shall be of the self-ventilated type, with simple means provided for exclusion of dust and water. Alternatively, fully enclosed proven air-cooled type motor will be considered.

18.24 Protection Devices

- 18.24.1 Miniature Circuit Breakers:
- i) Miniature circuit breakers (MCBs) shall be of the magnetically tripped type, with a frame size of 100 A. The OFF and Tripped position shall be the same, with toggle downwards.
 - ii) The toggle shall be arranged to include means to attach securely, a label or a seal, but tripping of the device shall not be inhibited by such a seal.

- iii) Operation of the tripping mechanism shall return the toggle to the OFF position. MCBs having alternative arrangements shall not be offered.
- iv) The MCB's shall be in accordance to IEC 60077 1 and 2 for railway applications. The load rating calculations for each MCB shall be submitted.
- v) Particular care shall be taken to ensure adequate creepage distances to earth and between terminals of adjacent MCBs are maintained with the units grouped as closely as possible.
- vi) MCBs shall be mounted in such a way that shrinkage of insulating panels does not cause loosening of the electrical connections.
- vii) Access shall be provided to the rear of the insulating panel, which may be hinged for this purpose where so Approved. Where mounted on a switch board in a cab or similar positions a front sheet metal cover shall be provided, so arranged that any one MCB can be removed from the front without disturbing the rest, after removal of an escutcheon plate or otherwise.
- viii) Irrespective of the toggle position, the upper connection to all MCBs shall be the line (ac circuits) or the positive (dc circuits).

18.24.2 Low Voltage Fuses:

All fuses shall comply with IEC 60269-1, and associated fuse carriers with IEC 60269-2. Fuse carriers shall be back inserted, provision being made to remove the complete fuse panel.

18.24.3 High Voltage Fuses:

High voltage fuses shall be subject to Approval.

18.25 Electronic Equipment

- 18.25.1 ~~As a minimum, all electronic equipment shall comply with IEC 60571/EN 50155: Electronic Equipment used on Rail Vehicles, for design, manufacture and testing, and shall use components purchased against an internationally recognised quality assurance and reliability certification procedure.~~

~~Dry heat test: The dry heat test shall be conducted for class T3 and temperature shall be considered 80°C against 70°C specified in IEC/EN. An extra performance check at 95°C shall also be carried out for 10 minutes over temperature value. LCD/LED display units may be tested into 70°C and an extra performance check at 85°C shall also be carried out for 10 minutes over temperature value.~~

Addendum-1 dated 05.12.2022, Sl. No. 157

As a minimum, all electronic equipment shall comply with IEC 60571/EN 50155: Electronic Equipment used on Rail Vehicles, for design, manufacture and testing, and shall use components purchased against an internationally recognised quality assurance and reliability certification procedure.

Dry heat test: The dry heat test shall be conducted for class T3 and temperature shall be considered upto 85 °C as specified in IEC/EN standard.

- 18.25.2 Following tests shall also be carried out on control electronics PCBs:

- i) Cyclic Humidity tests (IEC 60571)

- ii) Dust and sand test & Mould growth tests: The tests shall be done as per IEC 60068 & IEC 60721. The dust settlement rate shall be taken as 6gm/m²/day and dust particle size shall not be larger than 100 microns.

18.25.3 Variable resistors shall be avoided wherever possible.

18.25.4 Circuit boards in safety control systems shall be connected through a safety circuit to disable the train if a circuit board is removed, unless the control system is proven safe and tolerant of such circumstances.

18.25.5 ~~Electronic components shall only be purchased from suppliers having as a minimum, ISO 9001/2 certification.~~

Addendum-1 dated 05.12.2022, Sl. No. 158

Electronic components shall only be purchased from suppliers having as a minimum, ISO 9001/2 certification. **However, Sub-Contractor shall provide necessary compliance documents in this regard during the type test of their subsystems.**

18.25.6 Electronic equipment shall not be damaged, nor shall malfunction when subjected to direct spikes and surges on the supply and indirect burst transients as defined in IEC 60571: Electronic Equipment used on Rail Vehicles.

18.26 Microprocessors and Software-based Equipment

18.26.1 Where microprocessor systems incorporate technology such as surface mounted components, multi-layer circuit boards, or flexible PCBs, the Contractor shall demonstrate that he has operational experience of the successful use of these technologies in a similar Metro environment.

18.26.2 All microprocessor-based systems shall have watchdog circuits to ensure correct software operation. When the watchdog circuit detects a fault, it shall trigger hardware forcing all system outputs into a safe state before resetting the system and entering a self-test mode. Normal operation shall only be resumed if all self-test checks are satisfactory.

18.26.3 Microprocessor systems shall incorporate self-test and diagnostic facilities to locate and indicate faults within the system. The system shall have sufficient built-in diagnostic capabilities to automatically identify all system faults.

18.26.4 Where microprocessor electronics systems require additional test equipment this shall be portable for use on the car.

18.26.5 LED's shall be used to indicate faulty modules, to allow rapid fault diagnosis and maintenance.

18.26.6 Faults occurring during system operation shall be logged, the information being stored in a non-volatile memory.

18.26.7 Microprocessor system hardware block diagrams shall be provided.

18.27 Software

18.27.1 Software shall be written in a structured manner and fully documented during all stages of its design and development.

18.27.2 This shall meet the requirements of EN 50126-2: Dependability for Guided Transport Systems – Part 2: Safety, EN 50128: Railway Applications: Software for Railway

Control and Protection Systems, and EN 50129: Safety-related Electronic Railway Control and Protection Systems. Any deviation from this requirement will be subject to review by Project Manager in design stage.

- 18.27.3 The Contractor shall submit his Software Quality Plan for review by the Project Manager before work commences on software design. The software quality plan shall clearly state the controls and practices used in the software life cycle from specification through to in-service operation.
- 18.27.4 Independent review, verification and testing, using real and synthetic data, shall be performed at the software module and system level. The Project Manager may audit the Contractor against the Software Quality Plan at any stage in the Contract. The Contractor shall ensure that all software is fully de-bugged prior to final review by the Project Manager.
- 18.27.5 ~~Sufficient software documentation shall be provided to give the Project Manager a full understanding of the software function and operation. Documentation shall be complete, yet clear and concise, and include all modifications up to final acceptance. Documentation shall include software block diagrams showing signal flow, logic, and hardware interfaces. A top level flow diagram and description of detailed operation shall be provided.~~

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Sufficient software documentation shall be provided to give the Project Manager a full understanding of the software function and operation. Documentation shall be complete, yet clear and concise, and include all modifications up to final acceptance. Documentation shall include logic **and software parameters etc.** A top level flow diagram and description of detailed operation shall be provided.

18.28 Printed Circuit Board and Connectors

- 18.28.1 PCB's of standard design for Rolling Stock applications with components mounted on one/both sides will be acceptable.
- 18.28.2 The minimum thickness of PCB's shall be not less than 1.6mm. PCB's shall generally comply with IEC 60326-3: 1991 Printed Boards – Part 3 : Design and Use of Printed Boards.
- 18.28.3 Soldering of electronic components shall comply with the latest internationally accepted practice. Bidders shall indicate the standard with which they are compliant.
- 18.28.4 PCB's shall be connected to the case or rack wiring using multi-pin connectors, which shall have a successful service history in rail applications. Details shall be provided.
- 18.28.5 In any electronic rack system, the failure of any one module or individual circuit board shall neither cause loss of the electronics power supply within the rack, nor cause subsequent failure of circuits on other PCB's or modules.
- 18.28.6 ~~The Contractor shall provide detailed maintenance and troubleshooting procedures, including wave forms at critical locations of the circuitry.~~

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The Contractor shall provide detailed maintenance and troubleshooting procedures.

18.28.7 PCB's shall have mechanical polarisation to prevent insertion into a wrong socket. The use of PCB edge connectors is not permitted unless reviewed by the Project Manager, on a case-by-case basis. PCB's and modules shall be positively retained in the rack or case by a fastener or spring loaded locking pin.

18.28.8 All PCB contact faces of connectors shall be gold plated.

18.28.9 PCB's shall be held in place by screwed fasteners to prevent vibration causing wear on terminal contacts. Circuit boards shall be mounted vertically to minimise the accumulation of dust on the boards. Any deviation from this requirement in exceptional cases will be subject to review by Project Manager in design stage.

18.29 Integrated Circuits

18.29.1 All integrated circuits and semiconductor devices shall be standard devices.

18.29.2 All integrated circuits shall be burned in and screened for defects to a level equivalent to relevant international standards.

18.30 Paint Performance

18.30.1 The Contractor shall submit the guaranteed life cycles for the paint application for different equipment and sub-assemblies for Project Manager's review during design stage.

18.30.2 Painting Procedure for the complete equipment including bogies as well as minor repairs shall be submitted in the maintenance manuals. Local damages due to service conditions have to be repaired periodically.

18.30.3 End caps shall be painted with a painting system proven for similar applications with high abrasion resistance. The paint system supplier's technical data and instruction shall be submitted.

18.30.4 Protection and decoration by paint according to NF F 19-141-1 and NF F 19-141-2 or equivalent standards

18.30.5 The paint coating shall resist mechanical damage in accordance with the requirements of EN 23270.

18.31 Cables and Pipes Entries Seal

18.31.1 To prevent entry and ensure fool proof protection against water, dust, humidity, insulation damage/ failure, fire, vibrations, temperature variations, pull tension noise as well as rodents etc. and increasing life of cable/ equipment, all the cables and pipe transits in all cars including rooftop shall be sealed with a suitable EPDM (Ethylene Propylene Diene Monomer) based cable and pipe sealing system. Sealing and Protection application area shall be identified and got approved from Project Manager during design stage.

18.31.2 Suitable cable transit system with EPDM should be used for holding/ retention of running power cables and control cables, HT cables at underframe.

18.32 Deliverables

Contract deliverables required by this section of the Technical Provisions are summarized below: -

CDRL-18-1:	Corrosion Protection Plan (ref. ERTS 18.5.1)
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19 RAMS: RELIABILITY, AVAILABILITY, MAINTAINABILITY, SAFETY**19.1 Reliability, Availability and Maintainability: General**

- 19.1.1 Reliability, Availability and Maintainability (RAM) requirements and goals shall be developed in terms of Mean Distance Between Failures (MDBF), percentage Availability and Mean Time to Repair (MTTR). The Contractor shall perform RAM analysis up to the point of interface with other Contractor's systems.
- 19.1.2 The Contractor shall comply with the guidelines of EN 50126 (all parts), IEC 60300-1, IEC 60300-2 and IEC 60571 for electronic equipment, and IEC 60300-3-5 or similar international standards in meeting the reliability, availability and maintainability requirements of equipment.
- 19.1.3 The Contractor shall submit Reliability, Availability and Maintainability Plan as specified in the Chapter – 2 of the Employer's Requirements: General Specification. The Contractor shall verify, after system design have been completed, that the reliability, availability and maintainability requirement will be met
- 19.1.4 BMRCL attaches the greatest importance to the attainment of the highest possible Reliability during service of all the equipment and systems supplied and installed under this Contract. The design, manufacture, installation and commissioning of the equipment as also the training of the operating and maintenance staff shall be such as to ensure near Zero Failure performance in the initial stages and that the few defects and deficiencies that may be exposed during the Service Trial and the initial reliability growth period of one year are totally eliminated in the bulk supply. It shall also ensure that trains shall not be incapacitated under any condition unless there is inevitable mechanical failure.
- 19.1.5 The Contractor shall demonstrate by quantitative methods achievement of the specified levels of reliability for the train and specific individual items of equipment.
- 19.1.6 An evolving reliability model consisting of reliability block diagrams and probability of success equations shall be developed and submitted to the Project Manager for acceptance. This model shall show the relationships required for system and equipment to operate successfully. The reliability block diagrams shall include all elements essential to the successful performance of the system and the interrelationships and interface of these elements.
- 19.1.7 Reliability apportionment and prediction analysis shall be in accordance with established techniques or standards, which will be submitted for acceptance by the Project Manager. The analysis shall provide predictions for each major equipment and sub- system. Predictions shall be based on actual commercial / revenue service results for identical equipment operating under service conditions and duty cycles equivalent to Bangalore Metro Rail system, or more severe. The analysis shall be carried out in parallel with the design of the train. The relevant apportionment and prediction figures shall be part of the design submission documents for the individual equipment, sub-system and system.
- 19.1.8 Reliability Apportionment and Prediction Report shall be completed prior to build commencing and reports shall be submitted at this stage for acceptance by the Project Manager, who reserves the right to require the Contractor to carry out field data collection to verify the reliability model.

- 19.1.9 The design shall ensure that passenger deboarding cases in operational trains are bare minimum and avoided to the extent possible.

19.2 Definitions

- 19.2.1 Relevant Failure: A relevant failure of an item is an independent failure which results in a loss of function of that item caused by any of the following:

A fault in an equipment or sub-system of the train while operating within its design and environmental specification limits

Improper operation, maintenance, or testing of the item as a result of the Contractor supplied documentation.

Failures of transient nature including those with post investigation status as 'No fault found', shall be considered as relevant failure if in the opinion of the Project Manager these are attributable to rolling stock. The decision of the Project Manager shall be final.

- 19.2.2 Non-relevant Failure: Any failure of an item not included in the definition of relevant failure, such as the following:

A failure caused by malfunction of any other equipment or subsystem that are not supplied by the Contractor;

A failure caused by human error, except as noted in Relevant Failure above;

A failure caused by accidents not associated with the normal operation of the item. Such as collision or striking a foreign object on the right of way;

A failure caused by operating the equipment or sub-system outside of design or environmental specification limits.

- 19.2.3 Service Failure or SF: Any Relevant Failure or combination of Relevant Failures or delay in offering of the Trains by Contractor for reasons attributable to the Contractor which results in one of the following:

- i) Withdrawal of the train from commercial / revenue services.
- ii) A delay equivalent to or exceeding five (5) minutes from the Schedule / Time table as noted at the destination station for the one way trip.
- iii) A starting detention equivalent to or exceeding 3 minutes from the Schedule/Time table

The discretion of declaring a train as Not available to start commercial / revenue service after successful completion of pre-departure checkout or withdrawing a train from commercial / revenue service on account of any relevant failure rests solely with the Project Manager and shall be final.

- 19.2.4 Withdrawal Scenario:

The train withdrawal scenario is placed in Appendix F and includes possible anticipated failure scenarios which can affect safety, punctuality and passenger comfort. The train withdrawal scenario defined in Appendix F shall be considered as a service failure irrespective of whether the Employer is able to withdraw the train or not due to its operational constraints. This list shall be further developed during Contract period

For avoidance of doubt, end of trip withdrawal shall be treated as Service Failure.

- 19.2.5 Pattern Failure: Repeated occurrence of three or more relevant failures of the same replaceable part, item or equipment in same manner in identical or equivalent applications when they occur at a rate which is inconsistent with the predicted failure rate of the part, item or equipment. The detailed methodology for identification of pattern failures shall be finalized during the design stage. The decision of the Project Manager shall be final.
- 19.2.6 ~~Deboarding: Any failure attributable to contractor resulting in passenger de-boarding in mid-section or any station.~~
- [Addendum-1 dated 05.12.2022, Sl. No. 161](#)
[Deboarding: Any failure attributable to contractor resulting in passenger de-boarding in mid-section or any station **excluding terminal station.**](#)
- 19.2.7 Train Operation Plan (TOP): Operation plan for train placement and withdrawal from the main line in planned manner to meet the passenger traffic requirement on the main line
- 19.2.8 Train Running Time Table: Time Table for the running of trains based on the TOP.
- 19.2.9 Depot Control Center: The organization in overall charge of controlling the movements of trains inside the depot as well as controlling the movements of trains coming inside or going outside the depot from the main-line
- 19.2.10 Operation Control Center (OCC): The organization manned by Employer and overall responsible for controlling the movements of trains on the main-line
- 19.2.11 Depot PPIO: PPIO will be a centralized cell to be manned by Contractor personnel, responsible for overall co-ordination with respect to train maintenance, arrival, departure, power block co-ordination and single point contact with Employer for day to day working of depot.
- 19.2.12 Train Handover Point: Refer Procedure in ERGS Chapter 16.
- 19.2.13 Available Trainset: Refer 19.3.3 (i)
- 19.2.14 Non-Available Trainset: Refer 19.3.3 (iii)
- 19.2.15 Commercial / revenue Service: Passenger services on the main line

19.3 Availability Requirements

19.3.1. Definitions:

- i) Commercial / revenue Hours - is the time duration between 05:00 hrs to 24:00 hrs of a Day during which Trains will ordinarily run.
- ii) Non-Revenue Hours- is the duration between 24:00 hrs to 5:00 hrs of a day during which Trains will ordinarily not run.
- iii) Morning Peak Hours –mean the morning rush hours and shall ordinarily be the time duration between 08:00 hrs to 11:00 hrs on Weekdays
- iv) Evening Peak Hours - mean the evening rush hours and shall ordinarily be the time duration between 17:00 hrs to 20:00 hrs on Weekdays
- v) Peak Hours – means either Morning Peak Hours or Evening Peak Hours as the case may be. However, Employer can declare any time on any days not exceeding 15 days in any Year as Peak Hours by giving advance notice of not less than 24 hours

19.3.2. Availability Targets

- i) Contractor shall ensure that Trains are offered and made available for operation at the respective Depot as per the Train Operation Plan and in accordance with the procedures agreed upon during execution phase. The entire process pertaining to monitoring of Train Operation Plans shall be administered through DCC/PPIO. Detailed procedures for placement and withdrawal of the Trains, daily availability monitoring of trains and anything necessary to apply the above-mentioned requirements shall be finalized and agreed between the Parties during the execution phase.
- ii) Employer shall prepare the monthly Train Operation Plan (TOP) indicating the scheduled placement and withdrawal timings of Trains from the train hand over point and inform the same to the Contractor at least 7 (seven) days before start of each month.
- iii) In some emergency/festive scenarios, TOP can be changed subject to condition that it will be informed to the Contractor atleast 24 hours in advance and for not more than 15 days in a calendar year.
- iv) Maximum Availability Target at any given day at any given time as per 19.3.1 shall be as per the following Table - A (the "Availability Targets"):

SL. No.	Number of commissioned trainsets (N)	Availability Target
1	<19	N-1
2	>=19	N-8% of N (Rounded to nearest integer)

Table – A

- v) The above Availability Targets shall be validated between the Parties periodically.
- vi) At the time of major maintenance such as major overhaul etc. of 5RS-DM trains, the availability targets as applicable may be mutually agreed between BMRCL and RS contractor. However, decision of BMRCL shall be final and binding.

19.3.3. Availability and Availability Damages:

- i) A Trainset shall be considered as 'Available Trainset' if it is offered for commercial / revenue service before 30 minutes from its scheduled departure time as per Train Operation Plan. As far as possible, no train shall be inducted on mainline with any defect, but in case of emergency, if a train is inducted with minor fault/defect as per table B below, every effort shall be made to attend the fault on mainline or withdrawal of train shall be done in planned manner. Trains inducted with minor faults/defect as mentioned in table B below or where specific waiver has been obtained by RS contractor from BMRCL shall be considered as available. PPIO will be a centralized cell which will be responsible for overall co-ordination with respect to train maintenance, arrival, departure, power block co-ordination etc.

Table B: Minor Train faults/defects which may be allowed at the time of train induction

Sl. No.	Minor fault/defect which may be allowed at the time of train induction subject to their subsequent attention onmainline/planned train withdrawal	Remarks
1.	One door Inhibit/Faulty	With door isolation sticker
2.	Auto announcement not working	Train induction will be done innon-UTO mode
3.	One headlight is not working in either mode but other light is healthy in both full and half intensity	
4.	Wiper is not working	Only in non-rainy season
5.	Either of TNI/DIF/PIB not working	
6.	Train Operator seat defective	
7.	Any of CCTV including its backup notworking	Train induction will be done innon-UTO mode
8.	Horn (any one High/Low tone must blow)	
9.	One HVAC is not working in cool mode properly but working in ventilation mode	Except April-September
10.	One Traction Inverter is isolated (one out of four motor cars is affected and failure shall not result in delay in trip delay/cancellation.)	
11.	Partition door is closed but showing open on TCMS	

Note:

- a) Any fault/defect may be added/deleted in the above table at the sole discretion of BMRCL.
- b) The provision for seeking waiver from BMRCL or utilizing the provision under table B for making train available with defect or deficiencies shall be used sparingly. If it is noted that Contractor has made it a regular practice, BMRCL at its sole discretion may impose penalty of maximum Rs 20000/train/day.
- c) If the train is offered with defect/deficiency without specific waiver from BMRCL, such incidence may invite penalty of Rs 20000 per incidence.

- ii) Trainset available with delay – A Trainset shall be considered as available with delay if such Trainset is: offered with delay that it effects its scheduled departure time as per the Train Operation Plan. Availability damage in such case shall be as per No. of trip(s) delayed/cancelled as defined in Table-C below. If another train is made available in place of this faulty train and the train is departed as per TOP, then there shall be no penalty.

Employer shall return the trains as per TOP ordinarily. However, if on account of BMRCL, the delay in the returning of one or more train(s) to depot is more than 1 hour then Contractor shall be permitted to provide one or more such train(s) with same delays for commercial / revenue service Hours without any penalties. Contractor shall also have option to intimate BMRCL in advance about the hour

slots where it intends to provide trains with delays. It is however expected that Contractor shall try to minimize impact of any delayed arrival of train(s) duly utilizing the maintenance reserves available and make all efforts for timely departure of all trains to commercial / revenue service.

- iii) Non-Available Trainset: A trainset can be non-available on following accounts:

If there is fault/defect (service failure/relevant failure) in the train(s) attributable to RS contractor and it cannot be utilized in commercial / revenue service, then penalty corresponding to 2.2 of Table-C shall be applicable.

- iv) Detailed list of different conditions and corresponding penalty/damage shall be levied on the Contractor is as mentioned below:

Table C: Penalty/Availability Damage

Sl. No.	Conditions	Penalty/Damage (Figures in INR)
1.	Passenger De-boarding in mainline	15 Lakhs
Trip Delay/Cancellation:		
2.1	> 59 seconds <= 5minutes (TripDelay)	10000
2.2	> 5 minutes (Trip Cancellation)	75000 / per trip cancellation

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Sl. No.	Conditions	Penalty/Damage (Figures in INR)
1.	Passenger De-boarding in mainline	15 Lakhs
Trip Delay/Cancellation:		
2.1	> 2 minutes <= 5minutes (TripDelay)	10000
2.2	> 5 minutes (Trip Cancellation)	75000 / per trip cancellation

Note:

1. Penalty/Damage figures as indicated above are for first year of train operation. From 2nd Year onwards these figures shall be escalated as per Price Adjustment stipulated under Appendix 2: Price Adjustment of Section IX: Contract Forms, Part-3 of Bid document.
2. Delay/Cancellation shall be recorded from the Time Table as noted at the destination station for one-way trip. BMRCL's decision shall be final and binding on RS contractor in this regard.
3. Where both penalty scenarios 1 and 2.2 occur together, higher of the 1 and 2.2 of table C shall be applicable.
4. Where both penalty scenarios 2.1 and 2.2 occur together, penalty corresponding to higher of 2.1 & 2.2 of table C shall be applicable.
5. In case of partial trip cancellation, penalty corresponding to 2.2 of table C shall be applicable on pro-rata basis.
6. ~~The damages mentioned above are damages per train and are in INR.~~

~~Stabilization period of 1 month for each train shall be provided for failures mentioned under 2.1 and 2.2 of Table C.~~

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The damages mentioned above are damages per train and are in INR. Stabilization period of **6 months** for each train shall be provided for failures mentioned under 2.1 and 2.2 of Table C.

- v) Penalties as defined in Table C shall not be applicable to RS contractor for delay/withdrawal/de-boarding due to faults in equipment which are maintained by BMRCL or other designated contractors viz. Signalling, Telecom etc.
- vi) Whenever any fault attributable to RS contractor is developed in the train and Train Operator is not able to troubleshoot or wrongly troubleshoots then the responsibility of the same shall still be with RS contractor only.

19.3.4. Penalty on account of service failure

If train is withdrawn from service as per withdrawal scenario present in Appendix-F of ERTS then penalty shall be imposed if the replacement is not provided ontime resulting in trip delay and/or trip cancellation. The penalty amount shall be as per 2.1 and/or 2.2 of Table C.

19.3.5. RAM Liability

In the event the total Damages recoverable from the Contractor on account of Availability Damage as specified exceeds 10% (ten per cent) of the total quarterly payment otherwise due under Cost Centre-F, the Damage amount in excess of such 10% (ten per cent) shall be carried forward to the subsequent Quarter of the Maintenance Period. For the avoidance of doubt, if the amount carried forward under this Clause cannot be adjusted in the subsequent quarter, it shall continue to be carried forward to the following quarter of the maintenance period until it is fully adjusted, but only within the ceiling of 10% (ten per cent) specified herein above.

19.4 Maintainability Requirements

- 19.4.1. Simplicity of maintenance, operation and emergency procedures, ease of repair of damaged cars and equipment, are most important. These together with ease of exterior and interior cleaning will be taken into account throughout the development of the design.
- 19.4.2. Particular attention shall be paid during the design of the cars to ensure that scheduled maintenance tasks are achieved in minimum time and using minimum manpower.
- 19.4.3. Those components, systems and assemblies which require routine maintenance, frequent attention or unit replacement, shall be easily accessible for in situ maintenance.
- 19.4.4. The Contractor shall develop a comprehensive maintenance program for the trains.
- 19.4.5. The maintenance regime proposed for the train shall be developed during the design process. A Failure Mode Effect Analysis (FMEA) will be required, based on function and derived from the specification at conceptual design stage.
- 19.4.6. ~~At pre-final design stage the Contractor will develop this FMEA to include required maintenance derived from each failure mode. Any other maintenance required for the~~

~~train should be indicated at this stage. Methodology for deriving maintenance activities including service checks, maintenance work instructions etc. based on failure modes shall be finalized at pre-final design stage only and the same shall be further reviewed by the Project Manager during the DLP period.~~

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At pre-final design stage the Contractor will develop this FMEA to include required maintenance derived from each failure mode. Any other maintenance required for the train should be indicated at this stage. Methodology for deriving maintenance activities including service checks, maintenance work instructions etc. based on failure modes shall be finalized at pre-final design stage only and the same shall be further reviewed by the Project Manager.

- 19.4.7. The vehicle shall incorporate design, which reduces maintenance, substantially improving service intervals and component replacement. The design shall also minimize mean time to repair (MTTR) and costs throughout design life. MTTR is defined as ratio of Cumulative time for repair (including the access time expended during a time interval) to total number of relevant failures.
- 19.4.8. The objective of the maintainability program including corrective and preventive maintenance shall provide for:
- i) Enhancement of Vehicle availability.
 - ii) Minimization of maintenance cost.
 - iii) Minimization of vehicle down time.
- 19.4.9. During the Pre-Final design stage, the Contractor shall furnish a list of Least Replaceable Units (LRU's) for the equipment, Sub-system and Systems supplied, which should not take more than 30 minutes for replacement. Specific exceptions, if any, whose replacement is not achievable in 30 minutes, shall be indicated by the Bidders in their offer. In order to achieve this requirement, quick release connections such as plugs and adaptor shall be provided between LRU's and the equipment.
- 19.4.10. The Bidder shall submit the expected MTTR of the identified key systems as listed in Table D along with the bid and shall be further developed and finalized during design stage.

Table D: MTTR of major systems

S.N	System / Equipment	MTTR (hours)
(i)	Propulsion System	
	a) Third rail current collector	
	b) HSCB and Earthing switch	
	c) Traction Inverter	
	d) Traction Motor	
(ii)	Auxiliary Supply System	
	a) Auxiliary Inverter	
	b) Battery Charger	
	c) Back-up Batteries	

S.N	System / Equipment	MTTR (hours)
(iii)	Air Supply and Friction Brake Equipment	
(iv)	Door System and Controls	
(v)	HVAC System	
(vi)	Communication System	
(vii)	Couplers and Draft Gear	
	a) Automatic couplers	
	b) Semi permanent couplers	
(viii)	Bogies	
	a) Drive gear and coupling	
	b) Primary suspension	
	c) Secondary suspension	
(ix)	Lighting System	
(x)	TCMS	
(xi)	Fire Detection System	

- 19.4.11. During the final design stage, the Contractor shall submit periodicity, downtime and manpower requirements for the maintenance inspections and service checks considered necessary for maintaining the trains under normal operational conditions as per table E. The service check sessions shall include all routine maintenance activities including inspections, cleaning of equipment, washing, pest and rodent control etc.

Table E: Service checks

Session	Interval (Minimum)	Manpower and down time requirements (Maximum)	
		Downtime	Expected Staff
Service Check 1			
Service Check 2, if any			
Service Check 3, if any			
.....			
Service Check n, if any			

- 19.4.12. The Contractor shall also submit periodicity, downtime and manpower requirements for the maintenance activities as listed in Table F, for maintaining the trains under normal operational conditions, during the design stage. In Table F, some of the values against identified activities are furnished. The Contractor shall either meet or provide better performance for these activities.

The periodicity of all overhaul activities of major items shall be synchronized with the below mentioned periodic and intermediate overhauling schedules.

Table F: Maintenance Activities

Session	Interval (Minimum)	Manpower and downtime requirements (Maximum)	
		Downtime	Expected staff
Periodic Overhaul	(8+ years)		
Intermediate Overhaul		10 days	-
	(4+ years)		
LRU Replacement	-	30 min	-
Corrective Maintenance operations that do not require car lifting	-	4 hours	-
Corrective Maintenance operations that require car lifting, excluding time required for shunting	-	6 hours	-

Note:

- a) The Corrective Maintenance time as indicated above shall include defect identification, replacement of defective LRUs and restoration to service condition
- b) The design of the Train is expected to meet the following maintenance requirements: -
- The minimum maintenance periodicity shall be at least 7 days.

19.4.13. In addition, the mid-life refurbishment period shall be specified along with complete details during design stage.

19.5 Deleted.

19.6 Maintenance

19.6.1 The trains shall operate with minimum attention between the specified inspection periods, and shall, under the operating conditions specified, operate between overhaul periods without requiring replacement of components other than those on the agreed list of consumable parts to be proposed by the Contractor and accepted by the Project Manager.

19.6.2 Special tools shall be avoided for maintenance. If unavoidable, they shall be supplied by the Contractor in requisite quantities in all the depots to meet the maintenance requirements.

19.6.3 Equipment design shall be modular to minimize down time following failures of equipment and components. Provision for mechanical handling devices shall be provided for any single piece of equipment weighing more than 35kg and all such items shall be identified as a part of Pre-Final Design Review (PFDR). Equipment covers shall be provided with secure, visible, latching arrangements easily inspectable from the side of trains.

19.6.4 All underframe equipment which cannot be handled manually shall be configured such that it can be removed and replaced from track level using fork lift trucks or lift tables, with recognition being given to the confined environment of the pit and the rail level and underframe dimensions.

All underframe equipment shall be arranged such that it is capable of being removed and replaced without disturbing any other equipment.

All such items, that may be required to be accessed and worked upon (including operation) in the event of any unusual occurrence on line shall be such mounted that it shall be very easily accessible to the train operator from PF/track level.

- 19.6.5 If any equipment mounted above the ceiling requires the use of lifting equipment for its removal or refitting this shall be readily achievable without the risk of damage to the vehicle interior.
- 19.6.6 Removal and re-assembly of moving and wearing parts on bogies shall generally be carried out without the use of special tools.
- 19.6.7 Bogies shall be capable of being disconnected and reconnected to vehicle bodies with a minimum of operations. All connections must be easily and safely accessible to personnel located in pits or alongside the bogie at rail level. It shall be easy to inspect for correct reconnection, from alongside the bogie where possible.
- 19.6.8 Preference will be given to a design which permits release of the bogie to permit the raising of the car body, without the need for a pit in the Lifting Berth.
- 19.6.9 Each vehicle shall be capable of being lifted complete with bogies without the need to attach extra restraints or supports for the bogies or wheels.
- 19.6.10 Lubrication points shall have button head type grease nipples, and shall be easily accessible from rail level and shall, where possible, be grouped together.
- 19.6.11 On-vehicle test equipment shall be used on a vehicle to discriminate between a fault on the main equipment and a fault on the control electronic equipment.
- 19.6.12 Should the electronic equipment be found to be faulty, the equipment shall enable fault finding to be carried out at module level.
- 19.6.13 Off vehicle test equipment shall be used in the depot repair centre. This equipment shall allow fault finding down to the smallest replaceable item of equipment.
- 19.6.14 The unit shall have equipment cases and modules that are connected to the main vehicle wiring via connectors which are proven in equivalent service duties to achieve high reliability and are easily removable in the event of equipment replacement.
- 19.6.15 Equipment to which access will be required for fault finding shall be conveniently located. A list of such equipment and their location shall be supplied.
- 19.6.16 The unit shall have provision for the isolation and where applicable, earthing of all electrical sub-systems to facilitate safe and systematic maintenance and fault diagnosis.
- 19.6.17 It shall be physically impossible for plug and socket connections and connections on safety-critical circuits to be mismatched.
- 19.6.18 The unit shall have standard test points on pneumatic systems. There shall be unrestricted access to facilitate checks during routine maintenance and fault diagnosis.
- 19.6.19 The above-mentioned features shall be suitably reflected in the respective design documents, as applicable, during the design stage

19.7 Hazard Analysis report

- 19.7.1. Safety performance shall be assessed by the Risk levels of individual hazards identified during the System Assurance process.
- 19.7.2. The Contractor shall submit the Hazard Analysis report in accordance with the requirements of Chapter 2 of the Employer's Requirements – General Specification and shall evaluate and ensure that all the hazards are identified and satisfactorily resolved.
- 19.7.3. The Contractor shall take lead role in the interface Hazard Analysis for train borne equipment provided by other contractors.
- 19.7.4. The Contractor shall produce the Hazard Analysis Schedule for the complete train including all train borne systems and shall interface principally with the Signalling, Communication, Power Supply, Civil and Depot Contractor as well as any other Designated Contractors to obtain the information necessary, from their hazard analysis, to complete the analysis.
- 19.7.5. The Contractor shall, as part of the safety analysis, prepare analysis to identify Hazards and ensure their satisfactory resolution. The following analysis shall be prepared and submitted by the Contractor for the Project Manager acceptance.
 - i) Preliminary hazard analysis
 - ii) Interface hazard analysis (excluding EMI)
 - iii) Subsystem hazard analysis
 - iv) Operating hazard analysis including maintenance
 - v) Quantitative fault tree analysis
 - vi) Failure modes effects and criticality analysis (FMECA)
- 19.7.6. The Hazard Analysis shall be carried out in accordance with EN50126-1 as the primary standard, or any other internationally accepted equivalent standard, in areas not adequately addressed by the former standard.
- 19.7.7. The Contractor shall compile a list of critical and catastrophic items identified as a result of hazard analysis, FMECA or by other means. The Contractor shall carryout the Hazard and FMECA for the following equipment / sub-systems / systems:
 - i) Bogie and Suspension.
 - ii) Vehicle Body.
 - iii) Transmission Drive System.
 - iv) Gangways.
 - v) Coupler.
 - vi) Brake System.
 - vii) Door System.
 - viii) HVAC System.
 - ix) Pneumatic System.
 - x) Communication System.
 - xi) HV and Propulsion System.

- xii) Auxiliary Power System.
 - xiii) Control equipment.
 - xiv) TCMS.
 - xv) Fire Detection System.
 - xvi) Any item as deemed necessary by the Project Manager
- 19.7.8. All hazard resolution by procedural control shall be cross-referenced from the Critical and Catastrophic Items List to the appropriate manuals.
- 19.7.9. As example, and according to the probability of occurrence associated to the event, these objectives are the qualitative measures of hazard severity are defined as follows:
- i) Hazard Category I – Catastrophic: Operating conditions such that personnel errors, environment, design deficiencies, subsystem or component failure or procedural deficiencies may cause death or system loss. The safety target shall be based on internationally accepted standards.
 - ii) Hazard Category II – Critical: Operating conditions such that personnel errors, environment, design deficiencies, subsystem or component failure or procedural deficiencies may cause severe injury to personnel, severe occupational illness or major system damage. The safety target for the occurrence of all Category II hazards summed together shall again be based on internationally accepted standards.
 - iii) Hazard Category III – Marginal: Operating conditions such that personnel errors, environment, design deficiencies, subsystem or component failure or procedural deficiencies, may cause minor injury to personnel, minor occupational illness or minor system damage.
 - iv) Hazard Category IV – Negligible: Operating conditions such that personnel errors, environment, design deficiencies, subsystem or component failure or procedural deficiencies will not result in injury to personnel occupational illness or damage to the system.
 - v) The Contractor shall submit a Schedule for Hazard Analysis Submissions within 60 days of Effective Date and the Preliminary Hazard Analysis shall be submitted within 6 months of Effective Date. This draft shall include a comprehensive assessment of potential equipment failure modes during normal operating and overload conditions and assess the performance of the equipment for a range of hazard conditions. The final draft shall be submitted by the completion date of final design.
- 19.7.10. The procedures for Operation, Maintenance, Training and the Contractor's Quality Assurance manuals shall incorporate resolution of hazards so identified from this hazard analysis. Proper cross-referencing to the hazards and resolution measures shall be provided in all these aforementioned documents.
- 19.7.11. The following targets norms shall be employed for the Fault Tree Analysis These norms are subject to review by the Project Manager during the detailed design stage, and mutually agreed upon.
- i) No single point failure shall lead to fatality.

- ii) No combination of undetected failure and double point failures shall result in fatality.
- iii) No combination of undetected failure and single point failure shall result in major injury.
- iv) Under no conditions except for those specifically agreed by Project Manager, the train shall be rendered immobilised in section

19.7.12. Source of all failure rates employed to be indicated in the Hazard Analysis.

19.7.13. All hazard analyses submitted to the Project Manager are to be standardized by the Contractor such that format and forms employed by all sub-contractors are the same.

19.8 Fire Safety analysis report

The Contractor shall prepare a Fire Safety analysis report for review and acceptance by the Project Manager as required in Chapter 2 of the Employer's Requirements – General Specification. The design and materials used in the cars shall conform to fire safety requirements of EN 45545 Part 1 to 7 (Hazard level HL3) latest editions as a minimum or better international standard applicable for similar Metro for underground operations with side evacuation, subject to the acceptance of the Project Manager.

The Contractor shall engage an internationally reputed agency for the audit and certification of their fire safety design report. The Contractor shall obtain Project Manager's prior approval before selecting such agency. The audit report & certificate from this agency shall be submitted by the Contractor to the Project Manager.

19.9 Safety Assurance

19.9.1. Safety is defined as freedom from those conditions that can cause death, injury, occupational illness, or damage to or loss of equipment or property, or withdraw the train from service. Is considered as a risk all circumstance susceptible to cause injuries or person death (passengers, operation staff, maintenance staff), and by extension all event leading to a partial or total destruction of costly equipments. The objective of safety is expressed by "the capacity of the rolling material to keep the physical integrity of the passengers and persons in general". The safety of the metro train aims to reduce to an acceptable level the probability of occurrence of catastrophic and critical events (according to norm EN 50126-1).

19.9.2. The Contractor shall submit a 'System Safety Assurance Management Plan' for review and acceptance by the Project manager as specified in the Project manager's Requirements: General Specification chapter 2.

19.9.3. The System Safety Assurance Management Plan shall cover design, manufacture, testing, commissioning and integrated testing, and minimizing the magnitude and seriousness of events or malfunctions, which could result in injury to patrons or staff and damage to equipment or property, but cannot be completely eliminated.

19.9.4. All personnel deployed by the Contractor in BMRCL premises should have undergone requisite training on safety and should have the necessary valid certification from concerned authority.

19.9.5. All equipment and systems, including software, affecting train safety and the safety of train crew and passengers, and/or identified as being "vital", shall be designed according to the following principles:

- i) Only components having a high reliability and predictable failure mode shall be used.
- ii) Components must be utilized in such a manner that ensures that a restrictive, rather than a permissive condition will result from a component failure. (For example: brakes will apply, rather than release; train will decelerate, rather than accelerate.).
- iii) Circuits shall be designed such that when a normally energized electric circuit is interrupted or de-energized, it will cause the controlled function to assume its most restrictive condition. (Broken wires, damaged or dirty contacts, a relay failing to respond when energized, etc., shall not result in an unsafe condition.)
- iv) System safety equipment design must be such that any single independent component or subsystem failure results in a restrictive condition. Failures that are not independent, those failures which, in turn, always cause others, must be considered in combination as a single failure and must not cause a permissive condition.

19.9.6. During the Design Review process, the Contractor shall submit analyses for Project manager review, which demonstrate compliance with these safety principles. These analyses shall address the following issues:

- i) Circuit design.
- ii) Hardware design (Failure Modes, Effect and Criticality Analysis).
- iii) Electrical interference.
- iv) Software errors.
- v) System failures.

20 INSPECTIONS, TESTS AND COMMISSIONING

20.1 General

- 20.1.1. Factory acceptance tests (type test and routine test) at car level and train level shall be in accordance with IEC 61133 and as per tests specified in this chapter. Such tests may be performed either at the Contractor's works, or on site, as appropriate, and as agreed with the Project Manager.
- 20.1.2. The individual equipments, sub-systems and systems, shall be type and routine tested in accordance with the test specifications and test procedures drawn by the Contractor and agreed by the Project Manager. The test specifications shall be based on the requirements specified in respective IEC Standard or any other equivalent International Standards. After successful completion of the tests, Contractor has to submit the test reports for review and acceptance by the Project Manager.
- In addition to 'mandatory' tests as prescribed in IECs, the Contractor shall have to perform any additional test as requested by the Statutory Authority for obtaining the sanction of Rolling Stock for passenger service.
- 20.1.3. All the tests shall be carried out at the Contractor's cost, wherever performed, in the presence of and to the satisfaction of the Project Manager, who reserves the right to witness any or all of the tests and to require submission of any or all test specifications and reports.
- 20.1.4. Wherever any equipment, system or sub-system is not specifically covered by an internationally recognized specification or test procedure, or where the type and routine tests prescribed by IEC or other international standard do not adequately cover the requirement, tests which are acceptable both to the Contractor and to the Project Manager, shall be devised.
- 20.1.5. Type tests for certain equipment may be waived if these were carried out earlier on equipments of identical design, witnessed by a reputed organisation, and the service performance of such equipments was found to be reliable. The Contractor shall submit a proposal in this regard to the Project Manager for review. The waiver of Type Test is entirely at the discretion of the Project Manager.
- 20.1.6. The Project Manager reserves the right to reasonably call for additional tests as are considered necessary, including the quality of welds particularly in highly stressed areas, by non-destructive testing methods. Prototype tests may be required to verify the suitability of the process or the materials proposed. Project Manager may if considered necessary may call for conducting optional tests as per relevant standards without any additional cost to the Employer. In case, repeat tests are required to be performed either on account of failure of original tests or failure of the components/sub-systems/systems, the cost of the repeat test shall be borne by the Contractor. However, cost pertaining to travel and lodging for witnessing the test shall be borne by the Employer.
- 20.1.7. The results of all tests shall be submitted to the Project Manager, who will record his conclusions as to whether or not the equipment being tested has passed satisfactorily.
- 20.1.8. Repeated rejections, at either the Contractor's or a sub-contractor's facilities, shall be cause for the Project Manager to suspend inspection. In such case, the work in

question shall also be suspended until satisfactory corrective action is taken by the Contractor.

20.2 Inspections

- 20.2.1 The Contractor shall perform First Article Inspection (FAI) of all the components. The test reports of all the FAI shall be submitted to the Project Manager for review.
- 20.2.2 The Employer and the Project Manager shall have free access to the Contractor's and sub-contractor's premises, and to any other places where tests are proposed to be carried out, throughout the Contract, for the purpose of reviewing and inspecting the designs and manufacturing processes, and mock-ups. The Contractor shall provide the Project Manager full opportunity to inspect, examine, measure, and test any of the Works on site, or wherever carried out.
- 20.2.3 The Employer and the Project Manager shall be at liberty to inspect the manufacturing process at any stage. Without prejudice to any other provision of the Contract, the Project Manager reserves the right to reject all materials and workmanship, which do not fully conform to the specification.
- 20.2.4 The Contractor shall not be released from any liability or obligation under the Contract by reason of any such inspection, testing or witnessing, nor by submission of reports of inspection or testing to the Project Manager.

20.3 Inspection Hold Points

- 20.3.1 The Contractor shall, propose a set of inspection hold points in the Inspection, Testing and Commissioning Plan. The hold points shall be structured so that a formal hold point is allowed for each significant element of the car's manufacturing process. At each hold point the Inspecting Officer appointed by the Employer shall hold a formal inspection, or advise that the inspection has been waived.
- 20.3.2 The manufacture of each car or part thereof shall not proceed until the inspection by the Inspecting Officer has been completed or waived.
- 20.3.3 The Employer and the Project Manager shall be afforded the opportunity of inspecting all cars, trains and mock-up to be delivered under the Contract before they leave the Contractor's premises. No car shall be considered ready for delivery without Project Manager endorsement in writing.
- 20.3.4 The Contractor shall advise the Project Manager no fewer than 30 days in advance of a car or train being available for inspection and shall notify him of the tests proposed to be carried out. In case inspection is not carried out at the time agreed upon as a result of the Project Manager not being available, the Contractor shall notify the Project Manager immediately and he will deploy an Inspecting Officer within one week. In case the Inspecting Officer fails to turn up within this period, the Contractor may proceed with the work and the Inspection Certificate issued by the Manufacturer will be accepted by the Project Manager.
- 20.3.5 Once the inspection and any required remedial actions are completed to the satisfaction of the Project Manager, he shall give consent for the cars' or trains' shipment and/or dispatch.

20.4 Test Procedure

- 20.4.1 The Contractor shall furnish inspection, testing and commissioning master plan and programs as prescribed in the Employer's Requirements – General Specification (Chapter-4). **(CDRL-20-1)**
- 20.4.2 The Contractor shall submit detailed test procedures for each of the equipment/sub system/system for the review of the Employer as part of design submissions. The plan test procedures shall include the following information: **(CDRL-20-2)**
- i) Relevant specification applicable to each of the tests.
 - ii) Type, routine and special tests to be carried out.
 - iii) Description of the tests, scheduled dates, and locations of the tests.
 - iv) Test parameters to be measured.
 - v) Constraints to be applied during the test.
 - vi) Defined pass/fail criteria
 - vii) Facilities, equipment, and test and measurement tools shall carry an appropriate and valid calibration label and certificate.
 - viii) Test procedures shall be amended, as required throughout the duration of the Contract, to reflect changes in system design or the identification of additional testing requirements
- 20.4.3 As defined in the Employer Requirements –General Specification (Chapter-4), following tests shall be conducted.

20.5 Obligatory Tests on Prototype

- 20.5.1 The prototype 6-car metro train shall be supplied as per the delivery schedule.
- 20.5.2 Clearance of the prototype trains will be granted, only after successful completion of tests at the nominated place by the manufacturer, to the entire satisfaction of the Project Manager. Should any modification/ alteration based on results of the tests on the prototype be required, Contractor will be obliged to carry out necessary modifications at no additional charge on all trains.
- 20.5.3 The Contractor shall manufacture and supply complete 6- car train duly equipped with test and measuring equipment and sensors, for carrying out the following tests, in addition to those specified in IEC 61133 or an accepted International Standard, on respective lines.
- 20.5.4 For obtaining Safety Certification and Technical clearances from Statutory Authority, Contractor shall submit the documents and carry out the tests as specified in Annexure-A, Annexure-B of Procedure for safety certification and technical clearance of metro systems attached at Section XII of Part 4.
- 20.5.5 For introduction of a Rolling Stock in commercial / revenue service, tests are required to confirm that the design meets all the specified safety and statutory requirements and the train is fit for commercial / revenue service. The Contractor shall follow the procedure specified in Metro Railway General Rules-2013 attached at Section XIV of Part 4 for introducing the new Rolling Stock for passenger service

20.5.6 As per statutory requirements in India the passenger coaches have to fulfil the following requirements “under all conditions of track up to maintenance limits” (Table 20.1) at all speeds.

Table 20.1 Obligatory requirements on prototype:

Sl. No.	Term	Conditions	Acceptable Value
1.	Maximum vertical Acceleration on coach body	Measured on car floor of car body as near to bogie centre as possible	$\leq 0.27g$
2.	Maximum lateral Acceleration on coach body	Measured on car floor of car body as near to bogie centre as possible	$\leq 0.27g$
3.	Maximum Dynamic wheel unloading $\Delta Q/Q$		≤ 0.5
4.	Maximum value of RI	Calculated on the basis of acceleration values recorded in items (1 and 2) above	< 3.0 for both vertical & Lateral directions
5.	A general indication of stable running characteristics of the vehicle as evidenced by the movement of the bogie on a straight and curved track and by the acceleration readings and instantaneous wheel load variation.		
6.	The accelerations and spring displacements should decay within 2 to 3 cycles		
7.	There should be no hunting tendency noticeable up to the maximum speed of 90 km/h under any condition.		
8.	Bogie Rotation and Lateral Movement with respect to coach body.	By Measuring Lateral displacements between Bogie frame ends and Car body	Recording must establish that the Bogie can move without undue constraints.
9.	Safety of running.	By measuring Lateral accelerations on Bogie frame	Evaluation by simplified method as given in Para.10.1.3.1(4) of UIC-518.

20.5.7 The Rolling Stock available for such testing under this Contract will be totally new. Hence the evaluation of results will not satisfy the requirements of “under all conditions of track up to their maintenance limits”. Since reaching this condition will take a long time, it is essential that sufficient margin is available in the results of tests now being done so that enough cushion is available for the Rolling Stock to meet the statutory requirements.

20.5.8 BMRCL has decided that the new Rolling Stock on the BMRCL track shall satisfy the following maximum values:

- i) ~~Maximum R.I. for both vertical & lateral modes in inflated conditions = 2.5~~

[Addendum-1 dated 05.12.2022, Sl. No. 164](#)

[Maximum R.I. for both vertical & lateral modes in inflated conditions = 2.75](#)

- ii) Maximum R.I. for both vertical & lateral modes in deflated conditions = 3.0

- iii) Maximum value of vertical acceleration = 0.27 g

- iv) Maximum value of lateral acceleration = 0.27 g

- v) Maximum $\Delta Q/Q$ = 0.5
- vi) Derailment coefficient < 1 (based on simulation)
- vii) The accelerations and spring displacements should decay within 2 to 3 cycles.
- viii) There should be no hunting tendency noticeable up to the maximum speed of 90 km/h under any condition.

Note: The RI calculations will be done as per Para 2.1 of ORE –Report C116 using FFT method (Fast Fourier Transform method).

20.5.9 (i) Chapter VII (Introduction of new type of Rolling Stock) of General Rule 2013: Rule 24 specifies the following: -

- 1) The Metro railway administration when it desires to use new type of Rolling Stock different from those already running on a section of the metro railway, shall apply for sanction for the same to the Central government through the Commissioner
- 2) Any modification in the design of car of Rolling Stock which significantly alters the system of operation and control on the Rolling Stock like change in the braking system, or change in the principle of traction, shall be considered as a material modification and shall constitute a change in the type and design of Rolling Stock
- 3) Any significant modification in the car or Rolling Stock affecting the salient dimensions or suspension system or running gears, and any other modification which affect the riding quality of the Rolling Stock, shall also constitute a change in the type and design of the rolling stock
- 4) For new designs of Rolling Stock, oscillation and or other trials are required to be conducted as per the procedure specified by Central Government from time to time to determine safe speed potential and stability of Rolling Stock. This provision shall also apply for increasing speed of existing Rolling Stock by making improvements.
 - i) The oscillation trials are to be conducted with tare and fully loaded vehicles, in both inflated and deflated conditions up to maximum designed speed starting from 40 km/h in the incremental order of 10 km/h; up to 80 km/h and 90 km/h for inflated conditions, and up to 80 km/h for deflated conditions. Tests can be discontinued at lower speed if unsafe conditions are observed.
 - ii) The oscillation trials will be conducted on track blocks of approximately 200 m each for tangent track and 100m minimum for curve track. The minimum total numbers of blocks will be 25. The results will be calculated for each block separately. The maximum value of each index on the results of evaluation of all blocks independently will be the accepting criteria.
 - iii) The performance of each type of car will be separately evaluated.
 - iv) Besides the above statutory test following investigation test to confirm the safe behaviour of the coach will also be carried out:
 - a) Measurement of natural frequency in Bouncing, pitching and
 - b) Rolling modes using a wedge of 18mm (Investigation test).
 - c) Bogie Rotational resistance (x-factor).

- d) Damping Factors.
- e) Braking Distance Test.

Table 20.2 – The Limiting Values:

S. No.	Term	Conditions	Acceptable Value
1.	Damping factor (under AW0 and AW4 condition) (i) Lateral (ii) Vertical	By quick release side pull test Using wedge of 18 mm thickness	0.30 to 0.40 0.20 to 0.25
2.	Bogie Rotational Resistance	Under tare with inflated & deflated spring conditions	< 0.08 at 0.8 degrees per second rotational speed
3	Emergency braking distance of 6 car train set with all bogie brakes working under fully loaded conditions.	Pick up speed of 80 kmph on level tangent track & apply emergency brakes.	Values as per Table 20.3 below

20.5.10 BMRCL intends to appoint an independent and authorized certifier of Rolling Stock to supervise the trials and certifying the fitment of coaches for inductions in commercial / revenue service. The Project Manager will also witness the trial.

20.5.11 The instrumentation requirements and the manner of conducting the test etc. will be decided by him jointly with the Contractor and approved by the Project Manager. The Contractor shall provide full instrumentation for this purpose.

20.6 Integrated Testing and Commissioning

20.6.1 Complete propulsion system shall be tested on Combined Test Bed as per IEC61377. On completion of testing and commissioning of the Contractor's own system to the satisfaction of the Project Manager, the Contractor shall carry out all tests necessary to verify the functioning of his system with those of other Designated Contractors as per Appendix-D. These tests shall be carried out in various phases and for different sections, as the work progresses.

20.6.2 Tests and test procedures shall be submitted by the Contractor for acceptance by the Project Manager or as required by him.

20.6.3 The Integrated test procedures shall include, but not limited to, the necessary tests to verify the functioning with the Designated Contractors responsible for the following systems:

- i) Signalling and Train Control
- ii) Telecommunication
- iii) Third rail Equipment
- iv) Civil Constructions for underground sections
- v) Track works
- vi) Station Construction

vii) Depot Equipment Supply

20.6.4 All defects and shortfalls in the Contractor's system, discovered in the course of Integrated Testing and Commissioning, shall be made good and re-tested to the satisfaction of the Project Manager before the commencement of service trials.

20.6.5 On completion of the integrated testing and Commissioning, to the satisfaction of the Project Manager the Contractor shall confirm in writing to the Project Manager that the Rolling Stock provided by him is suitable for the purpose of service trials.

20.7 Service Trials

20.7.1 The prototype and other trains shall be subjected to pre-revenue Service Trials. Service trials are intended to prove not only the satisfactory running performance of the cars, but also to enable practical evaluation of their reliability in service, ease of maintenance and operation, in parallel with the work of other Designated Contractors, and adequacy of the cars and equipment for all performance requirements envisaged in the specification.

20.7.2 Service Trials for the prototype train shall be carried out for a minimum of 2500 km and for other trains 750 km.

20.7.3 The Contractor shall submit the Service Trial Procedure for review by the Employer, enlisting the various operability and maintainability aspects to be performed during the service trials.

20.7.4 During the Service Trial period, the Contractor shall make the train set completely fit for introduction in commercial / revenue service.

20.7.5 The Contractor shall make all necessary arrangements including temporary provisions in his system to ensure safety during service trial period. The Contractor shall provide full support by way of driving Instructors, staff and material during the Service Trials.

20.7.6 During the pre-revenue operations, the Contractor and designated contractors, will run trains subject to constraints of the ongoing construction activities.

20.7.7 Trains shall be inducted into Commercial / revenue Service only after Service Trials to ensure that functions and operations of various systems are satisfactorily integrated and permit all the technical systems to stabilise.

20.7.8 Upon completion of Service trials the Contractor shall submit a statement confirming that the Rolling Stock is safe and ready for commencement of commercial / revenue service.

20.8 Special Tests

The Contractor shall carry out the requisite tests to demonstrate the performance of equipment, sub system and system as per procedure mentioned above. The following clauses specify tests which are either not covered by standard specifications or require the provisions of the standard specification to be modified to some extent.

20.9 Vehicle Body Shell Tests

20.9.1 Car body strength test shall be carried out and a lifting test shall also be performed in accordance with EN 12663, under simulated loads and as specified in ERTS clause 6.10 as type test.

- 20.9.2 Crashworthiness shall be proved by submission of detailed calculations and demonstration by means of finite element analysis and simulations. Similar vehicle test results shall be submitted to establish proven design.
- 20.9.3 The strength of the saloon car side wall windows and of those in the doors shall be performed in accordance with EN 12663, as a type test.
- 20.9.4 The strength of the cab windscreen shall be tested in accordance with the requirements of both UIC 651 and UIC 566/EN 12663, also as a type test.
- 20.9.5 The strength of couplers and draught gear shall be carried out in accordance with international practice, also as a type test.
- 20.9.6 The car body shall also be subjected to a vertical deflection test. All side doors, on one side of the car shall be installed, complete with drive mechanisms, and all sealing and weather-stripping.
- 20.9.7 At each increment of test load the doors shall be opened and closed by means of the door controls. Any failure to operate at the prescribed speed profile, or any indication of binding, shall require corrective action to be taken by the Contractor, to the car structure, to the door arrangement, or both.
- 20.9.8 One out of six carbody shell shall be subjected to water tightness test as per an agreed procedure. If water leakage is observed in any of the tested shell then every subsequent carbody shell shall be subjected to water tightness test. All the fully assembled cars shall be tested for water tightness as per IEC 61133.
- 20.9.9 For the floor, fire test as per ERTS clause 9.10.9, noise suppression test and endurance tests shall be carried out by the Contractor to establish the performance.

20.10 Bogie Tests

- 20.10.1 The bogie frame shall be subject to static as well as fatigue tests in accordance with UIC 515-4 for T car bogie and UIC 615-4 for DM and M car bogie, with the design load as specified in Chapter 10. This shall be a type test.
- 20.10.2 Tests for clearances in the bogie, between bogie and body and between adjacent coupled cars shall be carried out on straight track as a routine test and on BMRCL mainline including 120m curve as a type test.
- 20.10.3 Tests for clearances in the bogie, and between bogie and body shall also be carried out by rotating the bogie to simulate a 90m radius curve. This shall be a type test.
- 20.10.4 The Contractor shall perform a wheel-unloading test to verify the calculations submitted. The test shall be conducted in the most disadvantageous combination of unloading and suspension conditions.
- 20.10.5 A load deflection test and accelerated ageing tests shall be performed to demonstrate that the spring rate of the primary suspension system and the creep rate for the materials used are within the design limits.
- 20.10.6 These tests shall prove that the primary suspension system behaves as predicted and will not result in excessive deflection or a decrease in bogie clearance above top of rail to less than the minimum specified herein.
- 20.10.7 Wheel disc and axle shall be subjected to type tests and routine tests as per EN 13262 and EN 13261.

20.10.8 Gear box and coupling shall be type tested as per ERTS clause 10.9.4.

20.11 Passenger Saloon Door, Type Tests

20.11.1 The body side doors shall be tested for strength as required in Chapter 8, for relevant parameters which are required to be met.

20.11.2 The following type test shall be carried out on a complete double leaf door and operating assembly equipment with its control gear.

(i) Endurance. One million operations shall be performed. A record of the velocity profile shall be taken at the beginning and the end of the test. It should also be demonstrated that no undue wear or compression of seals has occurred. This test shall be performed under representative dry and wet conditions.

(ii) Vibration Tests

Vibration test shall be carried out as defined in IEC 61373.

20.12 Passenger Saloon Door, Routine Tests

20.12.1 These will comprise functional test to verify that performance is consistent with accepted type test results and shall include tests to IEC 60077 1 and 2 for the electrical portion.

20.13 Seats

20.13.1 Passenger Seat and driver seat performance Tests. The seat assembly shall withstand without permanent deformation with type test strength requirements based on international recognized standards, subjected to mutual agreement.

20.14 Saloon to Cab Door Type tests

20.14.1 The Prototype Saloon to Cab door shall be subjected to an endurance test of one hundred thousand (100,000) operations, during which it shall be demonstrated that no component fails.

20.15 Air compressor and Motor Test

20.15.1 Type test: Starting Test. The motor shall undergo type- and routine-tests in accordance with IEC 60349-2, Electric Traction. Rotating Electrical Machines for Rail and Road Vehicles, Part 2-Electronic Converter Fed Alternating Current Motors. The compressor shall undergo type- and routine-tests in accordance with ISO 1217: 1996.

20.15.2 Type test: Voltage Interruption Test. The supply shall be interrupted and restored, at intervals of one second, five times in succession, allowing the normal load conditions to be re-established between successive interruptions, the motor operating at its maximum voltage and rated load. The motor shall withstand the test without mechanical deterioration.

20.15.3 Type test: Heat Run. The set shall be tested at its rated voltage against the specified pressure for six hours, to show that the motor temperature rise does not exceed the specified limit, based on the class of insulation, and that the permissible temperature rise of the compressor is not exceeded.

20.16 Brake Equipment Type Tests

20.16.1 Disc brake/Tread brake; Following Tests shall be carried out:

- i) Functional checks such as working stroke, slack adjuster operation and parking brake action.
- ii) Recording of the relationship of disc brake pad/tread brake block force to cylinder pressure over the full working range.
- iii) Plotting of brake force against pressure curves in all conditions of operation of brake cylinder and parking brake.
- iv) Vibration test as defined in IEC 61373.
- v) Air leakage test.

20.16.2 Brake Lining: The Contractor shall carry out testing of brake lining in respect of coefficient of friction with respect to the brake system proposed (wheel disc brake, tread brake) under dry and wet conditions, maximum temperature attained during braking, rate of wear etc as per UIC Standard.

20.16.3 Brake Control Equipment: individual items of electro-pneumatic equipment shall be type tested as follows:

- i) Mechanical Operation and Endurance as defined in IEC 60077 1 and 2
- ii) Vibration and Shock as defined in IEC 61373.
- iii) Air Tightness generally as in IEC 60077 1 and 2.
- iv) Electrical Test, generally as in IEC 60077 1 and 2.
- v) Characteristic Tests.
- vi) Each item of equipment having a pilot or transducing function, shall be tested to confirm compliance with the Contractor's design data. Oscillograms shall be produced in support.
- vii) Type Tests on Electronic Equipment. The electronic equipment used in brake system shall be tested as laid down in IEC 60571 and EN 50121-3-2.

20.16.4 WSP Test: Complete train (AW0 & AW4) shall be subjected to Wheel slip-slide type test as per UIC 541-05. The detail type test specification shall be got agreed from the Project Manager. Followings shall be included in the type test.

- i) Braking Modes as EB (Emergency Brake), FSB (Full Service Brake with ED Dynamic Brake), FSB (Full Service Brake without ED Dynamic Brake) and EB (Emergency Brake) with 1 M car isolated and EB (Emergency Brake) with 3 bogies isolated for Evaluation with at least 4 valid runs each.
- ii) Braking Modes as FSB (Full Service Brake with ED Dynamic Brake) followed by Failure of ED Dynamic Brake and FSB (Full Service Brake with ED Dynamic Brake) followed by EB (Emergency Brake) for Reference with at least 3 valid runs each.
- iii) Low Speed and Low Adhesion WSP Tests will be done for reference at speeds of 25kmph and initial adhesion < 5%

- iv) Initial Adhesion will be evaluated as per UIC i.e. when First axle starts sliding irrespective of location on train. In case of Full Service Brake with Dynamic Brake First axle to slide is expected from Motor car due to Dynamic Brake applied on Motor Car.
- v) An Axle will be considered Sliding if its speed is at least 10% lesser than Reference Speed.
- vi) Minimum Slide Criteria will be fulfilled on the basis of Braked Axles of complete Train Set i.e. At least 50% of braked axles, of train. Axle will be considered Sliding if it is sliding for more than 35% of the time (Actual time taken from 85-45 or 60-30).
- vii) Extension of Stopping Distance in Wet Condition over Dry Condition, for Adhesion Level of 6-8% will be 15% and 25% for adhesion level of 5% upto 6%.

Braking Distance under Dry condition and tangent track shall be within the distances specified in the Table 20.3.

WSP software shall be fine-tuned to ensure minimum reduction of brake distance due to low adhesion and shall be state of art being used in metros worldwide by the Contractor.

Table:20.3 – Braking Distance under Dry condition

Braking Mode	Speed (Kmph)	Maximum Braking distance for AW0 and AW4 (Meters)
		DRY
EB	80	181
	60	104
EB (1 car isolated)	80	216
	60	124
FSB with ED	80	251
	60	146
FSB w/o ED	80	251
	60	146

20.17 Complete Brake System, Type Tests

20.17.1 A complete set of brake equipment comprising all items of equipment forming the Brake System shall be assembled and shall be subjected to brake system bed test. These shall include the Brake Controller and interface with ATO equipment and a transceiver to measure force at the push rod of Brake unit. A complete series of tests shall be carried out on this rig under all service conditions to demonstrate the function of the brake system as a whole, both in manual and auto modes.

20.17.2 The Contractor may submit a proposal to combine the test of individual items with the system test if agreed by for review and acceptance of the Project Manager.

20.17.3 Instrumented tests shall be carried out at train level both in tare and loaded condition, to establish designed performance of pneumatic/ regenerative braking. Similarly, emergency braking distance tests shall be carried out in tare and loaded condition under dry and wet rail conditions. Wheel Slide Protection system shall be tested under dry and wet rail conditions. The Contractor shall submit detailed Test Procedure for review by the Project Manager.

20.17.4 The prototype train shall be used for carrying out emergency braking distance trials under tare and loaded conditions of the train as per IEC 61133.

20.18 Complete Brake System, Routine Tests

20.18.1 All reservoirs shall be tested to an appropriate international pressure vessel standard and necessary test certificates shall be provided from a recognised test agency.

20.19 Propulsion System Type Tests

20.19.1 The Contractor shall, in addition to type tests carried out individually on all electrical equipment, in accordance with internationally accepted specifications, shall undertake combined propulsion, braking and TCMS test, using simulated loads on the traction motors. The testing shall reflect, as far as practicable, the layout of equipment on the car. Combined propulsion system testing shall be in accordance with IEC 61287-1 and IEC 61377-1.

20.19.2 Testing shall include simulated service operation, fault handling, including wheel slip/wheel slide control, braking and load weight interfaces and abnormal operation and failure condition operation.

20.20 Auxiliary Systems, Type Test

20.20.1 Testing shall be carried out to demonstrate the ability of the auxiliary power system to provide the required level of standby power under the normal and emergency conditions.

20.20.2 Type tests shall be carried out on the lighting system including performances.

20.20.3 Type tests shall be carried out on the Battery in accordance with the requirements of IEC 60623 and shall also meet the requirements of IEC 60993 including emergency load tests.

20.21 TCMS Type Test

20.21.1 The Contractor shall perform tests on the TCMS system to verify designed capacity of the systems, proper functioning, robustness, efficiency, ease of use and maintenance for the TCMS software, with reference to the design specification, functional requirements and correct interfaces as described in Chapter 16. The real interface hardware and software should be used where possible. All software parameters, as well as the functionality and reliability of its associated hardware shall be validate on-board a completed train. The test procedure shall be submitted for acceptance by the Project Manager, prior to commencement of the test.

20.22 Roof Mounted HVAC Package Unit Type Tests

20.22.1 The following tests shall be carried out at the manufacture's works or a reputed testing laboratory on the prototype unit in the presence of the Project Manager.

- i) Dimensional and visual inspection.

ii) Conditioned air delivery test

- This test shall be conducted by adjusting static head at 25 mm WG over conditioned room air.
- Air velocity measurements shall be recorded at both return air filters. Both fresh air filters shall be closed.

iii) Fresh Air Quantity Test

Measurements of fresh air quantity shall be made with fresh air openings in

- fully opened and
- in the minimally opened condition to assess maximum and minimum air quantities.

iv) Cooling Capacity Test

- The package unit shall be tested in a climate laboratory capable of simulating the ambient environment and applicable heat loads. This test shall be made in the following conditions keeping static head of supply air at 25mm WG:

Table 20.4 HVAC unit test criteria:

Weather Conditions	External temperatures	Internal Conditions
Summer	Dry Bulb 35.2°C Wet Bulb 19.6°C	Dry Bulb 25°C < 60 % RH
Monsoon	Dry Bulb 27.3°C Wet Bulb 23.0°C	Dry Bulb 25°C < 60 % RH

- Cooling capacity shall be calculated both on the condenser and the evaporator side.

v) High Ambient Test

The aim of this test is to verify capacity of the HVAC unit at 100% cooling at ambient temperature up to 45°C and at 50% at temperature from 45°C to 52°C and the pressure should not exceed 2850 kpa. High pressure trip setting may be adjusted accordingly.

vi) Coefficient of performance of HVAC shall be validated during this test.

20.22.2 The power input to the module, as well as to each of the motors shall be recorded.

20.22.3 Insulation Resistance Test: insulation resistance tests under all weather conditions shall be undertaken on all equipment, using a 1kV D.C. Megger tester. The resistance reading shall in no case be less than 100MΩ.

20.22.4 Dielectric Test: the equipment shall withstand a high potential difference of 2kV for a duration of one minute.

20.22.5 Vibration and Shock Tests: this test shall be done as per IEC 61373.

20.22.6 EMC Test: EMC test shall be carried out in accordance with EN 50121-3-2: 2000 on one unit

20.22.7 Testing of Emergency Inverter: The Emergency Inverter unit shall be tested in accordance with IEC 61287 and IEC 61373.

20.22.8 All rotating electrical machines shall be tested in accordance with IEC 60349-2: Electric Traction – Rotating Electrical Machines for Rail and Road Vehicles Part 2- Electronic Converter Fed Alternating Current Motors.

20.23 Complete Car HVAC System Type Test

20.23.1 One car body equipped with all interior finish and all under frame mounted equipment, shall be tested to demonstrate the effectiveness of the equipment in meeting the specified temperature and humidity conditions inside the car. Heating and humidifying equipment shall be provided in the car for test purposes. Complete car shall be placed in the environment chamber and test conditions as specified (including those in the relevant EN) shall be conducted.

20.23.2 The extent of such test shall be decided by the Project Manager but shall include, as a minimum, the following:

- i) Air Flow Test; Air flow will be checked at the fresh air inlet to the unit, and at the return air inlet.
- ii) Air Distribution Tests. Saloon air ducts shall be checked to ensure even distribution of air along each duct.
- iii) Cooling capacity test (with doors opening every 2 minutes for 30 sec) including pre-cooling from steady state environmental condition.
- iv) High Ambient test.

20.24 Complete Car HVAC System Routine Tests

20.24.1 Every roof mounted HVAC package unit shall be subjected to routine test at the manufacturer's works as given below:

- i) Preliminary check
- ii) Phase check for AC power supply and Polarity check for DC power
- iii) Operation check and fresh Air flow test
- iv) Failure check (On-board test from TCMS)
- v) Emergency ventilation test
- vi) Smoke detector test
- vii) Damper operation check

20.25 Rescue Operation

20.25.1 After delivery of two trains, the ability of one healthy train to rescue a disabled train shall be tested as specified in clause 3.9 of ERTS.

20.26 Noise and Vibration, Verification

20.26.1 The Contractor shall perform noise and vibration type tests on complete 6 car metro trains to demonstrate compliance with clause 3.13 of ERTS. All test procedures, data and results shall be submitted to the Project Manager for acceptance.

20.27 Fire Performance Verification

20.27.1 Type tests according to the relevant ASTM, NFPA, BS, EN and NFF standards shall be undertaken to establish fire ratings for all materials proposed. However, test

certificates from any Testing Agency of international repute may be accepted in lieu by the Project Manager at his sole discretion.

20.27.2 Fire Detection System Functional Tests

The aim of these tests is to prove functionality and positioning of smoke and heat detectors in passenger areas and heat detectors/LHD in electric cabinets (enclosures/cubicles). The tests shall conform to the requirements of the ARGE Guideline (Part-1 for "Fire detection in Rolling Stock" and Part-3 for "System functionality fire detection & fire fighting in Rolling Stock") or any other applicable international standard.

Type tests shall be conducted for the following:

- i) Dual Smoke and Heat detectors (multi-sensors),
- ii) Heat Detectors,
- iii) Linear Heat Detectors (LHD).

20.28 System Safety Verification Tests

20.28.1 General: The Contractor shall perform safety testing to demonstrate the effectiveness of the safety features and devices incorporated into the design of the metro train. The Contractor shall verify all safety critical items and interfaces through testing and analysis as Safety Requirements.

20.28.2 Identification of those critical vehicle subsystems or subsystem elements to be subjected to safety tests, including the following:

- i) Automatic protection equipment;
- ii) Interlocks;
- iii) Trainlines, including couplers;
- iv) Communication links;
- v) Train Control (TC) interfaces between equipment supplied by the Vehicle Contractor and equipment supplied by the TC Contractor;
- vi) Propulsion;
- vii) Braking subsystem, normal and emergency;
- viii) Passenger door operation and safeguards;
- ix) Emergency ingress/egress equipment;
- x) Flammability and smoke emission of materials;
- xi) Vehicle safety equipment;

20.29 EMC Testing

20.29.1 The Contractor shall perform measurements to demonstrate EMC requirements specified in clause 3.12 of ERTS have been achieved. Demonstration of EMC compliance shall be considered a type test requirement.

20.30 Integrated Testing with Signalling -Train Control – Telecommunications Contractors

20.30.1 Integrated testing of each car shall comply with the accepted international standards agreed between the Contractors as agreed with the Project Manager. Integration testing shall be done at the Rolling Stock factory and main line to ensure satisfactory performance of all train control and telecommunications interfaces as per Appendix-D. The test certificate subsequently shall be issued jointly by the Rolling Stock, Signalling and Train Control, and Telecommunications contractors.

20.30.2 In case of ATO, the Integration test between the Rolling Stock, and Signalling and Train Control contractors shall include tests on mainline to confirm the realisation of demanded acceleration and deceleration rate by the ATO under various conditions.

20.31 Car Weight

20.31.1 The Contractor shall weigh each complete car before shipment. The weight of each car shall not differ from the target control weight by more than 2%. In addition, bogies of prototype train i.e. DMC, TC and MC each shall be weighed separately. Certified weight tickets shall be submitted to the Project Manager and copies thereof included in the car record book. Vehicle weight balance in tare condition shall follow the requirements of IEC 1133: 1992".

20.32 Deliverables

Contract deliverables required by this section of these Technical specifications are summarized below:

CDRL-20-1:	Inspection, testing and commissioning master plan and programs as prescribed in the Employer's requirements – General Specification (Chapter-4). (ref. ERTS 20.4.1)
CDRL-20-2:	Detailed test procedures for each of the equipment/sub system/system (ref. ERTS 20.4.2)



BANGALORE METRO RAIL CORPORATION LIMITED

BID No. 5RS-DM

**DESIGN, MANUFACTURE, SUPPLY, INSTALLATION, TESTING AND COMMISSIONING
OF 318 NOS. OF STANDARD GAUGE METRO CARS AND TRAINING OF PERSONNEL
INCLUDING COMPREHENSIVE MAINTENANCE UPTO FIFTEEN (15) YEARS UNDER
BANGALORE METRO RAIL PROJECT PHASE-2, 2A AND 2B**

PART- 2

- **SECTION-VI B: APPENDICES TO ERTS (EMPLOYER'S REQUIREMENTS –
TECHNICAL SPECIFICATIONS)**

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APPENDICES TO ERTS (EMPLOYER'S REQUIREMENTS – TECHNICAL SPECIFICATIONS)

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21 APPENDIX A. INTERNATIONAL STANDARDS**21.1 General**

- 21.1.1 A list of international standards used and applied to the material and workmanship to be supplied will be prepared and updated during the design stage. This list will be mutually agreed to.
- 21.1.2 During the design phase, the Contractor shall provide original copies of the standards used, with transfer of rights to BMRCL, as part of the Contract.
- 21.1.3 The standards shall preferably be provided in electronic format (soft copy). However, in case the same is not available, with the Project Manager's consent, original printed copy can be provided.
- 21.1.4 Standards are set out in alphabetical order of the Standards Organization (in English) in tables A1 to A18.
- 21.1.5 Where international or national standards are quoted and specified in the Contract, the Contractor may propose to work to equivalent internationally or nationally recognized standards. Not systematically, but if necessary, the Project Manager can require the Contractor to prove the equivalence between the European and other standards. Submission for Approval are to be supported by a copy of the proposed standards, a detailed comparison of the quoted and proposed standards and, where applicable, an English translation of the proposed standard;
- 21.1.6 Last version of the standards are required and also in case of standard replacements by more recent and equivalent standards,

Table A.1 American Society for Testing and Materials Standards

Standard Organization	Standard Reference Number	Title or Description of the Standard
ASTM	A36/A36M	Specification for carbon structural steel
ASTM	B 247	Specification for aluminum and aluminum-alloy die forgings, hand forgings, and rolled ring forgings
ASTM	A 480	Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip
ASTM	GR 301 L	Stainless steel grade 301 L
ASTM	B 280	Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service
ASTM	B 743	Standard Specification for Seamless Copper Tube in Coils
ASTM	D 2563	Standard Practice for Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts

Table A.2 British Standards Institution

Standard Organization	Standard Reference Number	Title or Description of the Standard
BS	476-7:1997	Fire tests on building materials and structures – method of test to determine the classification of the surface spread of flame of products
BS	1571: Pt. 2 1975	Specification for testing of positive displacement compressors and exhausters. Methods for simplified acceptance testing for air compressors and exhausters
BS	3682 Pt.1: 1994	Specification for railway brake hose. Specification for compressed air brake hose
BS	7668:2016	Weldable structural steels. Hot finished structural hollow sections in weather resistant steels. Specification
BS	5000-11:1973 (R12)	Specification for rotating electrical machines of particular types or for particular applications. Small-power electric motors and generators
BS	7608:2014+A1:2015	Guide to fatigue design and assessment of steel products
BS	7671:2008+A3:2015	Requirements for electrical installations
BS	9000 (1/2/3/4/5/6/7/8.1)	General requirements for a system for electronic components of assessed quality
BS	857:1967 (R12)	Specification for safety glass for land transport
BS	5892-6:1992	Railway Rolling Stock Materials. Specifications for wheelsets for traction and trailing stock
BS	HD 60269-2:2013, 88-2:2013	Low-voltage fuses. Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial application). Examples of standardized systems of fuses A to K
BS	3900	Methods of Test for Paint.
PD CLC/TR	50427:2004	Assessment of inadvertent ignition of flammable atmospheres by radio-frequency radiation. Guide
BS	7371-10:1994	Coatings on metal fasteners. Specification for organic coatings

Table A.3 CISPR

Standard Organisation	Standard Reference Number	Title or Description of the Standard
CISPR	16 1-1 2007	Specification for radio disturbance and immunity measuring apparatus and methods – part 1-1: radio disturbance and immunity measuring apparatus – measuring apparatus

Table A.4 German Standards / Deutsches Institut für Normung

Standard Organisation	Standard Reference Number	Title or Description of the Standard
DIN	2353: 2013-01	Solderless Pipe Fittings with Cutting Ring – Complete Fitting and Overview
DIN	7500-1: 2009-06	Thread-rolling screws for ISO metric thread – Part 1: Technical delivery conditions for case-hardened and tempered screws
DIN	7500-2: 2016-04	Thread-rolling screws for ISO metric threads – Part 2: Guide values for hole diameters
DIN	5566-1 to 3	Railway vehicles – Driver cabs
DIN	43263: 1971-12	Current collector for contact rail; directives for selection of dimensions
DIN	43265	Current collector for contact rail; main dimensions

Table A.5 Euro Norms

Standard Organisation	Standard Reference Number	Title or Description of the Standard
EN	3-7:2004+A1:2007	Portable fire extinguishers. Characteristics, performance requirements and test methods
EN	286-1:1998+A2:2005	Simple unfired pressure vessels designed to contain air or nitrogen – part 1: pressure vessels for general purposes
EN	286-3:1995	Simple unfired pressure vessels designed to contain air or nitrogen – part 3: steel pressure vessels designed for air braking equipment & auxiliary pneumatic equipment for railway rolling stock
EN	286-4:1995	Simple unfired pressure vessels designed to contain air or nitrogen – part 4: aluminium alloy pressure vessels designed for air braking equipment and auxiliary pneumatic equipment for railway rolling stock
EN	573 1/2/3/5:2013	Aluminium and aluminium alloys – chemical composition and form of wrought products
EN	754-2:2016	Aluminium and aluminium alloy cold drawn rod/bars and tube – part 2: mechanical properties
EN	755-1 to 9: 2016	Aluminium and aluminium alloys
EN	779:2012	Particulate air filters for general ventilation – determination of the filtration performance
EN	1011-1:2009	Welding – recommendations for welding of metallic materials – part 1: general guidance for arc welding
EN	1011-2:2001	Welding – recommendations for welding of metallic materials – part 2: arc welding of ferritic steels
EN	1011-4:2000	Welding – recommendations for welding of metallic materials – part 4: arc welding of aluminium and aluminium alloys

Standard Organisation	Standard Reference Number	Title or Description of the Standard
EN	1288	Determination of the bending strength of glass. Test with specimen supported at two points (four-point bending)
EN	10025-1 to 5:2004	Hot rolled products of structural steels
EN	10217-7:2014	Welded steel tubes for pressure purposes – Technical delivery conditions – Part 7: Stainless steel tubes
EN	10293:2015	steel castings for general engineering uses
EN	10210:2006	Hot Finished Structural Hollow Sections of Non-Alloy and Finer Grain Structural Steels.
EN	12663:2010	Structural requirements for Railway Vehicle Bodies “.
EN	12681:2017	Founding. Radiographic testing.
EN	13103:2009+A2:2012	Railway applications – wheelsets and bogies – non-powered axles – design method
EN	13104:2009+A2:2012	Railway applications – wheelsets and bogies – powered axles – design method
EN	13129:2016	Railway applications. Air conditioning for main line rolling stock. Comfort parameters and type tests.
EN	13452-1:2003	Railway applications – braking – mass transit brake systems – part 1: performance requirements
EN	13452-2:2003	Railway Applications – Braking – Mass Transit Brake Systems – Part 2: Methods of test.
EN	13260:2009+A1:2010	Railway applications – Wheel sets and bogies – Wheel sets – Product requirements
EN	13261:2009+A1:2010	Railway applications – wheelsets and bogies – axles – product requirements
EN	13262:2004+A2:2011	Railway applications – wheelsets and bogies – wheels – product requirement
EN	13 272:2012	Railway applications – electrical lighting for Rolling Stock in public transport systems
EN	13306:2017	Maintenance. Maintenance terminology
EN	13749:2011	Railway applications. Wheelsets and bogies. Method of specifying the structural requirements of bogie frames
EN	14363:2016	Railway applications. Testing and Simulation for the acceptance of running characteristics of railway vehicles. Running Behaviour and stationary tests
EN	14750-1:2006	Railway applications – air conditioning for urban and suburban Rolling Stock – part 1: comfort parameters
EN	14750-2:2006	Railway applications – Air conditioning for urban and suburban Rolling Stock – Part 2: Type tests
EN	14752:2015	Railway applications – Body side entrance systems for rolling stock
EN	15085:2007	Railway applications — Welding of railway vehicles and components
EN	15227:2008+A1:2010	Railway applications — Crashworthiness requirements for railway vehicle bodies

Standard Organisation	Standard Reference Number	Title or Description of the Standard
EN	23270:1991	Specification for temperatures and humidity for conditioning and testing paints, varnishes and their raw materials
EN	45545 Part 1 to 7:2013	Railway applications. Fire protection on railway vehicles.
EN	50085-1/2.1/2.3	Cable trunking systems and cable ducting systems for electrical installations
EN	50121 (1/2/3/3.1/3.2/4/5)	Railway Application – Electro-Magnetic Compatibility
EN	50124	Railway applications – insulation coordination
EN	50125-1:2014	Railway applications. Environmental conditions for equipment. Rolling Stock and on-board equipment
EN	50126-1:2017	Railway Applications. The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS). Generic RAMS Process
EN	50126-2:2017	Railway Applications. The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS). Systems Approach to Safety
EN	50128:2011	Railway applications – communications, signalling and processing systems – software for railway control and protection systems
EN	50129:2003	railway applications – communication, signalling and processing systems – safety related electronic systems for signalling
EN	50155:2017	Railway applications. Rolling stock. Electronic equipment
EN	50159:2010	Railway applications. Communication, signalling and processing systems. Safety-related communication in transmission systems
EN	50163:2004+A1:2007	railway applications – supply voltages of traction systems
EN	61287-1:2014	Railway applications. Power converters installed on board rolling stock. Characteristics and test methods
EN	50264-1:2008	Railway applications. Railway Rolling Stock power and control cables having special fire performance. Part 1. General requirements
EN	50264-2-1:2008	Railway applications – Railway Rolling Stock power and control cables having special fire performance – Part 2-1: Cables with crosslinked elastomeric insulation – Single core cables
EN	50264-2-2:2008	Railway applications – Railway Rolling Stock power and control cables having special fire performance – Part 2-2: Cables with crosslinked elastomeric insulation – Multicore cables
EN	50264-3-1:2008	Railway applications – Railway Rolling Stock power and control cables having special fire performance – Part 3-1: Cables with crosslinked elastomeric insulation with reduced dimension – Single core cables

Standard Organisation	Standard Reference Number	Title or Description of the Standard
EN	50264-3-2:2008	Railway applications – Railway Rolling Stock power and control cables having special fire performance – Part 3-2: Cables with crosslinked elastomeric insulation with reduced dimensions – Multicore cables
EN	61386-24:2010	Specification for conduit systems for cable management – particular requirements for conduit systems buried underground
EN	50306 1/2/3/4:2002	Railway applications – Railway rolling stocks cables having special fire performances
EN	50343:2014+A1:2017	Railway applications – Rolling Stock – rules for installation of cabling
EN	50355:2013	Railway applications – Railway Rolling Stock cables having special fire performance
EN	50347:2001	General purpose three-phase induction motors having standard dimensions and outputs. Frame numbers 56 to 315 and flange numbers 65 to 740
EN	60077-1:2017	Railway applications – Electric equipment for Rolling Stock – Part 1: General service conditions and general rules
EN	61000	Electromagnetic Compatibility (EMC)
EN	61010-1:2010	safety requirements for electrical equipment for measurement, control and laboratory use.
EN	61238-1:2003	Compression and mechanical connectors for power cables for rated voltages up to 36 kv (u[m] = 42 kv) – part 1: test methods and requirements
EN	61287-1:2014	Railway applications – Power convertors installed on board Rolling Stock – Characteristics and test methods
EN	61386:2008	Conduit systems for cable management
EN	438-2:2016	High-pressure decorative laminates (HPL) – Sheets based on thermosetting resins (Usually called Laminates) – Part 2: Determination of properties
EN	10089:2002	Hot rolled steels for quenched and tempered springs —Technical delivery conditions
EN	15152 :2007	Railway applications- Front windscreens for train cabs
EN	62676-4:2015	Video surveillance systems for use in security applications. Application guidelines
EN	50533:2011+A1:2016	Railway applications – Three-phase train line voltage characteristics
EN	55011:2016+A1:2017	Industrial, scientific and medical equipment radio-frequency equipment – disturbance characteristics – limits and methods of measurement
EN	55035:2017	Electromagnetic compatibility of multimedia equipment. Immunity requirements
EN	60077-2:2017	Railway applications. Electric Equipment for rolling stock. Electrotechnical components. General rules
EN	10293:2015	Steel castings. Steel castings for general engineering uses

Standard Organisation	Standard Reference Number	Title or Description of the Standard
EN	60332	Tests on electric and optical fibre cables under fire conditions.
EN	10210-1:2006	Hot finished structural hollow sections of non-alloy and fine grain steels. Technical delivery requirements
EN	10025-(1/3/4):2004	Hot rolled products of structural steels.
EN	61386-1:2008	Conduit systems for cable management. General requirements
EN	61238-1:2003	Compression and mechanical connectors for power cables for rated voltages up to 36 kV ($U_m = 42$ kV). Test methods and requirements
EN	45545-1 to 7	Railway applications. Fire protection on railway vehicles.
EN	60529:1992+A2:2013	Specification for Degrees of Protection Provided by Enclosures (IP Code)
EN	10293:2015	Steel castings. Steel castings for general engineering uses
EN	61010	Safety requirements for electrical equipment for measurement, control and laboratory use.
EN	1725:1998	Domestic furniture. Beds and mattresses. Safety requirements and test methods
EN	10293:2015	Steel castings. Steel castings for general engineering uses
EN	1011-2:2001	Welding. Recommendations for welding of metallic materials. Arc welding of ferritic steels

Table A.6 International Electro-Technical Commission

Standard Organisation	Standard Reference Number	Title or Description of the Standard
IEC	60349-1:2010	Electric traction – rotating electrical machines for rail and road vehicles – part 1: machines other than electronic convertor-fed alternating current motors
IEC	60349-2:2010	Electric traction – rotating electrical machines for rail and road vehicles – part 2: electronic convertor-fed alternating current motors
IEC	TS 60349-3:2010	Electric traction – Rotating electrical machines for rail and road vehicles – Part 3: Determination of the total losses of converter-fed alternating current motors by summation of the component losses
IEC	61082:2006	Preparation of documents used in electro-technology.
IEC	60034-1:2017	Rotating electrical machines – Part 1: Rating and performance
IEC	60038:2009	IEC standard voltages
IEC	60034-14:2003+AMD1:2007	Rotating electrical machines – Part 14: Mechanical vibration of certain machines with shaft heights 56 mm and higher – Measurement, evaluation and limits of vibration severity
IEC	61869	Instrument transformers
IEC	60051 (1 to 9)	Direct acting indicating analogue electrical measuring instruments and their accessories

Standard Organisation	Standard Reference Number	Title or Description of the Standard
IEC	60068 (1 and 2)	Environmental Testing
IEC	60077-1:2017	Railway applications – electric equipment for Rolling Stock – part 1 – general service conditions and general rules
IEC	60077-2:2017	Railway applications – electric equipment for Rolling Stock – part 2: electro-technical components – general rules
IEC	60085:2007	Electrical insulation – Thermal evaluation and designation
IEC	60115 (Part 1 to 9)	fixed resistors for use in electronic equipment
IEC	60228:2004	conductors of insulated cables
IEC	60268 (Part 1 to 18)	Sound System Equipment
IEC	60269 (Part 1 to 4)	Low Voltage Fuses
IEC	60297 (Part 1 to 3)	Mechanical structures for electronic equipment – Dimensions of mechanical structures of the 482,6 mm (19 in) series
IEC	60300-1:2014	Dependability management – Part 1: Guidance for management and application
IEC	60300-3-1:2003	Dependability management – Part 3-1: Application guide – Analysis techniques for dependability – Guide on methodology
IEC	60300-3-2:2004	Dependability management – Part 3-2: Application guide – Collection of dependability data from the field
IEC	60300-3-3:2017	Dependability management – part 3-3: application guide – life cycle costing
IEC	60300-3-5:2001	Dependability management – Part 3-5: Application guide – Reliability test conditions and statistical test principles
IEC	60310:2016	Railway applications – Traction transformers and inductors on board rolling stock
IEC	60319:1999	Presentation of Reliability Data for Electronic Components.
IEC	60332 (1 to 3)	Tests on electric and optical fibre cables under fire conditions
IEC	60349-1:2010	Electric traction – Rotating electrical machines for rail and road vehicles – Part 1: Machines other than electronic converter-fed alternating current motors
IEC	60349-2:2010	Electric traction – Rotating electrical machines for rail and road vehicles – Part 2: Electronic converter-fed alternating current motors
IEC/TR2	TS 60349-3:2010	Electric traction – Rotating electrical machines for rail and road vehicles – Part 3: Determination of the total losses of converter-fed alternating current motors by summation of the component losses
IEC	60384	Fixed capacitors for use in electronic equipment

Standard Organisation	Standard Reference Number	Title or Description of the Standard
IEC/TR	TS 61287-2:2001	Power convertors installed on board railway Rolling Stock – Part 2: Additional technical information
IEC	60502 (1/2/4)	Power cables with extruded insulation and their accessories for rated voltages from 1 kv (u[m] = 1,2 kv) up to 30 kv (u[m] = 36 kv)
IEC	60505:2011	Evaluation and qualification of electrical insulation systems
IEC	60529:1989+AMD1:1999+AMD2:2013	Degrees of protection provided by enclosures (IP Code)
IEC	60571:2012	Railway applications – Electronic equipment used on rolling stock
IEC	60605	Equipment reliability testing
IEC	60617-1/2/3/4/5/6/7/8/9/10	Graphical Symbols For Diagrams
IEC	60622:2002	Secondary cells and batteries containing alkaline or other non-acid electrolytes – Sealed nickel-cadmium prismatic rechargeable single cells
IEC	60623:2017	Secondary cells and batteries containing alkaline or other non-acid electrolytes – Vented nickel-cadmium prismatic rechargeable single cells
IEC	60664 (1-5)	insulation coordination for equipment within low-voltage systems
IEC	60747 (1-16)	semiconductor devices
IEC	60749	semiconductor devices – mechanical and climatic test methods
IEC	60754 (1-2)	Test on gases evolved during combustion of materials from cables
IEC	60850:2014	Railway applications – supply voltages of traction systems
IEC	60947:2018	low-voltage switchgear and control gear
IEC	60993:1989	electrolyte for vented nickel-cadmium cells
IEC	61034 (1-2)	measurement of smoke density of cables burning under defined conditions
IEC	61071:2017	Capacitors for power electronics
IEC	61133:2016	Railway applications – Rolling Stock – Testing of Rolling Stock on completion of construction and before entry into service
IEC	61287-1:2014	Railway applications – Power convertors installed on board Rolling Stock – Part 1: Characteristics and test methods
IEC	TS 61287-2:2001	Power convertors installed on board railway Rolling Stock – Part 2: Additional technical information
IEC	61373:2010	railway applications – Rolling Stock equipment – shock and vibration tests
IEC	61375	Electronic railway equipment – Train communication network (TCN)
IEC	61377:2016	Railway applications – Rolling Stock – Combined test method for traction systems

Standard Organisation	Standard Reference Number	Title or Description of the Standard
IEC	61508-1:2010	Functional safety of electrical/electronic/programmable electronic safety-related systems. Part 1. General Requirements
IEC	61508-3:2010	Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems : Part 3. Software Requirements
IEC	61881	Railway applications – Rolling Stock equipment – Capacitors for power electronics
IEC	62278	Railway applications – Specification and demonstration of reliability, availability, maintainability and safety (RAMS)(CMRL)
IEC	1133	Electric traction-Rolling stock-Test methods for electric and thermal/electric Rolling Stock on completion of construction and before entry into service.
IEC	60056 (1987-03) 60056 am3 (1996-10)	High Voltage Alternating Current Circuit Breakers .Amendment No.3
IEC	60099-4 (1991-11)	Surge Arrestors – Pt.4 Metal Oxide, without Gaps for A.C. Systems
IEC	60721	Classification of environmental Conditions -Part 1 : Environmental parameters and their severities
IEC	60871-1: (1997-10)	Shunt Capacitor for A.C. Power Systems having a Rated Voltage above 1000V – Pt. 1 General Performance, Testing and Rating – Safety Requirements – Guide for Installation and Operation
IEC	61131	Programmable controllers
IEC	61371	Shocks and vibrations standards
IEC	62290-1 (2006)	Railway applications –Urban guided transport management and command/control systems –Part 1: System principles and fundamental concepts

Table A.7 International Standards Organisation

Standard Organisation	Standard Reference Number	Title or Description of the Standard
ISO	272:1982	Fasteners – hexagon products – widths across flats
ISO	281/1	Steel for Railway Wheels
ISO	1553	Methods of the Determination of Copper, Lead, Iron, Aluminium and Nickel in Copper Alloys
ISO	1554	
ISO	1810	
ISO	1217:1996	Displacement compressors – acceptance tests
ISO	2631 1/2/4/5:1997	Mechanical Vibration and Shock – Evaluation of Human Exposure to Whole Body Vibration
ISO	11237:2017	Rubber hoses and hose assemblies — Compact wire-braid-reinforced hydraulic types for oil-based or water-based fluids — Specification

Standard Organisation	Standard Reference Number	Title or Description of the Standard
ISO	3095:2005	Railway applications – acoustics – measurement of noise emitted by rail bound vehicles
ISO	3381:2005	Railway applications – acoustics – measurement of noise inside rail bound vehicles
ISO	3864-1:2003	Graphical symbols – safety colours and safety signs – part 1: design principles for safety signs in workplaces and public areas
ISO	4014:2000	hexagon head bolts – product grades A and B
ISO	4017:2000	hexagon head screws – product grades A and B
ISO	5660-1:2002	Reaction-to-fire tests – heat release, smoke production and mass loss rate – part 1: heat release rate (cone calorimeter method)
ISO	5801:1997	Industrial fans – performance testing using standardized airways
ISO	7010:2007	Graphical symbols – safety colours and safety signs – safety signs used in workplaces and public areas
ISO	9329-4	seamless steel tubes for pressure purposes
ISO	9330-6	welded steel tubes for pressure purposes
ISO	2553	Welded, brazed and soldered joints – Symbolic representation on drawings
ISO	2439	Flexible cellular polymeric materials – Determination of hardness (indentation technique)
ISO	4649	Rubber, vulcanized or thermoplastic- Determination of Abrasion resistance using a rotating cylindrical drum device
ISO	7626-5	Vibration and shock – Experimental determination of mechanical mobility
ISO	8573	compressed air quality standard
ISO	105:2014	Textiles. Tests for colour fastness.
ISO	18286:2010	Hot-rolled stainless-steel plates. Tolerances on dimensions and shape
ISO	4014:2011	Hexagon Head Bolts. Product grades A and B
ISO	4017:2014	Fasteners. Hexagon head screws. Product grades A and B
ISO	5660-1:2015	Reaction-to-fire tests. Heat release, smoke production and mass loss rate. Heat release rate (cone calorimeter method) and smoke production rate (dynamic measurement)
ISO	14732:2013	Welding personnel. Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials
ISO	15614	Specification and qualification of welding procedures for metallic materials – Welding procedure test
ISO	5660-1:2015	Reaction-to-fire tests. Heat release, smoke production and mass loss rate. Heat release rate (cone calorimeter method) and smoke production rate (dynamic measurement)
ISO	9606-1:2017	Qualification testing of welders. Fusion welding. Steels
ISO	14175:2008	Welding consumables. Gases and gas mixtures for fusion welding and allied processes

Standard Organisation	Standard Reference Number	Title or Description of the Standard
ISO	3452-1:2013	Non-destructive testing. Penetrant testing. General principles
ISO	4136:2012	Destructive tests on welds in metallic materials. Transverse tensile test
ISO	17637:2016	Non-destructive testing of welds. Visual testing of fusion-welded joints
ISO	17636-(1&2):2013	Non-destructive testing of welds. Radiographic testing. X- and gamma-ray techniques with digital detectors
ISO	17640:2017	Non-destructive testing of welds. Ultrasonic testing. Techniques, testing levels, and assessment
ISO	13287:2012	Personal protective equipment – Footwear – Test method for slip resistance
ISO	1234:1997	Split pins
ISO	10042:2005	Welding. Arc-welded joints in aluminium and its alloys. Quality levels for imperfections
ISO	10007:2017	Quality management – Guidelines for configuration management
ISO	4892-2:2013	Plastics – methods of exposure to laboratory light sources – part 2: xenon-arc lamps
ISO	4759-1:2000	Tolerances for fasteners – part 1: bolts, screws, studs and nuts – product grades A, B and C
ISO	1478:1999	Tapping screws thread
ISO	1479:2011	Hexagon head tapping screws
ISO	7049:2011	Cross recessed pan head tapping screws
ISO	7050:2011	Cross recessed countersunk (flat) head tapping screws
ISO	7051:2011	Cross recessed raised countersunk (oval) head tapping screws
ISO	7045:2011	Pan head screws with type H or type Z cross recess – product grade A
ISO	7046-1:2011	Countersunk flat head screws (common head style) with type H or type Z cross recess – product grade A – part 1: steel screws of property class 4.8
ISO	7046-2:2011	Countersunk flat head screws (common head style) with type H or type Z cross recess – product grade A – part 2: steel screws of property class 8.8, stainless steel screws and non-ferrous metal screws
ISO	7047:2011	Raised countersunk head screws (common head style) with type H or type Z cross recess – Product grade A
ISO	7042:2012	Prevailing torque type all-metal hexagon nuts – property classes 5, 8, 10 and 12
ISO	7719:2012	Prevailing torque type all-metal hexagon regular nuts – Property classes 5, 8 and 10
ISO	9000:2015	quality management systems – fundamentals and vocabulary
ISO	9001:2015	Quality management systems – Requirements
ISO	9934-1:2016	Non-destructive testing – magnetic particle testing – part 1: general principles
ISO	15614:2017	specification and qualification of welding procedures for metallic materials – welding procedure test
ISO	9000	
ISO	9001	

Standard Organisation	Standard Reference Number	Title or Description of the Standard
ISO	9002	Design Management and Control. Quality Systems: Model for Quality Assurance in Design, Development, Production, Installation and Servicing
ISO	9662	Information Processing – Volume and File Structure of CD-ROM for Information Exchange
ISO	4126	Safety devices for protection against excessive pressure – Part 4: Pilot-operated safety valves
ISO	10005	International Standard: Quality management – Guidelines for the quality plans
ISO	10007	International Standard: Quality management – Guidelines for configuration.
ISO	1005 pt 3	Railway Rolling Stock material – Part 3: Axles for tractive and trailing stock – Quality requirements
ISO	9003	Software engineering – Guidelines for the application of ISO 9001:2000 to computer software
ISO	9126	Software engineering – Product quality – Quality model
ISO	9126	Software engineering – Product quality – Quality model
ISO	9126-2 to 4	Software engineering – Product quality – External metrics and Quality in use metrics
ISO	9614-2	Acoustics – determination of sound power levels of noise sources using sound intensity – part 3_ precision method for measurement by scanning

Table A.8 Japanese standards

Standard Organisation	Standard Reference Number	Title or Description of the Standard
JIS	G 4305	Cold rolled stainless steel plates, sheets and strip 50126
JIS	G 3114	Hot rolled atmospheric corrosion resisting steels for welded structure
JIS	G 3459	Stainless steel pipes

Table A.9 French Standards (Normes Françaises)

Standard Organisation	Standard Reference Number	Title or Description of the Standard
NF-F	63-808:1992	Halogen Free Cables for Low Voltage Applications
NF-F	63-826:1990	Halogen Free Cables for High Voltage Applications
NF-F	63-827:1995	railway Rolling Stock – halogen free electrical conductors, class 120 degrees Celsius
NF-F	16101:1988	Rolling Stock – fire behaviour – materials choosing
NF-F	16102:1992	railway Rolling Stock – fire behaviour – materials choosing, application for electric equipments
NF F	16103	Rolling Stock – fire protection and firefighting – design arrangements
NF	X 35002:1982	Anthropometric models of the male and female population

Standard Organisation	Standard Reference Number	Title or Description of the Standard
NF PA	130	Standard for Fixed Guideway Transit and Passenger Rail Systems
NF-F	01-281	Fiber reinforced thermosetting plastics
NF-F	T51-113	Plastic Materials Determination of Resistance to Scratching

Table A.10 Research and Study Organisation (ORE)

Standard Organisation	Standard Reference Number	Title or Description of the Standard
ORE	C116/RP8	DB WZ Ride Index: Frequency Weighting Curves

Table A.11 International Railway Union

Standard Organisation	Standard Reference Number	Title or Description of the Standard
UIC	410 O	Composition and Calculation of the Weight and Braking of Passenger Trains
UIC	510-2 510-2 OR	Conditions concerning the uses of various diameters Trailing stock: wheels and wheelsets. Conditions concerning the use of wheels of various diameters
UIC	515-3 OR	Rolling Stock – Bogies – Running gear – Axle design calculation method
UIC	515-4 O	Passenger Rolling Stock – Trailer bogies – Running gear – Axle design calculation method
UIC	518 OR	Testing and Approval of railway Vehicles from the Point of View of their Dynamic Behaviour, Safety, Track fatigue and Ride Quality
UIC	532	Trailing stock – Signal lamp brackets – Coaches – Fixed electric signal lamps
UIC	534 OR	Signal lamps and signal lamp brackets for locomotives, railcars and all tractive and self propelled stock
UIC	541-5 O 541-5 OR	Brakes – Electropneumatic brakes for passenger trains and freight trains
UIC	541-6 O 541-6 OR	Brakes – Electropneumatic brakes test programmes for passenger trains and freight trains
UIC	555 OR	Electric lighting in passenger rolling stock
UIC	555-1 OR	Transistorised inverters for supplying fluorescent lamps (1)
UIC	553	Heating, ventilation and air-conditioning in coaches
UIC	560 OR	Doors of coaches and luggage vans
UIC	564-2 OR	Regulations Relating to Fire Protection and Fire Fighting Measures in Passenger Carrying Railway Vehicles
UIC	565-3	Indications for the layout of coaches suitable for conveying disabled passengers in their wheelchairs
UIC	566 OR	Loadings of coach bodies and their components
UIC	615-1 OR	Tractive units – Bogies and running gear – General conditions applicable to component parts
UIC	615-4 OR	Motive power units – Bogies and running gear – Bogie frame structure strength test

Standard Organisation	Standard Reference Number	Title or Description of the Standard
UIC	651	Layout of driver's cabs in locomotives, railcars, multiple unit trains and driving trailers.
UIC	811-1 OR	Technical Specification for the Supply of Axles for Tractive and Trailing Stock
UIC	812-2 OR	Solid Wheels for Tractive and Trailing Stock Tolerances (1)
UIC	812-3	Technical Specification for the Supply of Solid Wheels for Trailing Stock
UIC	813 O	Technical Specification for the Supply of Wheelsets for Tractive and Trailing Stock : Tolerances and Assembly
UIC	854	Battery
UIC	861-3	Standard 60 kg/m rail profiles
UIC	S1002	Standardization of wheel profile

Table A.12 Institute of Electrical and Electronic Engineer (IEEE)

Standard Organisation	Standard Reference Number	Title or Description of the Standard
IEEE	304	Thermal Endurance of insulation
IEEE	429	Sealing Against Moisture
IEEE	16	Standard for Electrical and Electronic Control Apparatus on Rail Vehicles

Table A.13 Military standard (MIL)

Standard Organisation	Standard Reference Number	Title or Description of the Standard
MIL-HDBK-	454 (1)	General Guidelines for Electronic Equipment
MIL-I-	46058	Insulating Compound (for Coating Printed Circuit Assemblies)
MIL-STD-	882 C	Hazard Analysis
MIL-STD-	883 E (1)	Test Methods Standard Microcircuits
MIL-STD-	889 B (3)	Dissimilar Metals

Table A.14 American national standard institute

Standard Organisation	Standard Reference Number	Title or Description of the Standard
ANSI	S1.4	Specification for sound level meters and supplement ANSI A1.4a-1985

Table A.15 Bureau of Indian standard

Standard Organisation	Standard Reference Number	Title or Description of the Standard
IS	2553 (Part 1 & 2)	Safety Glass – Specification Part 1 : General Purpose Part 2 : For Road Transport
IS	8148	Packaged air conditioners —specification

Table A.16 SATRA

Standard Organisation	Standard Reference Number	Title or Description of the Standard
SATRA	TM 144:1999	Dynamic co-efficient of Friction (Slip resistance) of foot wear and floorings

Table A.17 Railway Group Standard

Standard Organisation	Standard Reference Number	Title or Description of the Standard
RGS	GM/RT 2472	Data Recorders on Trains –Design Requirements

Table A.18 Electronic Industries Association

Standard Organisation	Standard Reference Number	Title or Description of the Standard
EIA	SE-101	Amplifiers for sound equipment
EIA	SE-103	Speakers and sound equipment
EIA	SE-105	Microphones for sound equipment

22 APPENDIX B. CAR BODY MOCK-UPS

A full-scale, half-car-length engineering mock-up of DMC car is to be provided for the train end, driving cab, underframe and the passenger saloon of the DMC. The Contractor shall provide a single mock-up of both the exterior and interior to satisfy all of the requirements of this section. The full-scale mock-up of the vehicle shall be provided at the Project site before the final Design Review. This will show minimum of the following but not limited to :-

22.1 Car-body Mock-up

22.1.1. The mock-up shall show at least two full seating bays, with typical passenger doorway between, gangway and interfaces, including the interior details and finishes. The mock-up shall demonstrate, as a minimum, the following:

- (i) Location and type of seating.
- (ii) Location of grab poles.
- (iii) Accessibility for wheelchairs between grab-poles, to seating areas, and between cars.
- (iv) Wheelchair position.
- (v) Interior finishes and colours.
- (vi) Location and performance of the Passenger Information Display System (PIDS), route maps, Passenger Saloon Surveillance System (PSSS). At least one PID, one route map and one PSSS camera shall be operable in the final version of this mock-up.
- (vii) Lighting levels.
- (viii) Location of fire extinguishers.
- (ix) Quantity and locations of system route maps, advertising cards and other signage.
- (x) Location of and access to Passenger Emergency Alarm device allowing two-way speech channel to be established with train operator.

22.2 Car-body Engineering Mock-up

22.2.1. A Car-body Engineering Mock-up shall be provided for review by the Project Manager at the Contractor's manufacturing facility. It shall demonstrate, as a minimum, the following:

- (i) Location and access to light fittings.
- (ii) Location of and access to air-conditioning diffusers and ducting.
- (iii) Location of and maintenance access to door drive mechanisms.
- (iv) Access for window replacement.
- (v) Access to equipment cupboards.
- (vi) Gangway to car-end interface.
- (vii) Access to Electrical control (relay and MCB etc.) panels.

22.3 Cab Mock-up

All controls and indications shall be those proposed for the final build. The actual train operator's seat shall be installed. The mock-up shall include as a minimum the following:

- (i) Operation of Cab side-doors.
- (ii) Access to side door interlocking mechanism.
- (iii) Operation and adjustment of Train operator's seat.
- (iv) Location of and access to all train operator's controls and instrumentation.
- (v) Location of and access to light fittings.
- (vi) Location and stowage of, and access to safety equipment.
- (vii) Access to equipment for maintenance.
- (viii) Location and adjustment of Train operator's sun blind.
- (ix) Front and side visibility.
- (x) Lighting levels.
- (xi) Door into passenger saloon, demonstrating means of access by passengers in emergency.
- (xii) Colour and form of the cab internal finish.
- (xiii) Space / enclosure for keeping train operator's kit, manuals and log books etc.
- (xiv) Location of front end PSSS camera.

22.4 Cab Front End Mock-up

The front-end mock-up shall demonstrate, as a minimum, the following:

- i) Colour and form of the cab car external front end.
- ii) Indication of the crashworthiness structural features.
- iii) Location of and access to windscreen wipers, lights, horns, and other equipment mounted on the front of the cab car.
- iv) Location of auto-coupler and associated accoutrements.

The mock-up shall be mounted for easy transportation to Bangalore and shall be suitable for public display.

22.5 Deleted.**22.6 Underframe Equipment Layout Mock-up**

An underframe equipment layout mock-up shall demonstrate, as a minimum, the following:

- (i) Location of all equipment, and access to all mounting points.
- (ii) Routing of all cables including inspection covers to ensure easy accessibility.
- (iii) Routing of all piping including isolation cocks to ensure easy accessibility and proper identification using colour coding.

- (iv) Location of and access to all routine maintenance activities, including lubrication points, filter changes, monitoring points and pneumatic system test points.
- (v) Location of any skirts or covers, and access to equipment behind.
- (vi) Labels and markings of equipments.
- (vii) Cable layout, cleating, provision of additional cables.

23 APPENDIX C. ABBREVIATIONS**23.1 General**

23.1.1 Various abbreviations used in this document are set out in alphabetical order in Table C1

Table C1 - Abbreviations

Appendix	Appendix to bid means the completed pages entitled appendix to bid which are appended to and form part of letter of bid
ASHRAE	American Society for Heating, Refrigeration and Air-conditioning Engineers
ATC	Automatic Train Control (System)
ATO	Automatic Train Operation (System)
ATP	Automatic Train Protection (System)
ATS	Automatic Train Supervision (System)
Acceptance certificate	Certificate signed by the Contractor and the Project Manager for final acceptance at the end of the warranty period and possible extension of each metro train.
<u>Addendum-1 dated 05.12.2022, Sl. No. 165</u> Acceptance certificate	Certificate signed by the Contractor and the Project Manager for final acceptance at the start of Revenue service of the last train in GoA4.
BMRCL	Bangalore Metro Rail Corporation Ltd
BCE	Brake Control Electronics
BCP	Brake Cylinder Pressure
BCU	Brake Control Unit
BP	Brake Pipe
CELENEC	European Committee for Electro-technical Standardisation
Contract	Means the Contract agreement, the letter of acceptance, the letter of bid, these conditions, the Specification, the Drawings, the schedule, and further documents (if any) which are listed in the Contract agreement or in the Letter of Acceptance
Contractor	Means the Contractor of the present metro train and associated services supplying contract
CCTV	Closed Circuit Television
CDRL	Contract Data Requirement List
CTC	Centralized Train Control
DFF	Direct Fixation Fastener
DIN	German Industry Standard
DIS	Depot Information System
DLP	Defect Liability Period

<u>Addendum-1 dated 05.12.2022, Sl. No. 166</u>	Deleted.
DMC	Driving Motor Car – Motor car equipped with a driving cab
DMI	Driver Machine Interface
DMS	Dead Man System
EMC	Electromagnetic Compatibility
EMI	Electro-Magnetic Interference
Project Manager	Means the person named as Representative of BMRC
EN	European Norm
EP	Electro-Pneumatic
FFT	Fast Fourier Transform
FMEA	Failure Mode and Effects Analysis
FMECA	Failure Modes, Effects and Criticality Analysis
FRACAS	Failure Reporting And Corrective Action System
GoA	Grade of Automation
GSM	Global System for Mobile Communication
HVAC	Heating, Ventilation and Air Conditioning
HSCB	High Speed Circuit breaker
IC	Integrated Circuit
IEC	International Electro-technical Commission
IEEE	Institute of Electrical and Electronics Engineer
IGBT	Insulated Gate Bi-Polar Transistor
IMP	Interface Management Plan
ISO	International Standardisation Organisation
Km/h	Kilometre per hour
LAN	Local Area Network
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LHD	Linear Heat Detector
LRU	Least Replaceable Unit
LVS	Large Video Screen
Metro car	One metro car – part of a metro train
Metro train	Fixed composition of metro cars composed by several metro cars
MC	Motor Car without driving cab
MCB	Miniature Circuit Breaker
MDBF	Mean Distance Between Failures
MDBCF	Mean Distance Between Component Failures

MSS	Maximum Permissible Safe Speed
MTTR	Mean Time To Repair
MWI	Maintenance Work Instructions
NFPA	National Fire Protection Association
OCC	Operation Control Centre
ODD	Obstruction Deflection Device
OEM	Original Equipment Manufacturer
PA	Public Address (System)
PAS	Public Address System
PC	Personal Computer
PCB	Printed Circuit Board
PEA	Passenger Emergency Alarm
PIS	Passenger Information System
PLC	Programmable Logic Control
PPHPD	Persons per Hour and per Direction
PSSS	Passenger Saloon Surveillance System
PWM	Pulse Width Modulation
RAMS	Reliability, Availability, Maintainability, Safety
Reliability	The probability of performing a specified function, without failure and within design parameters, for the period of time indicated
RH	Relative Humidity
RI	Ride Index
RM	Restricted Manual (Driving Mode)
SBD	Safe Braking Distance
SCS	Safety Cut-out Switch
SOD	Schedule of Dimensions
Static Gauge	A maximum profile within which Rolling Stock may be constructed or loaded.
Structure Gauge	A description of a line inside which fixed infrastructure should not intrude. The description will include rules for curvature, cant, speed, track fixity and requirements for staff access and emergency evacuation.
Sub-Contractor	Means any person named in the Contract as a sub-Contractor, or any person appointed as a sub-Contractor for part of the Rolling Stock manufacturing or supply works.
Taking over certificate	Certificate signed by the Contractor and the Project Manager for preliminary acceptance at the beginning of the warranty period of each metro train when the metro train is declared as "suitable for commercial / revenue service".
TC	Trailer Car without driving cab
TCMS	Train Control Management System
TOD	Train Operation Data
TOR	Top Of the Rail
TR	Train Radio

Train ID	Train Identification Number
TV	Television
UIC	International Union of Railway (Union Internationale des Chemins de Fer)
VDU	Video Display Unit
VVVF	Variable Voltage Variable Frequency
ZVR	Zero Velocity Relay

24 APPENDIX D – INTERFACES**24.1 General**

24.1.1 The Rolling Stock Contractor shall interface the design, manufacture, supply, testing and commissioning covering with that of other contractors, principally the Contractors for the Designated Contracts as defined in the General Conditions of Contract. The Contractor shall keep the Project Manager fully informed in respect of such interfaces, such information being given to the Project Manager in a manner and form and at such intervals as stated in the Contract or as required by the Project Manager.

24.1.2 The Contractor shall comply with the requirements specified in BMRCL project wide interface document Nov-2021 of Part-IV Drawings & Manuals Section- XV. However, the requirements specified herein shall prevail in case of discrepancy with the corresponding requirements in the BMRCL project wide interface document Nov-2021 of Part-IV Drawings & Manuals Section- XV.

24.2 Interface Responsibilities

24.2.1 The responsibility for specification and provision of the requirements for the works that interface with Designated Contractors' equipment are tabulated in this appendix.

24.2.2 This Appendix shall be read in conjunction with the relevant clauses of the Employer's Requirements – General Specifications. The Rolling Stock Contractor shall be responsible for ensuring that all requirements of the specifications pertaining to interfaces are satisfied.

24.2.3 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 activities/works and throughout the execution of Contract, to ensure that:

- i) all interfacing issues between the two Contracts are satisfactorily resolved;
- ii) supply, installation and testing of equipment and software are fully co-ordinated; and
- iii) that all equipment supplied under the Contracts are fully compatible with each other, whilst meeting the requirements of the respective Specifications.

24.2.4 This Appendix outlines the interfacing requirements during the execution of the Works. However, the requirements herein specified are by no means exhaustive and it remains the Rolling Stock Contractor's responsibility to develop, update and execute jointly an Interface Management Plan (IMP) after the Effective Date and throughout the execution of the Work to ensure that:

- i) All interface issues between the Rolling Stock and the Designated Contractors are satisfactorily identified and resolved; and
- ii) All the construction tolerances at the interface shall meet the requirements of the respective specifications relating to the interface points.
- iii) The IMP shall be submitted to Project Manager for review and comments, and for Project Manager's use as the focal-point for monitoring and ensuring the interface efforts progress smoothly. The Employer shall play a lead role in ensuring that the designated contractors perform in a timely and cooperative manner.

- 24.2.5** Where details of the Rolling Stock design are required to enable the Designated Contractor to implement interface works, the Rolling Stock Contractor shall provide the Designated Contractors with the necessary information including, but not necessarily limited to, those described in the tables specifying interface summary and Division of Responsibility between Rolling Stock Contractor and other Designated Contractors appended to this requirement. The level of information provided shall be in sufficient detail to enable the Designated Contractors to design and / or construct the required interface activity.
- 24.2.6** The Rolling Stock Contractor shall take a lead in developing the Interface Management Plan. (IMP), which will be prepared in conjunction with the Designated Contractors to cover all aspects of the implementation of the interface activities required. The Plan will define the interface activities necessary to complete all the activities in this Contract and may not be limited to those listed in the tables specifying interface summary and Division of Responsibility between Rolling Stock Contractor and other Designated Contractors attached. However, Signalling & Train Control Contractor as a Lead Contractor shall prepare a comprehensive Operating Modes and Principle Document (OMPD) as specified in clause 24.6.4.1.36.
- 24.2.7** The IMP shall be fully conforming with the Works Program and shall, in respect of the Contractor and each of the Designated Contractors, show and be in logical agreement with Key Dates and Handover Dates for Rolling Stock. The IMP shall indicate dates for the commencement and completion of each principal activity by each contractor, and delivery and installation of principal items of equipment.
- 24.2.8** The IMP shall be submitted by the Contractor to the Project Manager, in a preliminary form, as per schedule furnished in Table 2-A of the Employer's Requirements – General Specifications. Thereafter, the IMP shall be updated by the Contractor at regular intervals, agreed with Designated Contractors and submitted to the Project Manager. Should it appear to the Project Manager that the progress of the Work, Works Program or the Three Month Rolling Program does not conform to the IMP, the Contractor shall be required to revise all such programs and plans such that they do reflect that are progress of the Works is mutually consistent and conforms to other provisions of the Contract.
- 24.2.9** The Rolling Stock Contractor shall review the details of interface works and notify the Project Manager of any amendments to the tables specifying interface summary and Division of Responsibility between Rolling Stock Contractor and other Designated Contractors required in the process of his activities. Unless such requests are reviewed without objection by the Project Manager, the Rolling Stock Contractor shall design and construct the Rolling Stock activities in accordance with the provisions outlined in this Appendix and the attached tables specifying interface summary and Division of Responsibility between Rolling Stock Contractor and other Designated Contractors.
- 24.3 Scope of Work of Interface Management Plan**
- 24.3.1** The information and scope of works to be provided by the Rolling Stock Contractor include but may not necessarily be limited to those outlined in the attached tables specifying interface summary and Division of Responsibility between Rolling Stock Contractor and other Designated Contractors. This table only defines those tasks at the interface point and is not a complete itemisation of the Scope of Work.

- 24.3.2** The Designated Contractors shall liaise with the Rolling Stock Contractor in the design, installation, testing and acceptance of the Rolling Stock activities.
- 24.3.3** The Rolling Stock Contractor shall provide all access and attendance necessary in accordance with the Contract requirements to enable the Designated Contractors to complete those activities defined under the tables specifying interface summary and Division of Responsibility between Rolling Stock Contractor and other Designated Contractors attached to this interface specification in a timely manner.
- 24.3.4** Where Rolling Stock Contractor works are identified as failing to meet the requirements of the Contract and which will impact the Designated Contractor's works, the Rolling Stock Contractor shall submit the proposed remedial measures to the Project Manager for review and shall copy the same to the Designated Contractors.
- 24.4 Interface with Power Supply and Traction(PST) Contractors**
- 24.4.1** Rolling Stock contractor shall interface with power supply contractor for interface with 3rd rail/750V DC supply.
- 24.4.2** The details of these contracts and contractors shall be made available during the execution of the contract.
- 24.4.3** A detailed design consultant may be engaged by BMRCL for the design.
- 24.4.4** Power Supply and 3rd rail Contractor shall collect necessary data of track/points and crossing from track contractor and Rolling Stock data from Rolling Stock Contractor for designing the 3rd rail including ramps in the points and crossing area. Power supply and 3rd rail contractor shall undertake the gap study to determine the bridgeable gap (BG) and non-bridgeable gap for main line movement and for diverted track movement and will avoid discontinuity of power to the train on main line while negotiating point and crossing. During movement of train on diverted track continuity of the power from 3rd rail to the train be maintain to maximum extent possible. Necessary relevant parameters of Rolling Stock shall be coordinated /interfaced by the Rolling Stock Contractor with 3rd rail contractor and track contractor to produce harmonious and compatible design for the three systems viz Rolling Stock, 3rd rail and Track point and Crossing.
- 24.4.5** The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

S. N.	Subject	Rolling Stock (RS) Contractor	PST Contractor
	Design Stage		
1	Supply of Basic data and information regarding <ul style="list-style-type: none"> Speed/current characteristics Speed/Tractive Effort curves Auxiliary power requirement 	Shall supply information to PST Contractor.	Shall incorporate details in the designs, system studies and verification of designs

S. N.	Subject	Rolling Stock (RS) Contractor	PST Contractor
	<ul style="list-style-type: none"> • Motor kW and specifications • Acceleration and braking • Regeneration • Harmonics • Power factor correction • Current Collection equipment details 		
2	Arrangement of the Sectioning scheme	RS Contractor to note the details and confirm their suitability	Shall provide information and drawings/scheme to RS Contractor
3	Detailed drawings of current collection system.	Shall provide information to PST Contractor.	Shall take into consideration for the design of the traction System
4	Traction current	Shall provide information to PST Contractor.	Shall take into consideration for the design of the traction System and bonding plan.
5	Third rail details	Shall design the current collectors on the basis of third rail design particulars	Shall provide information regarding third rail dimensions, adjustment / dimensional tolerances and sectioning for design of current collectors of rolling stock
6	Harmonic limitations of the power supply	Shall incorporate into the design of collector shoes	Shall provide information to RS Contractor
7	Electrical and mechanical clearances between third rail support assemblies and collector shoe	Shall incorporate into the design of the collector shoe gear	Shall provide information to rolling stock Contractor
8	Drawings, material, springing, damping, sway and other relevant details of collector shoe gear	Shall provide information to PST Contractor	Shall take into consideration for third rail designs
9	Third rail non bridgeable gaps	Shall provide details of current collectors location and continues length of 750V DC bus, maintenance tolerances etc.	i) Shall consider the RS details of current collectors relative positions in a car, maintenance tolerances etc. for design of third rail ramps ii) Shall undertake gap study to determine the bridgeable gap (BG) and non-bridgeable gap for main line

S. N.	Subject	Rolling Stock (RS) Contractor	PST Contractor
			movement and for diverted track movement in order to avoid discontinuity of power to the train on main line while negotiating point and crossing for design of third rail and air gaps. iii) To avoid discontinuity in 750V DC for very short duration (small peak).
10	Maximum traction return current	Shall provide information to PST Contractor	Shall incorporate into the design of the 750 DC Third Rail Traction System.
	Construction and Installation (C&I) Stage		
11	All relevant items	Shall manufacture the RS as per agreed interfaces	Shall install the PST system as per agreed interfaces
12	Location of Warning Boards and visual indications	Shall confirm the suitability	Shall supply and install the Boards and indications
	Testing and Commissioning (T&C) Stage		
13	Testing and commissioning	Shall request 750V power supply in the Third Rail for testing and commissioning of Metro Cars; shall co-operate and ensure that the harmonics generated are within the agreed levels	Shall provide 750 V dc power supply and co-ordinate with RS Contractor to conduct testing and commissioning of Metro Cars. Shall jointly check the electrical loads, harmonic levels and return current coming on Traction sub-station from Rolling stock
14	Integrated testing & commissioning	Shall lead the ITC including current collection test. Shall install on-board equipment and underframe camera for current collection test.	Shall participate for the ITC. Shall analyze the flash points on the third rail observed during current collection test and take necessary corrective action.
15	Negotiation of non-bridgeable gap in coasting	Shall provide train and co-ordinate with PST Contractor for checking	Shall demonstrate the safe speed to negotiate the Non-Bridgeable Gap in

S. N.	Subject	Rolling Stock (RS) Contractor	PST Contractor
		negotiability of non-bridgeable gap in coasting and identify the maximum safe speed before entering coasting	coasting.
	Maintenance Stage		
16	Nil		

24.5 Interface with Civil (Viaduct/ Tunnel/ Station) Contractors

24.5.1 The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

S. N.	Subject	Civil (Viaduct/Tunnel/Station) Contractor	Rolling Stock Contractor
	Design Stage		
1	Car Details	Shall obtain details of Rolling stock including length of train cars, height and location of doors for station design as per SoD.	Shall furnish required details of Rolling stock including Length of train cars (with front coupler), height and location of doors for station design meeting with the provisions of SoD.
2	Kinematic and structural gauges	Shall obtain details of kinematic and structural gauges from Rolling Stock Contractor and take into account during design to ensure platform and walkway clearance while train is running.	Shall furnish the details of kinematic and structural gauges respective to all speeds.
3	Viaduct/Tunnel Design	Shall provide the space proof details to Rolling stock Contractor	Shall coordinate with Viaduct/Tunnel Contractor
4	Design of walkway slab and Emergency Ramp	Walkway slab shall be designed as per SoD and with interaction of System Contractor (RS).	Shall study the track geometry including horizontal and vertical profile for the entire project. The project is designed with side evacuation. The Rolling Stock Contractor and Track Contractor shall jointly submit the calculation of horizontal

S. N.	Subject	Civil (Viaduct/Tunnel/Station) Contractor	Rolling Stock Contractor
			and vertical shift of carbody on inside curve and outside curve in stationary condition and running condition. Shall design the emergency ramps and provide suitable enclosures for housing the ramps inside the train.
	Construction and Installation (C&I) Stage		
5	Clearances checking with respect to platform alignment	Shall jointly check and confirm the curves, dimensional clearances, gradients, chainages, levels and emergency escape provision.	Shall co-ordinate and confirm with Civil/Station Contractor.
6	Construction & Installation	Shall participate in test run and perform modifications if required.	Required to conduct test run.
	Testing and Commissioning (T&C) Stage		
7	Integrated testing	Shall coordinate with RS Contractor to complete testing and commissioning work	Requires to conduct integrated test with all Systems.
8	Gap measurement at walkway and platform	Shall jointly check and measure the gap between walkway/platform and coach floor and shall rectify the defects noticed.	Shall provide train and jointly check and measure the gap between walkway/platform and coach floor for rectifying the defects noticed
9	Structure gauge checking	Shall jointly measure the various clearances required for structure gauge and shall rectify the defects noticed	Shall provide structure gauge and manpower and jointly support to measure the clearances.
10	KE test	Shall jointly check whether KE infringement is there or not. Shall rectify the defects noticed.	Shall provide the train with KE profile and jointly support the Civil/Station Contractor.
	Maintenance Stage		
11	Nil		

24.6 Interfaces between Rolling Stock and Signalling & Train Control Contractors**24.6.1 Definition and Scope**

24.6.1.1 This Appendix describes the interface requirements between Rolling Stock Contractor and Signalling & Train Control Contractor.

24.6.1.2 The details of these contracts and contractors shall be made available during the execution of the Contract.

24.6.1.3 The Signalling & Train Control and Rolling Stock Contractors shall ensure that all requirements of the Specification pertaining to interfaces are comprehensively satisfied.

24.6.1.4 The requirements specified herein are by no means exhaustive and it remains the responsibility of the Signalling & Train Control and Rolling Stock Contractors to develop and execute an interface plan during execution of the work to ensure that:

- i) All interface issues between the different contracts are satisfactorily resolved.
- ii) Supply, installation and testing of equipment and software are fully coordinated.
- iii) All equipment supplied in the contracts are fully compatible with each other.
- iv) UTO mode of operation is achieved with all inherent features.

24.6.1.5 The Automatic Train Protection (ATP) system shall issue the braking commands to the Rolling Stock when safety limits are exceeded or when over-speed is detected. The removal of traction power and the correct application of brakes shall be the responsibility of Rolling Stock Contractor. The ATP system shall be responsible for monitoring of speed and the issuing of braking commands when safety speed limits are exceeded.

24.6.1.6 Parking brakes shall be provided by the Rolling Stock Contractor. The parking brakes shall be capable of holding a fully loaded stationary train on a 4% gradient under all track conditions, indefinitely.

24.6.1.7 There shall be two stage commissioning. In the first stage, the train operation shall be commissioned in GoA-2 mode and in second stage GoA-4 mode of operation.

24.6.2 Interface Management

24.6.2.1 Each contractor shall establish a structured process to integrate with other systems to ensure safe, reliable, and efficient operations under both normal and degraded conditions to the satisfaction of the Project Manager.

24.6.2.2 Each contractor shall ensure that the equipment supplied under this Contract are properly interfaced and integrated with other systems in Bangalore Metro.

24.6.2.3 Each contractor shall appoint competent and experienced person (Interface Manager), with no fewer than 5 years of similar Metro railway project experience who shall be the single point of contact for all interface design and testing works with the interfacing contractors and the Project Manager.

- i) Full time mobilization of 'Interface Manager (IM)' at site shall be done by RS as well as Signalling Contractor within three (3) months of the Effective Date. Non-mobilization of the 'Interface Manager (IM)' within the stipulated three months would attract penalty (to be solely finalized by the Project Manager) for delay of each month or part thereof. The penalty amount shall include the consequential loss on account of non-availability of an approved and experienced 'Interface

Manager (IM)'.

- ii) All Interface Meetings, unless specifically approved by the Project Manager, shall be held at site and the Project Manager shall be given sufficient notice to attend the meeting.
- 24.6.2.4 Each contractor shall be responsible for interface identification, establishment, construction, and testing works either in the capacity as the lead contractor or participating contractor.
- 24.6.2.5 Signalling & Train Control Contractor shall be the Lead Contractor. The Signalling & Train Control 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 the Project Manager for acceptance. The Signalling & Train Control Contractor will also prepare and issue all interface meeting minutes after incorporating RS Contractor's comments within 3 days of the meeting and provide bi-weekly interface progress reports to all the participating contractors for information.
- 24.6.2.6 Later, forwarding of issued minutes of meeting and bi-weekly interface progress reports to respective Engineers shall be responsibility of concerned Contractors.
- 24.6.2.7 All the participating contractors shall ensure that copy of the Interface design documents submitted to the Engineer of the Signalling & Train Control Contractor shall also be submitted to their respective Engineer required to participate in the Interface Meetings.
- 24.6.2.8 Rolling Stock, Communication, PSD/PSG and TVS Contractors will be the participating contractors. The Participating Contractor shall collaborate fully with the Signalling & Train Control Contractor in the development and finalization of the interface design, joint production of the interface documents and interface progress reports.
- 24.6.2.9 The costs for all interface design and testing works shall be deemed to be included in the Contract sum regardless of the actual extent of effort required or expended by the Contractor.
- 24.6.2.10 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.
- 24.6.2.11 ~~The Signalling & Train Control Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of the trains till completion of Rolling Stock defect liability period. The Rolling Stock Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of trains till completion of Signalling defect liability period. It shall also be noted that changes in the interface specifications such as key alarms, remote commands, interface signals and GUI specifications are to be expected throughout the project execution stage and shall extend up to 6 months after commencement of UTO operation based on operational requirements.~~

Addendum-1 dated 05.12.2022, Sl. No. 167

The Signalling & Train Control Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of the trains during the DLP of Signaling and Train control Contract. The Rolling Stock

Contractor shall provide necessary support to resolve all pending or new interface related issues arising during the operation of trains till completion of Signalling defect liability period. It shall also be noted that changes in the interface specifications such as key alarms, remote commands, interface signals and GUI specifications are to be expected throughout the project execution stage and shall extend up to 6 months after commencement of UTO operation based on operational requirements.

- 24.6.2.12 Rolling Stock Contractor shall be responsible for development of the GUI (including hardware) for the RS controller (RSC) in the OCC (Operation Control Centre)/BCC (Backup Control Centre). Any other GUI(s) in OCC/BCC shall not be the scope of RS Contractor. Total number of the distinctively different screens with live buttons may be around ten. The exact number shall be confirmed in the design stage.
- 24.6.2.13 Signalling & Train Control Contractor shall ensure suitable connectivity between the workstations of the Traffic Controller, RS Controller, CCTV, and others as finalized during interface design.
- 24.6.2.14 Signalling & Train Control Contractor shall provide server for CCTV in the OCC/BCC. All the requirements of buffering to be done on the train for live streaming of video shall be the responsibility of RS Contractor.
- 24.6.2.15 Signalling & Train Control Contractor shall be responsible for enabling and implementing any addition / deletion of the alarms from the trains to OCC/BCC and remote commands from the OCC/BCC to train throughout the project execution stage including up to 6 months after commencement of UTO operation, as advised by the RS Contractor/Project Manager. Rolling Stock Contractor shall provide necessary support required to implement the same. Separate set of alarms and commands may be required to be reported/executed from the Traffic controller and the RSC workstations. RSC workstation shall be the responsibility of RS Contractor.
- 24.6.2.16 Adequate number of workstations as decided during the Interface Finalization shall be provided in OCC/BCC by the Signalling & Train Control Contractor for passenger communication with OCC/BCC on invoking of PEA (Passenger Emergency Alarm).
- 24.6.2.17 In the event of invoking of the PEA, automatic pop up of image from the relevant cameras shall be ensured in the OCC/BCC on the LVS, screens of traffic controller and RSC. RS Contractor shall interface with Signalling & Train Control Contractor for invoking of CCTV images on RSC workstation.
- 24.6.2.18 ~~Signalling & Train Control Contractor shall be responsible for free supply of cables, duly harnessed for connection of the On board signal equipment. RS Contractor shall be responsible for providing the cables for the train lines and/or Ethernet links required by the Signalling & Train Control Contractor. The Rolling Stock Contractor shall ensure the availability of adequate no. of train lines/ethernet considering the requirement of Signalling & Train Control Contractor, which shall be discussed and finalized during interface. RS Contractor shall ensure that adequate number of spare train lines (minimum 10% for each type) will be available at the end of the DLP.~~

Addendum-1 dated 05.12.2022, Sl. No. 168

Signalling & Train Control Contractor shall be responsible for free supply of cables, duly harnessed for connection of the On-board signal equipment. RS Contractor shall be responsible for providing the cables for the train lines and/or Ethernet links required by the Signalling & Train Control Contractor. The Rolling Stock Contractor

shall ensure the availability of adequate no. of train lines/ethernet considering the requirement of Signalling & Train Control Contractor, which shall be discussed and finalized during interface. RS Contractor shall ensure that adequate number of spare train lines (minimum 10% for each type) will be available **for future use**.

- 24.6.2.19 Signalling & Train Control Contractor shall certify relevant connections, cables to on-board Signalling equipment after their assembling in first (prototype) & subsequent trains at RS Contractor's premises.
- 24.6.2.20 Signalling & Train Control Contractor shall be responsible for providing suitable communication link for live streaming via CCTV network from Train to OCC/BCC and for live transmission of the advertisements or other data via CCTV network from OCC/BCC to Train. The live video stream transmitted from the train to the OCC/BCC shall be suitably buffered and to be streamed from OCC/BCC CCTV server for its onward multicast transmission to other terminals/networks and display on all relevant terminal/screens using Video Management System (VMS). This buffering arrangement in OCC/BCC via CCTV server including VMS and display large video walls shall be responsibility of Signalling & Train Control Contractor. For live video stream from OCC/BCC to train, the buffering on the train shall be responsibility of RS Contractor. The Rolling Stock Contractor shall provide Live Video Players with buffering capability on the Train. The RS Contractor shall also provide the advertisement and live video players in hot standby pair per train. The RS Contractor shall also provide redundant suitable arrangement (video controller/player/servers) in OCC/BCC for transmission of live video contents and stored video contents to be played in the train.
- 24.6.2.21 The contractors shall ensure that all the requirements of the latest Metro Railway General Rules are duly met by incorporating appropriate alarms, remote commands, and other features.
- 24.6.2.22 Signalling & Train Control Contractor in close coordination with the RS Contractor shall ensure that the ATO/UTO modes of operation designed are optimized for least energy consumption.
- 24.6.2.23 It is expected that complete duplication of the TCMS VDU screen with live buttons for executions the requisite commands shall be available on demand in the RSC-GUI.
- 24.6.2.24 Not used.
- 24.6.2.25 Both Signalling & Train Control as well as RS Contractor shall ensure that complete and detailed log of the signals exchanged between ATC and TCMS shall be retrievable on demand for diagnostics.
- 24.6.2.26 Not used.
- 24.6.2.27 Signalling & Train Control Contractor shall be responsible for slow speed movement on the Automatic Wash Plant (AWP). Interface will be required to be done with the AWP supplier for ATO/UTO modes. RS Contractor shall provide wash mode facility for other manual modes like ATP/RM/ROS/Cut-out.
- 24.6.2.28 Emergency brake application validation at slow speed (less than or equal to 25kmph) shall be achieved as a part of the wake-up procedure as finalized by the Signalling & Train Control Contractor. The speed at which brake test has to be

carried out shall be finalized during design phase based on the available length of stabling line.

24.6.2.29 Signalling & Train Control Contractor shall ensure that in the event of secondary suspension deflated condition detection or otherwise, the maximum speed shall not exceed the stipulated speed under such condition as advised by the RS Contractor. This information shall be provided by RS to Signalling & Train Control Contractor on board in a safe manner.

24.6.2.30 Signalling & Train Control Contractor shall provide location information to the RS Contractor. RS Contractor shall use the same for different distance-based algorithms provided in the RS like for station announcements, wheel flange lubrication, etc.

24.6.2.31 Signalling & Train Control Contractor to ensure that the maximum speed shall be regulated as advised by the RS Contractor on account of following:

- i) Secondary suspension deflated condition detection
- ii) Bogie brake failure/isolation (In both brakes fail to apply and fail to release cases)
- iii) Axle block detection
- iv) Isolation/Cutout of Electro dynamic braking

This information shall be provided by RS to Signalling & Train Control Contractor on board in a safe manner.

24.6.3 Train Operating Modes

24.6.3.1 General System Description

24.6.3.1.1. The train-borne Automatic Train Control (ATC) system will consist of Unattended Train Operation (UTO), Automatic Train Operation (ATO) system and Automatic Train Protection (ATP).

24.6.3.1.2. The Rolling Stock required shall be fitted with ATP/ATO/UTO system. The UTO system shall conform to Grade of Automation 4 (GoA4) as defined in IEC 62290-12014 or latest.

24.6.3.1.3. The Automatic Train Control (ATC) System shall be supplied by the Signalling & Train Control Contractor, who shall be required to liaise closely with the Rolling Stock Contractor, in regard to the installation, testing and commissioning of the Signalling & Train Control equipment.

24.6.3.1.4. Unattended Train Operation (UTO Mode)

This mode consists of full driverless unmanned operation and shall be the default mode at stage-2 of commissioning unless exceptional circumstances occur. This mode shall be available everywhere on the line and the depot except for the workshop lines. Details shall be finalized during interface and design finalization.

24.6.3.2 ATO Mode

24.6.3.2.1 The on-board equipment shall provide for Automatic Train Operation (ATO). In this mode, the train's speed, motoring, coasting and braking within the parameters dictated by the ATP system shall be performed by the on-board equipment without the train operator's intervention. The train shall operate in ATO mode when the

mode selector is at ATO mode and ATO Start button is activated. This operation shall include:

- i) Automatic operation of trains between stations including auto turn backs.
- ii) The ATO system shall provide control for acceleration, deceleration and coasting of trains in such a manner that the specified schedule speed is achieved with minimum energy consumption. ATO shall also provide "All-Out Mode" of train operation to make up time loss to the extent possible by reducing the coasting period, in case train is not running in accordance with Time-Table.
- iii) Control of acceleration & deceleration of Train including coasting.
- iv) Automatic stopping of trains at platforms within a tolerance of ± 250 mm for 99.98% of station stops.
- v) This stopping accuracy must be obtained under all train loading conditions and taking into account the possible different variations in Rolling Stock characteristics.
- vi) Automatic opening of doors on the appropriate platform side(s) when the train is berthed.
- vii) Prevent the train from starting if train doors are detected "not closed and locked".
- viii) Receipt and implementation of control to skip one or more stations.
- ix) CBTC system shall allow a train to enter a station platform only if the preceding train has a movement authority that shall allow it to fully leave the platform area and it has begun to move out of the station (i.e., within ATP constraints, train movement shall be controlled to minimize the likelihood of the train coming to a stop when only partially within the station platform limits).

The trains under ATO operation shall always remain under ATP protection. Transfer from ATP to ATO mode shall only be possible at standstill at a designated stopping point. However, transfer from ATO to ATP mode shall be possible at any time at standstill. The details shall be finalized during design stage.

- x) It shall be possible for train operator to close the doors and start the train in ATO mode even before dwell time at less crowded stations.

24.6.3.2.2 The automatic train operation unit is permanently supplied as soon as the train is ready for operation. It must be in normal operating status at power up. Transmission of orders to train equipment is only possible in ATO mode.

24.6.3.2.3 When the ATC system detects the stop short outside the station stopping window and the Trains is within station, it shall initiate Trains inching (forward) to bring the Trains to stop within station stopping window. Detailed design of inching operation shall be submitted for Project Manager's review during design phase. **(CDRL-24-1)**

24.6.3.2.4 Powering/Braking command and demand:

- i) The powering and brake commands shall be implemented through hardwired interface. However, powering and braking demands shall be implemented through TCMS interface. In case of UTO/ATO operation, powering/braking demands shall be implemented with safety data transmission protocol through

ethernet interface between ATO/ATC and TCMS.

- ii) Redundant communication shall be available between TCMS & ATO/ATC (Dual Homing) to implement the above functionality. TCMS shall also provide redundant communication network to transmit the powering and braking demand from ATO/ATC to traction inverters and BECU.
- iii) In case of failure of TCMS or failure of data transmission between ATO/ATC and TCMS, powering and brake demand shall be implemented through hardwired circuits under the supervision of ATC.

Details shall be discussed and finalized during design phase.

24.6.3.2.5 Door control

- i) The doors shall be arranged for cab control operation. The control circuit shall be hardwired so that all the doors on either side may be operated automatically by either ATO command or manually with respect to designated platform side.
- ii) The door control push buttons shall be illuminated with distinct colour lights. The details and schematic shall be provided for review of the Project Manager.
- iii) The opening and closing of doors shall only be possible from an operative cab. The door controls shall be located on train operator's console.
- iv) The door control panels shall be located conveniently for operation of the doors on that side of the train. The control devices located on each side of the cab shall only operate the doors on that side of the consist.
- v) All door control panels in the train operator's cab shall have an identical layout and shall be physically interchangeable.
- vi) A Door Mode switch shall be provided in the cab. In ATO mode, the automatic door open command may be overridden by operating this switch. Operation of this switch shall be monitored by TCMS.
- vii) The ATC system shall ensure that no movement of the Trains in ATP/ATO/UTO mode is possible until all Trains doors and PSD/PSG are closed (in case PSD/PSG is provided).
- viii) The ATC system shall also ensure that in ATP/ATO/UTO mode, if the PSD/PSG is opened, no Trains shall be allowed to enter the platform; approaching Trains shall stop immediately if it is already within braking distance from the platform; the leaving Trains shall stop immediately if it is within a preset length from the platform; the berthing Trains shall not be allowed to leave. When the interlock override switch is operated, Trains are allowed to operate in all modes into and out of the platform. This switch shall be supplied by the PSD/PSG Contractor and is a one-shot operation device (in case PSD/PSG is provided).

24.6.3.2.6 Door opening authorization in degraded operation

- i) In case of unavailability/failure of door authorization signal from ATP system, adequate safeguards shall be provided and also incorporated in control circuit to minimize the probability of error of opening of doors on wrong side (other than platform side) during commercial / revenue service.

- ii) In this case, the opening can be controlled by the train operator operating a sealed Safety Cut-out Switch (SCS) operation and the right opening button or a left opening button placed on the desk.
- iii) This mode may be also used:
 - a) On the stabling/de-stabling secondary track.
 - b) On the main track without platform (evacuation of passengers in inter station).
 - c) At the platform (in case of failure of automatic operation).
- iv) The opening of the doors shall only possible when the Train speed is Zero.

24.6.3.3 Coded Manual (ATP) Mode

24.6.3.3.1 The on-board ATC equipment shall provide Automatic Train Protection (ATP) on all lines/ sections. In this mode, the control of the train speed and braking within the parameters dictated by the ATP system shall be performed by the train operator.

24.6.3.3.2 The Coded Manual (ATP) mode shall include:

- i) Identification and enforcement of maximum safe speed at which the train may operate, as deduced from the most restricting ATP condition.
- ii) Identification and display of actual speed, target speed and target distance.
- iii) Identification and audible and visual warning when train is operating at a speed higher than the target speed. The equipment to provide audible and visible warnings shall be provided by respective Signalling & Train Control Contractor.
- iv) If the actual speed exceeds the target speed, an audible and visual warning shall be given to the Train Operator. The Train Operator shall be given at least 2 seconds before the intervention of the full-service brake. If the speed is not reduced by the Train Operator and actual speed exceeds the target speed after 2 seconds, full-service brake shall be applied up to a predefined speed exceeding the target speed (to be decided during the design phase). If the full-service brake fails or is not adequate and the speed exceeds the predefined speed, then ATP shall apply the emergency brake. The full-service brake intervention and emergency brake intervention must be recorded. Once applied by the ATP system, the emergency brakes shall not be able to be released until the train reaches a complete stop. Each such operation will be recorded on the train-borne data log. Details shall be submitted for Project Manager's review during design phase.
- v) Identifying the platform side of the train with the train berthed at a station. The system shall then enable the doors to be opened on that side upon completion of ATC changeover from rear to front, if any; and
- vi) Receipt of a door closed signal indicating that all doors are closed and locked before the train may start. Loss of this signal shall cause the ATP system to initiate an Emergency brake application.

24.6.3.4 Restricted Manual Mode (RM) and Run On Sight Mode (ROS)

- 24.6.3.4.1 In RM mode, principally for use in depots and on mainline in case of failure of the wayside Signalling. The maximum train speed shall be controlled by the on-board ATP. This limit may be configurable to a speed determined to be safe for unsupervised driving between 15kmph and 25kmph. This mode shall be available only when the on-board ATP equipment is operational. The RM mode shall be operational when selected by the Train Operator.
- 24.6.3.4.2 The train operator shall be given a warning, both audio and visual when the speed is above RM threshold but below 25 kmph.
- 24.6.3.4.3 In Restricted Manual Mode, the train operator shall be able to control Train doors when the Train is stopped within the station stopping limits.
- 24.6.3.4.4 In ROS mode of operation, the train operator Runs on Sight. ROS mode shall be selected by a ROS button/ Key. ATP authorizes ROS request. In ROS mode, the train speed shall be controlled by the on-board ATP as in the case of RM mode. ATP shall give cab signal indications as soon as the train reaches a track position where normal running can be resumed.
- 24.6.3.4.5 The ROS driving mode will be unselected and will automatically switch from ROS to ATP with no brake application.

24.6.3.5 Restricted Manual Reverse (RMR) mode

Reverse operation shall be possible by bringing the Mode Selector in RMR position with ATP protection. It shall be possible to run in reverse direction under ATP protection on mainline.

The maximum permissible speed of the train shall not exceed 10kmph in reverse mode for a predefined distance. This predefined distance shall be designed by the Contractor and submitted to the Project Manager for Approval. (**CDRL-24-2**)

24.6.3.6 Not used.**24.6.3.7 Manual Cut-out (or By-pass) Mode**

- i) By-pass Mode shall be provided for use in the event of failure of the ATP system. In this mode, the train speed shall be controlled entirely by the train operator, to a limit adjustable between 15 kmph and 25 kmph. RS Contractor shall provide equipment and means to ensure that the maximum train speed remains within the above limit when the Cut-out Mode is in effect, under all circumstances. In case speed of the train exceeds 25kmph, 70% FSB shall be applied by RS Contractor.
- ii) The ATP By-pass Mode shall be initiated by the train operator operating a sealed Safety Cut-out Switch (SCS) and simultaneously breaking its seal. The operation shall be recorded by the on-board digital counter and TCMS. The SCS shall be provided by RS Contractor. The on-board digital counter shall be provided by the Signalling & Train Control Contractor. In this mode the train doors shall only be enabled and controlled manually.
- iii) The availability of power supply to the ATC system during this mode will be decided during the design finalization.

24.6.3.8 Washing and coupling mode

In Wash & Coupling mode, the speed is between 3 kmph to 5 kmph to prevent any damages of the automatic washing machine equipment and for safety reasons. Wash/Coupling mode will be selected through TCMS with SCS switch in Normal position with Mode selector in Forward position.

24.6.3.9 Unattended Trains Operation (UTO)

24.6.3.9.1. UTO operation shall be compliant to EN 62290-1 to 3, IEC 62267:2009 or latest and IEEE1474-1 to 3-2008 or latest.

24.6.3.9.2. The Trains shall operate in Unattended Trains Operation (UTO) mode when the mode selector is at "OFF" position and the UTO button activate.

24.6.3.9.3. Information of the operation of the equipment shall be transmitted to the OCC/BCC via the Communication system or Signalling & Train Control system. Sufficient information shall be transmitted to enable the OCC/BCC to determine the status of the equipment, sub- systems, and systems of the Trains and to issue the required control commands to the Trains via the radio communication system or Signalling & Train Control system to control the equipment or reset any equipment to meet the safety and reliability requirements specified in this specification.

24.6.3.9.4. All radio communication equipment and Signalling equipment of the Trains shall be maintained in active status, ready to receive or transmit any data to and from the OCC/BCC.

24.6.3.9.5. All equipment shall be provided with self-diagnostics function and the health status shall be transmitted to the OCC/BCC via the Communication system or Signalling & Train Control system.

24.6.3.9.6. Under UTO mode, the train departure, train running, and train stopping shall be controlled by Signalling & Train Control system.

24.6.3.9.7. Under UTO mode, the Trains shall achieve a station stopping accuracy of $\pm 250\text{mm}$ with 99.98% accuracy.

24.6.3.9.8. To enable the OCC/BCC to handle "Undershoot or Overshoot" situations at station's normal stopping point, the OCC/BCC shall be able to command the Trains to perform inching movement via the Signalling & Train Control system.

24.6.3.9.9. The trains shall be capable of travelling between 3 kmph to 5 kmph (under Signalling control) to enable exterior cleaning at the Automatic Wash Plant. The Contractor shall submit the details during design phase. (**CDRL-24-4**)

24.6.3.9.10. Automatic opening of doors on the appropriate platform side(s) when the train is berthed. When the dwell time has elapsed, the Trains doors shall be closed automatically with PA and chimes prior to the door close operation.

24.6.3.9.11. Under UTO operation, it shall be possible for the Signalling & Train Control system or the OCC/BCC to remotely set the Trains to operate in any of the following operation modes:

i) Sleep Mode

- The Trains shall enter shutdown mode.
- Equipment required enabling the Trains to receive commands from the

Signalling & Train Control system and radio system shall remain live.

ii) **Wake Up Mode**

- All systems shall be initialized and a self-check to be carried out to confirm the health status.
- The Trains shall be put in a state ready for service.
- The OCC/BCC and the Signalling & Train Control system shall be notified when the Trains is ready for service.

In the event the Trains fails to complete the shutdown/initialization process, sufficient details of the failure shall be transmitted to the OCC/BCC to enable the determination of appropriate actions to be taken.

24.6.3.10 ATB (Automatic Turn Back) Mode

The ATO mode shall include Automatic Turn back at the terminal stations including intermediate turn back stations. The Automatic turn back facility will be without driver and shall be provided at terminal stations at

- a) Platform of the terminal station
- b) Turn back track at rear of the terminal station and
- c) Platform of intermediate turn back station.

The details of ATB function will be discussed and finalized during design stage. Rolling Stock Contractor has to interface with Signalling & Train Control Contractor to design ATB Feature and submit the proposal for Project Manager's review during design phase. **(CDRL-24-5)**

24.6.3.11 Fall-back mode

The ATP mode shall include a fallback mode if the ATP track side equipment or the radio infrastructure fails. In such case, the system shall use the axle-counter to detect the position of the trains, set protection area before and after the train and command the train operation with track side Signalling. The driver manually drives the train based on the display of the track side signal and cab signal.

24.6.3.12 Identification: Train operating mode, Train Description and Next Station Information

- i) The Signaling & Train Control Contractor shall provide a four-digit digital Train Identification Number (Train ID) to the Rolling Stock Contractor. The first two digits shall identify the destination while the second two digits shall be the service identifier. The destination codes shall signify unique routes. The destination code shall also be provided for different lines in a station so that this code can be utilized by other sub-systems for their respective purpose. The Rolling Stock Contractor shall accordingly use the relevant information such as names of intermediate stations, stopping pattern, station stop door opening side information, skipping station information, keep door close information, train going to depot information etc. for operation of on-train systems.
- ii) Train ID shall be allocated to train when it enters the service and shall be maintained until it finishes its service. It shall be possible by the Employer to amend and / or modify the Train ID, subsequently, to suit the operational requirements. The Signalling & Train Control and Rolling Stock Contractors shall provide necessary equipment and means for the same to be defined during the detailed design stage. Rolling Stock contractor shall provide suitable

arrangement for train operator to view the Train ID on TCMS and also Signalling & Train Control contractor shall provide suitable arrangement for train operator to view the Train ID on DMI.

- iii) The Rolling Stock and the Signalling & Train Control Contractors shall exchange information identifying the effective mode, the active or non-active status of each cab, the door status etc. The inputs shall be categorized as vital and non-vital. The levels and form of these inputs shall be Coordinated between the two Contractors.
- iv) The Rolling Stock Contractor shall provide necessary inputs to the Signalling & Train Control Contractor identifying the required mode and status of active cab etc. RS Contractor shall provide rake ID and other relevant information as mutually decided with Signalling & Train Control Contractor, the levels and form of these inputs shall be Coordinated between the two Contractors.
- v) The Rolling Stock Contractor shall log each time the mode is changed using the on-board TCMS equipment.
- vi) In By-pass or Cut-out Mode, an external indication light shall flash or occult. Details shall be finalized during design stage.
- vii) The Signalling & Train Control Contractor shall provide the necessary input signals (next station information code, platform side information, triggering signal, Departure bits, arrival bits, Destination bits etc.) to Rolling Stock for displaying and making next station announcements to passengers on-board. The Rolling Stock Contractor shall provide the necessary hardware. Levels and protocols shall be agreed between the contractors.
- viii) For UTO/ATO operation, the necessary train command digital inputs signals shall be provided by the Signalling & Train Control Contractor. The ATP/ATO/UTO initiated signal demands shall be redundant. The redundancy shall also be provided on TCMS side by RS Contractor. The form of these inputs shall be coordinated between RS and Signalling & Train Control Contractors.

24.6.4 Interface Requirements between Signalling & Train Control and Rolling Stock Contractors

24.6.4.1 General

- 24.6.4.1.1 The Signalling and Train Control Contractor shall provide the Rolling Stock Contractor with the final list of equipment to be provided on the Rolling Stock. The sizes and weights of the UTO/ATO/ATP on-board cab equipment and antennae etc. to be mounted on the Rolling Stock shall also be provided, as applicable. The location of the on-board cab equipment shall be mutually agreed between Signalling & Train Control and Rolling Stock Contractors so as to optimize seating & standing space duly considering maintainability and easy accessibility. However, the on-board ATC equipment shall not be placed in the under frame on account of maintainability issues.
- 24.6.4.1.2 The Signalling and Train Control Contractor shall deliver to the Rolling Stock Contractor's factories, all train-borne ATC equipment, as applicable, and data to

enable fitting and testing. Connector fixing and cable harnessing shall be done by RS contractor under the supervision of Signalling & Train control Contractor.

- 24.6.4.1.3 The Signalling & Train Control Contractor shall supply at Rolling Stock Contractor's factories pre-wired equipment racks with appropriate connectors for all wiring terminating inside ATC, including wiring between ATC racks. The Signalling & Train Control Contractor, with the details provided by Rolling Stock Contractor shall ensure that the exterior finish and colours of the respective equipment suitably harmonize with that of the Train interior and the vicinity.
- 24.6.4.1.4 For Compatibility, the Rolling Stock and train detection system (axle counters), shall conform to EN 50238.
- 24.6.4.1.5 Interfacing wiring for each module provided by Signalling & Train Control Contractor including the interfacing wiring between Signalling & Train Control equipment shall terminate in a quick disconnect robust plug connector suitable for traction applications, with direct cable connection as far as possible. All cable connectors shall be identified within the cubicle using robust cable markers with distinctive colors for identification of e.g. safety function cables.
- 24.6.4.1.6 For all relay contact interfaces Signalling & Train Control Contractor shall provide auto-contact jam detection and contact bounce elimination function to ensure proper operation of the system. Relays for safety functions shall comply with the appropriate internationally accepted standard specification.
- 24.6.4.1.7 Signalling & Train Control Contractor shall provide Rolling Stock Contractor with the number of wires and/or Ethernet connections required between cars of a married pair and between married pairs to transmit signals from one end of the rake to the other end through electrical jumper. Provisions of redundancy and spares shall be catered by contractor for train lines and/or Ethernet connections.
- 24.6.4.1.8 Rolling Stock Contractor shall provide necessary video ports, power points and space onboard the train for monitoring video camera installed in the saloon area from OCC/BCC. For this necessary liaison shall be made with Signalling & Train Control Contractor.
- 24.6.4.1.9 Vehicle control circuits shall be developed by the Rolling Stock Contractor. During the design stage, all the vehicle control circuits incorporating the identified interfaces shall be provided to the Signalling & Train Control Contractor, as applicable. Signalling & Train Control Contractor shall provide specific observations on these circuits to the Rolling Stock Contractor. The Rolling Stock Contractor shall suitably incorporate these observations in the design.
- 24.6.4.1.10 Screened cables for train borne Signalling & Train Control equipment shall be properly terminated so as to ensure that no return loops are formed to cause electrical noise.
- 24.6.4.1.11 Not used
- 24.6.4.1.12 Both Signalling & Train Control and Rolling Stock Contractors to ensure that all signal received from Signalling & Train Control equipment and signals sent to Signalling & Train Control shall be recorded and shall be available for retrieval for analysis / record. All signals exchanged between Rolling Stock and Signalling & Train Control shall be monitored through TCMS. Signalling & Train Control

Contractor shall interface with Rolling Stock Contractor to finalized the necessary format which their data will be captured by TCMS and shall also provide necessary reading tools to read this data from TCMS.

- 24.6.4.1.13 Rolling Stock Contractor shall ensure that all doors related and other safety / train control related signals including brakes, position of safety cut out switch, direction related relays, suspensions, obstruction on track etc. are communicated to the Signalling & Train Control Contractor. Safety related signal from Rolling Stock side shall be communicated to Signalling & Train Control Contractor as per the requirement for ATP/ATO/UTO mode of operation.
- 24.6.4.1.14 Signalling & Train Control Contractor shall define as a part of interface, the signals that will be provided by Signalling & Train Control train borne equipment to Rolling Stock Contractor for incorporating in Rolling Stock design.
- 24.6.4.1.15 Provision of “Jog mode” operation (for aligning train in case of undershoot/overshoot of Normal stopping point within a limit) and “creep mode” operation (for moving the train under protection of ATP in case of UTO system failure) shall be addressed in the interface. Details shall be discussed and finalized during the design phase.
- 24.6.4.1.16 The Rolling Stock Contractor and Signalling & Train Control Contractor will jointly finalize a list of actionable command and responses for UTO (GoA-4) mode of operation which shall be available at Central Automatic Train Supervision (CATS) system at OCC/BCC as well as Local workstation at Station Control Room (SCR). The two contractors shall also finalize the list of alarms and events for Rolling Stock monitoring and troubleshooting which shall be displayed on the Rolling Stock controller monitor of CATS system at OCC/BCC as well as on other suitable terminals in depot and on the mainline. The information given to the OCC/BCC shall be clear and concise on nature of the fault. The OCC/BCC shall only be informed of failures that could result in the train being unfit for passenger service. Superfluous and misleading information shall not be displayed.
- 24.6.4.1.17 The key alarms, which are related to the events of operation, safety etc. and critical/serious in nature shall be displayed to both Traffic Controller as well to Rolling Stock Controller. All other alarms and events shall be displayed to Rolling Stock Controller.
- 24.6.4.1.18 The list of alarms, events and remote-control commands shall be proposed by Rolling Stock Contractor and approved by the Project Manager. The implementation of alarms, events and remote-control commands shall be ensured by both the Contractors. The packet size should have margin to accommodate additional requirement for future.
- 24.6.4.1.19 The Project Manager shall be able to add/delete/modify the alarms, event and remote command up to 6 months after commencement of UTO operation. Necessary training and hands-on shall be provided during execution of project.
- 24.6.4.1.20 Rolling Stock Contractor shall propose a user-friendly Graphical User Interface (OCC GUI for RS Controller) in both OCC & BCC in the form of a conceptual schematic/wireframe that shall include page layouts, arrangement of the GUI's content, interface and navigational elements, and a description of how they work together. The features of OCC GUI for Rolling Stock Controller shall be as under:

- a) The GUI shall have the capability to monitor the information of all trains within the network. The GUI shall employ different colors for highlighting different status of trains. The status of various subsystems, MCBs, Relays & Switches, Train Lines shall be displayed on GUI, and it shall be possible to acknowledge faulty trains immediately. It shall be possible to identify cause of Events/Alarms on GUI.
- b) The GUI shall make available both current faults and historical fault records with provision of sorting and filtering the list.
- c) There shall also be a provision to request on-board TCMS VDU screen on demand for display on RS controller screen with automatic refresh periodically not more than 1 second, with navigation feature and actionable button.
- d) A user-friendly Troubleshooting Directory (TSD) shall also be made available in the GUI.
- e) The GUI shall also make available remote-control commands via clickable screen button elements that shall be visibly different from non-clickable icons/shapes. It shall be possible to distinguish which remote control command is active/inactive. Remote control commands from OCC GUI for RS Controller shall be additional to the commands from ATS.
- f) The screen elements shall be dynamic dropdown menus to make optimum use of screen area.

Transfer and display of OCC GUI from RS Controller workstation to LVS shall be responsibility of Signalling & Train Control Contractor for which Rolling Stock and Signalling & Train Control Contractors shall interface.

24.6.4.1.21 Train Operation Data (TOD) shall contain train status data and faults/alarms/information etc. to be displayed on the RS Controller console. The Signalling & Train Control Contractor shall ensure that sufficient margin in the data packet size have been kept and the bit mapping of the packet contents are easily editable independent of the ATS software. The TOD shall have a refresh rate of minimum 1 second.

24.6.4.1.22 The Rolling Stock Contractor shall provide CCTV NVR, cameras and other associated equipment in the train which will cover cab, saloon, front of the train, rear view camera, area for passenger initiated alarm, platform area to obtain entraining and detraining of passenger view etc. The CCTV recorder (NVR) shall provide for minimum 7 days of recording on-board of commercial / revenue operation. The Rolling Stock Contractor and the Signalling & Train Control Contractor shall interface for control and data transfer of CCTV images from the train to OCC/BCC on Rolling Stock controller (RSC) terminal, separate terminal provide by ATS terminal and Large Video Screen. The hardware interface in the train shall be furnished and installed by the Rolling Stock Contractor. The CCTV signal shall be provided by the Rolling Stock Contractor at a suitable port on-board to the Signalling & Train Control Contractor for transmission to OCC/BCC. There will be no processing of the CCTV data by the Signalling & Train Control Contractor. At OCC/BCC at suitable terminals shall be able to select any camera on-board and view the recording live at any terminal/workstation. The Levels and protocols shall be agreed between the two contractors during design phase. A joint Detailed Interface Documents (DID) shall be submitted for Project Manager's review. **(CDRL-24-6)**

24.6.4.1.23 The CCTV server shall be provided in OCC and BCC by Signalling & Train Control Contractor. The Signalling & Train Control Contractor shall interface with Rolling Stock Contractor for correct assessment of storage of all camera images to have virtual view of required area. Facility to transfer historic data for any event on demand from train to OCC/BCC shall be made available.

24.6.4.1.24 Necessary provision in terms of playing the historic data in OCC/BCC along with sufficient storage capacity to store data of 30 days shall be ensured in CCTV server. A joint Detailed Interface Documents (DID) shall be submitted for Project Manager's review. **(CDRL-24-6)**

24.6.4.1.25 CCTV image feed received in OCC/BCC shall support buffering with 10 min pre data stored on memory cache of CCTV server. The GUI for viewing CCTV images shall support rewinding the images up to 10 min before real-time. Rolling Stock Contractor shall interface with Signalling & Train Control Contractor for transmitting all camera footage to central server and also viewing real time footage of any train, any camera from OCC/BCC.

24.6.4.1.26 Rolling Stock and Signalling & Train Control Contractors shall interface to ensure that at least but not limited to following emergency conditions should result in the event-based auto popup of CCTV images via CCTV network on RS Controller Terminal. In case of such event-based popup, the corresponding video stream from onboard train (5 min. pre and 15 min post recorded CCTV feeds) shall be stored automatically in the CCTV server provided in OCC/BCC. The detail implementation shall be finalized during interface with the approval of Project Manager. The utilization of bandwidth of CCTV network shall be managed dynamically.

- PEA activation
- Obstruction Deflection Device (ODD) activation
- Side Door Obstacle detection
- Fire/Smoke Detection
- Driving console cover open
- Detection of track abnormality by Track Monitoring System

Transfer and display of such images from CCTV Server to LVS and Traffic Controller workstations shall be responsibility of Signalling & Train Control Contractor for which Rolling Stock and Signalling & Train Control Contractor shall interface. **(CDRL-24-7)**

24.6.4.1.27 Not used.

24.6.4.1.28 Rolling Stock Contractor shall make provision of CAT-7 or latest cable/Optical Fibre, power supply, switch (level 3) and space & bracket for mounting of Wi-Fi antennas & equipment in the train for Wi-Fi facility for passengers. The equipment for Wi-Fi in the train such as antennas, servers, etc. shall be supplied by Wi-Fi Contractor. Provision of dynamic bandwidth and its optimization for different uses shall be ensured suitably.

Details shall be submitted for Project Manager review during design phase.

24.6.4.1.29 Not used

24.6.4.1.30 There shall be 4 separate radio system for communication between Train and wayside. The system will broadly cater to Train Radio (TETRA) traffic, CBTC

traffic, CCTV traffic and Wi-Fi Traffic. The details of sharing of the 4 radio systems for sending control and data information, levels and protocols thereof, will be jointly agreed by Signalling & Train Control Contractor, Telecommunication Contractor, Rolling Stock Contractor and Wi-Fi Contractor. The radio system (including on-board equipment) for Train Radio traffic shall be provided by the Telecommunication Contractor while the radio system (including on-board equipment) for sending CBTC, CCTV and other data pertaining to passenger voice, control, alarm, events etc. shall be provided by the Signalling & Train Control Contractor including on board equipment.

The bandwidth allocation on CCTV network shall be dynamically managed. Detailed proposal for the same shall be submitted by Signalling & Train Control Contractor for Project Manager's review and approval. **(CDRL-24-8)**

24.6.4.1.31 The Rolling Stock Contractor shall prepare an interface document jointly with the Signalling & Train Control Contractor to address the procedures to be adopted for rescuing the failed train on main line by coupling the failed train with healthy train and subsequently clearing the line in pull/push mode with healthy train shall be submitted to the Project Manager for review and approval. **(CDRL -24-9)**

24.6.4.1.32 Automatic Trains Operation System (ATO) and Unattended Train Operation system (UTO) shall operate in accordance with timetable schedules and energy saving regulation strategies to ensure smooth and efficient operation of Trains in both Mainline, Depot Arrival & Departure tracks and Test Track. It shall drive Trains automatically by using the traction and brake controls in a controlled manner, regulate the speeds of Trains, ensure accurate station stopping and perform platform duties or other functions otherwise assigned to the Train Operator.

24.6.4.1.33 Roll Back Detection

The ATP system shall detect rollback. When excessive rollback is detected, the emergency brake shall apply.

Rollback is defined as movement in the reverse direction when any of the forward driving modes are selected (UTO/ATO, ATP or RM) or movement in the forward direction when reverse mode is selected.

This predefined distance and speed shall be finalized by the Signalling & Train Control Contractor in interface with the Rolling Stock Contractor and the same shall be submitted by Rolling Stock Contractor for Project Manager's review. **(CDRL-24-10)**

24.6.4.1.34 Signalling & Train Control Contractor and Rolling Stock Contractor shall interface for initiation, termination and success or failure of emergency calls initiated by passengers to OCC/BCC. The initiation of this passenger call shall automatically focus a CCTV camera on the passenger and raise a prompt on a suitable terminal of OCC/BCC. The hardware interface in the train shall be furnished and installed by RS Contractor. The Contractor shall submit the details for Project Manager's review. **(CDRL-24-11)**

24.6.4.1.35 Integrated Testing and Commissioning

The Rolling Stock, Signalling & Train Control and PSD/PSG Contractors shall perform System Integration Test and the tests shall include but not limited to traction and braking control, precision stopping, automatic turn back, jog function,

creep function, door operation, PSD/PSG operation, train wake up, PA/PIS functioning test, remote command and control for Rolling Stock, validating of modes of operation under Signalling (ATP/ATO/UTO), monitoring / troubleshooting from OCC/BCC/DCC to train (for UTO), reset commands jointly agreed by Rolling Stock Contractor and Signalling & Train Control Contractor as per requirement of GoA-4 mode of operation, safety related tests etc. All contractors shall jointly produce a protocol document for Integrated Testing and Commissioning for Project Manager's review. **(CDRL-24-12)**

24.6.4.1.36 The Signalling & Train Control Contractor as a Lead Contractor shall prepare a comprehensive Operating Modes and Principle Document (OMPD) **(CDRL-24-13)**

The Rolling Stock Contractor, PSD/PSG Contractor and Communication Contractor will assist the Signalling & Train Control Contractor in preparation of the document.

The Traction and Tunnel Ventilation Contractors will also assist the Signalling & Train Control Contractor in preparation of the documents. The Employer will provide necessary inputs such as standard operating procedures etc. 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.

24.6.4.1.37 The Rolling Stock Contractor and Signalling & Train Control Contractor shall implement automatic "sleep", "wake-up", "testing and dispatch etc. (pertaining to UTO mode of operation)" of trains stabled at depot/ siding /main line. Rolling Stock will send suitable signal through Signalling interface for display of indication and alarm at OCC/BCC/SCR/DCC level. The Rolling Stock Contractor shall submit details for Project Manager's review. **(CDRL-24-14)**

24.6.4.1.38 Train Event Recorder shall be provided by Rolling Stock Contractor, designed to resist tampering, that monitors and records data on train speed, direction of motion, time, distance, TBC position, brake applications and operations (including service brake, emergency brake) equipped, cab signal aspect(s) etc. Signalls from ATC/ATS side required to be recorded by Event Recorder & TCMS shall be decided during design phase and shall be tested during integrated testing and commissioning with Signalling & Train Control Contractor. The Rolling Stock Contractor shall submit the details for Project Manager's review. **(CDRL-24-15)**

24.6.4.1.39 In case of resumption of traction supply after failure/otherwise and when number of trains are standing in the section, ATS shall be capable of issuing sequential/staggered power on command and sequential/staggered starting of the train to avoid overloading of the Traction Supply. The Contractor shall submit the details for Project Manager's review. **(CDRL-24-16)**

24.6.4.1.40 In ATO/UTO modes of operation, Signalling & Train Control Contractor shall ensure that cross overs are negotiated in coasting mode only. In case the crossover cannot be negotiated in coasting due to factors such as gradient, minimum powering should be used to negotiate the cross over. Location of the

cross over shall be identified by the ATC system and necessary train control should be implemented. In other modes of operation (ATP, RM, ROS, etc.), a coasting icon shall be displayed on the Signalling DMI when approaching a crossover to inform the train operator. The crossover information shall also be communicated to TCMS by the ATC system. Rolling Stock Contractor shall use this information to implement necessary controls in the propulsion system to avoid flashing at CCD and minimize inrush/overcurrent conditions in the propulsion and auxiliary circuits when train is moving on crossovers. Signalling & Train Control Contractor shall interface with Rolling Stock Contractor & Power Supply Contractor to finalize the same.

24.6.4.1.41 The Rolling Stock Contractor shall provide necessary signals to the Signalling & Train Control Contractor for proper functioning of Platform Screen Door/Gate (PSD/PSG). The Rolling Stock and Signalling & Train Control Contractor shall interface for exchange of signals and develop protocol for proper working of Platform Screen Door (PSD)/PSG.

24.6.4.1.42 Rolling Stock Contractor shall provide KE and door drawings of train to Signalling & Train Control contractor for placement of Platform Screen Doors/Gates and shall share the location of Emergency Access Device (EAD) and parking brake release lever with the Signalling & Train Control Contractor and also their operating mechanism. The Contractors shall also interface for synchronization of Train door & PSD/PSG opening and closing and for access of PSD/PSG Local Control Panel from train operator side.

24.6.4.1.43 Rolling Stock and Signalling & Train Control Contractors shall exchange the defective/Isolated train door and PSD door information so that if a particular train door is defective/isolated, the corresponding PSD shall not open and vice versa. Also, Rolling Stock, Signalling & Train Control and PSD Contractors shall interface for provision of reclosing the door(s) without opening all doors in case of obstruction detection.

24.6.4.1.44 Both the Rolling Stock and Signalling & Train Control Contractors shall log the commands and indications sent / received to / from the PSD/PSG system and the PSD/PSG system shall also Log the commands and indications sent / received from the Rolling Stock and Signalling & Train Control systems.

All the three systems shall be synchronized with a common clock system, and the Logs in each of the systems shall be so configured such it shall be possible to correlate the commands & indications sent/received from/to each of the three systems for post-incident analysis of incidents of PSD/PSG Train doors not opening / closing.

24.6.4.1.45 Additionally, in the event of a Train Door not opening due to a corresponding PSD/PSG at a Station being isolated (due to a fault /any other reason), the RS Contractor shall make arrangements to provide suitable indications on/for that particular door, for informing the passengers that this Door shall not Open at the next station and passengers may move to adjacent Doors. E.g. a Red LED/Lamp on each Train Door may be provided to indicate that the "Train Door shall not Open on the next Station". The RS contractor may use a multi-colour LED on the Train Door where- in yellow colour (steady / flashing) shall indicate normal operating

status and RED colour (with suitable/associated stickers/screen printing) indicating a Fault condition of the Train Door (Door not opening).

Similarly, in the event of a PSD/PSG not opening due to a corresponding train door being isolated (due to a fault /any other reason), the Signalling & Train Control Contractor shall make arrangements to provide suitable indications on/for that particular PSD/PSG, for informing the passengers that this Door shall not Open when the train arrives and passengers may move to adjacent Doors.

Signalling & Train Control and RS Contractors shall interface together to provide the above functionality.

24.6.4.2 Rolling Stock Characteristics to be used by Signalling & Train control Contractor

24.6.4.2.1 The Signalling & Train Control system will work on moving block principle and the system shall be so designed to meet the headway requirements of 6-car train, based on the characteristics of the vehicles to be furnished (Annexure 1/D: Rolling Stock Characteristics) and the track geometry. The back-up (line-side) Signalling (In ROS/RM/cut out mode) shall use same axle counter as designed for the ATP working. Rolling Stock Contractor shall provide traction and braking characteristics of the actual vehicles and Signalling & Train Control Contractor must co-ordinate with Rolling Stock Contractor to fine-tune the system design based on the traction and braking characteristics of the actual vehicles furnished. Acceptance tests of the signal system will use the actual vehicles supplied. Brake capacity of the Rolling Stock shall be used optimally to ensure its maximum utilization when full brake equipment is operational. In case of isolation of any brake system or bogie/car, Rolling Stock Contractor shall furnish requisite information to Signalling & Train Control Contractor to optimize the brake rate including GEBR. However, GEBR shall never be compromised.

24.6.4.2.2 Not used

24.6.4.2.3 The model for calculating the safe braking distance (SBD) shall identify and take into account various systems' response times and train operators' reaction times and shall be in accordance with IEEE 1474.1 standard. The design of CBTC system shall also take into account the effect of track geometry on the traction and braking characteristics. The Rolling Stock Contractor shall furnish the Guaranteed Emergency Braking Rate (GEBR) at the normal braking efficiency (with no isolation/bogie isolation / CAR isolation) and at the lowest braking efficiency permitted in service including brake deterioration to Signalling & Train Control Contractor. Rolling Stock Contractor shall also provide the speed-time-/acceleration- time curves between stations and speed/tractive effort curves, for all loading conditions. The system shall be designed to optimize train performance to the best of its capability.

24.6.4.2.4 The Rolling Stock Contractor shall furnish as a minimum the Rolling Stock parameters to be used by the Signalling & Train Control Contractor for designing the CBTC system, as set out in the attached Table (Annexure 1/D: Rolling Stock Characteristics). The Rolling Stock Contractor shall also furnish a reasonable tolerance band for the identified performance parameters. The Rolling Stock

Contractor shall ensure that all the trains supplied perform within the tolerance band.

24.6.4.2.5 For any other information required by Signalling & Train Control Contractor, Signalling & Train Control Contractor shall co-ordinate with RS Contractor.

24.6.4.2.6 During the train operation, it may be desirable to optimize acceleration/ deceleration on the basis of varying loads/ line profile/ intended rising & falling gradients at entry/exit of the platforms. Rolling Stock Contractor and Signalling & Train Control Contractor shall resolve these issues during interface with the intention of optimizing train performance.

24.6.4.2.7 Rolling Stock Contractor and Signalling & Train Control Contractor shall share all the interface signals so as to enable logging / recording of these signals/data by either of them. During the design if any other signal needs to be shared for the purpose as above, the same shall also be ensured by either contractor.

24.6.4.2.8 The Rolling Stock Contractor shall provide optimized energy efficient run curve pattern to Signalling & Train Control Contractor for incorporation in the ATO/UTO mode of operation. All associated information as requested by Signalling & Train Control Contractor shall be duly handed over by Rolling Stock Contractor. The efficacy of the finalized run curves shall be jointly demonstrated by means of simulations as well as line trials. In this, Rolling Stock contractor shall take the lead role and Signalling & Train Control Contractor shall support Rolling Stock Contractor.

Optimization of energy efficient mode shall consider different TE (Tractive Effort)/ BE (Braking Effort) curve for different loads as well. Contractor shall demonstrate optimization of energy with respect to different TE (Tractive Effort) /BE (Braking Effort) curve for different loads. Rolling Stock Contractor shall submit the details for Project Manager's review **(CDRL-24-17)**.

24.6.4.2.9 The Rolling Stock Contractor shall provide facilities to detect any coupling detachment and/or separation of detachable units of a train consist. Upon detection of an impromptu uncoupling, detachment or separation, an immediate emergency braking to stop shall be invoked on all units of the connected train. The train parting information shall be shared by Rolling Stock to the Signalling & Train Control Contractor. On receiving the Signal from Rolling Stock, the ATC shall detect the unexpected uncoupling and establish appropriate limits of authority to prevent following trains from entering the area where the uncoupling has occurred. Consequently, an immediate alarm shall be raised and forwarded to the OCC/BCC/train operator.

24.6.4.3 **Signalling and Train Control Details to be used by Rolling Stock Contractor**

24.6.4.3.1 The following data shall be provided:

- a) The maximum power consumed by the Signalling & Train Control contractor equipment from the 110V D.C. supply under all specified operating conditions.
- b) The number of train wires/ connections required, and the specific function of each wire/communication architecture and protocols.
- c) Physical dimensions of the equipment to be fitted on Rolling Stock.

- d) All control logic outputs.
- e) Electrical characteristics of the interconnection cabling and wiring.
- f) Sensitivity levels and frequencies which must be avoided.
- g) The specific heat load for air conditioning purposes.
- h) Specific ventilation requirements if any
- i) The EMC/EMI requirements including the limiting value of psophometric current, to obviate interference in the operation of Signalling & Train Control equipment.
- j) Details of the provisions required to enable the bidirectional transference of data from the train to the wayside and vice versa.

24.6.4.4 ATC Equipment Cubicles:

- 24.6.4.4.1 The Rolling Stock Contractor shall supply the ATC equipment cubicle enclosure(s). All supports, braces, mounting holes, cabling apertures, accessories etc. required for mounting the cubicle and its equipment shall be properly Coordinated between the Signalling & Train Control Contractor and the Rolling Stock Contractor to ensure secure mounting, and access. The cubicle(s) shall be resiliently mounted and suitably protected to the requisite IP level. For housing of ATC equipment, suitable enclosed environment (minimum IP-52) needs to be provided by the RS Contractor.
- 24.6.4.4.2 To achieve the ATC control functions, the Signalling & Train control Contractor shall identify any interfacing circuits specifically required for ATC operation and liaise with the Rolling Stock Contractor. These include but not be limited to start, door control, motoring, coasting, braking and emergency brake commands. Door control circuit design shall allow opening of doors in stand by position of mode selector under manual responsibility in case of non-availability of door opening authorization from ATP without losing the ATP mode.
- 24.6.4.4.3 For train control circuits, the Signalling & Train Control Contractor shall respectively identify the voltage free contacts to be provided by the Rolling Stock Contractor, including the number and type of electrical signals required between the ATP/ATO equipment and the equipment provided by the Rolling Stock Contractor. The two contractors shall co-ordinate to agree on levels and protocols for each such signal.
- 24.6.4.4.4 As a minimum, all electronic equipment to be mounted on Rolling Stock, including those provided by the Signalling & Train Control Contractor shall comply with IEC 60571: Electronic Equipment used on Rail Vehicles, for design, manufacture and testing, and shall use components purchased against an internationally recognized quality assurance and reliability certification procedure. The enclosures provided by Rolling Stock shall comply with IP requirements specified by the Signalling & Train Control Contractor.
- 24.6.4.4.5 All cable connectors shall be identified within the cubicle using robust cable markers with distinctive colours for identification.
- 24.6.4.4.6 All labelling shall be in ENGLISH. Hand-written labels shall not be used.

24.6.4.5 Antennae:

- 24.6.4.5.1 The Signalling & Train Control Contractor shall identify roof, bogie, and underframe-mounted antennae, and associated disconnection box mounting brackets and location requirements to identify cable and conduit routes required to antennae, as applicable.
- 24.6.4.5.2 The Signalling & Train Control Contractor for their respective scope, shall supply the necessary disconnection boxes, terminal blocks, cables and adaptation mounting brackets, flexible conduit assemblies complete with connectors and cables from antennae to the junction boxes.
- 24.6.4.5.3 The Rolling Stock Contractor shall provide the antenna mounting brackets, conduits, support or clamping arrangements to ensure security and reliability.
- 24.6.4.5.4 The antenna system shall not infringe the kinematic envelope and fully meet the radio coverage requirements, the requirements both for normal and reverse directions of train working.

24.6.4.6 Speed Measurement Devices:

- 24.6.4.6.1 For each ATC equipment set (per driving cab), the Signalling & Train Control Contractor shall supply to the Rolling Stock Contractor for installation, axle mounting speed measurement devices, couplings & Radar, to be configured, and the data from them processed in such a way as to achieve the objectives of 24.6.4.6.3 below in fail safe manner.
- 24.6.4.6.2 The speed measurement device shall be mounted those axles, which are non-powered.
- 24.6.4.6.3 The Signalling & Train Control Contractor shall ensure that the speed measurement devices produce a signal which reflects the true speed of the train (within ± 1.0 km/h) under any operational, weather and track conditions including gradient, curvature, and wheel spin/slide. The error in the speed measurement due to wear in wheel diameter, up to the laid down limits shall be mitigated by automatic means or other safe method.
- 24.6.4.6.4 The Signalling & Train Control Contractor shall supply the necessary disconnection and terminal blocks, device mounting brackets and plates, flexible conduit assemblies complete with connectors and cables from speed measurement devices to the junction boxes. The Signalling & Train Control Contractor will supply all the mechanical fixing items like odometer, Antenna, Radar, pick up coil and cables required for ATC. like cables for Odometer, Antenna & Radar etc.
- 24.6.4.6.5 The Rolling Stock Contractor shall provide for each speed measurement device mounting brackets, support or clamping arrangements to ensure security and reliability.
- 24.6.4.6.6 The Signalling & Train Control Contractor shall furnish the zero-velocity detection apparatus (ZVR relay).
- 24.6.4.6.7 The Signalling & Train Control Contractor shall provide speedometer indicating the actual speed, and with target speed in digital format. The design shall be acceptable to the Project Manager.

24.6.4.6.8 The Automatic Train Protection (ATP) system shall issue the braking commands to the Rolling Stock when safety limits are exceeded or when over-speed is detected. Removal of traction power and the correct application of brakes shall be the responsibility the Rolling Stock Contractor. The ATP system shall be responsible for monitoring of speed and the issuing of braking commands when safety limits are exceeded.

24.6.4.6.9 Parking brakes shall be provided by the Rolling Stock Contractor. The parking brakes shall be capable of holding a fully loaded stationary train on a 4% gradient under all track conditions, indefinitely.

24.6.4.6.10 The Signalling & Train Control Contractor shall furnish the Rolling Stock Contractor with full mounting details, apertures, fixing holes, etc.

24.6.4.7 Train Operator's Display:

24.6.4.7.1 The equipment on driver's console used for various modes shall be ergonomically placed and shall be compliant to UIC 651. Indications to the train operator shall be displayed on the ATC Cab Display supplied by the Signalling & Train Control Contractor. It shall incorporate as a minimum, but need not be limited to the following information:

1. Train description, (ID) including crew identification.
2. Target Distance.
3. Target Speed.
4. Actual Speed
5. Service and Emergency Brake Initiation.
6. Train docked along with the deviation distance from NSP.
7. Trains hold status.
8. Station dwell time available.
9. Departure order.
10. In ATP zone or not.
11. ATP/ATO/UTO failure indications.
12. Skip Stop indication.
13. Door Indication (Door Close, Door Open).
14. Maximum Permissible Safe Speed (MSS) in ATP, UTO and ATO Modes.
15. Train stopped outside of expected stopping window.
16. Depot indication, when the train is identified as being in a depot.
17. Axle locked indication, for axles on which ATC speed sensors are mounted.
18. Door release available; indicating on which side(s) of the train the doors may be opened.
19. Operating modes.
20. ATC self (combined) test in progress.

21. ATC self (combined) test OK.
22. ATC self (combined) test NOK.
23. Change of End.
24. Skip Station.
25. Cross-over Zone.
26. Work Zone.
27. Direction of Travel.
28. Door Closed and Locked.
29. Date, Time and Life Indicator.
30. Close Doors Order.
31. Open Doors Order
32. PSD/PSG Status (PSD/PSG/Closed/Open/failure detected /unknown...etc.).
33. Over Speed Alarm.
34. Slip/Slide Detection.
35. Roll Back Symbol.
36. Any other indication required for efficient / effective GoA4 train operations.

24.6.4.7.2 The DMI shall display following text messages in the event of EB for the below. It shall incorporate as a minimum, but need not be limited to the following information:

- a. EB: Train doors unlocked
- b. EB: Train hold applied
- c. EB: Over Speed
- d. EB: Fatal Fault
- e. EB: safety immobilization not obtained
- f. EB: signal overrun
- g. EB: roll back
- h. EB: changing mode while running
- i. EB: Requested by ATS

During design stage, Rolling Stock and Signalling & Train Control Contractors shall have to interface to integrate TCMS/DMI inputs, if considered necessary to optimize the driving console in the cab for operation under GoA4. Also, Signalling & Train Control Contractor shall interface with Rolling Stock Contractor, to provide required inputs, like current speed, target speed, Normal Stopping Point (NSP), target distance and mode of the train, as a minimum, to Rolling Stock HMI for display purposes.

24.6.4.8 Interface between TCMS and On-board Signalling Equipment and OCC/BCC:

- 24.6.4.8.1 The Rolling Stock Contractor shall provide an on-board Train Control Management System (TCMS), to log the information from the ATP/ATO/UTO equipment supplied by the Signalling & Train Control Contractor, in addition to the information shown in the Rolling Stock specification. Signalling & Train Control Contractor shall provide required tools for reading ATC data stored in TCMS.
- 24.6.4.8.2 Data stored in the TCMS shall be password protected. Levels and protocols shall be agreed between the Contractors. Software for downloading the data from TCMS to maintenance terminal shall be provided by the Rolling Stock Contractor. Signalling & Train Control Contractor shall provide Windows compatible software for maintenance terminals for viewing the data logged in TCMS. It shall be possible to extract the data remotely from Rolling Stock depot server to a suitable terminal at OCC/BCC through the depot network.
- 24.6.4.8.3 All the vital commands by the on-board ATP, ATO and UTO systems, to the Rolling equipment and the responses of the Rolling Stock equipment to these commands, shall also be recorded in TCMS.
- 24.6.4.8.4 The signals to be supplied from the TCMS to the equipment of the Signalling & Train Control Contractor shall be decided jointly between the Contractors.
- 24.6.4.8.5 TCMS shall be able to communicate data to OCC/BCC/DCC/SCR on the Rolling Stock terminal of ATS system. The data shall contain identified train alarms. The Rolling Stock and Signalling & Train Control Contractors shall interface to make the data available to its destination in OCC/BCC/DCC/SCR.
- 24.6.4.8.6 The interface shall ensure that TCMS receives necessary inputs from the on-board ATP system to enable TCMS to synchronize its clock with the system master clock. All the microprocessor/ micro-controller based on-train systems shall synchronize respective clocks with TCMS clock.
- 24.6.4.8.7 The Signalling & Train Control Contractor and Rolling Stock Contractor shall liaise with each other regarding the electrical requirements on the TCMS interface. The Rolling Stock Contractor shall advise the Signalling & Train Control Contractor on the protocol of communication with the TCMS and the response time.
- 24.6.4.8.8 The data to be transmitted from the train borne ATC equipment to the TCMS and from the TCMS to the train borne ATC equipment shall be determined mutually by both the Rolling Stock and Signalling & Train Control Contractor and submitted to Project Manager for review.
- 24.6.4.8.9 Not used
- 24.6.4.8.10 Control Output from ATC System to Rolling Stock
The Signalling & Train Control Contractor shall provide, but not limited to, the following outputs to the Rolling Stock:
- a. Emergency Brake Command
 - b. Motoring command
 - c. Service Brake Command
 - d. Train stationary (zero velocity) signal & indication

- e. Door open command
- f. Door close command
- g. Door enable command
- h. Advance directional door display (left or right side)
- i. Defective PSD/PSG at upcoming station (individual door) signal
- j. ATC System Fault
- k. Wake up/sleep command
- l. Train Wash command
- m. Inching command
- n. CCD control command
- o. High beam
- p. Horn Command
- q. Saloon Lighting/Air-condition ON/OFF command

The details shall be submitted by Signalling & Train Control contractor in interface with the Rolling Stock Contractor as a joint interface document for Project Manager's review (**CDRL-24-18**).

24.6.4.8.11 Control Output from Rolling Stock to ATC

The Rolling Stock Contractor shall provide, but not limited to, the following outputs from the trains:

- a. Mode selector selection
- b. UTO mode
- c. ATC bypass switch
- d. Emergency brake
- e. Brake Pressure
- f. Brake defective/Brake isolation
- g. Train depart readiness
- h. Train door status – Open / Close / Defective / Manual Release operated / Failure to close door after obstacle detection reclose attempts
- i. Train Integrity status
- j. Smoke alarm
- k. CCD status
- l. Train alarms and status
- m. Obstruction detection alarm
- n. Track abnormality detection alarm
- o. Hot Axle detection alarm

The details shall be submitted by Signalling & Train Control contractor in interface with the Rolling Stock Contractor as a joint interface document for Project Manager's review (**CDRL-24-19**).

24.6.4.8.12 **Key Alarms and Remote-Control Commands from OCC/BCC**

The Signalling & Train Control Contractor and Rolling Stock Contractor shall coordinate to implement the following key alarms and remote-control commands from OCC/BCC. Below mentioned Alarms and Commands are bare minimum and shall not be construed as the entire list. Details shall be further discussed during design stage.

Key Alarms:

- a. Emergency Brake Applied
- b. Fire/Smoke detection inside train
- c. Emergency Egress Request
- d. EED cover broken
- e. Passenger Alarm Activation
- f. Driver desk cover opened
- g. Axle Lock
- h. No Light in any Car
- i. Train parting
- j. Failure of TCMS
- k. Train Fail to Start
- l. HSCB trip
- m. Obstacle / Derailment Detection
- n. Door Fail to Open (# of door)
- o. Door Fail to Close (# of door)
- p. Brake Fail to Apply/Release 'n' bogies (# of bogie)
- q. Traction Power Lost on 'n' Bogie (# of bogie)
- r. Smoke Detection outside train
- s. Failure of Fire Detector/ Fire Detection System
- t. Rail defect detected
- u. Failure of PEA
- v. Onboard CCTV Failure
- w. Speed restriction imposed due to
- x. Train in degraded mode

Remote Commands:

1. Door Open/Close
2. Emergency Brake Reset
3. Passenger Alarm Handling
4. Smoke Alarm Reset
5. Wake up/Sleep
6. CCD control
7. Inching movement
8. Wash Mode Control
9. HSCB Reset
10. Parking Brake Apply/Release
11. BLCOS (Brake loop cut-out)
12. Remote Isolation of Bogie for release of Service Brake only (Isolation shall not

- impact EB)
- 13.Compressor control
- 14.DPLCOS (Door Proving loop cut-out)
- 15.Door isolation
- 16.HVAC mode and temperature control
- 17.HVAC Reset Control
- 18.Damper Control
- 19.Interior Light Control
- 20.Stop all trains
- 21.ATC reset
- 22.Start-up tests
- 23.MCB reset
- 24.Door open in tunnel
- 25.Door Enable(DE)
- 26.PEA Reset
- 27.Flasher light On/ Off
- 28.Call on light control
- 29.Horn On/Off
- 30.Headlight On/Off
- 31.Cab light On/Off

The details shall be submitted by Signalling & Train Control contractor in interface with the Rolling Stock contractor as a joint interface document for Project Manager's review **(CDRL-24-20)**.

24.6.4.8.13 Signalling & Train Control Contractor in interface with Rolling Stock Contractor shall implement the following features:

- i) When a Startup Test (i.e., Combined test) is failed, ATS operator shall be provided an option to Re-Lunch the test again from OCC/BCC.
- ii) There shall be provision to stable and un-stable the trains automatically with timetable, without timetable or manually.
- iii) Waking up of trains from stabling shall be staggered to avoid sudden inrush current at the same time.
- iv) If due to any reason, Level Crossing is required to be provided in the depot, then the Level Crossing shall be controlled through Signalling & Train Control system.
- v) When a fire/smoke detection notification is received from a Train, the Signalling & Train Control System shall command any following Trains which have already departed the platform in the rear to stop immediately and prevent any further movement once stationary until authorized to do so by the OCC/BCC.
- vi) When a fire/smoke detection notification is received from a Train, the Signalling & Train Control System shall command any Train travelling towards the incident Train or the area where fire/smoke has been detected to stop immediately and prevent any further movement once stationary until authorized to do so by the OCC/BCC.

- vii) When there are no passengers in the train in main line service or during train movement in depot, Air Conditioning and Lighting shall be switched off automatically through interface between Signalling and Rolling Stock.
- viii) In UTO mode, if train gets delocalized, the system should use memorized location so that train can move with less speed until next beacon. Once train passes the next beacon, train shall be localized and get normal speed authorization.
- ix) Light Sleep and Deep Sleep functions shall be implemented.
- x) The Rolling Stock Contractor shall provide an Automatic Track Monitoring System using high resolution Digital Line Scan Camera in two trains (4Cameras, 2 in each train) of Line-6 and 4 trains of Silk Board – Kempegowda International Airport corridor (8 Cameras, 2 in each train) i.e. 12 Cameras in total. The proposed track monitoring system shall be proven for similar metro rail applications. Track monitoring system shall detect track conditions such as rail fractures, running edge defects, rail head surface defects, corrosion, missing fasteners etc. in real time using artificial intelligence up to 90 kmph of train speed. An on-board module shall be provided in the train to analyse and process the images/video stream eived from the Digital Line Scan Camera and detect defects in the track. Critical defects along with exact location of the defects shall be communicated to OCC/BCC in real time through the CCTV network to be supplied by Signalling & Train Control Contractor. The list of critical defects to be communicated to OCC/BCC shall be finalized during design phase. Necessary interface shall be ensured between the Rolling Stock, Signalling & Train Control and Track monitoring system contractor to achieve the required functionality. The Rolling Stock Contractor shall supply the on-board Digital Line Scan Camera, necessary software and hardware such as servers, workstations and networking equipment in OCC/BCC and the trains. Signalling & Train Control Contractor shall ensure communication of detection of track defects to OCC/BCC.
- xi) EB shall be applied on detection of obstruction by the Obstruction Deflection Device (ODD). The information shall be transmitted to OCC/BCC through Signalling & Train Control system. EB shall not be released unless the removal of obstruction is acknowledged by OCC/BCC or locally on the train.

24.6.4.8.14 Signalling and Train Control Contractor shall ensure synchronization between CATS, BATS, and DATS.

24.6.4.8.15 The Signalling & Train Control Contractor shall ensure that non-vital signals from the TCMS are not used by the ATP system for generating/enabling Vital control outputs.

24.6.4.8.16 Considering that the vital outputs generated by the ATP are SIL-4, normally all such Vital Outputs should use only hardwired inputs provided by the Rolling Stock or alternatively, if signals from the TCMS are used, then these Signals should generally be SIL-2 and shall be exchanged using Safety Data Transmission between ATP and TCMS as finalized during design stage.

- 24.6.4.8.17 Notwithstanding the above, if use of the TCMS signals for generating control (output) signals by the ATC is inescapable, then such TCMS interface signals to the ATP, should be constituent of the VITAL packet, configured for Safety to desired SIL (Up to SIL2) (as per Contract requirement). Details shall be finalized during design.
- 24.6.4.8.18 Detailed implementation of such interface between TCMS & ATP, clearly and unambiguously identifying the mode of connectivity (Ethernet, Serial Interface or Hardwired) for each & every interface signal shall be finalized between RS & Signalling & Train Control Contractors, during the interface design and submitted for approval of the Project Manager.
- 24.6.4.8.19 The TCMS & onboard ATC systems shall be connected with each other through redundant links (dual homing using independent communication ports for the redundant links on both TCMS and onboard ATC).
- 24.6.4.8.20 Staggered acceleration of the trains within the same power supply feeding zone shall be suitably ensured under UTO operation for both normal and extended feeding scenarios arising due to power supply disruption or bunching of trains within the same feeding zone as a part of interface design for avoiding tripping of HSCB of substation. Design shall be suitable for 90 sec headways. The details shall be submitted and finalized for Project Manager's review during design phase **(CDRL-24-21)**.

24.6.4.9 Power Supply and Earthing Arrangements:

- 24.6.4.9.1. Rolling Stock Contractor shall provide Independent 110V DC. Power supply circuits, as per interface document including positive and negative poles. At least three power supplies for the ATC Equipment shall be provided by the Rolling Stock Contractor and there shall be no physical or electrical links between these power supply circuits.
- 24.6.4.9.2. The Rolling Stock Contractor shall provide dedicated earthing arrangements for the train borne ATC equipment. The Signalling & Train Control Contractor shall specify the earth impedance required.
- 24.6.4.9.3. The power supply cable between the train power supply and the ATC train borne equipment power equipment shall be segregated, as short as possible and directly connected to the supply without any intermediate connection.

24.6.4.10 Factory Installation and Testing:

- 24.6.4.10.1 All the special equipment associated with the train borne ATC system, including the interface cables / wires shall be designed and supplied by the Signalling & Train Control Contractor to the Rolling Stock Contractor factory. Each contractor shall be aware of the locations of manufacturing plants, which could concurrently be manufacturing cars.
- 24.6.4.10.2 The Signalling & Train Control Contractor shall be responsible for providing all data and training of Rolling Stock Contractor's staff in all aspects of ATC installation and testing where applicable. The first set of ATC equipment shall be installed by Rolling Stock Contractor, under the supervision of the Signalling &

Train Control Contractor representatives, including the wiring for the interface of the ATC equipment with Rolling Stock.

24.6.4.10.3 The Rolling Stock Contractor shall be responsible for installation and wiring for equipment, and its testing on each car to the functioning standard agreed with the Signalling & Train Control Contractor.

~~24.6.4.10.4 Testing of each car shall comply with the accepted international standards agreed between the contractors as agreed with the Project Manager. Initial integration tests (static and dynamic) shall be done at the Rolling Stock factory and carried out by the test personnel of respective contractors jointly. Further main line integration tests will be required to be carried out to ensure all train control functions between OCC/BCC and Train which will be required to be done jointly by the Rolling Stock and Signalling & Train Control Contractor at site in Bangalore. The test certificate subsequently shall be issued jointly by the Rolling Stock and Signalling & Train Control Contractor. The certificates will pertain to the respective areas of the contractor's responsibility and shall be decided during the interface. Integrated testing of each train with Signalling & Train Control system shall be done as under:~~

Addendum-1 dated 05.12.2022, Sl. No. 169

Testing of each car shall comply with the accepted international standards agreed between the contractors as agreed with the Project Manager. Initial integration tests (static) shall be done at the Rolling Stock factory and carried out by the test personnel of respective contractors jointly. Further main line integration tests will be required to be carried out to ensure all train control functions between OCC/BCC and Train which will be required to be done jointly by the Rolling Stock and Signalling & Train Control Contractor at site in Bangalore. The test certificate subsequently shall be issued jointly by the Rolling Stock and Signalling & Train Control Contractor. The certificates will pertain to the respective areas of the contractor's responsibility and shall be decided during the interface. Integrated testing of each train with Signalling & Train Control system shall be done as under:

- a) Signalling & Train Control Contractor shall develop ATC- Rolling Stock (RS) joint test procedure for mainline testing. It shall be the responsibility of Signalling & Train Control and Rolling Stock Contractors to jointly test each 6-Car train set on mainline as per the ATC- RS joint procedure. **(CDRL-24-22)**
- b) Signalling & Train Control Contractor in interface with Rolling Stock Contractor shall develop a test procedure for obtaining the maximum energy saving in ATO/UTO mode over the entire section of corridor.

~~24.6.4.10.5 The Rolling Stock Contractor shall provide test facilities including test track for comprehensive static, dynamic and interface tests between the Rolling Stock and Signalling & Train Control systems at his premises. Dynamic interface test may be done at Contractor's premises or in depots. The Signalling & Train Control Contractor shall be responsible for the provision of special test equipment and instrumentation.~~

Addendum-1 dated 05.12.2022, Sl. No. 170

The Rolling Stock Contractor shall provide facilities for comprehensive static and interface tests between the Rolling Stock, Signalling & Train Control systems at his premises. Signalling & Train Control Contractor shall be responsible for the provision of special test equipment and instrumentation.

24.6.4.10.6 In case of UTO /ATO, the Integration test between the Rolling Stock and the Signalling & Train Control Contractors shall include tests on mainline to confirm the realization of demanded acceleration and deceleration rate by the UTO/ATO under various conditions.

24.6.4.10.7 Should the need arise for modifications in the configurations of respective equipment or systems as a result of Integration Test or otherwise, the scope of work and division of responsibility shall be jointly agreed amongst the contractors and detailed procedure shall be developed. The Rolling Stock Contractor shall provide the requisite manpower to monitor and/or implement the modifications on the Rolling Stock.

24.6.4.10.8 The Rolling Stock Contractor and Signalling & Train Control Contractor shall fully associate and render all necessary support during type testing of the respective systems. Rolling Stock type test may require all out mode of operation in GoA4 as per approved test specifications. The Rolling Stock Contractor and Signalling & Train Control Contractor(s) shall jointly finalize such test plan and schemes/operational modes and ensure the satisfactory completion of type tests.

24.6.4.10.9 For UTO, the critical scenarios under OMPD shall be type tested. The preparation of joint interface test specification shall be the responsibility of Signalling & Train Control Contractor. RS contractor shall assist in preparation and shall coordinate for review and approval of the same by the Project Manager.

24.6.4.11 **EMC/EMI Interface**

24.6.4.11.1 With respect to electromagnetic interference, the Signalling and Train Control Contractor shall provide a list of frequencies and any other EMC/EMI requirements to the Rolling Stock Contractor, to enable the Rolling Stock Contractor to avoid such frequency bands in design, and to provide devices to isolate the source of potential emission wherever required. The Signalling and Train Control Contractor shall have first right of use for radio frequency (2.4 GHz, 5.8GHz or any other free band notified by WPC) for CBTC application.

24.6.4.11.2 The Rolling Stock and Signalling & Train Control Contractors shall ensure that the emission and immunity level of their respective equipment meet the requirements of EN50121-3-1 and EN50121-3-2.

24.6.4.11.3 The Rolling Stock Contractor shall ensure that the return current in the track at the specified frequencies does not exceed the value specified by Signalling & Train Control Contractor.

24.6.4.11.4 The Contractors shall also jointly develop a test plan for verification of electromagnetic compatibility of Traction, Signalling & Train Control system and also Communication systems. The Contractors shall work together to assure that all electronic and electrical equipment on the Rolling Stock works properly without interfering with Signalling & Train Control and Communication sub-systems.

24.6.4.11.5 The cable layout of the Signalling & Train Control system in the cable ducts provided by the Rolling Stock Contractor shall be jointly agreed. The separation between Signalling & Train Control cables and power cables of 750 V DC, 415 V three phase AC, 230 V AC single phase, 110 V DC rating shall be in accordance with accepted international practice and jointly agreed.

24.6.4.11.6 The cable ducts shall be earthed at notionally at every 2 m and also at the ends and shall be in accordance with accepted international practices.

24.6.5 Division of Responsibility

24.6.5.1. The Signalling & Train Control and Rolling Stock Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to those mentioned in Table-24.6.5.

24.6.5.2. These shall include the following but not limited to:

Table-24.6.5 Division of Responsibility

S. N.	Subject	Signalling & Train Control Contractor's Responsibilities	Rolling Stock (RS) Contractor's Responsibilities
1.	On board ATC/ATP Equipment	<ul style="list-style-type: none"> Shall supply & deliver the equipment to the Rolling Stock Contractor's Works. Shall supply Odometer, Radar and associated equipment for measuring speed in ATC mode. 	<ul style="list-style-type: none"> Shall provide space in the vehicle design for fixing and installation at the manufacturer's facility, under the supervision of Signalling and Train Control Contractor. Shall supply speed measuring sensor and other associated equipment for non-ATC mode.
2.	On board UTO and ATO equipment		
3.	Antennae for ATP, ATS, etc.		
4.	Speed measuring sensors, speedometer, odometer, Radar etc.		
5.	ATO/ATP/ATC Cab Displays (Train operators MMI) including special cables etc.		
6.	Antennae for CBTC, CCTV/multimedia including special cables etc.	<ul style="list-style-type: none"> Shall supply the equipment to the Rolling Stock Contractor's Works. 	<ul style="list-style-type: none"> Shall provide space in the vehicle design for fixing and installation at the manufacturer's facility, under the supervision of the Signalling & Train Control Contractor.
7.	Train Lines /Ethernet Connection/Repeaters/Communication architecture	<ul style="list-style-type: none"> Shall specify at an early date the requirement of Train lines / Ethernet 	<ul style="list-style-type: none"> Shall provide the necessary train lines / Ethernet Connection /

S. N.	Subject	Signalling & Train Control Contractor's Responsibilities	Rolling Stock (RS) Contractor's Responsibilities
	and media	Connection / Repeater/Communication architecture and media.	Repeater/Communication architecture and media as per agreed interface.
8.	Power supply and earthing for on board ATP/ATO/UTO equipment	<ul style="list-style-type: none"> • Shall furnish required voltage values and earthing requirements to Rolling Stock Contractor for his scope. 	<ul style="list-style-type: none"> • Shall provide the required voltages and earthing.
9.	Logging of on-board information from ATP/ATO/UTO	<ul style="list-style-type: none"> • Shall supply data logger. • Shall facilitate identification of system level faults and segregate the faults on account of Rolling Stock or Signalling & Train Control System. • Shall co-ordinate with Rolling Stock Contractor for signal levels and protocols. • Shall supply the software required to read the ATC logs. 	<ul style="list-style-type: none"> • Shall provide the recording and monitoring of signals and faults from ATC in TCMS. • Shall supply TCMS. • Shall demonstrate the downloading of on-board ATC logs manually & remotely.
10.	Interface between ATP/ATO/UTO with train braking and propulsion systems for automatic braking, acceleration and deceleration	<ul style="list-style-type: none"> • Shall provide the requirements to the RS Contractor. • Shall supply ZVR & redundant EBR relays (within the ATC). • Shall provide redundant (dual homed) connections between ATC/ATO & TCMS for transmission of Traction/Braking demand with safety data transmission protocol. • Shall interface with Rolling Stock Contractor to transfer the Traction/Braking demand at agreed levels to Traction Inverter & EBCU through hardwired connection in case of failure of TCMS (Creep mode) under ATC supervision. 	<ul style="list-style-type: none"> • Shall co-ordinate with Signalling & Train Control Contractor to agree on levels and protocols for interface signals. • There shall be no delay in braking from Rolling Stock during the transition from ED to friction brake at slow speed. • Shall supply, install & incorporate in VCC the auxiliary relays for ZVR & EBR for additional contacts required. • Shall provide redundant (dual homed) connections between ATC/ATO & TCMS for transmission of Traction/Braking demand with safety data transmission protocol. • Shall provide redundant

S. N.	Subject	Signalling & Train Control Contractor's Responsibilities	Rolling Stock (RS) Contractor's Responsibilities
			<p>TCMS communication networks to transfer the Traction/Braking demand from ATC/ATO to Traction Inverter & EBCU.</p> <ul style="list-style-type: none"> • Shall interface with Signalling & Train Control Contractor to transfer the Traction/Braking demand at agreed levels to Traction Inverter & EBCU through hardwired connection in case of failure of TCMS (Creep mode) under ATC supervision.
11.	System master clock	<ul style="list-style-type: none"> • Shall provide master clock information to TCMS. 	<ul style="list-style-type: none"> • Shall synchronize TCMS clock with the system master clock. • Shall synchronize all subsystems clock in Rolling Stock with the TCMS clock.
12.	On board station (station arrival, current station, next station, skip station) Information/announcement to the passengers	<ul style="list-style-type: none"> • Shall provide necessary signals / bits on-board to Rolling Stock Contractor. 	<ul style="list-style-type: none"> • Shall provide for necessary hardware interface, display for on-board P.A. system inside the cars. • Shall perform on-board announcements & displays based on the Signal/bits received from ATC. • Shall ensure that the signals/bits received from ATC are displayed on a suitable page in TCMS.
13.	Climatic requirements for on board ATP/ ATO/UTO equipment	<ul style="list-style-type: none"> • Shall specify at an early date, the total heat load wattage, and maximum permitted temperature. 	<ul style="list-style-type: none"> • Shall provide conditioning air from the saloon to all relevant Signalling & Train Control installations to maintain a nominal temperature of 25°C. • Shall provide conditioned air ventilation for the console & cubicles.
14.	EMI/EMC interface between the Rolling	<ul style="list-style-type: none"> • Shall detail the EMI/EMC requirement and advise 	<ul style="list-style-type: none"> • Shall ensure the compliance of the EMI/EMC

S. N.	Subject	Signalling & Train Control Contractor's Responsibilities	Rolling Stock (RS) Contractor's Responsibilities
	Stock and Signalling and Train Control	<p>EMI/EMC plan for ATP/ATO equipment to Rolling Stock Contractor at early date.</p> <ul style="list-style-type: none"> • Shall jointly ensure the compliance with Rolling Stock. • Shall provide support to Rolling Stock Contractor in conducting necessary EMI/EMC interface tests and assist in the preparation of report. 	<p>requirements for Signalling & Train Control on board equipment.</p> <ul style="list-style-type: none"> • Shall conduct necessary EMI/EMC tests and submit report in coordination with Signalling & Train Control Contractor.
15.	Train Integrity Information	<ul style="list-style-type: none"> • Shall ensure ATC on-board receives Train integrity information as supplied by Rolling Stock. 	<ul style="list-style-type: none"> • Shall provide Train Integrity information to ATC on-board.
16.	Data transmission methodology for control command	<ul style="list-style-type: none"> • Shall interface with Rolling Stock Contractor for selection of best suited methodology i.e., bit by bit, code (1 byte) or any other. 	<ul style="list-style-type: none"> • Shall provide details for ATC to TCMS Communication.
17.	The polling cycle and delay times assessment between OCC/BCC and on-board ATC/CCTV	<ul style="list-style-type: none"> • Shall assess and furnish to Rolling Stock Contractor the polling cycle time, data transmission time (rate) between OCC/BCC and on-board ATC/CCTV under best and worst case scenarios for both CBTC and CCTV networks. 	<ul style="list-style-type: none"> • Shall provide TCMS to ATC/CCTV interface requirements to Signalling & Train Control Contractor to comply with functionality as specified in the Rolling Stock contract.
18.	OCC GUI for Rolling Stock controller	<ul style="list-style-type: none"> • Shall interface with Rolling Stock Contractor for transmission of the train operation data required for the OCC GUI from the trains to OCC/BCC via the Signalling CCTV network. • Shall be responsible for transmission and display of the OCC GUI from RS Controller workstation to the Large video screen/monitor (LVS). 	<ul style="list-style-type: none"> • Shall be responsible for development of the GUI (including hardware) for the Rolling Stock controller (RSC) in the OCC/BCC. • Any other GUI(s) in OCC/BCC shall not be the scope of Rolling Stock Contractor.

S. N.	Subject	Signalling & Train Control Contractor's Responsibilities	Rolling Stock (RS) Contractor's Responsibilities
		<ul style="list-style-type: none"> Shall provide necessary support during interface finalization to the Rolling Stock Contractor. 	
19.	Guaranteed Emergency Brake Rate (GEBR)	<ul style="list-style-type: none"> Shall use the Guaranteed Emergency brake rate (GEBR) value given by Rolling Stock Contractor in their design. 	<ul style="list-style-type: none"> Shall furnish value of GEBR to Signalling & Train Control Contractor.
20.	Emergency Brake application validation at low speed (≤ 25 kmph) as a part of wake-up procedure	<ul style="list-style-type: none"> Shall validate the EB Test based on details furnished by Rolling Stock Contractor. 	<ul style="list-style-type: none"> Shall furnish the pass/fail criteria based on the speed achieved and gradient of the track to the Signalling & Train Control Contractor.
21.	Live streaming from RS on-board CCTV to OCC/BCC and Live transmission of advertisements from OCC/BCC to train via CCV network	<ul style="list-style-type: none"> Shall provide the CCTV network and suitable buffering arrangement for live video streaming (at server of OCC/BCC) transmitted from the train to the OCC/BCC via CCTV network and for its onward multicast transmission to other terminals / networks and for transmitting Videos/ Images/ Text etc from OCC/BCC to Train. 	<ul style="list-style-type: none"> Shall provide suitable interface with CCTV camera / Recorder (NVR) so that Signalling & Train Control Contractor can fetch live stream to OCC/BCC. Shall provide suitable Buffering arrangement on the train for live video streaming, Live video players with buffering capability, Advertisement and Live video players in hot standby per train and Redundant suitable arrangement (video controller/player/servers) in OCC/BCC for transmission of live video contents and stored video contents to be played in the train.
22.	Negotiation of cross-overs	<ul style="list-style-type: none"> Shall ensure that cross overs are negotiated in coasting mode in ATO/UTO modes. Shall use minimum powering to negotiate the cross over in case the crossover cannot be 	<ul style="list-style-type: none"> Shall use this information to implement necessary controls in the propulsion system to avoid flashing at CCD Shall minimize inrush / overcurrent conditions in the propulsion and auxiliary

S. N.	Subject	Signalling & Train Control Contractor's Responsibilities	Rolling Stock (RS) Contractor's Responsibilities
		<p>negotiated in coasting due to factors such as gradient,.</p> <ul style="list-style-type: none"> • Shall identify location of the cross over by the ATC system and necessary train control should be implemented. • Shall display a coasting icon on the Signalling DMI in other modes of operation (ATP, RM, ROS, etc.) when, approaching a crossover to inform the train operator. • Shall communicate the crossover information to TCMS by the ATC system. 	<p>circuits when train is moving on crossovers.</p>
23.	Platform Screen Doors/Gates	<ul style="list-style-type: none"> • Shall design and install the PSD/PSG based on KE and door drawings of train received from Rolling Stock Contractor. • Shall ensure alignment of the PSD/PSG with the train doors. • Shall incorporate the information regarding EAD and parking brake release levers on the Rolling Stock in • the design of the PSD/PSG system to ensure access to the EAD and parking brake release levers from platform. • Shall exchange the defective / isolated PSD/PSG information with RS Contractor for disabling opening/ closing corresponding RS and PSD/PSG. • Shall interface with Rolling Stock Contractor for synchronization of train 	<ul style="list-style-type: none"> • Shall provide KE and door drawings of train to Signalling & Train Control Contractor for placement of Platform Screen Doors/ Gates. • Shall share location of EAD and parking brake release lever along with their operating mechanism with Signalling & Train Control Contractor. • Shall interface with Signalling & Train Control Contractor for synchronization of train door / PSD/PSG opening and closing. • Shall exchange the defective / isolated train door information with Signalling & Train Control Contractor for disabling opening/closing corresponding RS and PSD/PSG. • Shall prevent a train door from opening in case its

S. N.	Subject	Signalling & Train Control Contractor's Responsibilities	Rolling Stock (RS) Contractor's Responsibilities
		<p>door/PSD/PSG opening and closing.</p> <ul style="list-style-type: none"> • Shall prevent a platform screen door from opening in case its corresponding train door is under failure / isolated. • Shall display message at relevant PSD/PSG prior to train arrival to notify passengers that the particular PSD/PSG will not open in case of defective train door on an arriving train, based on location of the defective train door shared by Rolling Stock. • Shall restrict the speed of train to below 20 kmph and provide horn blow command to RS while entering/ leaving the platform area On receiving the Local Door Bypass Signal from PSD/PSG, 	<p>corresponding platform screen door is under failure/ isolated.</p> <ul style="list-style-type: none"> • Shall display message at relevant train door prior to train arrival to notify passengers that the particular train door will not open in case of defective PSD/PSG on upcoming station, based on the location of the defective PSD/PSG shared by the Signalling & Train Control system. • Shall interface with Signalling & Train Control Contractor for the provision of reclosing the door(s) without opening all doors in case of obstruction detection. • Shall blow horn while entering / leaving the platform area Based on the command from Signalling & Train Control system regarding Local Door Bypass Signal from PSD/PSG.
24.	On board equipment for CCTV image transmission to OCC/BCC	<ul style="list-style-type: none"> • Shall provide necessary equipment on-board to Rolling Stock Contractor for image transmission to OCC/BCC. 	<ul style="list-style-type: none"> • Shall provide for necessary on-board cameras, display equipment and inter connections as well as space and appropriate interface / protocols for Signalling & Train Control equipment.
25.	Limitations of Return Current for proper functioning of ATC	<ul style="list-style-type: none"> • Shall provide the return current limits. 	<ul style="list-style-type: none"> • Shall ensure the compliance of the requirements of Signalling & Train Control Contractor for ATC.

S. N.	Subject	Signalling & Train Control Contractor's Responsibilities	Rolling Stock (RS) Contractor's Responsibilities
26.	Reading software tools for reading the ATC data from TCMS	<ul style="list-style-type: none"> • Shall provide the same. 	<ul style="list-style-type: none"> • Shall interface with Signalling & Train Control to obtain software tools for reading ATC data recorded in TCMS.
27.	Automatic Turn Back (ATB) function	<ul style="list-style-type: none"> • Shall provide the ATB features as specified in Employer's requirement and shall also interface with RS Contractor for Rolling Stock circuit (VCC) design to achieve ATB function. 	<ul style="list-style-type: none"> • Shall interface with Signalling & Train Control contractor and shall make necessary circuit (VCC) design as per Signalling requirement to achieve ATB function.
28.	Rollback Protection	<ul style="list-style-type: none"> • Shall provide Roll Back protection system in ATC. 	<ul style="list-style-type: none"> • Shall interface with Signalling & Train Control Contractor to achieve the rollback protection. system.
29.	Remote Controlled Resetting Commands from OCC/BCC to facilitate GoA-4 mode of operation	<ul style="list-style-type: none"> • Shall be jointly discussed, finalized and implemented during design phase. • Joint test protocols shall also be finalized and implemented. 	<ul style="list-style-type: none"> • Shall be jointly discussed, finalized and implemented during design phase. • Joint test protocols shall also be finalized and implemented.
30.	Wheel Flange Lubricator (WFL)	<ul style="list-style-type: none"> • Shall provide signals/bits to TCMS for identification of curve location (curve start & curve end). 	<ul style="list-style-type: none"> • TCMS shall trigger WFL ON/OFF operation based on ATC signals/bits (curve start & curve end). • Shall make available ON/OFF status and WFL system healthy status in TCMS.
31.	Automatic Track Monitoring System	<ul style="list-style-type: none"> • Shall communicate critical defects such as rail fractures, running edge defects, rail head surface defects, corrosion, missing fasteners etc. as received from Rolling Stock along with exact location of the defects to OCC/BCC in real time through the CCTV network supplied by Signalling & Train Control Contractor. • Shall ensure communication of camera 	<ul style="list-style-type: none"> • Shall provide and install high resolution Digital Line Scan Cameras in two trains of Line-6 (4 Cameras, 2 in each train) and 4 trains of Silk Board – Kempe Gowda International Airport corridor (8 Cameras, 2 in each train) i.e., 12 Cameras in total and on-board module in the train. • Shall analyze and process the images / video stream received from the Digital Line Scan Camera.

S. N.	Subject	Signalling & Train Control Contractor's Responsibilities	Rolling Stock (RS) Contractor's Responsibilities
		images corresponding to track defects to OCC/BCC.	<ul style="list-style-type: none"> • Shall identify suitable location in the train to install the cameras and other associated equipment. • Shall supply necessary software and hardware such as servers, workstations and networking equipment in OCC/BCC and the trains. • Shall transmit the track defect information to Signalling & Train Control system.
32.	Obstruction Detection	<ul style="list-style-type: none"> • Shall transmit obstruction detection information along with the ODD camera view as received from Rolling Stock to OCC/BCC. 	<ul style="list-style-type: none"> • Shall provide Obstruction Deflection Device (ODD) on train. • Shall transmit the detection information and ODD camera view to Signalling & Train Control system.
33.	Standalone door operation	<ul style="list-style-type: none"> • Shall give standalone door operation command to allow driver / cleaning staff to enter / exit the train from designated door in designated Depot area / Main line siding. 	<ul style="list-style-type: none"> • Shall give the necessary support to the Signalling & Train Control Contractor.

Annexure-1/D : Rolling Stock Characteristics

Train composition	*DMC-TC-MC-MC-TC-DMC*
Average Acceleration rate from 0 kmph to 30 kmph	$1 \text{ m/s}^2 \pm 5\%$
Average service deceleration from 80 to 0 km/h	$0.95 \text{ m/s}^2 \pm 5\%$
Minimum average emergency deceleration	1.3 m/s^2
Maximum Jerk	$0.7 \text{ m/s}^3 \pm 0.05$
**Service Brake Response Time	<2 sec
**Emergency Brake Response Time	<1.5 sec
**Service and Emergency Brake Release Time	<2.5 sec
	$R = 14.01 + 0.264V + 0.00191V^2 \text{ (N/ton)}$

Resistance to motion (formula, curve, starting resistance)	for at-grade and Elevated corridors. $R = 21.96 + 0.4222V + 0.00876V^2$ (N/ton) For underground corridor. Where R→Train Resistance (N/ton) V→Train speed (km/h)
Maximum wheel diameter	860mm
Minimum wheel diameter	780mm
Maximum train design speed	90kmph
Maximum train service speed	80kmph
Door opening and closing times	Opening time: 2.5 s (± 0.5s) Closing time: 2.5 s (± 0.5s)
No. of axles per Car	4
Presence of non-service brake and non-powered axles	All DMC and MC car axles are powered while those of TC-cars are non-powered. All axles are friction braked.
Maximum Axle Load	15 Tons
Train length – 6 Car Train	130.3 m

Note:

1. All of the data in the above table are notional, and should be confirmed between the Contractors during design Phase.
2. For the items marked **, the timings are for a brake application from full release to 90% of full brake cylinder pressure, and for brake release from full brake cylinder pressure to 10% as per EN 13452-1.

Communication shall be configurable between any of these user groups.

24.7 Interfaces between Rolling Stock Contractor and Telecommunication Contractor

24.7.1 Introduction

24.7.1.1 Definitions and Scope

- (i) This Appendix describes the interface requirements between Telecommunication Contractor and Rolling Stock Contractor.
- (ii) Both the Telecommunication and the Rolling Stock Contractors shall ensure that all requirements of the Specification pertaining to interfaces are correctly satisfied.
- (iii) The requirements specified herein are by no means exhaustive and it remains the responsibility of the Rolling Stock Contractor to develop and execute an interface plan with the help of Telecommunication Contractor, during execution of the work to ensure that:
 - a) All interface issues between the two contracts are satisfactorily resolved;
 - b) Supply, installation and testing of equipment and software are fully coordinated;

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

24.7.2 Train Operating Modes

24.7.2.1 Telecommunication contractor shall interface with Signalling and Rolling Stock contractor for the details of train operating modes.

24.7.2.2 The train-borne Automatic Train Control (ATC) system will consist of Unattended Train Operation (UTO), Automatic Train Operation (ATO) and Automatic Train Protection (ATP) systems.

24.7.2.3 The Rolling Stock shall be fitted with ATP/ ATO/UTO system.

24.7.2.4 There will be on-board Radio system. The supply/delivery of Train Radio System for new trains shall be responsibility of the contractors for Telecommunication, and shall be required to liaise closely with the Rolling Stock contractor, in regard to installation, testing and commissioning of the Telecommunication equipment

24.7.3 TETRA Radio System

The TETRA Radio System shall provide a digital, standard radio communications system, conforming to the TETRA standards as defined by ETSI, capable of facilitating system-wide voice and data communication. The TETRA Radio System (TRS) shall guarantee secure Operational Communications for the OCC, BCC, Train operators, station staff, depot staff and mobile maintenance personnel. Communication shall be configurable between any of these user groups.

24.7.4 Interface Requirements between Telecommunication and Rolling Stock Contractors

24.7.4.1 The Telecommunication Contractor shall provide the Rolling Stock Contractor with the final list of equipments to be provided on the Rolling Stock. The sizes and weights of the on board Radio equipment and antennae etc., to be mounted on the Rolling Stock shall also be provided as applicable

24.7.4.2 The Telecommunication Contractor shall deliver to the Rolling Stock Contractor's factories, all train-borne radio equipment, as applicable, and data to enable fitting and testing. Connector fixing and cable harnessing shall be done by RS contractor under the supervision of Telecommunication contractor.

24.7.4.3 The Telecommunication Contractor shall supply all the train radio equipments including the Train Radio Control Panel at the Rolling Stock Contractor's factory. Telecommunication Contractor, with the details provided by Rolling Stock Contractor shall ensure that the exterior finish and colours of the respective equipment suitably harmonize with that of the cab and the vicinity.

24.7.4.4 Interfacing wiring for each module provided by the Telecommunication Contractor including the interfacing wiring between the Telecommunications contractors equipment shall terminate in a quick disconnect robust plug connector suitable for traction applications, with direct cable connection as far as possible. All cable connectors shall be identified within the cubicle using robust cable markers with distinctive colours for identification, for e.g. safety function cables.

24.7.4.5 For all relay contact interfaces (if applicable), the Telecommunication Contractor shall provide auto-contact jam detection and contact bounce elimination function to ensure

proper operation of the system. Relays for safety functions shall comply with the appropriate internationally accepted standard specification.

24.7.4.6 The Telecommunication Contractor shall provide the Rolling Stock Contractor with the number of wires/communication architecture and protocols required between cars of a married pair and between married pairs to transmit signals from one end of the rake to the other end through electrical jumpers.

24.7.4.7 Vehicle control circuits shall be developed by the Rolling Stock Contractor. During the design stage, all vehicle control circuits incorporating the identified interfaces shall be provided to the Telecommunication contractor, as applicable. The Telecommunication Contractor shall provide specific observations on these circuits to the Rolling Stock Contractor. The Rolling Stock Contractor shall suitably incorporate any (if applicable) observations in the design.

24.7.4.8 Certain vital and non-vital signals from Telecommunication side shall be monitored by TCMS. Details regarding the signals to be monitored shall be jointly agreed between the Rolling Stock and Telecommunication Contractors and submitted for Project Manager's review. **(CDRL-24-23).**

24.7.4.9 Hot axle box detection system for monitoring of axle box temperature shall be provided by Rolling Stock Contractor. On-board temperature sensors for detecting axle box temperature shall be provided and installed on all axles boxes of 318 cars by Rolling Stock Contractor. The wayside equipment for gathering and processing the data from on-board sensors shall be provided in 3 stations of Line-6 line and 3 stations of Silk Board – Kempegowda International Airport corridor (Phase 2A + Phase 2B) on both UP and DOWN track separately by Rolling Stock contractor. One data base server with workstation in each associated OCC, required software and communication network from way side equipment up to station Telecom Equipment Room (TER) shall be provided by Rolling Stock Contractor. The Telecom Contractor shall provide Ethernet/Fibre Optic channel from station TER (Telecom Equipment Room) to CER (Central Equipment Room) of each associated OCC. Data processing, interface equipment on both ends i.e. at wayside station and OCC shall be the responsibility of Rolling Stock Contractor.

24.7.5 Telecommunication Details to be Used by RS Contractor

24.7.5.1 The following data shall be provided:

- i) The maximum power consumed by the Telecommunications Contractor's equipment from the 110V DC supply under all specified operating conditions.
- ii) The number of train wires required, and the function of each wire/communication architecture and protocols.
- iii) All control logic outputs.
- iv) Electrical characteristics of the interconnection cabling and wiring.
- v) Sensitivity levels, and frequencies, which must be avoided.
- vi) The specific heat load for air conditioning purposes.
- vii) The EMC/EMI requirements including the limiting value of psophometric current, to obviate interference in the operation of telecommunication equipment; and
- viii) Details of the provisions required to enable the transference of data from the train to the OCC.

- ix) Physical dimensions of the equipment to be fitted on Rolling Stock.

24.7.6 Train Radio (TETRA) Equipment Cubicles

24.7.6.1 The Rolling Stock Contractor shall supply the Train Radio equipment cubicle enclosure(s). All supports, braces, mounting holes, cabling apertures, accessories etc. required for mounting the cubicle and its equipment shall be properly co-ordinated between Telecommunication Contractor and the Rolling Stock Contractor to ensure secure mounting, and access. The cubicle(s) shall be resiliently mounted.

24.7.6.2 To achieve the Train radio functions, the Telecommunication contractor shall identify any interfacing circuits specifically required for Train Radio operation and liaise with the Rolling Stock Contractor.

24.7.6.3 The Telecommunication Contractor shall respectively identify the voltage free contacts to be provided by the Rolling Stock Contractor, including the number and type of electrical signals required between the Train Radio equipment and the equipment provided by the Rolling Stock Contractor. The contractors shall co-ordinate to agree on levels and protocols for each such signal.

24.7.6.4 As a minimum, all electronic equipment to be mounted on Rolling Stock, including those provided by the Telecommunication Contractor shall comply with IEC 60571: Electronic Equipment used on Rail Vehicles, for design, manufacture and testing, and shall use components purchased against an internationally recognized quality assurance and reliability certification procedure.

24.7.7 Antennae

24.7.7.1 The Telecommunication Contractor shall identify roof mounted antennae (for train radio), and associated disconnection box mounting brackets and location requirements to identify cable and conduit routes required to antennae.

24.7.7.2 The Telecommunication Contractor for their respective scope shall supply the necessary disconnection boxes, terminal blocks, cables and adaptation mounting brackets, flexible conduit assemblies complete with connectors and cables from antennae to the junction boxes.

24.7.7.3 The Rolling Stock Contractor will provide the antenna mounting brackets, conduits, support or clamping arrangements, fixture and accessories to ensure security and reliability.

24.7.7.4 The antenna system shall not contravene the kinematic envelope and fully meet the radio coverage requirements both for normal and reverse directions of train working.

24.7.7.5 The Telecommunication Contractor shall furnish the RS Contractor with full mounting details, apertures, fixing holes, etc.

24.7.8 Interface Between TCMS (Train Control Management System) and Telecommunication Equipment

24.7.8.1 The Rolling Stock Contractor shall provide an on-board Train Control Management System (TCMS), to log information from the Train radio equipment supplied by the Telecommunication Contractor, in addition to the information shown in the Rolling Stock specification.

24.7.8.2 The signals to be supplied from the TCMS to the equipment of Telecommunications Contractor shall be decided jointly between the two Contractors.

24.7.8.3 The TCMS & onboard Telecommunications equipment shall be connected with each other through redundant links (dual homing using independent communication ports for the redundant links on both TCMS and onboard Telecommunications equipment).

24.7.9 Power Supply and Earthing Arrangements

24.7.9.1 The Rolling Stock Contractor shall provide independent 110 V DC power supply circuits/Power Supply requirement to Train Radio equipment as per interface document including positive and negative poles. Both Contractors shall co-ordinate to agree the power supply voltages and arrangements.

24.7.9.2 The Rolling Stock Contractor shall provide dedicated earthing arrangements for the train borne Radio equipment. The Telecommunication Contractor shall specify the earth impedance required.

24.7.9.3 The power supply cable between the train power supply and the Radio train borne power equipment shall be segregated, as short as possible and directly connected to the supply without any intermediate connection.

24.7.10 Other interface requirements

24.7.10.1 The Telecommunications Contractors shall furnish the Rolling Stock Contractor with the interface required between the train radio system and the on-train public address system to allow on-board announcements to be made from the OCC. The interface shall provide the necessary means to enable OCC to initiate triggering of real time announcement or pre-recorded messages in the on-train public address system.

24.7.10.2 The complete on-train public address system, and interface hardware, including the transmission link, and a communication panel shall be furnished by the Rolling Stock Contractor. Levels and protocols shall be agreed between the two contractors.

24.7.10.3 Signalling & Train Control shall provide Train ID to Train radio through ATS-Train Radio interface. However, Rolling Stock contractor shall also provide Train ID to Train Radio through TCMS train radio interface.

24.7.10.4 The Telecommunications Contractors shall furnish the Rolling Stock Contractor with the interface required between the train radio system and the TCMS for recording the initiation, termination, and success or failure of emergency calls initiated by the train operator and/or OCC on the radio. The hardware interface shall be furnished and installed by the Rolling Stock Contractor. Levels and protocols shall be agreed between the two contractors.

There shall be a provision of roving attendant to make the passenger announcement through his mobile handset (Tetra) inside a particular train through train radio network using radio identification number. The interface between train radio and on board communication (PA/PIS) system shall be done by Rolling Stock and Telecommunication contractors.

24.7.10.5 Telecommunication contractor and Rolling Stock contractor shall interface for initiation, termination and success or failure of emergency calls initiated by passengers to OCC. The initiation of this passenger call shall automatically focus a CCTV camera on the passenger and raise a prompt on a suitable terminal of

OCC/BCC. The hardware interface shall be furnished and installed by RS Contractor.

24.7.11 Factory Installation and Testing

24.7.11.1 All the special equipment associated with the train borne Radio system, including the interface cables/wires between the Train Radio equipment shall be designed and supplied by the Telecommunication Contractor to the Rolling Stock Contractor's premises. Each contractor shall be aware of the locations of manufacturing plants, which could concurrently be manufacturing cars.

24.7.11.2 The Telecommunications Contractor shall be responsible for providing all data and training of Rolling Stock Contractor's staff in all aspects of Telecommunication equipment installation and testing where applicable. The first set of Train Radio equipment shall be installed by Rolling Stock Contractor, under the supervision of the Telecommunication Contractor's representatives.

24.7.11.3 The Rolling Stock Contractor will be responsible for installing of wiring and equipment, and its testing on each car to the functioning standard agreed with the Telecommunication Contractor.

24.7.11.4 Testing of each car shall comply with the accepted international standards agreed between the two Contractors as agreed with the Project Manager. Initial Integration tests (static and dynamic) shall be done at the Rolling Stock factory and carried out by the test personnel of both Contractors jointly. Further main line integration tests will required to be carried out to ensure all train control functions between OCC and Train which will be required to be done jointly by the Rolling Stock and Telecommunication Contractors on site in Bangalore. The test certificate subsequently shall be issued jointly by the Rolling Stock and Telecommunication Contractors. Integrated testing of each train with Train Radio system shall be done as under:

- a) Telecommunication Contractor shall develop Telecom-Rolling Stock joint test procedure for mainline testing. It shall be responsibility of the Telecommunication contractor and Rolling Stock contractor to jointly test each 6 car train set on main line as per the Telecom- Rolling Stock joint test procedure.

24.7.11.5 The Rolling Stock Contractor shall provide facilities including test track for comprehensive static, dynamic, and interface tests between the Rolling Stock and Telecommunication systems at their premises. The Telecommunication Contractor shall be responsible for the provision of special test equipment and instrumentation.

24.7.11.6 Should the need arise for modifications in the configurations of respective equipment or systems as a result of the integration test or otherwise, the scope of work and division of responsibility shall be jointly agreed amongst the contractors and detailed procedure shall be developed. The Rolling Stock Contractor shall provide the requisite man power to monitor and/or implement the modifications on the Rolling Stock.

24.7.12 EMC/EMI Interface

24.7.12.1 Regarding electromagnetic interference, the Telecommunication Contractor shall provide a list of frequencies and other sensitive requirements to the Rolling Sock

Contractor, to enable the Rolling Stock Contractor to avoid such frequency bands in the design, and to provide devices to isolate the source of emission wherever required.

24.7.12.2 The Rolling Stock and Telecommunication Contractor shall ensure that the emission and immunity level of their respective equipment meet the requirements of EN50121-3-1 and EN50121-3-2.

24.7.12.3 The contractors shall also jointly develop a test plan for verification of electromagnetic compatibility of traction and telecommunication systems. The contractors shall work together to assure that all electronic and electrical equipment on the Rolling Stock functions properly without interference to the telecommunications sub-systems.

24.7.12.4 The cable layout of the Telecommunication systems in the cable ducts provided by the Rolling Stock Contractor shall be jointly agreed. The separation between Telecommunication cables and power cables of 750V DC, 415V three-phase AC, 230V AC single phase, 110V DC rating for traction and other power supplies or any other similar higher voltage rating shall be in accordance with the international practice and jointly agreed.

24.7.12.5 The cable ducts should be earthed notionally at every 2 m and also at the ends and should be in accordance with accepted international practices.

24.7.13 SCOPE OF INTERFACE

24.7.13.1 Division of Responsibility

The Telecommunication and Rolling Stock Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include, as a minimum but not be limited to, as given in Table-1 below:

Table-1: Division of Responsibility

S. N.	Subject	Telecommunication Contractor	Rolling Stock Contractor
1.	New 6 car consists trains shall be equipped with following main equipments: a) On-board Train Radio (TETRA) equipment b) Antennae for Train Radio (TETRA) Inclusive of all type of cables, accessories etc	To supply/deliver all the equipment under column "item Description" to the Rolling Stock Contractor's works as applicable	To provide space in the vehicle design for fixing and installation at the manufacturers facility, by the Rolling Stock contractor under the supervision of Telecommunication Contractor to achieve overall system functionalities.
2.	Power supply and earthing for on-board Train Radio equipments	Furnish required voltage values and earthing requirements to Rolling Stock Contractor.	To provide the required voltages and earthing.
3.	Logging of on-board information from Train Radio	Telecommunication Contractor shall provide	Provide the recording and monitoring of signals and

		signal levels and protocols to Rolling Stock Contractor.	Faults from Train Radio in TCMS.
4.	On board announcement from OCC including the triggering of pre-recorded messages.	Telecommunication Contractor shall provide necessary signals on-board to Rolling Stock Contractor.	Rolling Stock Contractor shall provide for necessary hardware interface, display for on-board and P.A. system inside the cars.
5.	Climatic requirements for on Board Train Radio Cab Equipments.	Telecommunication Contractor to specify at an early date, the total heat load wattage, and maximum permitted operating temperature	Rolling Stock contractor to provide conditioning air from the saloon to all relevant Telecommunication installations to maintain a nominal temperature of 25°C. Conditioned air ventilation shall be provided by the contractor for the console.
6.	EMI/EMC interface between the Rolling Stock and Telecommunications.	Telecommunication Contractor shall detail the EMI/EMC requirements for Radio equipments to Rolling Stock at an early date and also jointly ensure the compliance with Rolling Stock.	Rolling Stock Contractor shall ensure the compliance of the requirements of Telecommunication Contractor for on board Radio equipment.
7.	Train Lines /Communication architecture and media	Telecommunication Contractor shall specify at an early date the requirement of Train Lines/communication architecture and media.	Rolling Stock Contractor shall provide the necessary train lines/ Ethernet Connection/ communication architecture and media as per agreed interface.
8.	Hot axle box detection system	Telecommunication contractor shall provide Ethernet/Fibre Optic channel from station TER (Telecom Equipment Room) to CER (Central Equipment Room) of OCC.	Rolling Stock contractor shall install on-board temperature sensors for detecting axle box temperature on all axles boxes of 318 cars and supply wayside equipment for gathering and processing the data from on-board sensors in 3 stations of Line-6 line and 3 stations of Silk Board – Kempegowda International Airport corridor (Phase 2A + Phase 2B) on both UP and DOWN track separately. Rolling Stock contractor shall also provide one data base server with workstation in each associated OCC, required

			software and communication network from way side equipment up to station Telecom Equipment Room (TER). Data processing, interface equipment on both ends i.e. at wayside station and OCC shall be the responsibility of Rolling Stock Contractor.
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24.8 Interface with Depot Civil/E&M/Finishing Contractor(s)

24.8.1 The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

S. N.	Subject	Depot Civil/E&M/Finishing Contractor	Rolling Stock Contractor
	Design stage		
1	Requirement for and commissioning testing of cars	Based on Project Manager's / DDC's broad design and review of RS, DDC shall design the infrastructure facilities for commissioning and testing of cars in nominated Depot(s).	Review the planning by Project Manager / DDC and define the minimum facilities required for commissioning and testing the cars in the depot.
2	Metro train Maintenance requirement	Shall design the Depot maintenance facilities including all depot buildings, to suit RS requirement	Shall furnish the maintenance schedules and equipment requirement for complete cars, assemblies and subassemblies systems and sub systems
3	Plant and Machinery, test panels, tools and instruments etc.	Depot Engineer shall design and develop specifications for supply and commissioning of General-purpose plant and machinery, tools and instruments at Depot. DDC/Depot Civil Contractor Shall Incorporate structural provision and electrical & mechanical provisions for all Machinery and Plant.	Provide details of all special tools / test panels suitable for the rolling stock testing, commissioning and maintenance.
4	Store facilities for important items of Rolling Stock.	Shall design the store facilities for assemblies, sub-assemblies, capital spares etc. at Depot.	Shall furnish the special requirements for storage and the quantities for storage

S. N.	Subject	Depot Civil/E&M/Finishing Contractor	Rolling Stock Contractor
5	Layout of RS rooms and other RS related occupancies at the depot	Design the finishing works of the RS rooms, facilities and other occupancies in coordination and factoring in the requirements of the RS Contractor	Suitably interface and mark appropriately RS related requirements on the drawings in close coordination with the DDC/Construction/Finishing Contractor. Review design with the DDC/Construction/Finishing Contractor.
	Construction & Installation (C&I) Stage		
6	Requirement for commissioning and testing of cars	Shall construct the facilities for commissioning and testing of cars in nominated depot to meet the commissioning schedule of rolling stocks	Coordinate to ensure the minimum facilities required for commissioning and testing the cars in the depot are built timely
7	Metro train Maintenance requirement	Shall construct the facilities needed to meet the maintenance needs as advised by RS Contractor.	Coordinate to ensure the requisite maintenance facilities in the depot are built timely
8	Plant and Machinery, test panels, tools and instruments etc.	Incorporate structural provision and electrical & mechanical provisions for all Machinery and Plant.	Supply all special tools / test panels suitable for the rolling stock testing, commissioning and maintenance.
9	Store facilities for important items of Rolling Stock.	Shall construct the store facilities	Shall coordinate to ensure that the special requirements for storage are met
10	Central Depot Construction, Commissioning and Operational Readiness	To Liaise and coordinate with the RS Contractor to agree facility completeness and accessibility for car delivery to agreed delivery schedule as approved by BMRCL	Liaise and coordinate with the Construction Contract / DDC for car deliveries and access. Not to deliver cars in advance of agreed delivery schedule without agreement of DDC and approval of BMRCL.
11	Layout of RS rooms and other RS related occupancies at the depot	Provide rooms and other occupancies with finishes as agreed and as required.	Coordinate closely with construction / finishing Contractor to ensure the requirements at site are met.
	Testing & Commissioning (T&C)		

S. N.	Subject	Depot Civil/E&M/Finishing Contractor	Rolling Stock Contractor
	Stage		
12	Testing and commissioning	Shall jointly check and confirm the T&C of depot facilities.	Shall co-ordinate and confirm with depot Contractor.
13	Integrated testing	Shall coordinate with RS Contractor to complete testing and commissioning work	Require to conduct integrated test with all systems
	Maintenance Stage		
14	Nil		

24.9 Interface with Track Contractor

S. N.	Subject	Rolling stock (RS) Contractor	Track Work (TRW) Contractor
	Design Stage		
1	Track alignment drawings	Rolling Stock Contractor shall use the information for his design and train running simulation	Track Contractor shall provide the RS Contractor with the detailed track alignment drawings
2	Kinematic Envelope / structure gauge	Shall provide kinematic envelope / structure gauge information to Track Contractor	Take into account for checking the infringement at construction stages
3	Track design / drawings	The Rolling Stock Contractor shall provide the wheel profile details and other train parameters to the Track Contractor. The wheel and rail static and dynamic interface shall be optimized to achieve a good operational, maintenance and riding comfort performance. RS Contractor shall incorporate in its design the track parameters.	Shall provide information regarding track parameters including the track form and track work component stiffness, track gauge, rail type& hardness, curve radius, cant and all the parameters together with the tolerance and limits of each parameter Track Contractor shall consider RS parameters in track design.
4	Gauge widening	RS Contractor shall provide necessary information	The Track Contractor shall liaise with RS Contractor for the requirement and extent of Gauge widening on sharp curves.
5	Flange way clearances	RS Contractor shall provide necessary information	The Track Contractor shall liaise with RS Contractor for determining the requirement

S. N.	Subject	Rolling stock (RS) Contractor	Track Work (TRW) Contractor
			(including the required flange way clearances) for the provision of check / restraining rails, if considered, on sharp curves.
6	Simulation Studies	Shall carry out simulation studies & provide results with respect to attainable speed along the alignment.	The values of cant to be provided on every curve shall be fine-tuned based on the attainable speeds. The Track Contractor shall provide the cant accordingly during construction stage.
7	Buffer stops design	Shall provide details of Rolling Stock Shall liaise with Track Contractor to verify the design of friction buffer stops is interfaced satisfactorily with the car design	The Track Contractor shall liaise with the Rolling Stock Contractor to design the buffer stop and shall consider such details for supply and installation of buffer stops
8	Calculations for Design of walkway slab	Shall study the track geometry including horizontal and vertical profile for the entire project. The project is designed with side evacuation. The Rolling Stock Contractor and Track Contractor shall jointly submit the calculation of horizontal and vertical shift of carbody on inside curve and outside curve in stationary condition and running condition. Walkway slab shall be designed by civil Contractor based on the calculation submitted jointly by Rolling Stock Contractor and Track Contractor to ensure that gap between walkway and car floor shall not exceed 600mm as it is not possible to accommodate bridgeable ramp (emergency ramp) with more than 600 mm length under the train seat.	The project is designed with side evacuation. The Rolling Stock Contractor and Track Contractor shall jointly submit the calculation of horizontal and vertical shift of carbody on inside curve and outside curve in stationary condition and running condition. Walkway slab shall be designed by civil Contractor based on the calculation submitted jointly by Rolling Stock Contractor and Track Contractor to ensure that gap between walkway and car floor shall not exceed 600mm as it is not possible to accommodate bridgeable ramp (emergency ramp) with more than 600 mm length under the train seat.

S. N.	Subject	Rolling stock (RS) Contractor	Track Work (TRW) Contractor
9	Track hardness	RS shall incorporate in his design	Shall provide information to RS Contractor
10	Checking of track construction envelope	To provide skeleton vehicle of structure gauge and take lead for running structure gauge skeleton vehicle to identify infringement of structure along the track including 3 rd rail installation and Signalling Equipment and notify the infringement to designated Contractor.	Shall co-ordinate
	Construction & Installation (C&I) Stage		
11	All relevant items	Shall manufacture the RS as per agreed interfaces	Shall install the track system as per agreed interfaces
12	Bridge plate	RS shall design and supply	Shall perform and submit joint calculations along with RS Contractor as per Item at SN 8 above
13	Construction and installation	Required to conduct test run	Shall participate in test run and perform modifications, if required
	Testing & Commissioning (T&C) Stage		
14	Integrated testing & commissioning	Shall provide results of test runs including those pertaining to track conditions.	Shall associate during integrated testing & commissioning and carryout necessary rectification of track.
15	Structure gauge checking	Shall provide structure gauge and manpower	Shall jointly measure the various clearances required for structure gauge and shall rectify the defects noticed in track area.
16	KE test	Shall provide the train with KE profile	Shall jointly check whether KE infringement is there or not Shall rectify the defects noticed as relevant to track work

S. N.	Subject	Rolling stock (RS) Contractor	Track Work (TRW) Contractor
	Maintenance Stage		
17	Nil		

24.10 Interface with M&P Contractor

24.10.1 The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

S. N.	Subject	Rolling stock (RS) Contractor	M&P Contractor
	Design Stage		
1	Automatic Train Wash Plant	Define special water quality requirements if any. <ul style="list-style-type: none"> • Share the Drawings of the train. • To provide details of infringing objects if any, which cause hindrance to the washing • Share Rolling Stock dimensions, profile SOD and other details to design wash plant. • Provide the details of the detergents to be used. 	Provide plant GAD and other details as required by RS Contractor
2	CNC Under floor Wheel Lathe with Synchronized Shunting System	<ul style="list-style-type: none"> • Share Train data / drawing as required by M&P Contractor (including SOD) • Share Wheel cross section drawing • Share Type of brake for machining • Share Coupler details for shunting • Share wheel, bogie, brake disc data related to tare load, axle load, inter-wheel distance in bogie, allowances for wheel diameter difference on the same axles, on the same bogie, on different bogie of same coach required for design of machine. 	Provide plant GAD and other details as required by RS Contractor

S. N.	Subject	Rolling stock (RS) Contractor	M&P Contractor
		<ul style="list-style-type: none"> Share data for haulage requirement and auto coupler details 	
3	Under floor train lifting system for 6-car unit	Share Train data / drawings as required by M&P Contractor Share Lifting points details with lifting pad dimensions To ensure that there is no infringement in the vertical plane below the lifting points.	Provide plant GAD and other details as required by RS Contractor
4	Mobile lifting jacks for 6-car unit	<ul style="list-style-type: none"> Share Train data / drawings as required by M&P Contractor Share Lifting points details with lifting pad dimensions To ensure that there is no infringement in the vertical plane below the lifting points. 	Provide plant GAD and other details as required by RS Contractor
5	Bogie Testing Machine	<ul style="list-style-type: none"> Share Bogie data / drawings as required by M&P Contractor Share Wheel data / drawings 	Provide plant GAD and other details as required by RS Contractor
6	Rescue Vehicle with Re-railing & Allied Equipment	<ul style="list-style-type: none"> Share Train data / drawings and coupler details as required by M&P Contractor 	<ul style="list-style-type: none"> Provide plant GAD and other details as required by RS Contractor CRS requirements to be complied
7	Instrumented Third Rail Maintenance Vehicle	<ul style="list-style-type: none"> Share Train data / drawings as required by M&P Contractor Share Coupler details Share collector shoe drawing / details 	<ul style="list-style-type: none"> Provide plant GAD and other details as required by RS Contractor CRS requirements to be complied
8	Battery operated Rail-cum-Road Shunter	<ul style="list-style-type: none"> Share Train data / drawings and coupler details as required by M&P Contractor 	Provide plant GAD and other details as required by RS Contractor
9	Multi-functional work station	<ul style="list-style-type: none"> Share Train data / drawings as required by M&P Contractor Share traction drawing / details 	Provide plant GAD and other details as required by RS Contractor
	Construction & Installation (C&I)		

S. N.	Subject	Rolling stock (RS) Contractor	M&P Contractor
	Stage		
10	All relevant items	Shall manufacture the RS as per agreed interfaces	Shall manufacture and install the respective M&Ps as per agreed interfaces Design Manufacture and supply the M&P to suit the Rolling Stock.
	Testing & Commissioning (T&C) Stage		
11	Testing & commissioning	Shall collaborate and associate for testing & commissioning of respective M&Ps as required	Shall lead the testing & commissioning of respective M&Ps and collaborate / associate with RS Contractor as required
	Maintenance Stage		
12	Nil		

24.11 Interface with TVS Contractor

24.11.1 The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

S. N.	Subject	Rolling Stock Contractor	TVS Contractor
	Design Stage		
1	Train configuration information	Shall provide the details of train configuration and technical specification for Subway Environmental Simulation to design Tunnel ventilation and Track way exhaust system	Shall coordinate and obtain the details of train configuration and technical specification for Subway Environmental Simulation to design Tunnel ventilation and Track way exhaust system
2	Train operation data	Shall provide the details of train speed, acceleration, deceleration, dwell time and operating headways in each underground stations and tunnels to design Tunnel ventilation and Track way exhaust system	Shall coordinate and obtain the details of train speed, acceleration, deceleration, dwell time and operating headways in each underground stations and tunnels to design Tunnel ventilation and Track way exhaust system

S. N.	Subject	Rolling Stock Contractor	TVS Contractor
3	Train air-conditioner heat release data	Shall provide data of heat release rate from the train air-conditioners	Shall incorporate in the design
4	Train brake system heat release data	Shall provide data of heat release rate from the train brake system	Shall incorporate in the design
5	Location of air conditioners of cars	Shall indicate location of the car air conditioners viz.- a-viz. the train	Shall incorporate in his design as regard to location of track way exhaust duct
6	Train fire and heat release load	Shall indicate the fire load of the train	Shall incorporate in his design
7	Heat release rate from traction and auxiliary equipment and their location	Shall furnish data	To use data in TVS design
	Construction & Installation (C&I) Stage		
8	All relevant issues	Shall coordinate appropriately to ensure the agreed requirements are implemented	Shall construct and install the TVS system as per the agreed designs
	Testing & Commissioning (T&C) Stage		
9	System testing and commissioning	Shall participate for system testing	Shall participate for system testing
	O&M Stage		
10	TVS system O&M	Shall support the O&M activities of TVS system.	Shall Co-Ordinate.

24.12 Interface with ECS Contractor

24.12.1 The Contractors shall co-ordinate interactively in order to achieve the functional and operational requirements of the system. The roles and activities of the two Contractors shall include minimum following but not limited to:

S. N.	Subject	Rolling Stock Contractor	ECS Contractor
	Design Stage		
1	Location of air-conditioners of Cars (Applicable without PSD/PSG)	Rolling Stock Contractor shall indicate location of the car air-conditioners vis-à-vis the train	ECS Contractor shall incorporate in his design as regard to location of Track way exhaust duct
2	Heat release rate from air- conditioners (Applicable without PSD/PSG)	Rolling Stock Contractor shall provide data of heat release rate from the air-conditioners	For design review of ECS equipment selection
3	Design stage (Applicable without PSD/PSG)	Shall provide the details of train speed, acceleration, deceleration, dwell time and operating headways in each underground station to do PSD Infiltration and ex filtration simulation and to calculate heat load capacities in platforms	Shall get the details of train speed, acceleration, deceleration, dwell time and operating headways in each underground station to do PSD Infiltration and ex filtration simulation and to calculate heat load capacities in platforms
	Construction & Installation (C&I) Stage		
4	All relevant issues	Shall coordinate appropriately to ensure the agreed requirements are implemented	Shall construct and install the ECS system as per the agreed designs
	Testing & Commissioning (T&C) Stage		
5	System testing and commissioning	Shall participate for system testing	Shall participate for system testing
	O&M Stage		
6	Nil		

24.13 Interface with other Contractors

24.13.1 Besides above there are several designated contractors who would need the information regarding the design features and other parameters of the Rolling Stock. Their contracts shall have the provisions to interface directly with the Rolling Stock Contractor for the exchange of information.

24.13.2 The details of these contracts and contractors shall be made available during the execution of the contract.

24.13.3 These shall include the following but not limited to:

S. N.	Subject	Rolling Stock (RS) contractor's Responsibilities	Other Contractor's Responsibilities
1	Rolling Stock Details	RS Contractor shall provide the relevant details of Rolling Stock as per his design.	Other contractors shall design their systems compatible to the Rolling Stock parameters provided to them.

24.14 Deliverables

Contract deliverables required by this section of the technical provisions are summarized below:

CDRL-24-1:	Detailed design of inching operation (ref. ERTS 24.6.3.2.3)
CDRL-24-2:	Pre-defined distance in RMR mode (ref. ERTS 24.6.3.5)
CDRL-24-3:	Not Used
CDRL-24-4:	Automatic wash plant (ref. ERTS 24.6.3.9.9)
CDRL-24-5:	Automatic Turnback mode (ref. ERTS 24.6.3.10)
CDRL-24-6:	Joint Detailed Interface Documents (DID) (ref. ERTS 24.6.4.1.22 and 24.6.4.1.24)
CDRL-24-7:	Transfer and display of such images from CCTV Server to LVS (ref. ERTS 24.6.4.1.26)
CDRL-24-8:	Detailed proposal for bandwidth allocation on CCTV network (ref. ERTS 24.6.4.1.30)
CDRL-24-9:	Interface document for rescue operation (ref. ERTS 24.6.4.1.31)
CDRL-24-10:	Roll back detection (ref. ERTS 24.6.4.1.33)
CDRL-24-11:	Interface for initiation, termination and success or failure of emergency calls (ref. ERTS 24.6.4.1.34)
CDRL-24-12:	Joint protocol document for Integrated Testing and Commissioning (ref. ERTS 24.6.4.1.35)
CDRL-24-13:	Prepare a comprehensive Operating Modes and Principle Document (OMPD) (ref. ERTS 24.6.4.1.36)
CDRL-24-14:	Signalling interface for display of indication and alarm at OCC/SCR/DCC level (OMPD) (ref. ERTS 24.6.4.1.37)
CDRL-24-15:	Train Event Recorder provided as a part of TCMS design (ref. ERTS 24.6.4.1.38)
CDRL-24-16:	Sequential/staggered power on command and sequential/staggered starting of the train (ref. ERTS 24.6.4.1.39)
CDRL-24-17:	Optimization of energy with respect to different TE (Tractive Effort) /BE (Braking Effort) curve for different loads (ref. ERTS 24.6.4.2.8)
CDRL-24-18:	Control Output from ATC System to Rolling Stock (ref. ERTS 24.6.4.8.10)
CDRL-24-19:	Control Output from Rolling Stock to ATC System (ref. ERTS 24.6.4.8.11)
CDRL-24-20:	Remote Control from OCC (ref. ERTS 24.6.4.8.12)
CDRL-24-21:	Staggered acceleration of trains within the same power feed zone in UTO (ref. ERTS 24.6.4.8.20)
CDRL-24-22:	ATC-RS Joint test for mainline testing (ref. ERTS 24.6.4.10.4(a))
CDRL-24-23:	Monitoring of telecommunication signals by TCMS (ref. ERTS 24.7.4.8)

25 APPENDIX E. DRAWINGS AND DOCUMENTS

Table E.1 List of Drawings provided by the Project Manager:

SN	Description	Drawing / Document reference
1	Schedule of dimensions	Attached in Appendix-E/1
2	Station and inter-station distances	Appendix E - Table E.2 - Table E.4
3	Speed restriction for the different curve radius	Appendix E - Table E.5

25.1 Schedule of dimensions

25.1.1 This information, to be confirmed during the preliminary design stage of the vehicle, shall be used by the Bidder for static vehicle gauge calculations, the kinematic gauge calculation compliance, vehicle architecture, optimal width.

25.2 Third rail gauge and dimensions

25.2.1 Important dimensions of third rail are provided in Chapter 4 of SOD.

25.3 Deleted.**25.4 Station and inter station distances**

25.4.1 This information, to be confirmed during the preliminary design stage of the vehicle shall be used by the Bidder for the running trip calculations in order to achieve a minimum commercial speed of 34 km/h (excluding reverse time in terminal stations).

25.4.2 Line-6 Stations, Chainage, Inter-Station Distances and Platform Details are as below:

Table E.2: Line-6 – Stations, Chainage and Inter-Station Distances

S. No.	Station Name	Chainage as Per GAD	Int.-Dist	Cumulative Dist	Remark
1	KalenaAgrahara	660.224	-	-	ELE (side platform)
2	Hulimaavu	1722.401	1062.177	1062.177	ELE (side platform)
3	IIMB	3423.007	1700.606	2762.783	ELE (side platform)
4	JP Nagar	5055.456	1632.449	4395.232	ELE (side platform)
5	Jayadeva Hospital	5822.789	767.333	5162.565	ELE (side platform)
6	Swagath Road Cross	7232.503	1409.714	6572.279	ELE (side platform)
7	Dairy Circle	8520.703	1288.2	7860.479	U.G. (island)
8	MICO Industries	9468.288	947.585	8808.064	U.G. (island)
9	Langford Town	10417.555	949.267	9757.331	U.G. (island)
10	Vellara Road	11294.135	876.58	10633.91	U.G. (island)
11	M. G. Road	12561.065	1266.93	11900.84	U.G. (island)
12	Shivaji Nagar	13842.328	1281.263	13182.1	U.G. (island)
13	Cantonment	14894.701	1052.373	14234.48	U.G. (island)

S. No.	Station Name	Chainage as Per GAD	Int.-Dist	Cumulative Dist	Remark
14	Pottery Town	16005.305	1110.604	15345.08	U.G. (island)
15	Tannery Road	17133.906	1128.601	16473.68	U.G. (island)
16	Venkateshpura	18160.646	1026.74	17500.42	U.G. (island)
17	Arabic College	19539.756	1379.11	18879.53	U.G. (island)
18	Nagawara	20866.166	1326.41	20205.94	U.G. (island)

25.4.3 Phase 2A, Inter-Station Distances and Platform Details are as below:

Table E.3: Phase 2A – Stations, Chainage and Inter-Station Distances

S. No.	Station Name	Chainage as Per GAD	Int.-Dist	Cumulative Dist	Remark
1	Central Silk Board Junction	413.840			ELE (side platform)
2	HSR Layout	1485.363	1071.523	1071.523	ELE (side platform)
3	Agara	2817.116	1331.753	2403.276	ELE (side platform)
4	Ibbalur	5121.234	2304.118	4707.394	ELE (side platform)
5	Bellandur	7165.144	2043.91	6751.304	ELE (side platform)
6	Kadubeesanahalli	8117.297	952.153	7703.457	ELE (side platform)
7	Kodibisanahalli	9970.612	1853.315	9556.772	ELE (side platform)
8	Marathahalli	11416.461	1445.849	11002.62	ELE (side platform)
9	ISRO	12688.210	1271.749	12274.37	ELE (side platform)
10	Doddanekundi	13585.838	897.628	13172	ELE (side platform)
11	DRDO Sports Complex	14867.153	1281.315	14453.31	ELE (side platform)
12	Saraswathi Nagar	15906.210	1039.057	15492.37	ELE (side platform)
13	K.R Puram	17133.392	1227.182	16719.55	ELE (side platform)

25.4.4 Phase 2B, Inter-Station Distances and Platform Details are as below:

Table E.4: Phase 2B – Stations, Chainage and Inter-Station Distances

S. No	Station Name	Chainage	Int.-Dist	Cumulative Dist	Remark
1	K R Puram	-1294.000			ELE (side platform)
2	Kasturi Nagar	1600.160	2894.16	2894.16	ELE (side platform)
3	Horamavu	2751.700	1151.54	4045.7	ELE (side platform)
4	HRBR Layout	4201.230	1449.53	5495.23	ELE (side platform)
5	Kalyan Nagar	5303.820	1102.59	6597.82	ELE (side platform)
6	HBR Layout	6560.920	1257.1	7854.92	ELE (side platform)

S. No	Station Name	Chainage	Int.-Dist	Cumulative Dist	Remark
7	Nagawara	7508.790	947.87	8802.79	ELE (side platform)
8	Veeranna Palya	8314.000	805.21	9608	ELE (side platform)
9	Kempapura	9964.250	1650.25	11258.25	ELE (side platform)
10	Hebbal	11223.430	1259.18	12517.43	ELE (side platform)
11	Kodigehalli	12699.060	1475.63	13993.06	ELE (side platform)
12	Jakkur Cross	14120.040	1420.98	15414.04	ELE (side platform)
13	Yelahanka	17842.930	3722.89	19136.93	ELE (side platform)
14	Bagalur Cross	20022.280	2179.35	21316.28	ELE (side platform)
15	Bettahalasuru	23826.472	3804.192	25120.47	ELE (side platform)
16	Doddajala	28736.530	4910.058	30030.53	ELE (side platform)
17	Airport City	33705.170	4968.64	34999.17	At Grade (side platform)
18	KIA Terminals	36267.250	2562.08	37561.25	At Grade (side platform)

25.5 Speed restriction for the different curve radius**25.5.1** Statement showing the Radius of Curves and Speed limit:-**Table E.5: Speed restriction for different curve radius**

Sl. No.	Radius in meter	Speed Limit
A: Line-6		
1	1000	80
2	950	80
3	800	80
4	723	80
5	718	80
6	612	80
7	600	80
8	500	80
9	469	80
10	450	80
11	440	80
12	350	80
13	300	75
14	250	65
15	240	65
16	225	65
17	220	60
18	200	60
19	175	55
20	165	55
21	155	50
22	150	50
23	120	45

Sl. No.	Radius in meter	Speed Limit
B: Phase 2A		
1	1000	80
2	800	80
3	650	80
4	600	80
5	500	80
6	400	80
7	320	75
8	300	75
9	257	65
10	224.3	65
11	210	60
12	150	50
13	136	50
14	120	45
C: Phase 2B		
1	18000	80
2	9500	80
3	9000	80
4	8500	80
5	8000	80
6	6000	80
7	5500	80
8	5000	80
9	4000	80
10	3200	80
11	3000	80
12	1900	80
13	1500	80
14	1400	80
15	1300	80
16	1260	80
17	1200	80
18	1125	80
19	1100	80
20	1050	80
21	1000	80
22	960	80
23	950	80
24	940	80
25	900	80
26	850	80
27	840	80
28	812.5	80
29	800	80
30	775	80
31	750	80
32	740	80
33	730	80
34	715	80
35	690	80
36	675	80

Sl. No.	Radius in meter	Speed Limit
36	535	80
37	530	80
38	450.2	80
39	450	80
40	430	80
41	400	80
42	345	75
43	344.80	75
44	310	75
45	300	75
46	250.3	65
47	205	60
48	201	60
49	200.3	60
50	200	60
51	192.5	55
52	127.5	45

26 APPENDIX F. TRAIN WITHDRAWAL SCENARIOS

Decision on whether a system failure constitutes a train withdrawal condition will be based on the below Train Withdrawal Scenarios.

Sl. No.	System/Equipment	Withdrawal Condition
1	Car-body structure	Failure of the structural integrity of any car
2	Exterior equipment	Failure of the exterior equipment (HVAC, under frame equipment) resulting in risk to line side personnel or exceeding kinematic envelope
3	Windows & Draught screen	Failure of any one windows on train; 1. Window cracked due to defect of window 2. Draught screen broken
4	Internal controls	1. Failure of train door control circuits at either cab 2. Failure of brake control circuits in either cab
5	Windscreen Wiper	Rainy weather and defective wiper in any cab.
6	Under frame	Loss of integrity of any major equipment mounting
7	Head Lights/ tail lights	Failure of both head/tail lights at either end of train
8	Bogie	1. Loss of integrity of bogie structure 2. Anti-roll bar failure
9	Wheel set	1. Serious wheel flat with abnormal sound 2. Axle bearing seized
10	Primary Suspension (per bogie)	Any defect in primary / secondary suspension resulting in passenger safety, comfort or performance.
11	Secondary Suspension (per bogie)	
12	Gangway	Failure of gangway
13	Semi-permanent half coupler	Failure of coupler 1. Mechanical failure of coupler 2. Pneumatic connection failure if not isolated through isolating cock.
14	Auto-coupler (half coupler)	Failure of coupler 1. Mechanical failure of coupler 2. Pneumatic connection failure if not isolated through isolating cock.
15	Current collector	Failure of Current collector 1. No current collection from both collector shoes of one car 2. Damage to Power Supply Line
16	Propulsion System (Train)	Failure of propulsion system on train 1. Failure of more than 2 (two) VVVF group in a train. 2. Power Supply Failure such as HSCB trip in more than 1 (one) car. 3. Traction Motor Bearing seized

Sl. No.	System/Equipment	Withdrawal Condition
		4. Isolation of more than 4 motors. (In case train can be kept in commercial / revenue service operation after isolating failed VVVF group, it will be considered to be available for commercial / revenue service.)
17	Driving gear unit	1. Any defect resulting in high temperature / isolation 2. Abnormal Noise from underframe.
18	Gear Coupling and Reaction Rod	Reduction of propulsion power. - Failure of the drive gear causes the gear seized or major oil leakage from gear box
19	Auxiliary Power Supply (APS)	Failure of 1 (one) APS units in train-set.
20	Battery Charger	Battery Charger of one unit isolated.
21	Brake system (mechanical)	If isolation of an additional bogie (mechanical) leads to speed restriction.
22	Door Control and Actuator	Failure of two train doors on the same side of the train-set
23	Door and Lock	1. Failure of cab partition door spuriously opens or fails to lock closed.
24	HVAC control and Power Circuit	Failure of HVAC control circuits in occupied driver's cab
25	HVAC unit	Failure of 2 HVAC units per train
26	TCMS & Vehicle circuits	1. If HMI display fails & functionality is not transferred to redundant HMI. 2. Any failure in TCMS component / equipment /circuit element / software/communication system etc. resulting in loss of intended function. 3. Further cases will be included based on TCMS redundancy and configuration.
27	PA & CCTV	1. If automatic announcements fail & TO is not able to make manual announcements 2. if ≥ 1 unit rear/platformview CCTV not working 3. If >1 PEA in any car is defective 4. Any of the front CCTV not functioning during GoA4 operation
28	Saloon Interior	1. Interior panel including gangway panels fall off 2. Light diffusers damages or broken
29	Main compressor unit	1. Main Compressor Unit of one unit (3-car) isolated. 2. Train will be withdrawn only if MR and BP cannot be maintained.
30	Air leakage	1. Any leakage which necessitate continuous running of compressor.

Sl. No.	System/Equipment	Withdrawal Condition
		2. Any leakages which may lead to incorrect brake application. 3. Any leakages from brake valves, circuit breaker and etc.
31	Master Controller	1. If master controller prevents the train from moving. 2. Any defect in master controller even if no delays are reported. 3. Any defective cab switch leading to unsafe operation.
32	Partition Door	1. If door cannot be properly closed / locked 2. If doors are not operable through normal procedure.
33	Passenger doors	If ≥ 2 (two) doors per train side is isolated.
34	A failure or symptom which may endanger safe and/or normal operation of train	1. Failure in safety interlock or protection circuit such as door loop. 2. Abnormal noise in underframe. 3. Wheel flat 4. Failure of emergency equipment 5. Failure which may disable train's push out duty. 6. Train which that requires more than 2 instances of reset within 30 minutes 7. Jerky movement. 8. Failure of battery fuse 9. Unintended operation or malfunction of any safety device / emergency equipment causing operational exceeding 3 minutes delays 10. Train fail to start after successful completion of pre-departure checkout
35	Fire system	1. ≥ 2 in one car fire detector failure 2. Failure of fire control unit including its backup

Note:

In case the Withdrawal Condition arises solely for reasons not attributable to the Contractor, the failure shall not be to Contractor's account and shall not be considered for MDBF calculation.

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