



**KOLKATA METRO RAIL CORPORATION LIMITED
EAST WEST METRO PROJECT**

CONTRACT RS (3R)

**DESIGN, MANUFACTURE, SUPPLY, TESTING,
COMMISSIONING AND INTEGRATION OF PASSENGER
ROLLING STOCK (ELECTRICAL MULTIPLE UNITS), AND
TRAINING OF PERSONNEL**

TENDER DOCUMENTS

**VOLUME 3
(Part 2 of 2)**

EMPLOYER'S REQUIREMENTS - TECHNICAL SPECIFICATION

Date of Issue: January 9, 2015

KOLKATA METRO RAIL CORPORATION LIMITED

KMRCL Bhawan (HRBC Bhawan)

Munshi Premchand Sarani,

Kolkata 700 021

India

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SUMMARY OF TENDER DOCUMENTS

Volume 1

- Notice of Invitation to Tender
- Instructions to Tenderers (including Annexure)
- Eligibility Criteria Documents
- Form of Tender (including Appendices)

Volume 2

- General Conditions of Contract
- Special Conditions of Contract (including Schedules)

Volume 3

- Employer's Requirements – General Specification
- **Employer's Requirements – Technical Specification**

Volume 4

- Schedule of Dimensions (SOD)

Volume 5

- Tender Drawings

Volume 6

- Pricing Documents

Volume 7

- Safety, Health and Environment (SHE) Manual
- SHE Conditions of Contract

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EMPLOYER'S REQUIREMENTS: TECHNICAL SPECIFICATION

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1. INTRODUCTION

1.1. Scope of the document

- 1.1.1. The objective of this document is to provide the Technical and Functional requirements that shall be implemented for the new metro trains to be operated on East - West (E/W) line of the Kolkata Metro Rail project. The purpose of the present supply contract is the design, manufacture, factory acceptance, loading, transport, unloading commissioning, integration of supplied metro trains to a new construction Metro system..
- 1.1.2. The transformation of the functional requirements into technical solutions, well proven reliable and economically efficient remains within the metro train Contractor, and so best value solutions shall be achieved. Freedom of design is given to Contractors, who naturally will use well proven solutions as much as possible to produce more cost-effective design and reliable rolling stock. The Rolling Stock specification requires a metro train according to the state of the art, designed with the acknowledgement of high technology standard for a lifetime of 35 years.
- 1.1.3. On the basis of existing solution usually proposed by Manufacturers, it is supposed that the metro train will be composed by 6 cars (firm order of the contract). The 6 cars fixed composition of metro train will be:



6-Car Train Composition: DTC + MC + MC + MC + MC + DTC

- DTC: Driving Trailer Car.
- MC: Motor car.

- 1.1.4. The total number of cars to be supplied under this Tender is 84 cars. i.e. 14 Metro Train of 6-car composition.
- 1.1.5. This Tender also contains 25% Option Clause of same make up. All DTC and MC shall be totally interchangeable by the same type of car and at the same sequence without any modification.
- 1.1.6. In a global overview of the present technical requirements and Tenderer proposal, the option for 6 fixed car composition shall be anticipated and presented in the calculations, performance compliance, design and solution proposed.

2. OPERATIONAL ENVIRONMENT

2.1. Climatic and Environmental Conditions

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

Table 2.1: Climatic & Environmental Conditions:

Description	Limiting Values
Maximum ambient temperature	35.2°C
Minimum ambient temperature	28.6°C
Humidity	60% (100% saturation during rainy season which may be as long as 6 months)
Rainfall	Average annual rainfall is approx. 1582 mm. Maximum recorded rainfall in any 24h period is 306 mm in month of August. Very heavy rain occurs along with high frequency of lightning discharges.
Atmosphere during hot season	Extremely dusty
Maximum wind speed	Vehicle stopped on the line : 160km/h Vehicle running : 130km/h
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	100 m
Conditions in stations	All stations shall have Platform Screen Doors (PSD's). Full height PSD for UG stations and half height PSD for elevated stations. Underground stations will be fully air-conditioned.

Note: However, the Tenderer must confirm from ASHRAE, outside design data conditions for Kolkata. In case of any difference in ISHRAE and ASHRAE conditions, the severe of the two conditions shall be used for design purpose

- 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 greasy, conducting dust, textile fluff, long fibres, various papers and sulphuric gas.

- 2.1.5. Environmental Conditions In Tunnel: Consists of 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 45°C under normal as well as congested conditions.
- 2.1.6. 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.
- 2.1.7. Under platform supply and one Track 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 supply 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.
- 2.1.8. 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. Two mid shaft ventilation arrangement is there between Howrah & Mahakaran and between Sealdah and Phool Bagan.

2.2. Line characteristics

- 2.2.1. Total length of the KMRCL East / West line (EWL) is approximately 14.67 Km, connecting Howrah Maiden at the East and Salt Lake Sector V at the West. The route will be approximately 5.77 Km of elevated and 8.9 Km Tunnel Sections.
- 2.2.2. The KMRCL Metro System will include 12 passenger stations, equipped with Platform Screen Doors (PSDs). Each station will also be provided with smart card vending machines. ("Proof of Payment" operating principles).
- 2.2.3. One depot will be provided at Central Park for maintenance activities (stabling, daily, regular maintenance and heavy maintenance).

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 2.2: Track Structure Parameters (Tentative)

Description	Elevated and at-grade sections		Tunnel sections
	Ballasted	Ballast-less (DFF)	Ballast-less (DFF)
Track Laying Gauge	1435mm		
Rail Type			
Main Line and Test Track in CPD	60 E I Grade 1080 HH conforming to Specification IRS/T -12		
Depot	UIC 60 Kg (Grade 880) conforming to Specification IRS/T -12		
Inclination Of Rail	1:20		

Description	Elevated and at-grade sections		Tunnel sections
	Ballasted	Ballast-less (DFF)	Ballast-less (DFF)
Rail Seat spacing, Main line		· 650 mm ± 10 mm	
		In straight and curves with radius >300m	
		· 600 mm ± 10 mm	
		In curves with radius ≤ 300m	
Sleeper Spacing, depot	· 600±20mm in Test Track		
	· 650±20mm in other than Test Track		
	· Track on steel columns (1200mm)		
Ballast Cushion			
Depot	300mm		
Standard Rail Length	13m and 18m		
Rail Panel Lengths	Long welded rails		
	Mainline		Depot
Minimum Radius of Curvature	120m- Elevated and At-grade	200m -Underground	100m
Minimum Turn Out Radius. Main Line	190m (Tentative)		
Minimum Turn Out Radius Depot	140m (Tentative)		
Minimum Turn Out Angle Main line	1 in 9, except connection to Depot transfer in 1 in 7		
Maximum Cant Permissible in curves	125 mm		
Maximum Cant Deficiency Permissible	100mm		
Maximum Permissible Cant Gradient	1 in 440		
Turn-out Speed (maximum permissible) : Turn-out (Main line)	45 km/h		
Turn-out Speed (maximum permissible) : Scissors (Main line)	45 km/h		
Turn-out Speed (maximum permissible): In Depot	35 km/h		
Maximum Gradient	4% (compensated)		
Minimum vertical curve radius crest	1500m		
Maximum track axle load (AW4)	16.0 tonnes		
Widening of track Gauge on curves	Up to 9 mm		
Structural gauge and passing clearance in straight line, in curves, in open air grade, in tunnel	Refer to SOD		
Tunnel Profile (tentative)	Refer to SOD		
Line profile	The alignment drawings showing the line profiles are enclosed to Volume -5 of RS (3R) document:		

- 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 Engineer during the preliminary design of the vehicle.

Table 2.3 for Track Tolerances (tentative) Two separate tables for Ballasted & Ballast-less track

Ballastless Track

Sr. No.	Description	value
1	Gauge (Installation)	+2mm, -1mm
2	Gauge (Maintenance)	+4mm, -2mm
	Gauge(Maintenance) at < 500m radius curve (with respect to 1435mm)	+13mm, -0mm
3	Cross level on straight track (Installation)	± 1.5mm
4	Cross level on straight track (Maintenance)	± 5mm
5	Super elevation on curved track (Installation)	± 1.5mm
6	Super elevation on curved track (Maintenance)	± 3mm
7	Vertical alignment over a 20m chord (Installation)	± 3mm
8	Vertical alignment over a 20m chord (Maintenance)	± 6mm
9	Lateral alignment over a 20m chord on straight track (Installation)	± 2mm
10	Lateral alignment over a 20m chord on straight track (Maintenance)	+2mm, -1mm
11	On curves-variation over the theoretical versine on 20m chord (Installation)	± 2
12	On curves-variation over the theoretical versine on 20m chord (Maintenance)	13mm -0mm

Ballasted Track

Sr. No.	Description	Value
1.	Laying Tolerance of Vertical Alignment measured by 10m chord (Designed level)	□ ayi
2.	Alignment (Laying) (Base 10m)	□ lig
3.	Cross Level Laying Tolerance (Designed)	□ ros
4.	Twist (Other than transition curve) (Laying)	1mm/600mm
5.	Cross Level Difference (Maintenance)	10 mm
6.	Gauge measured at a point 14mm below crown of rail (laying) (with respect to 1435 mm)	+ 3 mm - 3 mm
7.	Unevenness (Maintenance) (Base 10m)	□ neven
8.	Alignment (Maintenance) (Base 10m)	□ lign
9.	Gauge variation maintenance (sleeper to sleeper)	□ auge
10.	Gauge (Maintenance) – Tangent track (with respect to 1435 mm)	+ 10 mm - 3 mm
11.	Gauge (Maintenance) - >500m radius (with respect to 1435 mm)	+ 10 mm - 3 mm
12.	Gauge (Maintenance) - <500m radius (with respect to 1435 mm)	+ 19 mm - 0 mm
13.	Gauge Face Wear	10 mm

2.4. Flood Proofing

- 2.4.1. The traction equipments mounted on the under-frame will 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 depot
Nominal voltage	750 V DC
Type of Current collection	Through Third Rail (Top of Rail) in all sections.
Current Collection	Through current collector shoes.
Height of Current collecting surface of the conductor rail shoe from rail level (refer to SOD)	Refer to SOD
Distance between Centre line of the Conductor rail and track centre (refer to SOD).	1380 mm max. 1360 mm min.
Minimum abnormal voltage	500 V DC
Maximum operational voltage	900 V DC
Maximum voltage during regenerative braking	1000 V D.C
Minimum Voltage for guaranteed performance	700 V DC.

- 2.5.2. In the event that third rail voltage drops below 700VDC, the line current drawn by the traction motors shall remain constant from 700VDC to 525VDC and shall diminish gradually below 525VDC until the cut off Voltage.

- 2.5.3. Typical third rail schematic, gauge and dimensions are given in SOD

2.6. Signalling System

- 2.6.1. Principal details of the Signalling and Telecommunications System are set out in the interface and shall be ATP/ATO.

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 Chapter 24 - Interfaces.

2.8. Kinematic Envelopes

- 2.8.1. The Tenderer 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 maximum to 2880 mm metres according to structure gauge, swept envelope, dynamic movement and passing clearances. The Tenderer 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 SOD).

- 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 SOD. 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.
- 2.8.4. Kinematic envelope for 6 car metro trains shall be submitted by the contractor.
- 2.8.5. Normal Conditions:
- (i) All vehicle speeds between 0 and 90 km/h (design speed)
 - (ii) All vehicle loads between tare and dense crush load (AW4).
 - (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 up to the maximum speeds given in Table 2.1 on the At-grade and Elevated portions of the line
 - (viii) Vehicle yaw and vertical movements.
 - (ix) Track tolerances.
- 2.8.6. Abnormal Condition is any combination of bogie air spring deflated

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 (4-minutes head way initially on service start-up and 2 minutes possible projected), off-peak periods (10 minutes headway).
- (ii) Running of services for 18 hours of a day (5 AM to 11PM) with a station dwell time of 20 seconds at all stations except Howrah, Sealdah and Central which will be 45secs.
- (iii) Reverse minimum time in terminal stations, 180 seconds.
- (iv) Minimum 8 % coasting is expected to achieve the specified commercial speed.
- (v) Average mileage per year for a metro train in the range of 150 000 km.
- (vi) Motorization rate expected is 66.67% for a 6 car metro train composition.
- (vii) Total power of the 6 car metro train shall be defined and calculated by the Tenderer in order to achieve the operation performances. Anticipated total power to be submitted by the contractor.
- (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 by the Tenderer in order to achieve the operation performances. Anticipated total tractive and braking effort to be submitted by the contractor.
- (ix) Driving mode, driver supervised by ATO/ATP systems.
- (x) Normal single unit operation, double unit only for rescue conditions 6 car metro composition.
- (xi) Maximum specific energy consumption of 70 units/1000GTKM.

3.2. Commercial speed requirements

3.2.1. Performances of the metro train in Dense Crush load AW4 (8 persons standee /m²) under normal conditions shall be compliant to achieve a minimum commercial speeds of 34 km/ph (excluding reverse time in terminal station). Curves and alignment is given in Volume 5 – Alignment Drawings.

3.2.2. The trains shall operate in the following modes:

(a) Normal Mode:

- Accelerate the train using the designed speed-TE characteristic of the rolling stock.
- Coast (minimum 8% by time) to achieve the specified schedule speed.
- Apply blended brakes to achieve rate of deceleration of 1.0 m/s² till the train comes to a stop. Dynamic braking should 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 20 sec at all stations except Howrah, Sealdah and Central Station. For Howrah, Sealdah and Central Station dwell time should be 45 seconds.

(b) All-out Mode:

This will be the same as normal mode excepting that there will be no coasting and Dynamic blended braking will be to achieve a retardation of 1.0m/sec² from top speed till stop.

- (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 mode, the train will get appropriate commands from Signalling system
- 3.2.3. The Tenderer shall submit typical round trips and the speed time of a fully loaded train under the specified voltage and wheel conditions between the various stations of the various lines, and also with the following conditions (Typical line profile, inter-station distances, curves are given in SOD for the calculations):
- (i) Inter-station running time for each line, each way
 - (ii) Actual schedule speed with a dwell time of 20 sec for all stations except Howrah, Sealdah and Central Station. For Howrah, Sealdah and Central Station dwell time should be 45 seconds.
 - (iii) Percentage coasting achieved in terms of time and distance, if any.

3.3. Software package

- 3.3.1. The contractor shall hand over the software package employed by him for the above studies along with the requisite documentation, to the employer.

A suite of Computer-Based Training (CBT) equipment comprising of 6 PC workstations networked to one instructor PC for 24 hours of training including training and assessment modules. The CBT software package will comprise training and assessment modules.

- 3.3.2. The software shall simulate Run Time performance of the train viz inter station timing, schedule speeds with different costing percentage(s) under varied loads, route profiles, headway, inter-station distances, train resistance, train transformation and TE/BE characteristics etc. The software shall not be restrictive to the above and shall be for general application will Engineer selective parameters. Software shall be user friendly and menu driven. List of variable inputs that the software should be designed for shall be designed by the Engineer during detailed design decision of Engineer will be final & binding.
- 3.3.3. 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. Engineer shall be fully trained and made fully conversant by the Contractor for this purpose.

3.4. Passenger Capacity

- 3.4.1. The following data and assumptions shall be used by the Tenderer for all normal and degraded performance requirements and calculations.
- 3.4.2. Detailed capacity per car for the different passenger load AW1, AW2, AW3, AW4 shall be provided by the Tenderer for 6 car metro train composition.
- 3.4.3. The Contractor shall maximise the number of seats in each type of car. For a 6 car metro train composition with the seating and standee capacity expected are as under in Table 3.4:

Table 3.4 – Seating and Standee Capacity

	Full load AW2 (4 person standee /m ²)	Crush load AW3 (6 person standee /m ²)	Dense Crush load AW4 (8 person standee /m ²)
Seats	≥286	≥286	≥286
Standees	≥893	≥1340	≥1782
Total capacity	≥1179	≥1626	≥2068

- 3.4.4. Seats shall be provided for handicapped persons in compliance with India PWD Act: 1995. A minimum of one (1) wheelchair location shall be provided for at each cab end of each driver car. Flip-up type passenger seats or suitable alternative proven design shall also be provided for in same area, in case not used for wheelchair.

3.5. Traction efforts and braking effort performances

- 3.5.1. The Tenderer shall provide typical traction effort and braking effort curves including Train Resistance Formulae "Davis adapted for metro" or as per international standard in normal and first degraded mode (loss of one traction converter) in different typical gradients for the different cases of passenger load (AW0, AW1, AW2, AW3, AW4) for a 6 car metro train composition. This shall be demonstrated during test trial.
- 3.5.2. The Tenderer shall provide the maximum line current versus line voltage curves for traction and electric braking guaranteed performance.
- 3.5.3. Minimum rail wheel adhesion limit will be as required to achieve 1m/s² acceleration but not limited to 18%. Maximum rail wheel adhesion limit of 16% shall be taken into account for At-grade and Super- elevated sections and 18% for tunnel sections.
- 3.5.4. A broken down train can be towed by another train. In the healthy train the driver has the possibility to increase the traction effort by pushing the push out button. After pushing the push out button the traction effort is increased. This may be necessary to tow the defective train under certain circumstances (e.g. slope, load, applied parking brake). The push out mode automatically stops after a defined speed or duration. By pushing the push out button the push out mode can be stopped manually. A healthy train can push/pull a train of same load. The requirements and solutions implemented and proposed by the Contractor will be agreed during the detailed design stage. This mode shall have interface with TMS system.

3.6. Metro train acceleration performances

- 3.6.1. The Tenderer 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 converter or one motor car) in different typical gradients for the different cases of passenger load (AW0,AW1, AW2, AW3, AW4).
- 3.6.2. On dry, tangent and level track at 700 V DC for AW4 car weight. i.e. 8 passengers/m² Train performance calculations shall be based on half worn wheels with maximum rail wheel adhesion.
- 3.6.3. Average accelerations expected on dry, tangent and level track at 700 V DC for AW4 car weight and adhesion limits are.

- | | | |
|------|---|-----------------------------|
| (i) | Average acceleration rate from 0 to 30 km/h | 1 m/s ² ± 5% |
| (ii) | Jerk: | 0.7 m/s ³ ± 0.05 |

3.7. Metro train performances in braking mode

3.7.1. The Tenderer shall provide typical braking curves in normal and first degraded mode (loss of one traction converter or one motor car) in different typical gradients for the different cases of passenger load (AW0, AW1, AW2, AW3, AW4).

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	1.0 m/s ² ± 5%
(ii)	Average deceleration rate from 60 to 10km/h achieved by electric braking only	1.0 m/s ² ± 5%
(iii)	Instantaneous full service deceleration	1.1 m/s ²
(iv)	Expected running adhesion but not limited to	18%
(v)	Maximum jerk (d _y /dt)	0.7 m/s ³ ± 0.05
(vi)	Minimum average emergency deceleration	1.3 m/s ²
(vii)	Maximum equivalent response time taken into account for the calculations is for service and emergency braking shall be compliant with EN 13452-1.	

3.8. Metro train speed performances

3.8.1. The Tenderer shall provide typical speed performances curves in normal and first degraded mode (loss of one traction converter or one motor car) in different typical gradients for the different cases of passenger load (AW0, AW1, AW2, AW3, AW4).

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 speed of 80 km/h shall be achieved in operation in a permanent 4% (compensated) gradient (starting from 0 km/h).
- (iv) All intermediate speed shall be available step less.

3.9. Rescue mode performances

3.9.1. An empty metro train, in normal working condition, without any damage regarding hour rating of traction motor and other equipments, shall be capable to start and to push or haul a failed metro train with the same composition in Dense Crush load AW4, on all Lines including sections of 4% gradient compensated up to the next station.

3.9.2. Thereafter, the healthy train shall, after all the passengers have detrained from the defective train 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 traction effort curves shall be provided and relevant information as wheel rail adhesion ratio, speed etc

3.10. Degraded conditions

- 3.10.1. The Tenderer should also furnish the inter-station running time for a fully loaded train, under the 2 degraded conditions of running, for each Line, each way for:
- (i) The train Dense Crush load AW4 shall be capable of continuous unrestricted daily operation with one motorcar cut out. (25% of motorization rate out)
 - (ii) The train Dense Crush load AW4 shall be capable of clearing the entire route and returning to the maintenance depot with two motor car cut out. (50% of motorization rate out).
- 3.10.2. The continuous thermal rating of the traction system shall meet all the conditions of normal working. During emergency conditions and continuous working, one hour thermal rating should not be exceeded for one round trip.

3.11. Energy Consumption and saving performances

- 3.11.1. The estimated specific energy consumption figures for a round trip and each line shall be submitted by the Tenderer along with the bid. The Tenderer shall also furnish the break-up of the estimated specific energy consumption as follows:
- (i) Total traction energy consumed.
 - (ii) Total auxiliary energy consumed.
 - (iii) Total regenerative energy fed back into the system.
 - (iv) Net energy consumption.
- 3.11.2. During the preliminary design phase, verification of the estimated energy consumption will be carried out. The Contractor shall give all the information and calculations regarding simulation with the computer programme for energy consumption.
- 3.11.3. The Tenderer shall also furnish the following information:
- (i) Quality specification of the regenerated energy including its harmonic analysis.
 - (ii) Efficiency of each auxiliary power consumption point.

3.12. Electro-Magnetic Compatibility performances

- 3.12.1. The Contractor shall submit an Outline Environmental Plan for the Engineer 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.
- 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 analyze 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. 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.
- 3.12.7. The conducted emission test shall be performed under selected fault condition. The conducted emission test shall also satisfy special requirements of the ATO.
- 3.12.8. The complete 6-car metro trains shall be tested to meet the requirements of standard EN 50121-3-1.
- 3.12.9. The Contractor shall carry out joint testing with respective Signalling and Telecommunications Contractors as detailed in Chapter 24 - Interfaces.
- 3.12.10. An electromagnetic compatibility test shall be performed on one vehicle for compliance and for compatibility with KMRCL's signal and communication systems. During these tests, confirmation of appropriate emissions limits as previously developed shall be conducted by monitoring the signal and communication system functions.

3.13. Noise and Vibrations performances

- 3.13.1. 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. Noise and vibrations performances of a 6 car metro train composition shall be the same.
 - (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. The Contractor shall submit an Outline Environmental Plan for the Engineer review including a noise and vibration 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 noise and vibration protection features:
 - (i) Expected total car noise levels, and sub-system noise levels for all equipment and systems.
 - (ii) Expected vibration levels for equipment, system and measurement locations specified herein.
 - (iii) Expected dynamic characteristics of the primary and secondary suspension.
 - (iv) Details of proposed approach to determining noise and vibration of the cars.
 - (v) All codes and standards to be used during the design and verification of the cars.
 - (vi) Plan for noise and vibration design reviews.

- (vii) Details of proposed sub-system testing to be carried out during the design and manufacture of the cars.
 - (viii) Details of proposed metro train 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 Engineer 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 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 (LAeq) measured at a height 1.5 meters from the floor at the centre of the vehicles will be less than 70 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 (LAeq) 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 0 to 80±5kph in free field conditions with all the auxiliary equipment are operated normally, windows and doors closed, the internal equivalent noise level (LAeq) measured at 1.5 meters from the floor will be lower than 77 dBA in the passenger area and 74 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 72dBA (LAeq) during the sliding operation and 78 dBA (LAeq) for the locking/unlocking. This should be measured in free field 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 (LAeq) could show a difference of 6 dBA to 8 dBA at 80 kph between free field and tunnel.
- 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 (LAeq) 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 69 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 (LAeq) measured while a train running in the free field conditions, specified in the ISO 3095 , is passing will not exceed 86 dB(A), at a stabilised speed of 80 km/h ± 5%.
- 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 Engineer.

3.13.9. Vibrations

- (i) Provisions are taken to limit transmission of vibrations produced by onboard equipment to the passengers.
- (ii) Following ISO 2631-1/2 standards, vibration frequencies shall be outside of the maximal sensibility range.
- (iii) Equipment and auxiliaries mounted at any position on the car or bogie 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. See clause 9.10.9. There shall be no hatches in the floor of passenger areas. Floor hatches in the driving console shall be avoided.
- (iv) The Contractor shall submit a fire safety design management plan to the Engineer 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 Engineer

3.14.2. Materials used in the cars shall meet the Flammability, Smoke Emission and Toxicity requirements of the following standards:

- (i) Compliance with NFF 16101 (category A1) and NFF 16102, BS 6853 class 1B, NFPA 130 (except for cables) or DIN 5510 1/2/4/5/6 standard (Preventive fire protection in railway vehicles. Level 2-3 for the vehicle)
- (ii) Flammable material shall not be used or contained. Material emitting poisonous gas during combustion will not be used.

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): 28 000 MJ
- (ii) Below floor level : 28 000 MJ

3.14.4. Fire Extinguisher

- (i) At least one fire extinguisher, complete with a pressure gauge, shall be fitted at one end of each car saloon.
- (ii) 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.
- (iii) 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.

3.15. Life Cycle Cost

- 3.15.1. 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.
- 3.15.2. 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.
- 3.15.3. Design Clearance: The rolling stock contractor shall be responsible for submission of any data for design clearance and certification by Commissioner of Metro Rail Safety (CMRS).

4. VEHICLE DRIVING MODES

4.1. Principle

- 4.1.1. The metro train (6 cars) shall be equipped with ATC system composed by an ATO/ATP/ATS system allowing automatic train driving with a driver in the cab.
- 4.1.2. Supply of the ATO/ATP System shall be responsibility of the Contractor for Signalling and Telecommunications which shall be required to liaise closely with the Rolling Stock contractor in regard to the installation, testing and commissioning of the Signalling and Telecommunications Equipment.

4.2. On-Board Equipment for ATO includes but not limited to-

- 4.2.1. Sensors mounted on bogies receiving track information.
- 4.2.2. Components required for measurement of real train kinematics (spacing, speed, acceleration)
- 4.2.3. An automatic train operation box collecting signals transmitted by the above mentioned subassemblies as well as controls from the driving cab. After this information has been processed, this box sends the commands required to perform the start-up, train stopping or braking and emergency braking functions. These commands are sent to train equipment by means of the corresponding train lines. When the automatic train operation box is inactive it must be galvanic insulated from these train lines.
- 4.2.4. Over-speed monitoring equipment mounted in the automatic train operation box.
- 4.2.5. Where applicable, local equipment in each car to correct train braking as a function of the commands received from a deceleration control device mounted in the automatic train operation box.

4.3. Safety

- 4.3.1. Any faulty operation of the transmitting device or the on-board automatic train operation equipment must cause an action so that train movement safety is never engaged. Any ATO equipment operating fault or train fault likely to involve safety when the automatic train operation system is active should cause immediate stopping of the train by emergency braking and simultaneous opening of the traction supply circuit breakers of all motor cars under command of the ATO/ATP system. The rolling stock Contractor and the ATC Contractor will perform the interface management between the vehicle and the ATO/ATP system.

4.4. ATO Mode

- 4.4.1. The onboard equipment shall provide for Automatic Train Operation (ATO) on both lines. 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. This operation shall include:
 - (i) Automatic operation of trains between stations.
 - (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.

- (iii) Automatic stopping of trains at platforms within a tolerance of $\pm 300\text{mm}$ for 99.5% and $\pm 500\text{mm}$ for 99.98% of station stops.
- (iv) Automatic opening of doors and PSD/PSG opening authorization on the appropriate platform side(s) when the train is berthed at the stopping point within the tolerance.
- (v) Prevent the train from starting if train doors and PSD/PSGs are detected not "closed and locked".
- (vi) Receipt and implementation of control to skip one or more stations & also hold a train in station.

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 station stopping point; however transfer from ATO to ATP mode shall be possible at any time at standstill.

- 4.4.2. 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 if the driving selector switch is in the appropriate position (ATO).

4.5. Metro Train Departure ATO mode

- 4.5.1. Train operation departure is governed by the following conditions:

- (i) Drive selector shall be in ATO driving mode.
- (ii) Starting of departure sequence by the driver (first sound sequence and door closing after time delay).
- (iii) Effective closing and locking of doors (visual and audible information in cab) and PSDs on station.
- (iv) Train safety loop, or other device assuring this function, not interrupted.
- (v) Reception of information authorizing operation delivered by the continuous speed control system.
- (vi) Train effectively stopped (zero speed information acquisition).

- 4.5.2. The function of the train safety loop is to verify in security that all conditions are fulfilled before the departure of the train (verifications of the doors closing, departure push-button not in driving mode ...).

- 4.5.3. The departure order must be maintained by the driver till the light of the indicator "Release Departure Push-button". If the driver interrupts the departure order, emergency braking is automatically implemented by ATO / ATP equipments.

- 4.5.4. This procedure is useful to remedy certain operating incidents (for example, passenger dragged along after door closing). Between stations, the departure order does not have to be maintained for train start-up as the "release departure push-button" indicator comes on as soon as departure is ordered.

4.6. Metro Train running ATO mode

- 4.6.1. In ATO mode, running is governed by permanent reception of operating authorization, supplied by the continuous speed control system from ATC equipment.

- 4.6.2. If this operating information is no longer available, emergency braking is immediately and irreversibly ordered at the same time as traction circuit breaker opening (the latter function need not be a safety function) under command by the ATC.

- 4.6.3. Emergency stopping is obtained under the same conditions when a fault is detected by the continuous speed control system.

4.7. Metro Train stopping ATO mode

- 4.7.1. For train stopping in ATO mode the performance levels required from the device are as follows:

- (i) $\pm 300\text{mm}$ for 99.5% and $\pm 500\text{mm}$ for 99.98% at station stops under ATO mode. This precision implies from the electrical and friction brakes performances in terms of response time, linearity and stability of the friction coefficient that will be defined in the interface management between the rolling stock and ATC contractors. The rolling stock contractor will participate the validation tests with the ATC contractor and will, if necessary, fine tune the vehicle dynamics parameters in order to reach a correct closed-loop control of the vehicle.
- (ii) Stopping up to 10m localization, the driver can select 'Reverse mode and position the train at stopping point.
- (iii) Stopping further shall lead the train to continue its journey till the next station/stopping point when the necessary authorizations are obtained.

- 4.7.2. This stopping accuracy must be obtained under all train loading conditions and taking into account the possible different variations in rolling stock characteristics.

- 4.7.3. Stopping must be gradual and comfortable. When the train stops with accuracy, the train doors and PSDs open automatically. No jolting must be felt by passengers. The stopped train waits at train stations with enough braking force to stop the train safely.

4.8. Door Control

- 4.8.1. 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. Signals interfacing the "designed platform side" will be provided by ATO/ATP equipment to EMU. The rolling stock contract is in charge of processing this information in order to safely ensure doors can not open on the opposite side of the platform.

- 4.8.2. The door control pushbuttons shall be illuminated with distinct colour lights. The details and schematic shall be provided for review of the Engineer.

- 4.8.3. 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 and also near each cab side door.

- 4.8.4. The cab side door control panels shall be located conveniently for operation of the doors 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 metro train.

- 4.8.5. All door control panels in the train operator's cab shall have an identical layout and shall be physically interchangeable.

- 4.8.6. A switch shall be provided, preferably at the back wall of the driving side 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 TMS.

4.9. Door Opening Authorization in degraded operation

- 4.9.1. 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 revenue service.
- 4.9.2. In this case, the opening can be controlled by the train driver by the action on a right opening button or a left opening button placed on the desk.
- 4.9.3. This mode may be also used:
 - (i) On the stabling/de-stabling secondary track.
 - (ii) On the main track without platform (evacuation of passengers in inter station).
 - (iii) At the platform (in case of failure of automatic operation).
- 4.9.4. The opening of the doors is only possible when the speed is Zero.

4.10. Driving Cab indications ATO mode or Automatic

- 4.10.1. Release departure push-button: Extinguishing of this indicator by the automatic train operation box authorizes the driver to stop his action on the departure control push button. When this action effectively stops the indicator remains "OFF".
- 4.10.2. No information from the automatic train operation ground device: This indicator is supplied by the automatic train operation box when it does not receive information from the fixed part, if the driving mode selected is ATO.
- 4.10.3. Track free indicator: This indicator is "ON" if the ATO spacing conditions are satisfied and if the selected driving mode is ATO.
- 4.10.4. On-board ATP status takes the colour orange if the auto-test succeeds but the train is not localized, takes the colour green if the train is localized and takes the colour red as soon as communication fails.
- 4.10.5. Available driving modes indicators take a distinct colour when available according to ATP-ATO equipment status. The contractor shall submit description of driving cab indications and control.

4.11. ATP Manual Mode Driving (ATPMD)

- 4.11.1. The onboard equipment shall provide Automatic Train Protection (ATP). 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.
- 4.11.2. The 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, target distance, and the maximum safe speed.
 - (iii) Identification and audible and visual warning when train is operating at a speed higher than the maximum safe speed. The equipment to provide audible and visible warnings shall be provided by respective Signalling and Telecommunications Contractor.

- (iv) Provision of an audible and visual warning to the train operator, when the system identifies that the train is operating at a speed in excess of the maximum safe speed; recognition of a delay of 3s for the train operator to react, and a service brake application should the train operator fail to reduce the speed below the maximum safe speed in a specified time. In the event of the service braking rate being inadequate, an irrevocable Emergency Brake application shall be made, automatically, by command of the ATC.
- (v) Identifying the platform side of the train with the train berthed at a station. The system shall then enable the train doors and PSDs to be opened on that side.
- (vi) Receipt of a door closed signal indicating that all doors including PSDs are closed and locked before the train may start. Loss of this signal shall cause the ATP system to initiate a brake application.

4.12. Restricted Manual Mode (RM) and Run-On Sight Mode (ROS)

- 4.12.1. In RM mode, principally for use in depot, the maximum train speed shall be controlled by the on-board ATP, to a limit adjustable between 10 km/h and 25 km/h. This mode shall be available only when the on-board ATP equipment is operational. RM mode shall be operational with mode selector in Forward position.
- 4.12.2. In ROS mode of operation, the train operator Runs On Sight. ROS mode shall be selected by a ROS button / key with the mode selector in ATP position. ATP authorises 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 train is localized.

4.13. 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 km/h and 25 km/h. 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.
- (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 TIMS. The SCS shall be provided by RS Contractor. The on-board digital counter shall be provided by the Signalling & Telecommunication Contractor. In this mode the train doors shall only be enabled and controlled manually.

4.14. In Manual washing and coupling mode

The speed is limited to 3 km/h to prevent any damages of the automatic washing machine equipment and for safety reasons.

4.15. In Reverse mode,

The speed is limited to 3km/h for maximum length of 10 meters. The emergency brake shall be triggered by command of the ATC if the vehicle covers 10m in reverse mode.

4.16. Regenerative Braking Authorization

- 4.16.1. Trains are fitted with a recovery braking system. In certain cases, operating this braking must be prohibited, so as to stop powering of a track section where the traction power is cut.

- 4.16.2. Therefore, it is necessary to transmit a signal to the train authorizing the use of recovery braking.
- 4.16.3. This information must be sent in safety mode whether the train is in ATO or ATPMD mode.

4.17. Identification

- 4.17.1. The Signalling and Telecommunications Contractor shall provide an alphanumeric Train Identification Number (Train ID) to the Rolling Stock Contractor in order to identify the destination and the a service identifier. The destination codes shall signify unique routes. The Rolling Stock Contractor shall accordingly use the relevant information such as names of intermediate stations, stopping pattern, station stop door opening side information etc. for operation of on-train systems.
- 4.17.2. 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 Engineer to amend and / or modify the Train ID, subsequently, to suit the operational requirements. The Signalling and Telecommunications, and Rolling Stock Contractors shall provide necessary equipment and means for the same as specified in Chapter 24 - Interfaces; to be defined during the detailed design stage.
- 4.17.3. The Rolling Stock and Signalling and Telecommunications Contractors shall exchange information identifying the effective mode, the active or non-active status of each cab, the door status etc. The inputs shall be categorised as vital and non-vital. The levels and form of these inputs shall be co-ordinated between the two Contractors.
- 4.17.4. The Rolling Stock Contractor shall provide necessary inputs to the Signalling and Telecommunications Contractor identifying the required mode and status of active cab etc. The levels and form of these inputs shall be co-ordinated between the two Contractors.
- 4.17.5. The Rolling Stock Contractor shall log each time the mode is changed using the onboard TMS equipment.
- 4.17.6. In By-pass or Cut-out Mode, an external indication light shall flash or occult.
- 4.17.7. The Signalling and Telecommunications Contractor shall provide the necessary input signals (next station information code, platform side information, triggering signal, 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.
- 4.17.8. All video and audio signals from cab to OCC/BCC thru signalling system.

5. VEHICLE DESIGN AND ARCHITECTURE

5.1. Proven Design

“Proven Design” for Main Equipment means the Contractor satisfy Category 1, Cl. 1.1.6.14 of Volume 2-GCC and the Contractor or Sub-Contractors satisfy the Category 2, Cl. 1.1.6.14 of Volume 2-GCC for Sub-Assemblies.

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.

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 in 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. On the basis of existing solution usually proposed by Manufacturers, it is supposed that the metro train will be composed by 6 cars with the following composition:

DTC + MC + MC + MC + MC + DTC

where:

- (i) DTC: Driving Trailer Car.
- (ii) MC: Motor car.

5.3.5. All DTC and MC shall be totally interchangeable by the same type of car and at the same sequence and without any modification.

5.3.6. As regard the vehicle main dimensions, the following are given as indicatives:

- (i) Total train length a 6 car metro train, over body, is approximately 130 meters.
- (ii) Approximate distance between bogie centres 14700 +/- 250 mm
- (iii) Car max. Width: 2.88 m within the limits of the Kinematic envelops given in SOD.
- (iv) Car floor height shall be >5mm and <50mm above the platform height compatible with the access conditions for disabled people.
- (v) Nominal clear height inside the car: 2.10 m (+0.0, -0.01 m).
- (vi) Car max. height (rail top to roof top) with Air-conditioning units: 3.780 to 3.873 within the limits of the Kinematic envelops given in SOD.

5.3.7. The Tenderer shall furnish static metro train profiles and cars with dimensions and typical cross sections of the vehicles.

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, accelerations...

5.4.3. The axle load not exceeding 16.0 tonnes in Dense Crush load AW4

5.4.4. The gross weight of any type of coach should not exceed 64 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: Empty rake operating weight, ready to run,
- (ii) AW1: Fully seated rake load and one Driver, plus AW0
- (iii) AW2: Normal load rake weight at 4 passengers per m² exclusive of seating and Driver cabs, plus AW1
- (iv) AW3: Crush load car weight at 6 passengers per m², exclusive of seating and Driver cabs, plus AW1
- (v) AW4: Dense Crush load condition at 8 passengers per m², exclusive of seating area and Driver cabs, plus AW1
- (vi) AW5: Extra Dense Crush Load conditions at 10 passengers per m², exclusive of seating area and Driver cabs, plus AW1.

5.4.6. The Tenderer shall provide the weight distribution for 6 car Metro Train Composition, in Table 6.4, as defined in IEC 61133:

Table 5.4 - 6 car metro train composition:

Kg	DTC	MC	MC	MC	MC	DTC	Train
Tare AW0							
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.
- 5.4.8. Difference in weight measured from bogie pivot centre to bogie pivot centre shall be in accordance with IEC 61133.
- 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 Engineer and the Contractor.

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. If an off-the shelf proven design is used for the car body structure, and the contractor can prove its adequacy in meeting the requirements of these specifications. KMRCL will consider accepting such design as adequately complying with the requirements of the specification. Structural elements or structural systems of the overall car body structure will be considered for approval on a case-by-case basis.
- 6.1.3. The contractor shall demonstrate in the design of the body structure the philosophy with respect to the following factors;
 - (i) Ease of repair
 - (ii) Thermal and acoustic insulation
 - (iii) Aerodynamics; for benefits of energy efficiency
 - (iv) Sealing against the ingress of water and dirt.
 - (v) Strength of materials and light weight for benefits of reduced power consumption and overall energy efficiency
 - (vi) Use of high recycled material content and low toxicity materials
 - (vii) Corrosion resistance and ease of external washing and cleaning.
 - (viii) Outside contour of the coach shall be such that entire surface of sidewalls, roof and skirt can be cleaned spotlessly by automatic coach washing plant.
 - (ix) The vehicle structure materials shall be stainless steel conforming to ASTM GR 301L (for external) or equivalent international standard.
 - (x) Stainless steel ASTM GR304L or equivalent international standard
- 6.1.4. 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 elements.
 - (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 Tenderer including choices of colours, front face etc.
- 6.2.4. The Tenderer 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.
- 6.2.5. The KMRCL 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.
- 6.2.6. The exterior style of the vehicle shall be subject to the Engineer'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 vehicle side wall, roof and under frame 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 or with mild 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 Tenderer 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 Kolkata 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.

6.4. Vehicle body construction

- 6.4.1. Welded construction is preferred to assemble the different elements of the vehicle body shell (side walls, front end car, cab structure, roof, under frame). Alternative service proven construction methods can be proposed by the Tenderer with justifications.
- 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.

- 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 Kolkata 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.

6.5. 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 2 mm. Any fluting, if offered, shall be shown to have advantages and shall be subject to review by the Engineer. 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 demounted 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 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 61133 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 captured and shall not infringe the Kinematic Envelope. 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 equipment boxes and covers shall be of stainless steel or anodized/painted aluminium or corrosion resistant steel (corten).
- 6.8.6. Similarly, pneumatic and brake equipment shall be provided in a brake panel for easy access from the side.

- 6.8.7. 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.

6.9. Roof structure and equipment mounting

- 6.9.1. The roof structure shall be designed to support the VAC 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.
- 6.9.2. The stainless steel roof 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 revenue service.
- 6.9.3. The VAC Equipment package VAC units shall be mounted at each end of the car roof, housed in suitable water tight 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. Alternate mounting proven design may be offered for KMRC approval.
- 6.9.4. The Cab VAC unit shall be mounted on each end of DTC car adjacent to saloon VAC unit. The supply air filter shall be accessible from the cab.
- 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 1200kN applied at the end of the car body at the centreline of the coupler, and shall be compatible in respect of crashworthiness as per EN 12663 PIII
- 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 shall be taken as one per seat and standing as 8 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 fully loaded condition shall be such that the structure shall not sag below the horizontal plane throughout the vehicle's 35 years life. However, for shells fabricated with modular elements, the coach shall be built with a suitable camber under tare condition.
- 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. 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. Detailed calculations shall be submitted by the contractor during the detailed design phase for the expected deflection so as to confirm that the deflection is within permissible limits under all conditions throughout the life of the coach. Tests for stresses etc. as well as other tests as per relevant standard for the method of construction deployed shall be carried out under specified loads.
- 6.10.9. 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.
- 6.10.10. Assessment of fatigue load shall be in compliance with EN 12663 or equivalent. The car structure shall withstand the following loads such that the sum of the individual partial damages for all load cases does not exceed unity.

6.11. Crashworthiness

- 6.11.1. The metro train structure shall be designed according to European standard EN 12663 category PIII and crash design defined in GM/RT 2100 or EN15227 scenario C(ii).
- 6.11.2. The cab of each car shall meet crashworthiness requirement as per specification Rail Group Standard GM/RT 2100 or the end structures shall have crashworthiness features as per EN15227 scenario C(ii).
- 6.11.3. The car body design shall be suitable for 6 car metro train compositions 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. The car structure and its supplemental energy absorption devices shall be designed to minimize accelerations transmitted to passengers, by absorbing collision energy, whilst not permitting one vehicle to over-ride another, nor to telescope one into another. A suitable proven energy absorption feature with associated collapse features shall be incorporated into the coupler draft gear.

6.11.5. The Tenderer shall submit predicted values for the following in respect of fully loaded cars. The Contractor shall submit a detailed technical proposal and analysis to specify the following in respect of the fully loaded vehicle:

- (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 brushed finish stainless steel left un-painted. The doors shall also to be made with stainless steel skin having same finish as the car body. In case the CAB exterior is other than stainless steel than painting shall be required following agreed specifications with the Engineer and the Employer. (Note: Painting of the Stainless Steel doors will not be necessary).

6.12.2. Under frame member made of high tensile steel only, shall be painted with a half gloss black paint system which has been proven in metro rail transit 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 lifting 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 track-side.

6.14. Automatic Couplers and Draft-gear

- 6.14.1. Each DTC shall be provided with automatic couplers at the front end of the train without electric head.
- 6.14.2. The split of the 6 car fixed metro train composition into 2 parts composed by 3 cars shall be possible for maintenance purpose (lifting). The disconnection of the cars shall be easy and quick. Each part of the train will be moved only by shunting.
- 6.14.3. The automatic coupler shall, in conjunction with the draft-gear automatically effect mechanical, pneumatic coupling. It shall also permit separation of units either manually from the track side or remotely from the cab.
- 6.14.4. Height of the coupler shall be in the range of 740 mm to 815 mm in the same alignment of the under frame structure.
- 6.14.5. The automatic coupler and draft-gear shall 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.
- 6.14.6. 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, auto-couplers shall be arranged so that pneumatic connections shall be automatically protected from the ingress of water and extraneous foreign matter.
- 6.14.8. Auto—couplers shall also incorporate provision for the selective isolation of air connections whilst remaining mechanically coupled. The electromagnetic valves used for actuation of coupling / uncoupling action shall have IP protection of 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 couplers shall be identical.

6.15. Electrical Coupler:

Semi-permanent jumper or jumper cable shall be fitted at the ends or all cars, including both ends of metro trains, with a separate coupler for power, auxiliary power and control circuits. Electrical connections between cars in a metro trains as well as between two metro trains will be carried out manually.

- 6.15.1. The DTC intermediate ends and trailer end cars shall be equipped with Semi permanent couplers at each end to ensure a permanent connection of cars which in traffic form a metro train and therefore do not need to be separated during normal operation activities, unless in an emergency situation or in the workshop.
- 6.15.2. 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.
- 6.15.3. 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.

- 6.15.4. Electrical end connections shall be semi-permanent by means of jumpers or jumping cables. When uncoupled, these electrical connections shall be automatically protected to IP65. 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 shall be done by means of flexible hoses or through the semi-permanent coupler.
- 6.15.5. 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.
- 6.15.6. The weakest portion for parting shall be at the junction of the two coupler heads, interrupting electrical jumper cables and pneumatic connections, and thus causing an instant emergency brake application.
- 6.15.7. To couple and to uncouple cars including gangways in workshop should be simple and efficient without any mechanical tool and maximum two persons will do the process of couple and uncouple cars including gangways. The above complete process should not take more than 30mins.

7. TRAIN DRIVER CAB

7.1. Train Driver Cab layout

- 7.1.1. 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.
- 7.1.2. The main constraints for the design of the cabs shall be the following ergonomics and comfort for the driver and possibly one other person:
- (i) Visibility.
 - (ii) interfaces with passengers.
 - (iii) interfaces with the operational staff.
 - (iv) fast exit of the driver in case of emergency.
- 7.1.3. The driver shall be seated in an optimal position to operate comfortably during a regular working day. Relevant standard is UIC 564-2.
- 7.1.4. The dimensions of the "standard" driver are characterised by the anthropometric models of male and female persons for 5% to 95% of the Indian population. These dimensions shall be used to define the dimensions of the driving cab, the driving desk, the windscreen, seats. (Refer to standards NF X 35 002, UIC 651).
- 7.1.5. The driving commands and on driving desk shall be organized as follows:
- (i) The Train drivers control desk will be located on the centre of the cab front and will be designed to optimise ATO working, with the Operator seated.
 - (ii) Ceiling panel will be used for location of lighting, air conditioning outlets, and loudspeaker for PA.
 - (iii) 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.
 - (iv) Secondary zone including the commands and information sporadically used, hand operated from the driver in seating position.
 - (v) 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.
 - (vi) All buttons, switches and indicators shall have description tags in English language.
- 7.1.6. 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
- 7.1.7. An opening window shall be located on both sides of the cab. They shall be adjustable via a device with a minimum opening adjustment with one position (half of the window)
- 7.1.8. The console of the operator's shall include, but not limited the following controls; Design and layout of cab console shall be proposed by contractor for approval by KMRCL.
- ATO start controls(one either side of the cab)
 - Passenger door open/close push buttons (one set either of the cab); train doors & PSDs indications.

- Two emergency brake stop push buttons(one either side of the cab)
 - Master control switch ,mode control switch
 - Adjustable ventilation, which can be directed on to operator's upper body
 - Warning horn controls(one either side of the cab)
 - Traction brake controller
 - Other train system alarms and indicators
 - Auxiliary power supply controls
 - Cab lighting
 - Air conditioning controls
 - Communication and radio controls
 - Automatic voice announcement system controls
 - Couple/uncouple controls
 - Over ride switches
 - Windshield wiper controls
 - Miniature circuit breakers(MCB,s)
 - Maintenance and operating Driver screens
 - Video screen for display of door closed condition, emergency, and on-board camera visuals, alarms & status given by train computer etc.
- 7.1.9. In addition adequate displays, such as pneumatic pressure gauges, speedometer, voltmeter, operator display's unit etc. And appropriate fault indicators shall be included in the operator's cab.
- 7.1.10. Sufficient Hard-Wired fault indicators shall be provided to facilitate indication and appropriate recovery action.
- 7.2. Train Driver's Seat**
- 7.2.1. A driver's seat shall be provided in each cab. The seat shall be a folding type, supported from the bulkhead wall behind the driver or from the cab floor. The seat shall have a metal frame, low density foam cushioning, and be upholstered.
- 7.2.2. The seat shall be of the highest quality, heavy duty, long life, trouble-free and maintenance free.
- 7.2.3. The design of the seat shall permit the following adjustments :
- (i) Longitudinally, over a distance of minimum 100 mm.
 - (ii) Vertical Adjustment shall be 100 mm minimum.
 - (iii) Adjustments shall have positive position restraints.
 - (iv) Upward movement to fold the seat against the rear wall.
- 7.2.4. In all positions, the seat structure, support, and attachments shall withstand, without permanent deformation or disengagement, the following loads :
- (i) A vertical, uniformly distributed load of 1 470 N applied at the forward edge of the seat.
 - (ii) A horizontal, uniformly distributed load of 900 N applied to the forward edge of the seat along every direction in the horizontal (but one direction at a time).

- (iii) A horizontal uniformly distributed load of 2 205 N applied normal to the upper edge of the seat back.
- (iv) Alternative strength requirements based on internationally recognized standards are also acceptable.

7.3. Windscreen

- 7.3.1. 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 and UIC 566/EN 12663. The inner and outer surfaces of the windscreens shall be scratch resistant.
- 7.3.2. A 180° 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 tender. The design will allow clear external sight lines such that all drivers can meet the vision requirements.
- 7.3.3. The front side of the metro train shall not have intermediate jamb.
- 7.3.4. The external facing surface of the windscreen shall be resistant to abrasion by the windscreen wipers or cleaning equipment, e.g. wash plant.
- 7.3.5. All windscreen surfaces shall resist attack by atmospheric pollution and cleaning solvents and shall be resistant to cracking and chipping.
- 7.3.6. All interfaces between the windscreen and the metro train body shall be sealed to prevent the ingress of draughts, water and foreign matter.
- 7.3.7. 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.
- 7.3.8. The desk instrument lighting shall not dazzle the driver or produce reflection on the desk or on the windscreen.
- 7.3.9. The passenger area shall not cause visual inconvenience to the driver.
- 7.3.10. The windscreen and windows shall keep the visual aspect of the signalling and panels, that means the colour, shape and inscriptions integrity.

7.4. Sun Protection Visors

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

7.5. Cab Floor

- 7.5.1. 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.

7.6. Facilities

- 7.6.1. The following facilities will be provided in each driver cab:

- (i) Handset
- (ii) Footrest adjustable in height above floor level.
- (iii) Document Holder located close to the Train driver's seat.
- (iv) Clipboard Holder located close to the Train driver's seat.
- (v) Cup holder shall be provided.
- (vi) An emergency equipment cupboard shall be provided at the cab front, beneath the non-driving side windscreen, to house the portable bridging device, First Aid box, key multiplier and safety equipment including fire extinguishers, safety torch etc...
- (vii) Reading light above the Train driver's Console.

7.7. Saloon-to-Cab Door

- 7.7.1. Suitable designed door between the saloon and the cab to permit access to the passenger saloon shall be provided. The clear door opening shall be of appropriate width. In normal operation, opening the door from the saloon shall require the use of a special key.
- 7.7.2. The door shall not get jammed due to pressure exerted by passengers or distorted due to minor mishaps.
- 7.7.3. The finish of the door shall harmonize with that of the cab and the passenger saloon.
- 7.7.4. Opening the door from the cab side shall not require any key.
- 7.7.5. The locking mechanism shall only use heavy duty locks, levers and actuating arms with proven record in metro applications.
- 7.7.6. The door shall not be possible to be bolted, wedged or otherwise locked, from either side of the door to prevent opening.
- 7.7.7. A visual and audible alarm shall be activated in the event that the saloon-to-cab door is opened in the unoccupied cab.

7.8. Cab Side Doors

- 7.8.1. There shall be a cab side door on both sides of the cab. The doors shall be manually operated doors. It shall be possible to lock, unlock, open and close the cab side doors from track level.
- 7.8.2. The cab side doors shall be lockable from inside without the use of a key, or from outside using a swipe card/ Key. The cab side door shall be positively retained in the closed position under all operating conditions.
- 7.8.3. The assembly of the cab side door, including the mounting tracks, door retaining mechanism, cushioning bumper, stopper, etc., shall be of a robust design that can withstand rough handling including slam-open and slam-close by operation and maintenance personnel.
- 7.8.4. The doors shall be sealed against draughts, noise and water.
- 7.8.5. The door shall be positioned such that access to the cab is free from obstructions. The clear door opening width shall be 650mm \pm 50mm.
- 7.8.6. Heavy duty locks with proven record in metro applications shall only be used. The open/close and lock/unlock status of the cab side doors shall be monitored using reliable & suitable sensors. The train control logic shall be designed so that the train shall not be able to move unless all the cab side doors are proved, closed and locked. The open/close and

lock/unlock status of the cab side doors shall also be used to provide the status to TMS and also to actuate the cab lights.

7.9. Lighting System

7.9.1. Head and tail-lights

- (i) Head and tail-lights in watertight sealed, vermin-and-insect proof integrated housings placed at approximately 3m centres and 1.5m above top of rail datum, beneath the windscreens. The units shall be "handed", left and right, so that the taillights are outboard of the headlights.
- (ii) Two white sealed beam lamps (headlights) shall be mounted at the front of the driving end of the DT Car, to provide even illumination of the tunnel bore, track bed and track side signal posts. It shall be possible to read the number plates provided on the way side and other boards. Each sealed beam lamp will be equipped by a two-filaments bulb of 150 W in order to get a main (high) beam and a dipped (low) beam.
- (iii) Each beam (headlight) shall be separately and mechanically adjustable both horizontally and vertically. The On/Off and Beam controls shall be switched from the train driver's console.
- (iv) Two red tail lights shall be provided which will be lit in the non-active cab. The taillights shall be LED type.
- (v) The taillights shall be clearly visible at a distance of 300m in daylight conditions. The minimum viewing angle shall be 45° from the centre line of the beam. The two taillights shall be placed on the same horizontal plan and symmetrically positioned either side of the car. Tail light cannot be white it should only be red, while the front light will be white, Red and white should not operate simultaneously.
- (vi) When a driving cab is activated by a Train driver, in the occupied cab the head lights shall be lit and the tail lights shall be switched off, while in the non-active cab the head lights shall be switched off and tail lights shall be lit.
- (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 in less than 1 minute from track level.
- (xi) Access for cleaning and the replacement and adjustment shall be from the car exterior.
- (xii) Two white markers shall also be provided at each end of the car.

7.9.2. Flasher Light

- (i) In emergency in order to attract the attention of the train driver of the following train or a train approaching from the opposite direction, 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.

7.9.3. 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 shall cause the tail lights at the rear of the failed train to flash on and off, indicating to the train driver of the rescuing train that he may proceed to affect coupling.

7.9.4. Closed Circuit Television(CCTV) and Video Rear-view System

- (i) CCTV monitors for interior saloon and exterior platform video surveillance including the control electronics and associated power supply shall be installed in the operator's cab
- (ii) For the exterior surveillance cameras, observation of passengers on the platform shall stop after 50 meters travelled by train (according to speedometer), or as it is triggered by signalling interface.
- (iii) The images of on-board CCTVs shall be transmitted to OCC, BCC (Back-up OCC) and station control centre via signaling equipment.

7.9.5. Vehicle Operator's Display

- (i) The Operator's Display Unit (ODU) shall be located such that it is suitable for continual reference and actuation, without discomfort or fatigue.
- (ii) The ODU shall be clearly visible to the Operator in both the sitting and standing positions, from bright sunshine to darkness, without developing a brightness level that interfaces with the operator's vision.
- (iii) The ODU shall provide primary screen display for interface with Operator and maintenance technicians. The contactor shall submit the proposal to KMRCL for approval. Single VDO touch screen with selectable modes is clarified.
- (iv) Each screen, except the operating screen, may employ one or more levels of subsidiary screens which present more extensive information and control choices.
- (v) Subsidiary screens shall be arranged hierarchically, with a consistent interface to facilitate moving up and down the hierarchy. Information shall be divided among screens and presented in a logical and orderly manner. Information shall be displayed textually and/or graphically, depending on the clearest and most efficient method.
- (vi) The ODU information shall be capable to display the time (24-hour system), the date(dd/mm/yy) and the train configuration (to include cars numbers)
- (vii) The operating screen shall present information and control functions useful to the Operator when the train is in motion or during a normal station stop.
- (viii) Items of urgency shall flash and generate audible alarms to bring attention to the Operator.
- (ix) Flashing and audible alarms shall be cancelled by use of a Fault Acknowledge control.
- (x) Control screens shall present information and control functions relevant to set-up, configuration or preparation of the train for service.
- (xi) Set-up function shall be limited to monitoring and diagnostics, signs and announcements.
- (xii) The purpose of the Faults screen is to provide pertinent information regarding conditions which affect the immediate operation of the train.
- (xiii) Console Annunciation: Each operator's cab shall be equipped with a console annunciation to perform all the functions described for in Chapter Communications.

7.9.6. Cab Illumination

- (i) The cab shall be provided with 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.

Separate lighting of the train driver'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.

8. PASSENGER SALOON DOORS

8.1. Number of doors and size

- 8.1.1. Optimal body side door arrangement and number shall be proposed in order to obtain a short stopping dwell times. Each car shall have necessary sets of electrically powered bi-parting, exterior sliding doors on each body side. It is expected to have 4 double leaves doors on each side of each car conforming to EN14752. The minimum door width shall be 1400mm. The free passing through height of the open doors shall be 1900 mm minimum.
- 8.1.2. A maximum time of 45 seconds for dwell time (including opening and closing time) is required. The Tender 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 over the length of each individual car.
- 8.1.4. During door operation at the station, the door leaf should not strike with the PSD/PSG at any load condition. There should be sufficient safe clearance between PSD/PSG and door leaf movement at the station.

8.2. Door leaves

- 8.2.1. Exterior doors shall be provided to the passengers and its operation should ensure the complete safety against any passenger load condition in Kolkata.
- 8.2.2. All exterior 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. The two door panels at each passenger doorway shall be synchronously controlled and shall provide a door clear opening width of equal spacing of not less than 1400 mm. Since platform screen doors (PSD/PSG) will be used at the stations, the location and size of the door panel are important for PSD/PSG equipment supplier.
- 8.2.5. The contractor is advised that platform screen doors (PSD) will be installed on all platforms under a separate contract. The Contractor shall coordinate with the KMRCL to provide the necessary interface information data for the separate contract including, ATP/ATO signals to coordination the opening and closing of PSD/PSGs, station dwell times, door opening and closing announcements, and all else necessary for the proper design, interface and operation of PSD/PSGs.
- 8.2.6. 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.
- 8.2.7. 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.

- 8.2.8. 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.
- 8.2.9. 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.
- 8.2.10. No single defect or failure of any part of any door system shall produce a situation capable of causing injury to any door user.
- 8.2.11. 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.
- 8.2.12. The materials used for the door track rollers and seals shall take into account of hygroscopic effects in high humidity tropical environments.
- 8.2.13. 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. 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 and to vandalism.
 - (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.
- 8.2.14. The Tenderer shall indicate the amount of time required to replace a door leaf on the car, adjust it, and test it.

8.3. Door windows

- 8.3.1. Please refer to chapter 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 leaves with respect to the door centre line.

- 8.4.2. A belt driven type for door leaves is not acceptable.
- 8.4.3. Doors shall be electrically operated from 110V d.c. supply through train line. The door operating mechanism shall be of a proven design in service.
- 8.4.4. The door system shall continue to operate correctly with the car battery voltage supply range between 110V d.c. +25% -30%.
- 8.4.5. 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.

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 closing force of the passenger doors panel shall be fully adjustable between 100 N and 150 N for each door leaf which shall remain applied whilst the passenger doors are closed. The end of the passenger door opening and closing strokes shall be damped.
- 8.5.3. Opening and closing time of the passenger doors shall be adjustable in the range 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. 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, localised door status indicator light within the saloon shall also be provided for each saloon doors.
- 8.5.9. 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.

8.6. 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 TMS.
- 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) authorise 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.
- Detection of small objects, hands, clothes shall be detected by sensitive edge door devices. Size of the obstacle and detection shall be the defined and proposed by the Contractor according to EN 14752 or more restrictive relevant EN standard.
- 8.6.6. If a passenger door whilst closing should be obstructed by an object, then the door movement shall pause to enable removal of the obstacle, then another attempt to re-close will follow. The passenger door shall attempt to re-close 3 times, which shall be adjustable. After each attempt a partial 50 mm reopening shall be carried out before next attempt.
- 8.6.7. In the event that the passenger door fails to close following the three attempts, further door movement shall cease on the offending passenger door and door will go to and 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.
- 8.6.8. 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 120N.
- 8.6.9. Door closed and obstruction sensing information shall be sent from each vehicle in the train to Central Control via the ATO system.
- 8.6.10. The door system shall continue to operate correctly within the car battery voltage supply in the specified range.
- 8.6.11. 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.

8.7. 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.

- 8.7.2. 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. The keyhole location shall be subject to review by the Engineer.
- 8.7.3. When the isolation is activated, the door shall be mechanically locked in the closed position. Manually isolated doors shall be indicated on the train driver's cab visual display unit (VDU).
- 8.7.4. The door leaves will need to be provided with the appropriate means of applying a locking device. Full details of the Tenderer's proposal shall be provided.
- 8.7.5. The door closed interlock described in this Section shall provide a signal in the cab for door open/closed indicator.
- 8.7.6. An exterior door open LED indicator shall be provided, visible from each end of the Vehicle.
- 8.7.7. NOT USED
- 8.7.8. Door open/closed status shall be communicated to the Operator through the Diagnostic Monitoring System (DMS) and shall identify malfunctioning doors individually on the VOD.
- 8.7.9. Doors Out of Service Indicators shall be provided on the vehicle interior and exterior that denote that the door panel(s) of a cut-out door operator is (are) out of service and shall be integrated with the vehicle's aesthetic styling. The type, style, and location of these indicators shall be submitted for KMRCL approval
- 8.7.10. A visual indication of the doors status, by means of the "Door Close" illuminated pushbuttons, shall be provided to the operator. The indicators shall be available at all times and shall be controlled by means of a monitoring circuit that illuminates the lamps when all the following conditions are detected:
- all the passenger doors are closed and mechanically latched;
 - both the non-controlling cab doors are closed;
 - None of the passenger door emergency release devices are activated.

8.8. Passengers Alarm and Emergency Systems

The contractor shall submit the proven design of passengers alarm and emergency systems to KMRCL for approval

- 8.8.1. Passenger emergency door shall be fitted with a passenger alarm.
- 8.8.2. An indication (Flasher Light) shall also be provided on the exterior of each side of each car to indicate that a passenger alarm has been activated in that car. Flasher Light when lit and flashing shall be able to attract attention at a distance of 300m under clear sunny daylight.
- 8.8.3. Activation of any passenger alarm within a train shall cause a visual and audio indication in the cab.
- 8.8.4. In the event that a passenger alarm is activated when the train is out of the station zone, no prevention of train movement shall be implemented
- 8.8.5. Following an initial activation of a passenger alarm unit or emergency an audible tone shall be broadcast in the cab

- 8.8.6. Once the operator has acknowledged the call, he/she shall be capable of initiating a communication link with the activated alarm unit
- 8.8.7. A Hard-Wired passenger alarm loop circuit shall be provided to monitor the status of each passenger alarm unit
- 8.8.8. The circuit shall ensure continuity throughout all non-operated alarms, and the loss of continuity, due to an operated alarm, or failure of the circuit shall inhibit motoring and apply a full service brake once the Train has been proved to be stationary in the station zone
- 8.8.9. Further train movement shall be inhibited until the activated alarm(s) has been reset
- 8.8.10. In the event of a failure that prevents either the passenger alarm unit from being reset or a fault of the monitoring circuit, then a sealed isolating switch (located in the driving cab) shall be provided to enable the train to move.
- 8.8.11. The isolating switch shall override the passenger alarm monitoring circuit, as far as the controlling cab is concerned
- 8.8.12. Activation of the isolating switch shall enable the service brakes to be released and traction power to be taken, under abnormal operating conditions
- 8.8.13. Each passenger doorway shall be fitted with an internally mounted manual emergency egress device. One (1) emergency door on each side, two (2) per car shall be fitted
- 8.8.14. The emergency egress device shall be provided with restricted access to passengers by means of a suitable clear breakable sealed cover, which shall protect the device when not in use
- 8.8.15. The cover shall be designed to allow for easy but deliberate breakage. The material, when broken, shall not leave any sharp or jagged edges. "The emergency egress device could also be placed behind a properly marked sliding hatch. The proposal shall be a proven design for similar metro system.
- 8.8.16. A means shall be provided to enable the operator to activate the emergency egress device without breaking the cover, but by using the door access key.
- 8.8.17. When the device is in the 'normal' position the passenger door shall respond normally to all control commands specified.
- 8.8.18. Moving the device to the 'emergency release' position shall mechanically un-latch the associated passenger doorway and enable the door leafs to be manually opened.
- 8.8.19. The opening of the passenger doors shall then be possible by the effort of one person manually opening the passenger doors, once the train is proved to be stationary, and the brakes applied.
- 8.8.20. Once the device has been activated to the 'emergency release' position, the device shall be mechanically latched in that position, and shall require the use of the reset key to reset back to the 'normal' position.
- 8.8.21. When the emergency egress device is in the 'emergency release' position, the passenger alarm system shall be activated, as referred to in above clause.

- 8.8.22. In the event that the passenger doorway has been opened by activating the emergency egress device, the door leafs shall be capable of both being manually set to 'close and latch' and being closed by the operation of the close door control in the cab.
- 8.8.23. One passenger doorway on each side of the car shall be capable of being opened manually, without the assistance of power, using an externally mounted non-lockable bi-stable manual emergency door release device to release the mechanical door latch.
- 8.8.24. The emergency passenger door release device shall operate in two positions, 'normal' and 'emergency release'.
- 8.8.25. The emergency passenger door release device shall be capable of operation from both the track and station platform levels.
- 8.8.26. When the emergency passenger door release device is in the normal position the passenger door shall respond normally to all control commands.
- 8.8.27. Moving the emergency passenger door release device to the emergency release position shall mechanically un-latch the associated passenger doorway and enable the door leafs to be manually opened.
- 8.8.28. The opening of the door leafs shall be possible manually by the effort of one person.
- 8.8.29. The manual emergency release device (spring loaded) shall be provided. A suitable cover must be provided to ensure security of tampering and accidental application and must provide for visibility and water tightness. This emergency device shall require a special key so that only authorized personnel can reset the same. Manual emergency release device shall be unobtrusive, flushed with, or recessed into, the car side, but readily available in an emergency. Functionally, once the emergency passenger door release device has been activated and the door leafs are open, the emergency passenger door release device shall revert to the normal position and reset by a special key.
- 8.8.30. In the event that a passenger doorway has been opened by activating an emergency passenger door release device, the door leafs shall be capable of being set to 'close and latch' after reset by the special key

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 Engineer
- 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.
- 8.10.5. Irrespective of the operating mode, the train shall not be able to move unless all the saloon doors and cab side 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 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 shall be recorded by the Train Management System TMS.
- 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 Engineer.

8.11. Interfaces

- 8.11.1. With TMS: the door controller unit shall have communication link with TMS. TMS shall also be interfaced with the related circuits and interlocks so that all the doors related status and commands are logged. With ATP/ATO. See TS Clause 24.7 for full details of the division of responsibility between the Contractor and Signalling Contractors.
- 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:
 - (i) 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.
 - (ii) A door close announcement followed by a chime shall be triggered each time the "Door Close Announcement" button is pressed. The door close chime shall continue to play till the Doors achieve locked position. 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.
 - (iii) While chime is played over the PA system, any existing auto announcement shall be aborted.

8.12. Emergency Conditions:

- (i) Flashing light on outside of all cars must be installed which indicate the car at emergency. These flasher lights should be mounted on end of each car body side near emergency door. Layout for the proposed facility should be submitted for KMRCLApproval.

9. SALOON INTERIOR

9.1. General Considerations

- 9.1.1. The Tenderer 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 Engineer during the preliminary design phase.
- 9.1.2. The metro train layout is defined by the distribution of seats, supports and handles in the passengers compartments. It shall be designed in order to fit with local transport capacity requirements and comfort needs.
- 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) large open space for standing passengers next to the saloon doors,
 - (iii) maintaining a minimum free passage in the area accessible to the passenger with wheel chairs (relevant standard UIC 565-3),
 - (iv) ensuring good visibility of all obstacles inside the metro train under any light condition,
 - (v) ensuring any passenger holding points for at least one hand under any load condition (columns, handles...).
- 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 » passenger are characterised by the anthropometric models of the male and female of the local population.
- 9.1.9. Design of the metro train shall be suitable for passengers from the size of children of 1 meter height to the 95th percentile of male population. Average weight of each passenger is estimated to 65 kg.

9.2. Habitability

- 9.2.1. A height of 2.100 (+0.0 / -0.01) m 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.

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.
- 9.3.2. The body side and roof outer skin shall have a suitable thickness of approved acoustic insulating material bonded to their interior surfaces.
- 9.3.3. The design of interior fittings shall be safe under all conditions of passenger impact, during emergency braking and buffing under fully loaded condition.
- 9.3.4. All non-metallic materials shall satisfy the requirements of flammability, toxicity and smoke emission limitations.
- 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.
- 9.3.6. All internal panel surfaces shall be smooth finished with modern low flammability, low smoke emission and low toxicity material. All internal panels shall be resistant to graffiti, scuffing, vandalism and cleaning agents. 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.
- 9.3.7. All linings should be of modular design, easily and rapidly removed and replaced independently by trained personnel, but difficult to dismantle by general passengers.
- 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 lining panels, kick strips, seat shell, etc. shall be minimized. The effects of thermal expansion shall be taken into account and all unsealed gaps shall not exceed 2 mm in depth wherever feasible. 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.
- 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.

9.4. Seats

- 9.4.1. Longitudinal banks of seats 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 comfort, have a good 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 contractor shall submit interior seating conceptual layout that the best trade off between seating capacity, interior standing and circulation space. Effort shall be made to ensure maximum passenger capacity of not less than 2068 (seating & standing) under AW4 condition.
- 9.4.4. The seating arrangement with the size, colour, profile and shape of the individual seats shall be ergonomically designed.
- 9.4.5. The seats shall be formed of metal stainless steel or FRP on metal supports.
- 9.4.6. The seats shall provide some resistance to passenger movement longitudinally along the vehicle during acceleration and braking.
- 9.4.7. Seats shall not be upholstered and shall not have sharp edges or protrusions that could cause injury to passengers or staff.
- 9.4.8. 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.
- 9.4.9. 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.
- 9.4.10. 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 Tenderer for the approval of the Engineer.
- 9.4.11. Seats shall meet the requirements of UIC 564-2 or equivalent international standard.
- 9.4.12. Minimum of 2 rows of seating /Metro Car shall be designated with signage for ladies only.

9.5. Passenger Access

- 9.5.1. It shall incorporate wide double leaf automatic doors along each side, longitudinal seating, enclosed by stand-back areas and draught screens, grab-poles and rails, fluorescent lighting, air conditioning outlet grilles, passenger information displays, public address loud speakers, and passenger alarm devices to permit passengers to make the train driver aware of problems. Performances and requirements of the doors are defined in the chapter "body side doors".
- 9.5.2. The metro train floor height of the platform access shall allow passenger access with platforms described in the operation environment chapter and structural gauge.
- 9.5.3. 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) Nominal 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.
- (iii) At saloon doors adjacent to wheel chair users parking area, the contractor is to provide either Gap bridge/Ramp/Sliding Steps.

9.5.4. Specific information shall be provided by the Tenderer regarding these requirements.

9.6. Stanchions and Handholds

- 9.6.1. 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/m² loading (AW4) 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.
- 9.6.2. The stanchions and handholds shall suffer no permanent deformation when subject to loading conditions arising in service, in accordance with UIC 566/EN 12663.
- 9.6.3. 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.

9.7. Disabled People

- 9.7.1. A dedicated space shall be provided in the Driving Trailer car, near the first door of the DT 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. Seats shall be designated with signage for elders & handicapped persons.

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) an air gap permanently sealed against ingress of moisture should be provided between inner and outer glass.
- 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. Body side and door glazing shall be capable of rejecting 50% to 70% solar energy with visible light transmission of 50% to 55%.
- 9.8.12. Deflection at window and door openings under a compressive load of 1200KN and tensile load (UIC 566/EN 12663) shall not damage the window or door and also the windows and doors shall operate smoothly in these service .
- 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.

9.10. 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 aluminium or stainless steel honey-comb boards with cork, rubber cushion, glass wool insulation and floor covering to achieve low noise level inside the cars and less weight
- 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 similar applications.
- 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, 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/m²) and to a stamping effort of 35 daN on a surface of 25 mm².
- 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 a fire barrier in accordance with either of the following requirements:
 - (i) in accordance with NFPA130, or,
 - (ii) a fire barrier of thirty minutes duration tested in accordance with NFF 16103,
 - (iii) a fire barrier of thirty minutes duration according an equivalent international standard subject to the Employer's approval.
- 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 is also acceptable.
 - (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. 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 Tenderer.
- (v) All inter-car gangway structures shall be totally interchangeable with one another.
- (vi) 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.
- (vii) The covers shall be lockable in position to withstand high wind conditions.
- (viii) The gangway shall incorporate longitudinal resilience to allow for coupler movement during minor collisions, in order to minimise damage.
- (ix) The gangway shall be designed to ensure that the requirements for coupling and uncoupling are not affected.

9.11.2. 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.

- (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) The gangway shall maintain its performance and remain stable over the full range of relative vehicle movements encountered in normal operation.
- (viii) Sealing of the gangway shall eliminate leakage of water into the saloon area.
- (ix) The elements of the gangway shall give a service life of 8 years minimum..
- (x) 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.

9.11.3. 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) The gangway floor shall have a resilient, durable non-slip surface.
- (vi) Any bonding between the floor covering and the gangway tread-plate shall remain effective under all operating conditions, throughout the life of the gangway. In the event of movement between floor sheets, provision shall be made to take up any abrasion wear.

9.12. Interior Illumination System

9.12.1. Saloon Illumination

- (i) Energy efficient modern state of the art lighting, in luminaries meeting flame, smoke and toxicity requirements shall be recessed into the ceiling panelling. 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.
- (ii) Modern state of the art lighting shall be arranged in such a way that it extends along the saloon ceiling.

- (iii) The lighting fittings shall be of an accepted robust construction, with the access to components. This shall be in a manner which does not significantly increase heat input to the saloon.
- (iv) Each lighting fixture module shall have a translucent lens. The lens shall be protected against ultra-violet radiation degradation and discolouration and shall be fully sealed, at their periphery to exclude water, dirt, and dust ingress to the inner surfaces. The entire arrangement shall be free from rattling.
- (v) The lighting fittings shall be of an accepted robust construction, and preferably hinged for access to components mounted on the back. This shall be in a manner which does not significantly increase heat input to the saloon. The numbers and spacing of the lighting shall be such as to achieve a minimum lighting level of 300 Lux over the whole saloon area, measured at a height of 1.20m above floor level. The difference of lighting level in any place at 1.20 m height level from the metro train floor level shall not exceed 50 Lux.
- (vi) Light sources shall be diffused white light type and indirect so as not dazzle passengers, nor limit horizontal vision, particularly at night (observation on the outside).
- (vii) The internal lighting device for cab and passengers area shall comply with EN 13272 or equivalent international standard.
- (viii) Fluorescent light fittings shall be provided along the entire length of the saloon. The no. of 230V a.c. and 110V d.c. fluorescent fittings in saloon cars shall be same.
- (ix) The size and number of light fittings shall be sufficient to provide a sensibly constant level of illumination of 300lux at a height of 1.20 m above floor level, along the entire length of saloon."
- (x) Separately protected lighting circuits shall be used, such that in the event of one tripping, the others provide evenly distributed lighting throughout the saloon.
- (xi) At least 50% of lamps, evenly distributed over the saloon area, shall remain illuminated, energized even when there is temporary break in 750 V D.C.
- (xii) The Contractor shall submit service life of fluorescent lamp during the design stage which shall be as per the best international practices.
- (xiii) The Contractor shall submit layout of fittings and control circuit for review by the Engineer.
- (xiv) The Tenderer can suggest modern state of the art for diffused and indirect type lighting as an alternative and to be decided during the preliminary design.

9.13. Door Indicator Lights

- 9.13.1. An amber indication lamp shall be located at an appropriate location near each door.
- 9.13.2. The lamp shall remain extinguished when respective door is fully closed and locked.
- 9.13.3. 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.
- 9.13.4. The lamp shall flash whenever door close announcement button from the active cab is pressed. It shall continue to flash till such time the door is closed.

9.14. Signage

- 9.14.1. 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.
- 9.14.2. 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) Fixed Static route map above each saloon door.
 - (vii) Metro network map
- 9.14.3. The design and supply of the signage described above shall be the responsibility of the Contractor.
- 9.14.4. All signs within the passenger areas shall be in English / Hindi / Bengali.
- 9.14.5. The labels for the emergency signage/instructions shall be reflective types.
- 9.14.6. 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 and to be submitted to the engineer.
- 9.14.7. Individual signs shall be fixed so as to enable easy replacement by authorized personnel.
- 9.14.8. 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.
- 9.14.9. The door number identification sign shall be provided adjacent to each doorway.
- 9.14.10. Information and warning signs shall be located in the ceiling and door coving panels.
- 9.14.11. At each end of each car, a four-digit car number shall be provided. The number shall be bold style numerals 100mm high. KMRCL will furnish the specific numbering strategy. Numbers shall be on the exterior of both sides of the cars
- 9.14.12. 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.

10. BOGIES

10.1. General Requirements and Features

- 10.1.1. The bogies shall be of the two axle bolster or bolster-less type incorporating a primary suspension system of proven steel-and-rubber or helical coil steel springs, and a secondary pneumatic suspension system, with vertical and lateral dampers and with axle bearings outboard of 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.
- 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. Tenderer shall indicate the minimum radius of the curves on which axles will take the radial position. This shall be verified during testing by measuring the wheel flange forces using the measuring wheel to be supplied by the Contractor.
- 10.1.4. The bogie proposed to be supplied against this tender shall be of proven design as per clause 1.1.6.14 of Volume 2 - GCC.
- 10.1.5. Bogies shall be designed and manufactured to have as many items as possible to be interchangeable between motor bogies and trailer bogies.
- 10.1.6. 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
- 10.1.7. The design shall provide means for easy compensation for wheel wear and loss of height in the bogie resulting from other causes.
- 10.1.8. The bogie and bogie mounted equipments shall be designed to minimize unsprung mass.
- 10.1.9. The maximum permissible static load per axle is 16.0 Tonnes (AW4) and to be designed for a maximum operational speed of 80 km/h and designed and tested for 90km/h.
- 10.1.10. Bogie wheel base shall be 2200mm to 2400 mm as per Schedule of dimensions. Tenderer 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.
- 10.1.11. Bogie shall be configured such that equipment is positioned and oriented in a manner that facilitates access for maintenance. The bogie design shall include the mounting arrangements for the ATO/ATP equipment, which shall include, but not be limited to (i) the location and mounting for transponders or similar antennas; (ii) the location and mounting of tachogenerators; and the location, (iii) mounting arrangements and termination of the associated cabling.
- 10.1.12. There shall be sufficient clearance (but not less than 25 mm between the bogie and car body to allow the vehicle to operate with a deflated secondary suspension system such that damage does not occur at maximum operating speeds under conditions of maximum

loading and maximum wheel and suspension system component wear, including creeping or settling.

10.2. Dynamic Requirements

- 10.2.1. Dynamic requirements shall be compliant with the specific Indian regulations and legislation and relevant international standard.
- 10.2.2. Not Used
- 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.
- 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 tare conditions, the value of which should not exceed 0.08 at rotational speed of 0.8 degrees/second. The rotational resistance shall neither cause excessive flange wear nor cause any possibility of flange climbing but shall be adequate to avoid bogie hunting on straight track. The Contractor shall show by analysis that no flange climbing occurs on any curve 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 / analyzed.
 - (i) Natural frequencies of the suspension.
 - (ii) Stability of the vehicle.
 - (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
- 10.2.8. The Contractor shall submit a proposal covering the scope of the analysis and the model for review by the Engineer. KMRCL may engage an experienced International Consultant who shall also carry out validation of the design of the proposed bogie.

10.2.9. Maximum value of acceleration measured at central pivot point are:

- (i) vertical acceleration 0.27 g
- (ii) lateral acceleration 0.27 g

10.2.10. The design of the bogie, including the wheel profile, shall prevent the generation of high Lateral to Vertical force (L/V) ratios on any wheel that could result in derailment under all track conditions defined in TS 2, and at all permitted vehicle speeds over the KMRCL alignment, up to 10% above the maximum speed permitted, the L/V ratio shall not exceed Nadal's limit under railhead coefficient of friction conditions up to and including 0.5. Yard operation and deflated secondary suspension conditions shall also be considered.

Nadal's limit is the limiting L/V ratio for a single wheel and is defined as:

$$\frac{L}{V} = \frac{\tan(\delta) - \mu}{1 + \mu \tan(\delta)}$$

Where:

- L is the lateral force component exerted by the single wheel on the rail
- V is the vertical force on a single wheel
- δ is the flange angle of the wheel relative to the rail
- μ is the wheel to rail coefficient of friction.

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

The 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 load of wheels shall not exceed 55% of nominal wheel loads in inflated up to maximum permissible speeds and shall not exceed 65% of nominal wheel in deflated conditions up to maximum permissible speeds.

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 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. Use of cast steel inserts of acceptable grade in fabrication of bogie is permissible.
- 10.3.2. The composition and physical and mechanical properties of the steel shall be fully documented.
- 10.3.3. The bogie frame shall be fabricated of steel construction made of cold or hot rolled plates and forged and cast parts. It shall be welded hollow girder construction and designed in shape of an H. Structure design shall be considered to reduce any stress concentration; select low sensibility steel on crack. If possible, measures should be taken to remove welding stress of bogie frame.
- 10.3.4. 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 Engineer including calculated stress levels showing that fatigue stresses are within allowable limits.

- 10.3.5. The bogie frame shall, consistent with good mechanical design, be as light as possible and particularly minimize the concentration of masses at the extremities of the bogie.
- 10.3.6. The contractor shall provide finite element analysis as per manufacturing drawings. Strain gauge and other bogie test results shall be correlated with the FEM results. The bogie frames for all the cars shall be identical unless justified otherwise.
- 10.3.7. 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 or ultrasonic inspection. The visual and the magnetic particle inspection will be carried out in all bogie frames, and the radiographic or ultrasonic inspection will be carried out for the critical welding joints in sampling inspection.
- The contractor shall submit the method used to define the sampling.
- 10.3.8. The Contractor shall undertake full fatigue test strain gauge and suitable non-destructive tests on a pre-production bogie frame and submit the report. The strain gauge fixing locations and the application of forces for static as well as for fatigue testing shall be reviewed by the Engineer before start of testing.
- 10.3.9. All fasteners for bogie mounted equipment or components shall be positively locked. The use of self-locking nuts alone is not acceptable.
- 10.3.10. Adequate corrosion protection shall be provided. A corrosion protection control programme for the bogie shall be submitted.

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 or equivalent international standard 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.
- 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.
- 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‰ 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: $\pm 25\%$ of the Loaded Weight (AW5) applied vertically for 10 million cycles.
 - Lateral: $\pm 15\%$ of the Loaded Weight (AW5) 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 Loaded Weight (AW5) condition passes over the track twist.
 - Traction/Braking: 10 million complete reversals of the loads applied to the bogie when a Loaded Weight (AW5) vehicle accelerates and decelerates under its maximum tractive effort and decelerates at emergency brake rate.
- (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 Chapter 9.5.
- 10.5.4. 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. The maximum floor height reduction on this account shall be for review by the Engineer.
- 10.5.5. Under the worst condition of track, along with deflated air springs & deflection of primary springs and with uncompensated wheel tread wear (of 10 mm), the minimum clearance of body mounted equipment from rail level shall not be less than 102mm under dynamic conditions of fully loaded vehicle.

- 10.5.6. Under the worst condition of track, along with deflated air springs & deflection of primary springs and with uncompensated wheel tread wear (of 10 mm), the minimum clearance of bogie mounted equipment from rail level shall not be less than 75mm (i.e. 65 + 10 mm) under dynamic conditions of fully loaded vehicle.
- 10.5.7. 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 according to table 2.1.
- 10.5.8. 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.
- 10.5.9. 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.
- 10.5.10. 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 air springs that are spatially flexible.
- 10.5.11. 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.
- 10.5.12. 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.
- 10.5.13. 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.
- 10.5.14. 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 for all speeds up to the maximum service speed of 80 km/hr. Suspension will not be considered acceptable if maximum acceleration and spring displacements do not decay within 2-3 cycles.

- 10.5.15. 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 default to the maximum laden condition.
- 10.5.16. The Contractor shall submit a detailed dynamic model, to demonstrate the running behaviour and performance characteristics of the proposed service-proven bogie design.

10.6. Bogie to Body Connection

- 10.6.1. The body centre pivot shall be capable of allowing for bogie rotation without excessive restraint.
- 10.6.2. Traction and braking forces shall be transmitted between bogie frame and car body 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
- 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. The car body bogie connection shall be capable of permitting the full range of bogie movements without excessive restraint.
- 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 fully loaded weight of the carbody (excluding bogies).
 - (ii) A lateral load of half fully loaded body weight subjected to an acceleration of $\pm 1.1g$.
 - (iii) A longitudinal load equivalent to the bogie mass subjected to an acceleration of $\pm 3.0g$.
- 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 3.2.

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 pad shall be easy to replace by one man working on a car where all air pressure has been removed.
- 10.7.4. Items of equipment mounted on the bogie frame and axle boxes, including their mountings shall be designed to withstand the forces associated with the accelerations according to CEN Standards TC 256 WY13 Annex E or equivalent standards.
- 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.
- 10.7.8. For designs in which failure of a bogie-mounted equipment support may allow the equipment to intrude into the safety clearance, (i.e. outside of the Kinematic Envelope), safety supports shall be provided. These should be designed to support twice the static load of the equipment to be supported without yielding. Safety hangers shall be provided for emergency support of major components, including traction motors and gear units, so that they shall maintain the safety clearance of the track in the event of primary mount failure. Safety hangers shall be an integral part of the bogie frame and shall not support any weight until a failure has occurred.
- 10.7.9. Failure of any long bolts or links shall not cause these items to drop and intrude into the safety clearance. Appropriate safety devices shall be provided to prevent this occurring if the potential for such failures exists.
- 10.7.10. Flexible safety ground leads shall be provided between the carbody and all parts of the Bogies including the traction motor and gearboxes. These ground leads shall ultimately connect to the safety ground brushes to ensure that all bogie parts are at rail potential. Grounding arrangement shall be such as to prevent current flowing through journal, gearbox or motor bearings.
- 10.7.11. The grounding bar required for the Traction Power Supply circuits on each Vehicle shall be electrically connected to at least two wheel sets, on two bogies, by means of separate flexible earth bonds.
- 10.7.12. Each Vehicle body shall be electrically bonded to at least two wheel sets, on different bogie to that used for the Traction Power Supply return, by a means of separate insulated flexible

bonds. The grounding connection for any one system shall not be combined with that of any other system.

- 10.7.13. Each traction motor frame shall be electrically bonded to the adjacent wheel set.
- 10.7.14. The negative or neutral of each Vehicle circuit shall be connected separately to the corresponding grounding bar in the same Vehicle.
- 10.7.15. All metallic boxes, cases and enclosures containing electrical equipment, including cable ducts, which are not intended to be part of the live circuit shall be properly grounded with an insulated flexible earth bond to the relevant earth bar.
- 10.7.16. The removal of any grounded equipment or item shall not interrupt the grounding arrangement of any other remaining earthed electrical equipment.
- 10.7.17. No protective device shall be inserted in any pole connected to earth unless it is immediately adjacent to and protecting the battery.

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.
- 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. The gears including bearings shall not require overhaul at least earlier than 1.0 million km.
- 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 except for the first flush after provided into the service.
- 10.9.4. The gearbox shall be subjected to a test based on the actual duty cycle on a specified line with the specified torque and speed conditions. Testing shall start with gearbox at temperature of at least 30°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. Gears shall be designed and applied to require inspection and adjustment no more frequently than once every 800,000 km and designed for a minimum life of 1,600,000 km.

10.10. Wheels, Wheel sets, 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 (for 1435 gauge). Grade of the material shall be decided during the design stage when rail details will be available.
- 10.10.2. Based on UIC 860 Standard, detail of rail hardness and track type UIC 60/60 E1 and an inclination of rail 1:20, the Contractor shall propose wheel tread profile for most optimal vehicle performances. The profile recommended in Appendix 2 UIC 510-2 can be considered.
- 10.10.3. Diameter of the wheels shall be 860 mm when new. Optimal diameter in order to get maximum life span shall be proposed by the Contractor which should not be higher than specified in SOD.
- 10.10.4. The wheel shall not cause squealing in curves, track curves are 120m with grade compensation of main line and 100m on depot. This must be confirmed by test.
- 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. 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.
- 10.10.10. Wheel sets comply with requirements as per UIC Codes 811, 813-1.
- 10.10.11. The axle shall be designed in accordance with UIC 515-3/EN 13103/EN 13104.
- 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. The Contractor shall provide two reliable and proven laser based wheel profile measuring and recording system to be used by KMRCL.
- 10.10.15. Objective is that the cars shall achieve approximate of 300 000 kilometres before re-profiling of the wheels is necessary, which is equivalent to an average flange wear rate of not

exceeding 0.02mm per 1000km for the wheel, whilst operating on the routes as specified in line. The Contractor shall provide a re-profiling program in order to optimise the life span during the design stage and it shall be verified during the operation.

- 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.
- 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 as per IEC 61133 between wheel loads within a bogie shall be maximum $\pm 2\%$ with symmetrical loads at the air springs. With carbody landed onto the bogies, the wheel load deviation shall be maximum $\pm 4\%$ of the mean wheel load of the related bogie.
- 10.10.23. Axle load deviation as per IEC 61133 between axle loads of bogies of a car with carbody on bogies shall be maximum $\pm 5\%$ of the mean axle load of the related car.
- 10.10.24. Axle end covers shall consider the required axle end components, such as grounding, speed, sensors, etc.
- 10.10.25. Axle bearing boxes shall be isolated with respect to secure the bearing from electrical shocks.
- 10.10.26. Provisions shall be made to allow for wheel truing without removing the bogies or axles. Access to axle centers shall be available if necessary for truing alignment.
- 10.10.27. Details for wheel truing interface requirements shall be submitted for KMRCL approval.

10.11. Bogie Brake Equipment

- 10.11.1. Please refer to chapter "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 Engineer. 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 Equipment

10.13.1. About 20 % of the wheels could be fitted with lubrication device(s) preferably of solid lubricant type according to the rail greasing philosophy of the system operator. Wheel flange lubricators of a proven design in EMU metro application shall be proposed.

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 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. Inspect. 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.

10.14.7. Lubricated bearings shall be adequately sealed to ensure that water and cleaning fluids shall not enter during the cleaning process.

10.14.8. Arrangements shall be made to exchange wheel sets with the minimum dismantling of bogie components being required. The procedure for dismantling shall be furnished.

10.14.9. 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.

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

- 10.14.11. 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.
- 10.14.12. 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.

11. PNEUMATICS, AIR SUPPLY AND BRAKE SYSTEM

11.1. General

- 11.1.1. Since the Brake equipment is a safety item, the Contractor /Sub-contractor who are the manufacturer of the Brake equipments and satisfying the Proven Design concept shall supply the complete brake equipments i.e. from Brake Control Electronics (BCE), Electro – Pneumatic Brake Control Unit (BCU), Brake Cylinder, Disc Brake, Parking Brake, Wheel Slip and Slide Devices etc. Supply of Sub –assembly of Brake Equipment from other supplier will not be allowed.
- 11.1.2. Motor driven air compressors operating from the 3 phase A.C. power supply shall be provided with their associated reservoirs in order to supply the necessary compressed air. A main reservoir pipe and the brake pipe that shall be connected continuously throughout the Train. All necessary pneumatic sub-systems shall be supplied from the main reservoir pipe line and the brake pipe. When two metro trains of 6 cars are coupled together, the main reservoir pipe shall be automatically connected through the coupled Train.
- 11.1.3. The working pressures (up to 10 bars) of the compressed air system shall be sufficient to meet all the requirements for the associated components that require the supply of compressed air.
- 11.1.4. The pneumatic brake isolation devices shall be provided and shall be located in both saloon area and under-body for the 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. The brake isolation devices located on the under-body shall be located to enable operation from the side of the Vehicle at track level.
- 11.1.5. 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 drier 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.

11.2. Brakes, Principles and Blending Rules

- 11.2.1. Deceleration performance required for operations are specified in the chapter related to operation performances.
- 11.2.2. The Tenderer 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 service braking application and release shall be smooth and step less from the maximum speed to 0 km/h.
- 11.2.4. The brake system shall be complete in each three-car unit (DTC+MC+MC), being 1/2 metro train and shall consist of:
- (i) Electro-pneumatic friction brake (EP): for limited 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 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-dynamics 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 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.
- 11.2.5. The blending between electro-dynamics and pneumatic 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 (taking into account the effort produced by the electro-dynamics 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. The calculation for emergency braking distances under dry and wet conditions shall be submitted. Braking distances for normal service braking with electric brake blending shall also be submitted.
- 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, and shall default to AW4 braking control mode. In case of 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 or anodized/painted aluminium or corrosion resistant steel (corten).
- 11.2.11. The air supply and distribution systems shall be arranged such that any single type failure can be readily isolated such that the impact on the performance capabilities is maintained.

11.3. Emergency Braking

- 11.3.1. Emergency braking in normal mode is performed in friction brake only. Calculations shall be performed for a train charged in AW4 passenger load per square metre weighing 65 kg each, each axle braking its mass and taking into account wheel wear.
- 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 fully loaded train (AW4) 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. 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.
- 11.3.7. The Contractor shall furnish emergency braking distances to standstill, for a fully loaded (AW4) train 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.
- 11.3.8. The friction brake system shall be rated to, and have sufficient thermal capacity to safely complete three 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 three cycles, the brake system shall show no abnormalities. The requirement shall be demonstrated during testing.

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% (compensated) gradient. The brake application shall be retained while traction power is applied and the train takes forward movement.
- 11.4.3. The friction brake shall be fully rated to meet, on its own and at least during 3 round trips the full braking performance, and shall be capable of sustaining the full emergency braking performance.
- 11.4.4. 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 the Dense Crush Loading condition (AW4).

- 11.4.5. The metro train shall be provided with disc brake system both on Motor Coach and Trailer Coach. Motor Coach & Trailer Coach may be provided with similar wheels for better maintainability/interchange-ability.
- 11.4.6. Disc brake pad wears are automatically compensated by an adjuster integrated to the actuator. Life span of brake pad expected is in the range of 150,000 km and commensurate with quarterly scheduled maintenance.
- 11.4.7. The friction brake actuation system shall be in accordance with the following general requirements:
- (i) It shall be capable of reliable operation in service with regular routine maintenance.
 - (ii) It shall be capable of functioning satisfactorily with regular routine maintenance. (Schedules) is followed.
 - (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.
- 11.4.8. The friction brake system shall so designed that a brake control electronics (BCE) or unit (BCU) can be taken over completely by another BCE, respectively BCU, in the case of failure of individual electronic or electrical control elements or units.
- 11.4.9. Disc brake pad shall be of high-grade composite material and shall contain no toxic material and be compliant with the UIC standards. Heating by disc brake pad shall in no case cause the disc material to exceed its permissible temperature limits above which incipient thermal surface cracks appear. The discs brake unit and shoes 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 without the need for special tools. It shall be possible to easily inspect disc shoes and discs "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. It should be possible to move the train further by isolating the bogie brakes of this portion of the train. The safe speed shall be proposed by the Contractor taking into account safety operation and be decided 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 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 dynamic braking and friction braking 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 combination of motor cars 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 dynamic brake shall be continuously available from maximum speed down to a minimal low speed that should be less or equal to 8km/h for the purpose of minimizing the friction brake wears and maximizing the regeneration of energy within the limits of adhesion. Dynamic brake curves, speed/traction curves shall be provided by the Tenderer for a 6 car metro train composition. The dynamic brake alone shall be able to achieve the average service deceleration rate ($1.0 \text{ m/s}^2 \pm 5\%$) from 60 to 10km/h.
- 11.5.7. The dynamic braking shall consist of regenerative and rheostatic braking, which shall complement each other, depending on the third rail receptivity and braking priorities as specified below:
 - (i) Under normal circumstances, regenerative braking shall have the first priority in the braking process.
 - (ii) In case the line voltage transiently increases up to 900V dc, regenerative braking shall transferred to rheostatic braking without noticeable change of brake effort, i.e. the blending of regenerative and rheostatic brake shall be smooth, continuous and reversible. A suitable rated resistor shall be used to ensure smooth braking transition from the above transient over voltage conditions. The regenerative and rheostatic brakes transferring process shall be continuously reversible.
 - (iii) When the third rail system continues to be either partially or totally non receptive, dynamic braking shall still be maximized. This shall be done by means of a smooth transition from regenerative to rheostatic braking and vice versa until the receptivity of the third rail system is resumed.
 - (iv) When there is no 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 safety critical equipment or control failures that could impair braking performance or compromise safety. Such failures shall be transmitted / announced to the OCC system and to the operator's console when the vehicle is being manually driven.
- 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 resettable, 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.
- 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. 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% (compensated) 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. A means for manual release of each parking brake which can be accessed from track level without the need to reach underneath the car shall be provided.
- 11.7.3. 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.
- 11.7.4. 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.
- 11.7.5. The parking brake shall be an integral part of the friction brake actuation system. Parking brake application indication should be available on the brake actuators and on the active cab.
- 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. The Contractor shall provide calculations to support his compliance with the performance requirements.

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 ATO system.
- 11.8.3. An emergency brake control system shall be provided by two independent Hard Wired circuits that shall demand an emergency brake application on all Vehicles unless a satisfactory status of all the Train's integral safety devices are proved to be safe. 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. The local auxiliary vehicle supply required for each Vehicle's emergency brake system shall be independent to that required for the service brake control.

11.9. Brake Control Unit

- 11.9.1. Each car shall be driven with fail safe Brake Control Electronics (BCE) and an associated electro-pneumatic Brake Control Unit (BCU). The BCE 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 control system shall control the rate of change to be in accordance with the specified levels of jerk and response times;
 - (iii) the BCE shall maximise the use of the dynamic brake at all times by interfacing with the traction system. Any shortfall in the effort provided by the dynamic brake shall be achieved using the friction brake. Service proven design in accordance with international standards may be submitted for KMRCL approval
 - (iv) during braking, if the dynamic braking is operating and is providing all the required effort, the BCE shall maintain sufficient EP brake pressure to keep the shoes nearly in contact with the disc/wheel but shall not contribute to any braking effort or cause wear to the shoes and discs/wheels;
 - (v) the BCE shall contain fault diagnostic facilities, which record all the relevant fault information and status of the equipment at the instant of failure to facilitate maintenance;
 - (vi) the fault diagnosis function shall be compatible with the TMS to enable fault log information to be accessed through the TMS. A comprehensive set of indications shall be available on the BCE 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.
- 11.9.2. The associated EP brake unit 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 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 (AW0) and Dense Crush Loading conditions (AW4).
- 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 Dense Crush (AW4) Loading condition on that Vehicle.

11.10. Air Compressor

- 11.10.1. Equipment using compressed air shall be grouped by function. Each function shall be capable of being isolated from the air supply.
- 11.10.2. Air compressor shall be reciprocating or any other type and oil lubricated type with proven design (clause 1.1.6.14 of Volume 2-GCC) in metro train operations for at least 5 years.
- 11.10.3. Four compressors shall be provided for a six car train composition. Optimal capacity shall be calculated taking into account the redundancy, reliability and proposed by the Tenderer.
- 11.10.4. An "intelligent air compressor management" shall be provided to ensure that the compressors on a six-car train are operated during fill-up and all the four compressors in the train are operated alternatively thereafter, to avoid moisture condensation in the compressor due to low duty cycle. The required capacity of each compressor shall be more than 50% of the total demand.
- 11.10.5. 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:

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

- 11.10.6. The time required to charge up to full main reservoir line pressure of a metro train with all reservoirs and equipment at atmospheric pressure, shall be less than 15 minutes and full air suspension inflation shall be achieved in a further 5 minutes.
- 11.10.7. In the event of total failure of electro-dynamic brakes and one air compressor on a fully loaded six-car train 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.
- 11.10.8. The Contractor shall by calculations or otherwise establish that the compressor will meet the above conditions.
- 11.10.9. 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 55 protection.

- 11.10.10. The compressor shall be designed to achieve reliable performance between overhauls. Routine maintenance shall not be required at a frequency more than once per year.
- 11.10.11. 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.
- 11.10.12. 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 within at 10 bar. Detailed figures shall be defined during design process to achieve the required number of subsequent emergency brake applications.
- 11.10.13. 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.
- 11.10.14. 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.
- 11.10.15. The intake air shall be directed through a properly designed filter, suitable for the dusty atmospheric conditions prevailing in Kolkata. Filters shall be easy to clean and shall be easily accessible for cleaning and replacement.

11.11. Air Dryer and Filtration

- 11.11.1. Each compressor installation shall be fitted with a means of cooling the air produced prior to drying.
- 11.11.2. 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.
- 11.11.3. 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 Kolkata shall be provided. The air dryer shall have IP65 protection.
- 11.11.4. The grade of filtration at rated pressure shall be provided by the Tenderer.
- 11.11.5. 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 Kolkata, no condensation takes place.

- 11.11.6. A proven regenerative type of air dryer using desiccant and of a suitable capacity shall be provided between the air compressor and the main reservoir.
- 11.11.7. 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 Engineer. Interval for replacement of desiccant in the dryer unit shall be furnished.
- 11.11.8. In case of continuous purging through air-drier, an isolating cock shall be provided to bypass air drier.

11.12. Reservoirs

- 11.12.1. 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.
- 11.12.2. Main reservoirs with a capacity adequate shall be provided on each three-car train / unit to distribute the air to various systems. The reservoirs shall incorporate an automatic drain valve and a safety valve shall be installed near the reservoirs. The Contractor shall provide calculations to substantiate correct sizing of the reservoirs.
- 11.12.3. Main reservoirs shall also have a manual device for venting/draining the contents of the reservoir.
- 11.12.4. A protected supply of air pressure for friction brake equipment shall be supplied by a separate brake supply reservoirs. 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 fully loaded (AW4).
- 11.12.5. 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.
- 11.12.6. Separate reservoirs of suitable capacity shall be provided for satisfactory operation of other on-train pneumatic systems.

11.13. Piping System

- 11.13.1. A main reservoir pipe shall run continuously throughout the train.
- 11.13.2. All piping shall be of stainless steel conforming to the requirements of ISO 9329-4 and ISO 9330-6 or equivalent with flare less compression fittings. The pipe fittings shall conform to the requirements of DIN 2353.
- 11.13.3. 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.
- 11.13.4. 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 pipes etc. shall be incorporated as required.

- 11.13.5. Quick release coupling test points made of stainless steel, with blanking plugs shall be provided. They shall be located in easily accessible positions.
- 11.13.6. 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.
- 11.13.7. Foreign matter shall be removed from all pipes prior to installation.
- 11.13.8. Suitable colour coding shall be applied to all pipe-work for identification. The proposed colour coding shall be reviewed during the design review. This clause applies for main pipes, cocks and valves.
- 11.13.9. All pipes shall be installed by means of clamps with integral, moulded vibration damping inserts or resilient liner to prevent any rattling in service. Clamps shall not be welded to the pipe.
- 11.13.10. Where piping passes through holes in the floor, structure member etc, it shall be rigidly clamped immediately adjacent to the hole to prevent contact to the edge of the hole.

11.14. Pressure Gauges

- 11.14.1. All driving cabs all these information shall be provided to the driver:
 - (i) The pressure in the main reservoir.
 - (ii) The pressure in the brake reservoir and brake cylinder pipe.
 - (iii) The releasing pressure in parking brake unit
 - (iv) The pressure in the brake pipe
- 11.14.2. 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 release pressure.
 - (v) Brake pressure reservoir.
 - (vi) Brake pipe.
 - (vii) Overflow valve.
 - (viii) Air spring pressure.
 - (ix) Any other point, which in the opinion of Engineer is required.

11.15. Air Suspension Equipment

- 11.15.1. 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.

11.16. Automatic Coupling Actuating Equipment

- 11.16.1. Control of the auto coupler operation shall be provided by air supplied from the main reservoir via an isolating cock, and magnet valves.

11.17. Wheel Slip and Slide Protection

- 11.17.1. 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.
- 11.17.2. 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.
- 11.17.3. In the event of wheel slip/slide, the traction equipment shall manage the strategy to adopt, in implementing either the electric braking or the pneumatic braking reaction, without having the blending in opposition.
- (i) Digital wheel slide protection with gradual slide correction shall be provided in all braking modes. The slide detection shall be performed per axle and the correction per bogie. 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 Tenderer shall incorporate the complete compatibility for slip/slide with signalling system and interfaces. The Tenderer 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 TMS system.

11.18. Failure Management

- 11.18.1. It shall be possible to recover a dead metro train (i.e. one having no traction power and no means of generating further compressed air, but with the air brake system intact) using only an air connection from the rescue train or vehicle. The emergency brake application dead train shall be possible from the driving cab of the assisting engine or train by its operator. The detailed scheme shall be subject to the Engineer's review.

11.19. Monitoring

- 11.19.1. The safety critical systems shall be monitored by the train integrated management system (TIMS) and displayed in the train driver's cab.

12. HIGH VOLTAGE AND ELECTRICAL PROPULSION EQUIPEMENT

12.1. General Requirement

- 12.1.1. All electrical equipment proposed shall comply with the relevant sections of IEC60077 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 in compliance by the Contractor.
- 12.1.2. 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.
- 12.1.3. The propulsion and brake control system shall provide regenerative braking blended with pneumatic service braking as required. Regenerative braking shall be fully compatible with the power supply system under all train loading conditions. The principal highest priority service brake shall be regenerative and its capability shall be maximised.
- 12.1.4. The Contractor shall be responsible for the safe and correct transfer of interface information between the brakes and propulsion systems and also with other systems.
- 12.1.5. The Traction-braking system shall be predominantly controlled by micro-processor based control systems inter-linked via a communication data bus system. Train propulsion, brakes, auxiliary control, onboard equipment status monitoring, fault data logging and first line diagnostics shall be integrated into the proposed train control system (TMS). Alternative Service Proven Design may be provided to KMRCL for approval.
- 12.1.6. 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.
- 12.1.7. All under frame mounted electrical equipment shall be sealed to IP65 at the exception of the ventilated areas unless otherwise agreed. These enclosures will not be affected by corrosion in service life.

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 pads. The main electrical protection of the nominal 750 V DC Traction Supply to each motor cars (MC) shall be achieved by means of a High Speed Circuit breaker (HSCB).
- 12.2.3. A surge arrester 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.
- 12.2.4. Brake resistors in charge to dissipate the brake energy during dynamic braking if regeneration energy is not receptive by third rail shall be provided.

- 12.2.5. The traction and braking equipment shall not suffer damage under any conditions that may be encountered including development of maximum traction or braking effort continuously and worst case of slip/slide conditions.
- 12.2.6. The traction and braking system and associated equipment shall be fully integrated with control circuits, diagnostic and monitoring facilities, load-weighing and wheel-slip/slide systems. The integration shall be designed to 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.
- 12.2.7. The traction equipment shall be designed so that the tractive and braking effort of the metro train is dependent on the passenger load.
- 12.2.8. The manufacturing standards shall have already been proven widely in the railway traction industry.
- 12.2.9. The types of power semi-conductors used shall have had extensive use and experience in traction applications. The circuit breakers, contactors and conventional electromagnetic components used shall comply with the requirements of IEC 60077 1 and 2.

12.3. DC / AC Traction Inverter

- 12.3.1. DC/AC traction inverters shall be housed in a stainless steel or anodized/painted aluminium or corrosion resistant steel (corten) frame container, which is mounted under floor in each of the motorised cars. The container shall house the power electronics, the monitoring devices and the traction control unit. It is connected to the vehicle via high voltage power connections, control connections and 3-phase output to the traction motors.
- 12.3.2. Traction propulsion system for each MC can be one inverter for two traction motor or one inverter for four traction motor control for each MC. The inverter shall be proven, four quadrants IGBT (or later metro transit proven technology based unit VVVF control)
- 12.3.3. The traction inverters shall be of natural or forced cooled type.
- 12.3.4. 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 Kolkata and surrounding.
- 12.3.5. The continuous rating of the traction inverter shall meet all the normal, degraded, rescue condition in traction and braking modes.
- 12.3.6. 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.
- 12.3.7. Accurate and detailed computer simulations of single power component failures shall be performed in the design of the equipment.
- 12.3.8. 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

TMS, to enable protective or corrective action to be taken immediately, when necessary.

- (iii) The traction inverter shall use a control scheme that contains extensive self-diagnostic logic, which shall be fully integrated with TMS. 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) The train operator from the cab shall be able to isolate any defective traction inverter.

12.4. Traction Motors

- 12.4.1. 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 converter/inverter operation shall be offered. The motor shall have adequate built in margin to cater to the environmental conditions given in the specification. The motor shall be designed to suit ripples and harmonics from the inverter and shall have a high degree of reliability in service during motoring as well as regeneration.
- 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.
- 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 Kolkata. 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.
- 12.4.7. The temperature rise limit for the stator winding shall be the maximum temperature index of the insulation minus 70°C when the traction Motor undergo the temperature-rise tests, which is specified by IEC60349-2.
- 12.4.8. Simulations on a typical round trip for each line 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.
- 12.4.9. 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.
- 12.4.10. The motor bearing maintenance inspection interval (excluding lubrication if required) shall exceed 0.8 million kilometres and the bearing shall have a design life of 1.6 to 2.0 million

- kilometres. 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.
- 12.4.11. Insulated bearing shall be used on both drive and non-drive end of traction motors to prevent current through the transmission to the axle.
- 12.4.12. Protection shall be provided to prevent current flow through the bearings in normal and under fault conditions.
- 12.4.13. The grease used for the traction motor bearings shall be selected so as to ensure the expected maintenance interval considering the maximum temperature estimated to be reached in the bearings, under the worst conditions. It should be provide to replenish the grease periodically in situ and overflow arrangement should be provided to avoid the possibility of the over greasing.
- 12.4.14. The motor shall be mounted on the bogie frame via flexible coupling and gear unit, which shall be totally enclosed and free from lubricant leakage. The coupling design and the motor to gear unit mounting arrangement shall minimize coupling dynamic angular displacement. The motor shall be dynamic balanced. Alternative service proven design can be provided for KMRCL approval.
- 12.4.15. The traction motors shall be designed for a life of thirty five years with no need for major overhaul before 840,000kms.
- 12.4.16. The mounting arrangement of the traction motor shall be designed to prevent the motor from dropping onto the track should the primary mounting arrangement become disconnected. All components shall have been already proven in previous railway service in similar operating and environmental conditions.
- 12.4.17. 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.
- 12.4.18. Rotor design shall be of copper alloy or Die-cast Aluminium. However, rotor must have previous proven service record.
- 12.4.19. Any inspection covers shall be robust and designed for quick and easy removal/replacement and have secondary retention to prevent loss. Inspection openings shall be as large as possible to facilitate inspection and maintenance.
- 12.4.20. The gearbox case design shall give due consideration to minimizing weight.
- 12.4.21. The coupling of the gearbox shall accommodate all relative movements between the motor and the gearbox, including that caused by a free standing bogie, without damage to coupling.
- 12.4.22. The design of the motor installation shall permit the motor to be removed from, and refitted to, the bogie from above, without any need to disturb the axle and any bogie mounted equipment.
- 12.4.23. Where cables pass through holes in the traction motor frame, oil resistant resilient bushes suitably clamped shall be provided to prevent chafing of cables and to seal against the

ingress of oil and water. The cables shall have sufficient freedom of movement to prevent stressing of fouling of other equipment during the full envelope movement of the bogie

12.4.24. There shall not be any permanent flying lead attached to the motor. All connections to the motor shall be bolted, torque tightened and marked.

12.4.25. Traction motors shall be fully interchangeable. All components requiring periodic replacement, whether mechanical or electrical, shall be fully interchangeable unless approved by the Engineer.

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 car and shall be mounted adjacent to the current collector.

12.5.3. Over-voltage protection shall be designed according to international standard IEC61287-1.

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 fitted shall have minimum maintenance. A means of indication shall be provided for easy identification by visual inspection 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 surge arrestor shall be tested to EN 50124-2 or equivalent International standard.

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. In case of failure of one traction inverter, the HSCB safely and reliably shall disconnect the traction inverter from the line.

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 to IEC standard to 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. An isolation switch of knife type or rotational type 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 car-borne systems. If the knife switch type is employed, it shall be arranged so that the enclosure cover cannot be closed when the switch is in OPEN position.

12.8. Power Line Filter - Reactors and Capacitors

- 12.8.1. The reactors shall comply fully with the requirements of IEC 60310 standard.
- 12.8.2. The Capacitors shall comply with IEC 61881 standard.
- 12.8.3. 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 2 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 comply with clause 11.5.7.
- 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.

12.10. 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 converter 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 $\pm 5\%$ 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 management system and shall be tamper proof.

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 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. A manual device shall be provided to retract and latch the collector shoes. The manual control device shall be accessible from track level
- 12.12.4. It shall not be possible to retract the collector shoes with either traction or auxiliary circuits energized.
- 12.12.5. 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.
- 12.12.6. The third rail current collector shoe arrangement shall be mounted on the bogie frame such that it shall suit for top current collector system.
- 12.12.7. The current collector shoe arrangement shall be mounted such that it shall not infringe the kinematic envelope shown in SOD.
- 12.12.8. 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.
- 12.12.9. 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.
- 12.12.10. The current collector shoe arrangement shall be suitable for Bogie pitching, rolling all dynamic requirements.
- 12.12.11. It shall have a suitable disconnection mechanism for isolating the power from the current collector rail.
- 12.12.12. 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.
- 12.12.13. The shoe head shall be capable for current carrying capacity according to the energy consumption.
- 12.12.14. All collector shoe equipment and mountings shall be identical, irrespective of the type of bogie on which they shall be mounted.
- 12.12.15. 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 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 MC car can provide propulsion power for traction. While it is energized, it is isolated with all current collector shoes.
- 12.13.3. The Rolling stock Contractor shall also supply the mating half of the connector, which shall include a full complement of female contacts. Even connection to DTC should also be available for testing in workshop. When not in use it shall be protected from rain water, dust and dirt. A protection scheme shall be submitted to KMRCL for approval
- 12.13.4. Similar arrangement of receptacle on both sides of Trailer car shall be made available.

12.14. EMI

- 12.14.1. The Contractor shall demonstrate that adequate protective measures have been taken to prevent EMI from all equipment on board the rolling stock and shall demonstrate compliance with EN 50121 Parts 1-3
- 12.14.2. All design data, test specifications and test reports shall be delivered and all tests, with the exception of commissioning tests, shall be completed prior to the delivery of the first train.
- 12.14.3. The rolling stock shall be required to operate in the vicinity of various types of equipment, which are susceptible to the radiated electromagnetic waves of the rolling stock.
- 12.14.4. The rolling stock radiated emissions shall not affect any equipment operating in the vicinity, which may include but not be limited to
 - (i) heart pacemakers.
 - (ii) public broadcast services and communication service.
 - (iii) train radio system.
 - (iv) track based personnel/police and fire department/nearby buildings.
 - (v) mobile radios and mobile phones.
 - (vi) Hospitals.
 - (vii) SCADA
 - (viii) visual passenger information system and cab/station platform CCTV
 - (ix) station public address system
- 12.14.5. Each item of equipment shall be tested in accordance with the requirements of EN 50121 and the results submitted for approval of the Employer.
- 12.14.6. The maximum levels of radiated EMI of any individual item of equipment shall not exceed the levels specified in EN 50121 and EN 50392.
- 12.14.7. All electrical and electronic equipment on board the rolling stock shall not exceed the conducted interference levels as defined in EN 50121. These limits shall apply under all normal conditions.

13. AUXILIARY SUPPLY ELECTRICAL EQUIPMENT

13.1. Auxiliary Supply System

- 13.1.1. Auxiliary power supply shall be provided on a three-car train/unit basis and provisions for extension of power during emergency of 6 fixed car compositions shall be taken if relevant. This shall consist of static inverters together with back-up batteries and battery charger.
- 13.1.2. Suitable protection and warning systems shall be provided so as to enable the train to complete its journey before withdrawal from service in the event of battery charge failure.
- 13.1.3. NOT USED
- 13.1.4. Design life of the auxiliary converters shall be a minimum of 35 years and be capable of operation for a period of fifteen years without major maintenance.
- 13.1.5. The auxiliary power supply system shall be configured such that it performs reliably for all operating situations. The whole power supply network includes:
 - (i) Static inverters.
 - (ii) Battery charger.
 - (iii) Storage Battery along with Back-up Battery

13.2. Auxiliary Inverters

- 13.2.1. There shall be two independent inverters mounted in two separate boxes in the trailer car. Each of the auxiliary inverters is protected by two fuses, 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. Four static inverters per 6 car metro train shall be provided, with natural air ventilation system or forced cooling ventilation system. However, if forced cooling is offered complete details of the arrangement including the method of dust filtration shall be furnished.
- 13.2.5. Static type auxiliary inverters shall be of latest metro transit-proven technology (IGBT or later) 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. Each auxiliary inverter shall be connected to the traction supply by means of an independent main fault isolation device, which automatically isolates the system in the event of any of the following fault conditions.
- (i) current overloads
 - (ii) output over voltage
 - (iii) output frequency out of range
- 13.2.8. 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 60850.
- 13.2.9. The AC supply shall provide, as a minimum, the power for the air conditioning units and the pneumatic compressor.
- 13.2.10. The design and installation of the auxiliary converter shall ensure continuous operation of the auxiliary supplies, not withstanding any interruption to the traction supply on any section of the train.
- 13.2.11. The AC output three-phase supply shall be regulated to within $\pm 5\%$ of the nominal voltage and frequency over the full load range. The AC supply output frequency shall be quasi sinusoidal under all conditions of load and shall be maintained between 47 Hz to 53 Hz.
- 13.2.12. In the event of an interruption of the traction supply, the auxiliary inverter shall automatically re-start safely once the traction supply is re-established, provided that the auxiliary inverter has previously been started.
- 13.2.13. 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.
- 13.2.14. 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.
- 13.2.15. 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
- 13.2.16. 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.
- 13.2.17. 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.
- 13.2.18. The dc output provided by the auxiliary inverters shall be arranged to ensure that neither the control nor the battery charging supplies are lost in the event of a failure of an auxiliary converter or both auxiliary inverter.

- 13.2.19. The efficiency of the Auxiliary Inverters shall be a minimum of 92% at any voltage as defined in chapter 2.5.1.
- 13.2.20. All auxiliary inverters shall be adequately rated to enable the supply of load imposed by all the cars in the train.
- 13.2.21. 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. Static inverters shall be provided with natural air ventilation system.
- 13.2.22. The output circuits are galvanic-ally isolated from the input and each other.
- 13.2.23. Staggered starting shall be provided between auxiliary power supplies on the train to minimize start up loads.
- 13.2.24. 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. Auxiliaries.
- 13.2.25. 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 integration management system (TMS), to enable protective or corrective action to be taken immediately, when necessary.
 - (iv) The auxiliary converter shall use a control scheme that contains extensive self-diagnostic logic, which shall be fully integrated with TMS. 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 converter 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 driver from the cab 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.
- 13.2.26. 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.
- 13.2.27. The box for auxiliary converter 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.
- 13.2.28. 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 power up is not possible when shore supply is applied to the train. The design and type of the interface connector shall be submitted to the contractor's representative for review. Minimum 50 numbers of the mating connectors shall be supplied for installation in the depot.
- 13.2.29. The shore supply shall have sufficient capacity, rating and provision to enable Engineer's maintenance personnel to test all electrical auxiliary equipment in each car/three-car unit/six car unit. The shore supply connector of adequate capacity shall be provided at diametrically opposite convenient locations on either side of each car.
- 13.2.30. 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.

13.3. Battery Charger

- 13.3.1. The battery shall be charged from the local static battery charger. Four battery chargers corresponding to four auxiliary inverters per 6-car train set shall be required. The battery charger with automatic control shall be capable of providing a 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.
- 13.3.3. It shall also be possible to charge the batteries externally.

13.4. Back-Up Batteries

- 13.4.1. Each six-car unit shall be equipped with four sets 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.
- 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.
- 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.

- 13.4.4. The proposed list of equipment of the emergency systems shall be submitted. Emergency loads shall include, but not be limited to:
- One (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) TMS.
 - (viii) Electric horn.
 - (ix) Cab console indicators, lighting and interlocking.
 - (x) VAC controls,
 - (xi) ATO/ATP equipment (ATP/ATO/ATS).
- 13.4.5. The design and control of the battery shall ensure that there is sufficient capacity left under all conditions to start the auxiliary power supply 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. The battery shall have a large capacity of electrolyte to allow topping-up intervals to be at least 60 days. 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 Engineer.
- 13.4.7. The battery capacity shall be sufficient to maintain emergency lighting, emergency ventilation, saloon doors radio and public address system for at least 60 minutes from an 80% charged condition.
- 13.4.8. The materials used for construction shall be flame retardant and halogen free. The design shall be submitted for KMRCL approval
- 13.4.9. The battery terminal voltage shall float on the 110V d.c. 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.
- 13.4.10. The control elements taking power from the battery shall be capable of operating between 110V dc, +25% -30%. The instantaneous battery voltage shall be monitored and recorded through TMS.
- 13.4.11. The battery shall be adequately protected using fuse or circuit breaker. These shall be mounted as close to the battery as possible. The status of fuse or circuit breakers shall be monitored by TMS.
- 13.4.12. Three sets of battery electrolyte automatic topping up devices shall be provided. These 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 to be 60 days or longer. Contractor shall provide a single point topping-up system.

13.4.13. The battery shall follow UIC 854R requirement.

13.4.14. 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 isolating switch 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.

13.5. Battery Box

13.5.1. Batteries box shall be removable as a single module with mechanical handling equipment. It should equip with sliding device to benefit the maintenance work.

13.5.2. 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.

13.5.3. 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.

13.5.4. 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

13.5.5. The battery box location shall be arranged to provide easy access for maintenance inspection and topping up of water.

13.5.6. 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.

13.5.7. The battery boxes shall be made of stainless steel lightweight construction suitably protected.

13.5.8. A lid, with top mounted lift off hinges shall be provided with safety straps.

13.5.9. 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.

13.5.10. The lid, in the closed position, shall be secured by spring clips.

- 13.5.11. 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.
- 13.5.12. Activation of the locking mechanism shall separate the battery tray from the battery box.
- 13.5.13. 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.
- 13.5.14. The battery box shall be sized to have at least 10% extra space to accommodate augmented capacity battery. Extra space shall be suitably packed.

14. VENTILATION AND AIR-CONDITIONING

14.1. VAC for Passenger Saloon

- 14.1.1. The Ventilation and Air-conditioning (VAC) 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.
- 14.1.2. The VAC equipment or units that are roof-mounted shall not interfere with the Kinematic Envelope. The system shall be driven by AC motor.
- 14.1.3. The Contractor shall submit proposals relating to measures to be incorporated to prevent unloading of air-conditioning units under the conditions of stoppage of train at the platforms and inside the tunnels due to high condenser temperature.
- 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.
- 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 weigh signal shall be used for controlling the performance of VAC system.

14.2. Design Criteria – Cooling and Heating Capacity of the Unit

- 14.2.1. The VAC unit shall be designed as per ASHRAE 1% for DB/MWB respectively, 1% WB/MDB conditions for rating of the VAC equipment. However outside Design Data Condition for Kolkata is given in table below:

Table 14.1 External/internal conditions for VAC

Weather Conditions	External temperatures	Internal Conditions
Summer	Dry Bulb 35.2°C Wet Bulb 26.°C	Dry Bulb 25°C 60 % RH
Monsoon	Dry Bulb 28°C Wet Bulb 26°C	Dry Bulb 25°C 60 % RH

The above Data is taken from ISHRAE.

However, the Tenderer must confirm from ASHRAE, outside design data conditions for Kolkata. In case of any difference in ISHRAE and ASHRAE conditions, the severe of the two conditions shall be used for design purpose.

- 14.2.2. Heat gains to be considered for each car shall be mainly as follows:

- (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.

Tunnel air temperature up to 45°C.

- 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 VAC unit shall be detailed in the tender.
- 14.2.4. The air conditioning units shall be sized to cater for fully laden load 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 so that they do not exceed 25°C and 60%RH respectively, for ambient temperatures of 35.2°C dry bulb and 26°C wet bulb.
- 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. The temperature shall be recovered to 25°C within 2 minutes after a door opening of 20 seconds and closed for a load of AW4 under surface design conditions.
- 14.2.8. The temperature variations inside saloon room shall follow EN 13129 (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 2.5 litre/sec/passenger (AW4 load) and this air shall be filtered.
- 14.2.11. In nominal regime (ventilation) renewal of filtered air shall be approximately 7.5 litres / sec /passenger (AW4 load).
- 14.2.12. In the event of the failure of both VAC 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 2.5 litres / sec /passenger (AW4 load). The emergency ventilation fan shall be fed from the 110V DC supply with its dedicated inverter.
- 14.2.13. The ventilation shall pressurize the car with all doors closed and car stationary. The proposed value of pressure shall be submitted.

14.2.14. 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. Full details of the system proposed shall be given.

14.2.15. No Heating System is required for KMRCL metro trains.

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 available	Available	Available
Emergency	Not required	Full	Not required
Smoke	Available	Not required	Full
Smoke & Emergency	Not required	Not required	Full

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 TMS.
- (iii) In winter also it may require working in ventilation mode.

14.3.3. Emergency Mode

- (i) Provision shall be made to power the evaporator blowers from the battery in the event that primary power to the car is lost. This provision shall automatically come in to operation 45 seconds after primary power is lost and be discontinued upon reinstating of primary power.
- (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 2.5 (minimum.). l/sec/pas.(AW4)
- (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 TMS.
- (vi) As emergency ventilation is a safety requirement, the battery shall be rated to provide power to the blowers in addition to that required for other emergency loads for a period of 1 hour

14.3.4. Smoke Mode

- (i) In the event of smoke being detected by the system in the fresh air intakes, the system shall shut off the fresh air intake and provide a full (100%) recirculation of return air within the saloon.
- (ii) The system shall maintain supply of cooling to the saloon.
- (iii) In the event of a loss of the emergency power supply, the dampers keep the "Closed" position.
- (iv) The dampers shall be reset by the train driver via the TMS if the system resumes normal.
- (v) The dampers shall be capable of being reset locally from the saloon if remote reset has failed.
- (vi) Operation of the smoke mode ventilation shall be reported to the TMS.

14.4. Smoke Detection

- 14.4.1. The Contractor shall propose a smoke detection system suitable for railway application.
- 14.4.2. The detection system shall be designed to give a fast and accurate response with minimized nuisance activation.
- 14.4.3. The detection system shall be activated if there is dust or smoke in the fresh air intakes. Smoke detection shall be reported to the TMS.
- 14.4.4. The detection system shall be able to be checked and replaced from the saloon or from the roof including the sensitivity test.
- 14.4.5. The detection system shall be design to minimize the maintenance.

14.5. Roof Mounted VAC Units

- 14.5.1. Two package type VAC units, with all equipments required for satisfactory functioning of the system, shall be provided for each cars of 6-car metro train.
- 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 VAC 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 VAC unit without needing any attention.
- 14.5.5. The VAC 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 TMS. Failure of one of the VAC units on a car shall not adversely affect operation of the other unit. The Contractor shall submit calculations for the inside conditions with one VAC 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 protect 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 IP65 protection. The electric switches, contactors and relays etc. should be proven in Metro application. The cables shall be Halogen free compliant to BS6853 Category 1B in respect of flammability, smoke emission and Toxicity requirements.

14.6. VAC Control and Temperature Setting

- 14.6.1. The saloon temperature setting shall be controllable through both the TMS 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 shall be solid state. The controls for the two air conditions shall be coordinated such that as the cooling load reduces, the unit can be unload in stages from full to half capacity to one unit being shut off except for the ventilation blower.
- 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 TMS to enable diagnosis via the TMS or locally through a portable PC.
- 14.6.7. A pressure control panel shall be provided for each air conditioning unit, which shall be located for easy maintenance and containing pressure switches and gauges with refrigerant shut off valves to enable easy replacement.

- 14.6.8. High and low pressure cut-out devices shall be provided to shut down operation if the refrigerant pressure exceeds the preset 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.
- 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.
- 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 VAC 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 TMS.
- 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 TMS 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. In order to cope for cases where a defect makes it impossible to isolate the unit by network communication from the cab, facilities for cutting-out and resetting of a faulty air-conditioning unit should be provided in the car (protected from passenger access or vandalism).
- 14.6.19. High Pressure (HP) and Low Pressure (LP) statuses shall be monitored by TMS.
- 14.6.20. The single failure of an auxiliary power unit shall not lead to the loss of the 2 A/C units of a car.

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 shall be reported to TMS.

- (i) Compressor overload thermal cut-out.
- (ii) Ventilation blower failure.
- (iii) Saloon over-temperature (rising at 33°C). A sensor shall be provided in each return air grille.

14.7. Compressor/ Condenser Section

14.7.1. Compressor shall be scroll hermetic type of metro 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 IP65.

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 copper or aluminium fins mechanically crimped to the tubes.

14.7.6. The condenser fan(s) shall provide for adequate airflow over the coil(s) at the design condition. The fan(s) shall be direct driven by an AC induction motor (3ph) rated for continuous duty. In order to optimize power consumption, the adjustment of the air flow shall be possible to match with the actual cooling needs. At least one intermediate stage is required.

14.7.7. A sight glass in the liquid line shall be provided to allow for check of refrigerant level. In case of fully hermetic circuit type, a circuit without sight glass is acceptable.

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. The condenser and evaporator coils, including tubes and fins, shall be constructed from copper or copper tubes suitable coated.

14.7.9. A filter/dryer and a refrigerant flow sight glass and system moisture indicator shall be provided. In case of fully hermetic circuit type, a circuit without those devices is acceptable.

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 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 copper or aluminum 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. If a sight glass is fitted in the refrigerant liquid line, it shall be easily visible from the saloon area through an inspection hole or from the roof.
- 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 Engineer. 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.

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 with weight arrest of 80% as per ASHRAE Standard 52.1 and 2, 1992 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 Kolkata, the cleaning of the filters shall not be required before 5000 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 power from 110 Volt D.C. batteries, 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. The inverter shall be located in evaporator section of the unit.

14.15. Driver's Cab Air-conditioning

- 14.15.1. In order to improve driver comfort, each driving cabs shall be fitted with an independent air conditioning system (VAC).
- 14.15.2. The air conditioning system shall consist of cooling/heating units and a ventilation unit to ensure air renewal inside the cab.
- 14.15.3. The driver shall be able to adjust the system operating conditions within the cab via a 3-position switch:
 - (i) ventilation,
 - (ii) stop,
 - (iii) air conditioning.
- 14.15.4. The operating temperature is 25°C, 60% RH.
- 14.15.5. Vibrations and noise shall be limited.
- 14.15.6. Air heating system shall ensure the function of wind screen demister.

- 14.15.7. Ventilation is possible without the cooling device in service. Manual On-Off and two-speed controls shall be provided for fan operation.
- 14.15.8. The minimum volume of fresh air supplied by the artificial ventilation shall be in the range of 30m³/h and this air shall be filtered. In nominal regime debit of filtered air shall be approximately 400 m³/h to 600m³/h.
- 14.15.9. When the cooling function is activated, the air velocity shall not exceed of 1 m/s and shall vary progressively (EN 14750-1: Appendix B).
- 14.15.10. Stagnant water in the cooling device is prohibited.
- 14.15.11. Adjustable louvers and airflow control shall be provided. Louvers design shall prevent to produce the echo interference between the public address loudspeakers and cab microphone.
- 14.15.12. Other characteristics of the air conditioning system shall be compliant with relevant EN standard. The other requirement shall generally be same as for VAC units for passenger saloon cars.
- 14.15.13. The design shall ensure changing of filters from inside the cabs.
- 14.15.14. In case of failure of the air cab air conditioning unit, a ventilation system shall be provided for each cab supplying conditioned air from the main air duct to the cab.
- 14.15.15. The exhaust of the equipment ventilation discharging to the cab or saloon areas shall not be allowed if impacting the interior temperature distribution.

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.
- 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. 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.
- 15.1.4. TMS link shall be used to execute non-vital commands and controls of the train.
- 15.1.5. In addition, TMS link shall be used for the identified non-vital control functions through VDU interface. TMS link shall also be designed to provide back-up signals of certain identified vital commands.
- 15.1.6. The Contractor shall develop overall control logic for review of the Engineer. The proposed equipment shall be service proven and reliable and safe.

15.2. Train Control and Operational Principles

- 15.2.1. A modern ergonomically designed console located between the train driver's seat and the cab front end structure shall be equipped with vital train operation controls mainly master controller, back-up brake control, door controls, screens, indicators, push buttons etc... as approved by the Engineer. In addition to the above direct controls, an indirect access to miniature circuit breakers, fault indicator lights, sealed switches shall also be provided. The console shall also be provided with TMS, VDU and ATP/ATO displays.
- 15.2.2. 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.
- 15.2.3. The supply of the train control circuit shall have redundant and safety design when working in a 6 car metro train composition. 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.

- 15.2.4. 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.
- 15.2.5. 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) +25% -30% dc according to IEC 60077 1 and 2.
- 15.2.6. As a minimum the following functions shall required 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) Trainline integrity ;
 - (vi) Air gauge ;
 - (vii) Coupler control ;
 - (viii) Door safety relevant controls and indications ;
 - (ix) General fault indication for TMS indicated with one lamp on drivers cab;
 - (x) Parking brake control;
 - (xi) Master controller;
 - (xii) CCTV and PA / PIS
 - (xiii) Additional trainline circuits as required for train borne signalling and communications systems. Information shall be supplied and finalized at design stage.

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, TMS display, ATO, start, stop buttons, performance level selectors, 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 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.
- 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 Engineer. 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, coast and propulsion. The centre position for the master controller shall put the train in the 'COAST' 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 Tenderer may be as follows

MODE	FUNCTION
POWER	Continuous Control between minimum and maximum tractive effort
COAST	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)

- 15.3.8. The master control key switch shall be mechanically interlocked with the mode switch to ensure that removal of the master control key can only be achieved when the mode switch is in the "Off" or "Standby" position.
- 15.3.9. The controlling cab shall be the cab in which the mode selector switch is set in any other mode than an "Off" or "Standby"
- 15.3.10. The train shall become fully operational within 5 seconds when a controlling cab, which was previously in "Standby" mode has been activated
- 15.3.11. Interlocking shall be provided to ensure that if more than one controlling cab has been selected, the cab initially selected takes priority and ensure that the second controlling cab position shall be ignored by all sub-systems
- 15.3.12. The mode selector switch shall include the following switch positions.

REVERSE - The rake shall be capable of being driven manually, but shall be limited to a maximum permitted speed of 3 km/h in the reverse direction and limited to a distance of 10 metres

OFF - In this state the master control key shall be removable and the auxiliary supplies on the rake shall be switched off.

STANDBY - In this state the train shall be active once the master control key has been inserted and the mode switch turned to the unlock position and the auxiliary supplies are operating. The master control key shall be removable; with no effect on the operation of the auxiliary power supplies and the minimum of cab controls shall be available. In this state the train shall not be capable of motoring and the emergency brake shall be applied. The passenger door controls and other passenger facilities, such as communication, lighting and air conditioning shall be available.

AUTOMATIC - In this state the Train shall be capable of automatic operation under the control of the ATO. The passenger door controls shall be available. The maximum permitted speed shall be controlled by the ATP system. The departure push button which closes the PSD and train doors. The departure from station is given manually by the driver.

FORWARD - CODED MANUAL: The Train shall be capable of being driven manually in the forward direction up to the permitted speed by ATP, indicated visually in the cab on cab display.

FORWARD – RUNNING ON SIGHT (Main Lines): If the ATP function is not localized or it is not fully operational, the train shall be capable of being driven manually in the forward direction but shall be limited to a permitted speed of 25 km/h by the on-board ATP. When ATP signals from the track are received, this mode is automatically changes to Forward coded Manual.

FORWARD – RESTRICTED MANUAL MODE (Depot only): The Train shall be capable of being driven manually in the forward direction but shall be limited to a permitted speed of 10 to 25 km/h by the on-board ATP.

FORWARD – CUT-OUT MANUAL DEGRADED MODE: The Train shall be capable of being driven manually in the forward direction up to a speed limited by the traction control unit. The traction control unit shall activate the train emergency brake if the permitted speed is exceeded

- 15.3.13. A wash/coupling momentary illuminated pushbutton shall be provided, operable only at zero speed, which when held down moves the train forward at a maximum speed of 3 km/h for coupling purposes. The traction system shall regulate the tractive effort to ensure the permitted speed is not exceeded. This facility shall only be available when the train is in “Forward – cut-out manual degraded mode” and shall be referred to as WASH / COUPLING MODE.
- 15.3.14. Permitted mode changes that require a change in direction shall only be possible when the train is proved to be stationary by the ATP system or the traction equipment in the event of an ATP failure. Attempts to change direction when the train is in motion shall activate the emergency brake.
- 15.3.15. It shall not be possible to directly select “Automatic” mode from the “Reverse” position, or vice versa, without previously selecting all the other modes
- 15.3.16. The position of the Mode Selector Switch is monitored by the TMS.
- 15.3.17. The control console shall be arranged to allow access to all mechanisms by removal of a dust-proof cover.

15.4. Equipments Cabinets

- 15.4.1. Equipment cabinets shall be provided at the cab. Equipment cabinets shall include but not be limited to, the following:
 - (i) Auxiliary controls;
 - (ii) ATP, and ATS equipment (free issue by Signalling Contractor);
 - (iii) Passenger alarm indicator and audible warning;
 - (iv) Fault indicating and brake proving indicators;
 - (v) Public address, intercom, cab to cab communication;
 - (vi) Alarms;
 - (vii) Train Management System;
 - (viii) Passenger information display system.

Information shall be supplied and finalized at 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. The only exception is change from ATO to Supervisory Manual mode.

15.5. Brake Control

- 15.5.1. The brake command circuit shall be comprised of two systems i.e. emergency braking and service brake, which shall be functionally separate
- 15.5.2. Emergency braking circuit shall operate base 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 Engineer 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 not 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 that 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. Application of "deadman" device will cut off supply to the motoring circuit immediately.
- 15.5.9. The dead man safety device shall be monitored by 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 Chapter 24 - Interfaces document 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 Chapter 24 - Interfaces document 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 and Telecommunication 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 ceiling mounted antenna, and cab mounted loudspeakers, handsets, controls, ancillary radio communications equipment shall be supplied by the respective Contractors as per Chapter 24 - Interfaces.

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 side door and all cab side doors. These interlocks shall prevent the car from operating when any door is not closed and locked.
- 15.8.2. Door interlock cut-out shall be provided to enable operation of the train in yard manual mode.
- 15.8.3. Separate door operator and door enable train lines shall be provided for each side of the train. The contractor will submit the design to the engineer for approval.
- 15.8.4. Not used
- 15.8.5. The door unit shall be provided with fault monitor output and displayed in Train Management Systems (TMS).
- 15.8.6. 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.
- 15.8.7. 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 revenue service.
- 15.8.8. 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.
- 15.8.9. 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 driver or due to a signal point failure.
- 15.8.10. Operation of the passenger doors shall only be possible when the key switch is moved away from the "off" position.
- 15.8.11. 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.

- 15.8.12. The enable signals for the door control units are combined with the zero velocity signals. Only if Zero Speed is detected, the signal to enable the door control unit is issued by the ATC. In case of faulty ATC the Zero Speed transmission shall be decided by the Contractor.
- 15.8.13. The ATC Enable signals shall be transmitted through a dedicated interface control hardwired train line between the ATC system and the door control circuits.
- 15.8.14. 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:
- (i) When the key switch is moved to the "off" position, all saloon doors shall stay in the previous condition either opened or closed ;
 - (ii) 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 ;
 - (iii) Thereafter the door state shall follow the operation of the associated door control pushbutton of the active cab.

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 Management System (TMS) 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, in the cab, the positive confirmation of the response of the friction brake to a release of the 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 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 a 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.
- (vi) It shall be possible to operate one or both of the wipers in the operating cab.
- (vii) The wipers shall not obstruct the operator's vision when in the parked position. The wipers shall provide efficient operation at all train speeds and environmental conditions

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 Engineer. No air horn is allowed.

16. TRAIN MANAGEMENT SYSTEM (TMS)

16.1. General

- 16.1.1. The Train Management System (TMS) shall be a microprocessor based control system using the latest and proven technologies of semi-conductor, software and data communication to control and monitor the major train borne equipment, such as, the door, brake, propulsion, auxiliary, air conditioning systems etc..., through the network system.
- 16.1.2. The design of the TMS shall consider the train as a total complete system and the TMS shall provide a centralized function to control and monitor all its subsystems operation and fault status, fault data logging, incident investigation and reporting.
- 16.1.3. The TMS shall provide for real-time distributed control and modular processing of subsystems in a redundant manner with high reliability and availability.
- 16.1.4. The TMS shall function as an Event Recorder to record operating status of critical control circuits and components.
- 16.1.5. The TMS shall be designed to minimize the needs for individual train line wires and hardwires across couplers. The type of TMS transmission link to be used shall fibre optic cable may also be proposed as an alternative. These proposed links should be proven in a comparable operating environment.
- 16.1.6. The TMS shall be designed for ease of fault diagnosis and maintenance.
- 16.1.7. The network system shall be similar to LonWorks, TCN/MVB, or other equivalent and service proven communication system, compliant with IEC 61375-1 subject to the Employer's approval. It shall be composed by several transmission links used as "transmission support backbones" with specific functions according to their critical importance:
 - i. IP technology with Ethernet communication protocol or other similar and service proven technology subject to the Employer's approval.
 - ii. Hardware support for safety function.
 - iii. Multifunction Vehicle Bus (MVB) or similar and service proven technology subject to the Employer's approval for control command.
- 16.1.8. Obsolescence of the several transmission links using IP technology shall be anticipated by the Contractor to avoid regular retrofits.

16.2. TMS Architecture

- 16.2.1. The system shall be made up of subsystem processing nodes interconnected through a train data communication link. Both subsystems processing nodes shall be redundant to increase system reliability and availability. All communication protocols, architecture and data acquisition concepts shall be of the latest state of the art technology.
- 16.2.2. Diagnostic capability incorporated in the system shall detect node or line section failure rapidly to ensure no impairment of normal control and monitoring functions. The Tenderer shall submit proposed system architecture.
- 16.2.3. The TMS shall be of fault tolerant distributed control system architecture. A single point failure of any individual part shall not cause any adverse performance impact or loss of data.

- 16.2.4. The TMS shall be modular in functional design at all levels with at least 10% spare capacity for expansion.
- 16.2.5. The TMS unit shall incorporate built-in self-test diagnostic functions.
- 16.2.6. The hardware system shall conform to IEC 60571.
- 16.2.7. Data protocols and standards should be to international and railway industry standards. The Tenderer shall advise the proposed applicable standards, for review.
- 16.2.8. Contractor shall submit details of the communication protocols used in their design at different levels clearly indicating how the requirements of monitoring and control are complied with. Further details along with any hardware/software tools required shall be submitted during design stage.

16.3. Performances Requirements

- 16.3.1. From power up initialization of the train, the Train Communication Network (TCN) of TMS shall complete its initialization and start data transmission within 20 seconds. The Initialization of the TMS display shall take within 60 seconds. The Train Systems Initialization shall then be started to perform checking of the healthiness and correct functioning of all train borne systems, which shall be completed within 5 minutes.
- 16.3.2. Once power up initialization is completed; operation of the Train Communication Network shall not be interrupted by occupation status of either driving cab.
- 16.3.3. For the equipment status monitoring function, the total system response time from the change of equipment status to be shown up on the display unit shall not be greater than 0.5 second.
- 16.3.4. For train control purpose; the Train Communication Network shall be able to complete the data transmission of the train driver's command from the display terminal to the output port of the local process unit within 0.5 second.
- 16.3.5. Delays in displaying diagnosed fault message on the display unit following a failure of equipment under monitoring shall be less than 2 second.
- 16.3.6. Any failure of the TMS shall not affect the emergency performances specified in this document.
- 16.3.7. Proven train data communication links, which is immune to EMI and harmonics generated by traction equipments, will be provided between the cars. Suitable physical bus interfaces, to ensure error-free and high speed data transmission shall be provided.
- 16.3.8. TMS shall synchronize its clock with the system master clock through the ATP/ATO interface. All the microprocessor/ micro-controller based on-train systems shall synchronize respective clocks with TMS clock.

16.4. Train Operating Aids

- 16.4.1. General
 - (i) Real-time information including diagnostic results and fault logs shall be reported to the train driver.

- (ii) In order to avoid saturation of the Train Communication Network due to the vast volume of data transmission of the real time information, the minimum requirements of data managements as specified but not limited to shall be complied with.

16.4.2. Automatic System Monitoring and Information Display

- (i) The TMS shall be used to monitor and display the operation status of all train systems and display the essential information to the train driver through the display terminal. The Contractor shall submit the list of the proposed system and/or subsystems that are to be monitored and displayed by the TMS with their interface details.
- (ii) As a minimum requirement but not limited, the following information shall be displayed on the train driver display terminal :
 - 1 General operational information
 - Station Identity.
 - Destination.
 - Train number.
 - TMS system real time.
 - Driver's identification code.
 - 2 General train information.
 - Line voltage.
 - Line current.
 - Auxiliary equipment.
 - Saloon temperature.
 - Car loading.
 - Vehicle speed.
 - Operation of brake system.
 - Status of each door.
 - Status of traction.
 - Emergency alarm handles status from passenger area.
 - Status of the parking brake.
 - Status of lighting in the passenger area.
 - CCTV display.
 - 3 Passenger information (PA / PIS).
- (iii) The display shall also be integrated with the other screening function to provide specific information of other train borne systems, if available.

16.4.3. Automatic Fault Reporting and Recording

- (i) A diagnosis function shall be provided to ensure that unusual legitimate operations or genuine faults of train borne equipment are identified, logged, and, if appropriate, reported to the train driver and illuminate the general fault indicator for attention.
- (ii) Faults detected shall be classified into five criticality levels:
 - Critical Fault
 - Fault, which requires the immediate action/attention of the train driver, is classified as critical fault.

- Operating Event
 - Event, which is triggered by the train driver and requires the attention of the Operation Control Centre (OCC).
- Maintenance Event
 - Event, which requires the attention of the maintenance staff after the train, complete the scheduled service.
- Record
 - Maintenance record, which requires the attention of the maintenance staff during routine maintenance.
- Notice
 - Information or reminder to aid the train driver during normal service under defined conditions.

Based on the failure effect, the criticality level of each diagnosis requirements shall be designed and submitted.

(iii) The TMS shall respond according to the following table :

Critical level		Response of TMS			
		Request acknowledge (1)	Display fault (2)	Log in the memory (3)	Communication channel (4)
1	Critical fault	X	X	X	X
2	Operating event		X	X	X
3	Maintenance event				X
4	Record				X
5	Notice	X	X		

- (1) Request the train driver in the active cab to acknowledge the occurrence of the fault through the train driver display.
 - (2) Display the fault message in the current fault screen.
 - (3) Record the fault/event in the memory.
 - (4) Provide information via interface.
- (i) In addition to the classification of the fault message criticality level, the fault information shall be prioritized into two groups, namely, primary and secondary. For primary group of fault information, it shall include those safety critical systems, such as, automatic train control, current collector, traction and braking, doors, communication, ventilation and emergency lighting, whilst the other auxiliaries systems would be in the secondary group.
 - (ii) For fault information in the primary category, fault message shall be available at an interface to a communication channel to transmit the information via the communication channel to the OCC.
 - (iii) In order to facilitate incident investigation, an Event Recorder shall be provided by the TMS.

16.4.4. Defect Handling

Based on the capability of the individual train systems and the associated failure effect, faults detected shall be handled by the following three modes:

- (i) Automatic defect handling:
 - When a train system is reported faulty, it shall report to the TMS and automatically attempt to re-start.
 - For those system/equipment failure, which significantly affects normal passenger service, shall be managed automatically through the TMS and displayed to the train driver.
- (ii) Semi-automatic defect handling
 - When a train system is reported faulty, it shall report to the TMS and advise the train driver to re-start it through the display terminal.
 - For those system/equipment failure, which requires operation decision to be made by the train driver, shall be managed semi-automatically through the TMS and displayed to the train driver.
- (iii) Manual defect handling
 - When a train system is reported faulty, it shall report to the TMS and to advise the train driver how to re-start it remotely from the driving cab and/or locally in the concerned car.
 - For those system/equipment failure, which requires operation intervention to be made by the train driver, shall be managed manually and displayed to the train driver. In order to reduce the time for fault recovery, due consideration shall be given to ensure full automatic defect handling functions are provided as far as practicable.

Note: The TMS shall not intervene with safety related control function of the specific train system.

16.4.5. Diagnosis Rules

- (i) To facilitate the defect handling process, the Contractor shall provide a complete set of diagnosis rules for TMS to identify the faults and perform appropriate defect handling activities according to the operability requirements as specified.
- (ii) Each diagnosis rule shall have a time delay function to avoid spurious fault detection.
- (iii) A fault shall be detected only if the detection criteria have been satisfied for a pre-defined period of time.
- (iv) The pre-defined time delay shall be adjustable from 0 to 10 second with a minimum step of 500ms. The time delay shall be easily adjustable on-site by the maintainer.
- (v) An easy to program with password-protected software, which shall form part of the special tools and test equipment, shall be provided for the maintainer to modify the above diagnosis rules. The system shall provide 20 events as spare.

16.5. Equipment Control and Monitoring

16.5.1. General

- (i) In order to ensure the safety integrity of the train systems, the TMS shall not intervene with any safety related control function of the specific train system, such as, the door, traction and braking systems operation. The primary role of TMS shall be limited to reliably transmit the required data to and from the train systems.
- (ii) A testing function for system healthy check of the train borne equipment shall be provided for the train driver via the display terminal.

- (iii) A data management strategy shall be submitted to define the design concepts of what and how the equipment information will be displayed, fault data will report and recorded and defect will be handled.
- (iv) A detailed list of features proposed to be controlled through TMS shall be submitted in the technical proposal.

16.5.2. Traction and braking system

The TMS shall provide the following functions of:

- (i) Monitoring and recording the traction energy consumption on a car basis.
- (ii) Facilitating the train driver to initiate the traction test, any fault detected shall be logged and recorded by the TMS.
- (iii) Recording and displaying any fault status of the wheel slip/slide protection system.
- (iv) Recording and displaying any identified permanently locked axle.
- (v) Facilitating a remote isolation of the failed traction and dynamic brake function.
- (vi) Recording and displaying any brake rate deviation.
- (vii) Recording the accumulative mileage run of each car for maintenance scheduling.
- (viii) Recording and displaying the train speed on the TMS display terminal.
- (ix) Conveying all logical commands generated by the associated mode selector, traction brake controller, which are activated by the train driver into the associated hardwire train lines and transmit to the required circuits.
- (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 automatically logged into the Event Recorder for the train driver acknowledgement.
- (xi) Monitoring the integrity of the speed detection circuit and report when fault is detected.

16.5.3. Monitoring the control commands received from the ATO. The train system shall be operated through the TMS. For any illegal logic state i.e. this fault shall be automatically logged into the event recorder for the train driver acknowledgment. Door System

The TMS 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 ATO/ATP safety signals when the 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) Facilitate maintenance adjustment of train door operation profile parameters by using a monitor programmer at the local door control unit.
- (v) The TMS 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 are energized; the train system shall be responded. This fault shall be automatically logged into the Event Recorder for the train driver acknowledgment.

16.5.4. Air conditioning system

- (i) 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:

- Daily basis: it shall be possible for a preset period of time, such as, the non-traffic hours, all air conditioning units to be automatically shut down by the TMS until the starting period of traffic hours is reached, then all air conditioning units shall be re-started again.
- Seasonal basis. It shall be possible for a pre-defined period of months, the target saloon temperature setting to be regulated by the TMS.
- 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 TMS.
- All the above setting of time/periods shall be easily adjustable by the maintenance personnel via the TMS.
- The saloon temperature of each car shall be monitored in real time and reported to the TMS.
- 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 TMS.
- The TMS 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 has to react automatically. If there is no smoke outside the damper system has to be open.

16.5.5. Auxiliary Supply System

- (i) The TMS shall monitor the status of the auxiliary inverter and record any failure.
- (ii) The ac and dc supply shall be monitored by the TMS particularly the battery charger output.
- (iii) 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 TMS.

16.5.6. Suspension System

- (i) Passenger loading on a car basis shall be measured and fed back to the TMS in real time for the controls of train systems, such as, traction and braking systems.
- (ii) The TMS shall monitor the passenger loading feedback signal, the TMS shall record and display when any abnormal passenger loading is detected.

16.5.7. Pneumatic System

- (i) The run time and duty cycle of each air compressors of a train shall be recorded for maintenance scheduling.

16.5.8. Interface with Automatic Train Control System

- (i) The TMS shall interface with the Automatic Train Control (ATO/ATP) system in the active cab through the onboard communication network interface to exchange data with the ATO/ATP. Detailed information shall be provided.

16.5.9. Train Communication and Passenger Information:

- (i) Broadcasting of pre-recorded announcements shall be triggered by the real time information received via the interface with TMS.

- (ii) The Passenger Information System shall receive the required information from TMS to display.
- (iii) Any operation of the Emergency Intercom shall be report to the Event Recorder
- (iv) The healthiness status of Passenger Announcement and Passenger Information System shall be monitored.

16.6. Maintenance Support

16.6.1. Train Fault Record

- (i) The following information of conditions/parameters when a fault is detected shall also be recorded for the purpose of assisting failure investigation, they shall include but not limit to the following types:
 - Fault type.
 - Car type and number.
 - Date and time the fault is detected.
 - Station name.
 - Distance travelled.
 - Train speed.
 - Date and time the fault is cleared.
- (ii) In addition to the above train fault, the TMS shall be able to detect and record the significant variation of the critical train performance, such as, brake rate, door operating time and saloon temperature. Proposed detection scheme and type of performance variation to be recorded shall be submitted.
- (iii) The memory shall be capable of storing a minimum of 1000 faults data per car. Data recorded shall be retained for a minimum of 4 weeks with no external power supply present.
- (iv) Algorithms shall be provided to prevent the repeated detection and recording of a permanent failure on the train, which will unnecessarily occupy the memory space.
- (v) The fault shall be recorded based on a first-in-first-out principle, when the memory is full.

16.6.2. Portable maintenance terminal:

- (i) A portable maintenance terminal in the form of an IBM compatible portable PC shall be provided that enables a technician to configure the TMS.
- (ii) It shall also be able to upload/download the program and retrieve/view the fault log and the train data.
- (iii) The interface to the TMS shall employ latest state of the art technology communication.

16.6.3. The contractor shall provide equipments and means to enable remote wireless downloading of all the stored TMS data.

16.6.4. A minimum of ten notebook computers, together with all associated accessories and software necessary for all diagnostic functions for all train-borne equipment shall be provided. These shall be duly equipped with remote wireless access features with TMS. Two copies in approved non-volatile memory, of all the software uploaded in the notebook computers shall also be provided, separately.

16.7. Event Recorder Function

- 16.7.1. An events recording function in the TMS, with a minimum capacity of 10 hours and a minimum of 32 channels continuous recording at a sampling rate of 1 sample per 500 ms, shall be provided.
- 16.7.2. This function shall monitor and flag any operation of critical function, such as, emergency brake applied by the train driver via the activation of emergency stop push buttons or dead-man switch, emergency door. In addition, any abnormal operation shall be recorded including wrong side saloon door operation. Detailed monitoring arrangement shall be agreed with the Engineer.
- 16.7.3. The event recording function shall incorporate playback function for signals recorded and shall be equipped with diagnostic software for analyzing the recorded data.
- 16.7.4. The memory module used for the storage of data shall be removable to allow playback.
- 16.7.5. The location of the memory module used for the storage of data shall be carefully selected in order to ensure that all recorded data is protected from loss due to vibration, shock and impact force in the event of train collision.
- 16.7.6. The memory module shall be able to withstand a shock of 5g in the direction of travel without any loss of the data.
- 16.7.7. The data recorded on the memory module shall be well protected and facilities shall be provided to prevent:
 - (i) Unauthorized access and the accidental erasure of the recorded data.
 - (ii) Removal of the memory module from the train by unauthorized person.
- 16.7.8. The data shall be read out of the memory.
- 16.7.9. All extracted data shall be compatible with the operating system of MS WINDOWS and its standard application programs like EXCEL.
- 16.7.10. The TMS shall have sufficient capacity to retain information for a period of 120 minutes or more 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.
- 16.7.11. The recorded data within any period of time shall be retrieved from the recorded data without ambiguity.
- 16.7.12. Data recorded shall be non-volatile type in the event of loss of train power supply and retained for a minimum of 4 weeks with no external power supply present.

16.8. Man-Machine Interface (MMI) Requirements

- 16.8.1. General
 - (i) The purpose of MMI is to achieve effective, efficient and safe train control through integration of the train driver into the train control system.
 - (ii) The train driver shall be provided with one or several display unit, touch screen type, inside the driving cab in order to inter-react with the TMS.
 - (iii) On MMI, graphical display shall be used for easy and quick understanding of the fault and status. If required, clearly assigned hard keys around the screen shall be used.
 - (iv) The fault or conditions to be displayed shall be grouped together for easy viewing, such as doors, brake, auxiliary power system, traction, air conditioner and Passenger Information System. Detailed arrangement shall be approved by the Engineer.

16.8.2. Display Terminal

The display terminal shall be provided with an input device, such as, key pad or touch screen, so that the TMS is able to:

- (i) Receive display control command (for example, brightness setting, selection of page/menu), and
- (ii) Receive TMS control command (for example, air-conditioning temperature setting) from the train driver.

16.8.3. Control Requirements

- (i) As long as the dc circuit is started up, the display control functions of the train driver display terminal shall be remained operative irrespective of the state of the driving mode.
- (ii) Once the driving mode is being selected, the control functions of the train driver display terminal of the active driving cab end shall be remained operative. In the non-active cab end, only the display control functions of the train driver display terminal shall be operative.
- (iii) If it is attempted to select a driving mode at both cabs apart from the shutdown mode, only the display control function of the train driver display terminal shall be available at both cab ends.

16.8.4. MMI Proposal

- (i) The proposed MMI shall be submitted in the form of a detailed description document.
- (ii) The program shall be run on PC operating under MS Windows.

17. COMMUNICATION SYSTEM

17.1. Train Communication Equipment

- 17.1.1. Train borne communication equipment shall be provided on the train which shall be an integrated system of audio and data communication between the passenger and train driver.
- 17.1.2. The Signalling and Telecommunications Contractor shall supply at the Rolling Stock Contractor's factory pre-wired equipment racks with appropriate connectors for all wiring terminating inside the metro train.
- 17.1.3. The Rolling Stock Contractor is required to interface and co-ordinate with the Signalling and Telecommunications Contractor in accordance with Volume 3: Employer's Requirements – Technical Specifications (Chapter 24: Appendix D-Interfaces).
- 17.1.4. The following on-train communications requirements shall be provided:
 - (i) Two-way Communication between the Operations Control Centre (OCC)/ Backup control centre (BCC) and train driver, via train radio equipment (Supplied by S&T Contractor).
 - (ii) Cab-to-Cab communication.
 - (iii) Emergency passenger announcements on the train by OCC/BCC via train radio system (Supplied by S&T Contractor).
 - (iv) Means for the train driver to address passengers throughout the train from the driving and non-driving cab.
 - (v) Facilities to permit simplex conversation between a passenger who has operated a passenger alarm device, and the train driver.
 - (vi) Facilities for simplex conversation between occupants of driving cabs in two coupled trains.
 - (vii) An automatic voice announcement system.
 - (viii) A passenger information display system.
 - (ix) Chime when doors are closing and opening.
 - (x) Passenger saloon surveillance system using CCTV camera.
 - (xi) Complete tools for configuring route /station data, announcements, messages & fonts and interface of the system with other sub systems etc. shall be supplied. It shall be possible for the engineer to configure the PIS/PSSS software for implementing operational & maintenance related modifications.
 - (xii) 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 but not restricted to flow charts (for complete software), signal flows, and interpretation of signal etc. shall be provided. Engineer shall be fully trained and made fully conversant by the contractor for this purpose.
 - (xiii) Network Video Recording System (NVRs) - Video Analytics software enabled.

17.2. OCC to Train driver and On-Train Public Address Communication Link

- 17.2.1. A Train-to-OCC radio communications link (supplied by the S&T Contractor) shall be provided to enable:
- (i) Voice communication between the OCC/BCC and passengers, and between the OCC and the train driver.
 - (ii) Vehicle health data communication from TMS to OCC/BCC at designated times and locations. The data required to be transferred from the train to the OCC/BCC shall be finalised by the Contractor at the preliminary design stage and submitted for review by the Engineer.
 - (iii) The S&T Contractor shall furnish the Rolling Stock Contractor with the interface required between the train radio system & the On-board TMS for recording initiation, termination and success or failure of the emergency calls initiated by the train driver and/or OCC on the radio. The hardware interface shall be furnished & installed by the Rolling Stock contractor. Levels and protocols shall be agreed between the two Contractors.
 - (iv) A radio control head, which shall be integrated with the driving console, shall be supplied by S&T Contractor.
 - (v) Voice shall have priority over data communication.
 - (vi) When the OCC/BCC to passenger communication occurs, any other system set at that time shall be overridden.
- 17.2.2. A suitable interface shall be provided by the Contractor to enable the OCC/BCC -to-Passengers announcements to be transmitted over the train public address system.
- 17.2.3. Adequate space and reliable battery backed power supply shall be provided to S&T Contractor for the on-board radio system.

17.3. DVAS and PAS

17.3.1. General

- (i) The Rolling Stock Contractor shall install the DVAS (Automatic Digital Voice Announcement) and PAS (Public Address System) 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 according to the division of responsibilities initially defined in chapter 24.7.
- (iii) The Rolling Stock Contractor shall provide accommodation including mountings, equipment cabinets and cable access for installation of all the DVAS and PAS equipment.
- (iv) The Rolling Stock Contractor shall include in his supply, a portable maintenance terminal able to modify/add any pre-recorded announcements in the Digital Voice Announcement Unit.

17.3.2. The DVAS and PAS 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.
- (ii) The following equipment, as a minimum, in each car:

- 8 loudspeakers.
 - 4 Emergency Intercom units.
- (iii) The following equipment, as a minimum, in each 6-car metro train:
- A Digital Voice Announcement Unit (DVAU).
 - A Public Address Unit with Public Address amplifier.
 - A dc Voltage Regulator Unit.
- 17.3.3. The following modes of communication shall be provided by the DVAS and PAS :
- (i) Public Address System (PAS) to passengers including:
 - Radio broadcasting in which traffic controller in OCC/BCC can make live announcements to all passengers via Train Radio.
 - Broadcasting of pre-recorded announcements based on real time information received via the interface with TMS.
 - (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/BCC 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 17.1

Driving Cab	Public Address System (PAS)	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 System, 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 17.2

Priority	Communication Mode
1	PAS – Manual Broadcasting by train driver
2	Cab-to-Cab Intercom
3	Cab-to-OCC/BCC Intercom
4	Passenger Alarm system
5	PAS – Radio Broadcasting by train traffic controller
6	PAS – Broadcasting of pre-recorded announcements based on real time information received via interface with TMS

- 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; except Cab-to-Cab intercom or the Cab-to-OCC/BCC intercom which shall not interrupt the PAS - broadcasting of pre-recorded announcements (priority 6).

- 17.3.7. The DVAS and PAS 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 DVAS and PAS equipment shall not be affected by the driving cab EMI environment. All DVAS and PAS equipment shall conform to the EMC requirements.
- 17.3.9. The DVAS and PAS 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 TMS via the interface unit.
- 17.3.10. The DVAS and PAS 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 PAS 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.
- 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 DVAS and PAS system to the train radio equipment shall be designed to enable the traffic controller in OCC/BCC 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/BCC, 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 PAS system and shall cater for the requirements of a six car metro train composition.
- 17.3.17. Power amplifiers are required for the PAS 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. When automatic level adjustment is at its minimum, the sound pressure level measured at 1.5 metres above floor in each zone shall be not less than 70 dB(A). Ambient noise monitoring shall ensure PAS output 10 dB(A) higher than the ambient noise level in all zones. Full details shall be submitted for review by the Engineer.

- 17.3.19. The PAS 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.
- 17.3.20. The public address amplifiers shall be protected against short circuit at the outputs of the amplifier.
- 17.3.21. 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.

17.4. 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 DVAS and PAS shall store, select and broadcast all the required messages for the East-West Line.
- 17.4.3. There shall be three types of pre-recorded announcements in either the Hindi, English and Bengali languages or a combination of two or three of languages stored in the DVAS :
- Door messages for all stations, for example “Please stand clear of the doors”
 - Station messages for particular stations, for example “The next station is Central Park etc.”
 - 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”.
 - 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:
- Reception of real time station information via the TMS interface and messages shall be automatically broadcast.
 - The operation of the ‘Door Open’ button for door message for door opening.
 - The operation of the ‘Door Close’ button for door message for door closing.
- 17.4.5. All the special and emergency messages shall be selected and initiated by the train driver via TMS. 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 DVAS in the corresponding textual format. Synchronization of audio and textual announcements (in Hindi, English, Bengali) shall be achieved such that the message broadcast (either triggered by the train driver or by ATO/ATP via TMS) by the DVAS and PAS 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. This audio and textual announcement synchronization feature shall be able to be deactivated via the portable maintenance terminal.

- 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 TMS 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 Hindi, Bengali and English shall also be displayed. This message information shall be displayed from power to be made available from Auxiliary Inverter or battery.
- 17.4.9. On selecting the correct line and starting station message via the TMS display, the train driver shall be able to initiate the broadcasting of the correct station message via the TMS. After the announcement, the selected message shall be automatically switched to the next station message ready for the next station broadcasting. The sequence and control shall take into account of the turn-around of trains at all the terminus stations.
- 17.4.10. Real time information including the name of the next station, door opening side and the destination of train shall be received via the TMS interface from the train borne ATO/ATP equipment. Based on these information received, correct station messages shall be automatically selected and broadcast.
- 17.4.11. 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 TMS mode, where messages are triggered by driver over TMS.
- 17.4.12. Via the TMS 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 Voice Announcement System shall be fully integrated with the On-train PAS system. Any failure of component which can adversely affect functionality shall be logged by the system itself and also be communicated to TMS for reporting to the train driver and data logging. Full details shall be submitted for review by the Engineer
 - (ii) The pre-determined messages (voice announcements and text messages) shall be automatically triggered by train events and / or the ATP/ATO system to make an announcement. Close liaison is required between the Contractor and the Signalling Contractors in this regard. Full details shall be submitted for review by the Engineer.
 - (iii) One monitor repeater shall be provided in each cab.
 - (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 Voice Announcement System shall also allow the display and announcement of computer generated messages. The Contractor shall provide equipment and means to achieve this by Engineer's maintenance personnel.
 - (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 Engineer.

- (vii) A door close announcement followed by a chime shall be triggered each time the "Door Close Announcement" button is pressed. The door close chime shall continue to 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.
- (viii) It is proposed to provide commercial / general audio and/or visual messages in between the announcements. The system shall be capable of playing / displaying of such advertisements. Details shall be submitted for review by the Engineer.
- (ix) One device shall be provided in each cab which shall be on hot standby. In case of failure of the identified master, the device at the other cab shall automatically become master. The device shall be operable from the train driver's cab.
- (x) 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 Hindi, English and Bengali languages. Messages shall be recorded in the voice of professionals Announcers to be approved by the Engineer. The hardware and dedicated software etc. for editing and modifying the speech and route database shall be handed over to KMRCL at an appropriate time, during the Contract period, to be decided during the design stage. The Engineer's staff shall be associated during the editing activity. Messages shall be digitally stored.
- (xi) 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.
- (xii) The system shall be capable of storing 120 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 Engineer.
 - Door and station message: 90 min.
 - Special message : 15 min.
 - Emergency message : 15 min.
- (xiii) The stored messages of the DVAS shall be delivered naturally in speech tones and shall meet the following performance :
 - Bandwidth : 300 – 7000 Hz (-3dB).
 - Distortion at 1 kHz : < 1%.
 - Dynamic range : 80 dB minimum.
- (xiv) The DVAS shall not at any time generate any incorrect message and shall not interfere with station PAS broadcasts under any circumstances.
- (xv) A portable maintenance terminal in the form of an IBM compatible portable PC shall be provided that enables a technician to customize the DVAS and manage the stored messages. The interface to the DVAS 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 DVAS. The location of the interface port shall be readily accessible.
- (xvi) The following functions shall be provided as a minimum:

- System configuration and programming.
- Fault diagnosis of the DVAS.
- Downloading/uploading of digitized messages via state of art 01 interface with the IBM compatible PC.
- The recorded messages in three different languages of Hindi, English and Bengali shall be provided.
- The digital voice recording file shall be .WAV, MP3 or other approved format.

17.6. Cab to Cab Intercom

- 17.6.1. In the cab-to-cab mode, the train driver shall be able to communicate with a person at the other end of the train or with the train driver of a train coupled to this train (e.g. to undertake a push-out). Two way communications shall be established in this mode.
- 17.6.2. The train driver on either driving cab shall be able to initiate the Cab-to-Cab Intercom function.
- 17.6.3. The Cab-to-Cab Intercom shall only be established when one of the mode selector (master key switch) is moved away from the shutdown position.
- 17.6.4. The Cab-to-Cab communication system shall be able to operate independently of, and simultaneously with, automatic announcements and with the passenger alarm system operative.
- 17.6.5. Simplex mode operation between two trains while in proximity shall be possible, via OCC/BCC on the radio communication system (supplied by S&T Contractor).
- 17.6.6. The Contractor shall submit procedure for review by the Engineer.

17.7. Emergency Intercom

- 17.7.1. An Emergency Intercom system consisting of four Emergency Intercom units per car, including microphones, loud-speakers and alarm buttons shall be provided. The ceiling mounted loudspeakers shall enable the train driver to alert the passengers in emergency case.
- 17.7.2. When a passenger alarm device is operated, a warning sonic device shall sound in the cab, an indication shall be given to the train driver of the location of the operated device, views from surveillance cameras provided near the location of activated PEA shall be displayed in the monitors inside cab and a visual indication on the exterior of the car shall advise station staff which is the affected car.
- 17.7.3. The train driver shall acknowledge the alarm by operation of an override device, which shall terminate the cab sonic alarm, and simultaneously cause an indicator to illuminate at the emergency device location.
- 17.7.4. Passenger communication shall be train driver 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 driver and the passenger.
- 17.7.5. In case that more than one Emergency Intercom Units have been activated, the list of activated units shall be displayed and the train driver can talk back to the passenger Emergency unit in the sequence the events occurred.

- 17.7.6. Any operation of the Emergency Intercom system shall be reported to the Event Recorder via the interface with TMS.
- 17.7.7. Whilst the communications system is in the passenger alarm mode, it shall be possible for the train driver to move between passenger alarm, OCC/BCC, PA and Cab-to-Cab communication.
- 17.7.8. In the event that the train driver fails to acknowledge a passenger alarm call, within a specified time, the call shall be logged by TMS. TMS 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 driver.
 - Once the doors have been opened, it shall not be possible to restart the train until all the passenger alarms have been reset. Once this has occurred the system shall revert to its normal form of operation.
 - Screened cable pairs of fire survival type shall be provided for the passenger alarm system.
- 17.7.9. Under no circumstances shall cab-to-cab conversation or train driver to OCC/BCC conversation be relayed to any passenger.
- 17.7.10. Full details shall be submitted for review by the Engineer.

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
- (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 :

- Sound Pressure Level
- 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 dB±1 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.
- Differential Sound Pressure Level
- The Sound Pressure Level between maximum and minimum along the length of each saloon measured as in (1) above shall not be greater than 3 dB within each saloon.
- Bandwidth: 50 Hz to 7 kHz (-3 dB)
- Total Harmonic Distortion: less than 1% at 1 kHz at rated output.
- Signal to noise ratio: greater than 60 dB.
- Hum level: -80 dB at full rated output.

17.8.5. Interface Description

An interface shall provide the following interfaces with TMS, EIDS and Train Radio:

- (i) An interface with TMS shall be provided to allow:
 - the transfer of system status, message displayed in the EIDS display boards;
 - the receipt of ATO/ATP information;
 - the receipt of door open/close status;
 - the reporting of activated Emergency Intercom button as stipulated.
- (ii) An interface with EIDS shall be provided to allow :
 - the transfer of route, station and message information;
 - reception of message displayed in the EIDS display boards and EIDS 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 DVAS and PA system for broadcasting the PA message to the passengers by the Train Radio.

17.9. Passenger Information Display System (PIDS)

17.9.1. General

- (i) The passenger information system (PIS) shall comprise of the below two sub-systems:
 - Electronic Information Display (EID),
 - Electronic Destination Display (EDD)
- (ii) For each car several EIDs per car shall be provided. The general arrangements of these displays shall be submitted.
- (iii) For each driving cab, one EDD shall be provided behind operator cabs' wind screen.
- (iv) EID and EDD shall be capable of displaying the requisite information in Hindi, Bengali and English language.

- (v) All passenger information displays shall comply with IDA and shall consist of a minimum of 15 characters at least 60 mm.
 - (vi) Passenger information displays using LED technology shall comply with IDA and shall consist of a minimum of 15 characters at least 60 mm and LCD TFT based displays shall be sufficiently flexible to be able to display letters.
- 17.9.2. Location of all the displays shall be reviewed during preliminary design review.
- 17.9.3. Interface with TMS. The PIS shall meet the following interface requirement with the TMS :
- (i) To transmit and receive the required information from TMS.
 - (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) The display shall be readable in direct sunlight or complete darkness and all degree of light in between. The screens shall be glare free or equipped with shading composition.
 - (v) The horizontal and vertical readable viewing angles shall be minimum of 120degree.
 - (vi) During the normal circumstances, the station code shall be updated according to the station information provided by the ATO/ATP system. In the event that the data transmission link between the ATO/ATP system and the TMS fails, this fault shall be reported to the train driver and the TMS shall automatically perform the update of the station codes according to the following sequential control logic:
 - the train speed is decreased to 0 km/h; and
 - the passenger doors of the train has been commanded to open and close once, then
 - the station code of the next station shall be updated and displayed in the EIDS according to the system routes specified.
- 17.9.4. The following control functions shall be provided for PIS to facilitate the train driver control;
- (i) to remotely power on or off of the display boards of the PIS;
 - (ii) to manually change the name of route and names of next and destination stations through the TMS; and
 - (iii) to manually reset the PIS to the default state for re-initialization purpose.
- 17.9.5. 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 TMS.
- 17.9.6. Electronic Information Display System (EIDS)
- (i) Performance Requirements:
 - The EIDS display shall be able to display the passenger information of two types of data, namely, operation and commercial.
 - The location and number of the display units is proposed by the Rolling Stock Contractor taking into consideration the need for all-round good visibility by passengers within the saloon. The Rolling Stock Contractor shall submit proposal, including diagrammatic representation of the angle of visibility of the display units.
 - Advertisements, messages

(ii) Display Control Unit (DCU):

- The Display Control Unit (DCU) is the main control part of the whole train borne EIDS. DCU shall control display sequences of messages, interface with different systems and manage all the EIDS Display Panels.
- DCU shall decode data received from all interfacing systems using an error detection and correction protocol.
- Diagnostic function shall be provided to check the status of the DCU. The self-diagnostic function shall be performed automatically by DCU. The diagnostic result shall be sent to TMS.
- Automatic Digital Voice Announcement System (DVAS and PA)
 1. DCU shall interface with the TMS, DVAS and PA to obtain information of door status, next station, pre-recorded DVAS and PA message codes to display next station name, pre-recorded A and PA text message in parallel with the audible announcement from DVAS and PA.
 2. DCU shall transmit the corresponding station name or station code to instruct the display.

(iii) Electrical Requirement of DCU:

- DCU shall be supplied by 110V dc, +25% -30%.

(iv) Mechanical Requirement of DCU:

- A metallic case shall be used as enclosure for all components of the DCU. The enclosure case shall be sealed to IEC 60529 IP41.

17.9.7. Electronic Information Display (EID)

LCD / TFT and LED screens shall be provided to display the required information in form of animated graphics and text.

(i) Electrical Requirement of EID:

- The EID shall be equipped with a highly efficient and reliable internal power supply converter to supply power for control and displaying functions.
- The noise power level generated by the converter shall be limited below 30dB in the audible frequency ranged from 20Hz to 20 kHz.

(ii) Mechanical Requirement of EID

- 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 LCD 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.

17.9.8. Electronic Destination Display (EDD)

Several solutions may be proposed by the Tenderer using modern and well proven technology as screens composed by separate graphical windows.

- (i) The EDD shall be able to display the destinations, train number and special messages. Nature of the messages shall be decided during the preliminary design studies.
- (ii) The colour and the character size of the display shall be designed to achieve the required visibility by the train drivers and the passengers, and also to match with the overall aesthetic design of the cab front.
- (iii) The characters of EDD shall be legible from the station platform on either side of the train at a minimum distance of 50 m ahead of the train and at an angle of up to 45 degree, by a person with normal eyesight.
- (iv) The EDD shall be legible in direct sunlight when the train is running in open section, and in artificial light and darkness in underground section.
- (v) There shall be no escape of light from the backside of the EDD into the cab.
- (vi) No incorrect information shall be shown by the EDD. The display shall be switched off if any fault is detected in the EDD.
- (vii) Mechanical Requirements:
 - The EDD completed with the power supply shall be designed in modular form to minimize the cable connections.
 - The protective glass or equivalent shall be provided to prevent any damage from heat and sunlight (colour fading), and shall not affect the colour quality of the display.
 - The method of mounting the EDD behind the windscreen in the driving cab shall allow easy installation and removal. All the cable connections to EDD shall be of plug and socket type, and the female connector shall be mounted on the car body side. Removal and installation of one EDD shall be easily by maintenance staff.
- (viii) Electrical Requirements:
 - The power supply for the EDD shall be taken from the dc output of the auxiliary inverter system. The supply shall be available when either one of the auxiliary inverter set is running.
 - Suitably rated MCB shall be provided.
- (ix) Provision for Future Expansion:
 - The software of the EDD shall be designed to allow new destinations to be incorporated easily by the KMRCL. The memory shall be sufficient to store up to 100 destinations and 20 messages. Details shall be defined during design stage.
 - Hardware and software tool shall be provided to carry out the change. The required software change shall be carried out with IBM compatible computer equipment.
 - The Contractor shall provide all the necessary detailed instructions and special equipment to enable the Engineer to reprogram the unit to incorporate the new destinations.

17.10. CCTV System

17.10.1. The video communication system includes the following:

- (i) IP based CCTV system with IP cameras: Four internal fixed cameras per car shall be considered.

- (ii) Network Video Recorder System (NVRs): It shall include video analytics software. The contractor shall provide sufficient storage medium to archive minimum 7 days of stored recording of all on board cameras. The operator shall be able to retrieve, monitor and playback images from the system without affecting any of the recording functions.
- (iii) Each camera shall be enclosed at 4CIF (25 frames per second) with dual stream capability such that the viewing & recording at different resolutions & frames per second are possible in MPEG4 or better standard.

17.11. Internal/External Cameras

- 17.11.1. The Passenger Saloon Surveillance System (PSSS) shall comprise of a close circuit television (CCTV) network using surveillance cameras, routers and cables, monitors and other accessories.
- 17.11.2. Each car shall be provided with at least four surveillance camera devices at appropriate location to cover the maximum passenger saloon area and ensuring complete surveillance of each emergency door egress device in that saloon. The camera shall be suitably selected in respect of resolution, clarity of images, illumination conditions for on-train applications and shall be of proven design. Mounting of camera shall be unobtrusive, flushed with, or recessed into the interior panel.
- 17.11.3. Each operator cab shall be provided with one monitor screen of appropriate size. It shall be so placed in the cab that normally it does not cause distraction to the train driver but it shall be easily viewable by the train driver when needed.
- 17.11.4. Under normal operation, the views gathered from each of the camera located in the train shall be sequentially played in the monitor screens of both the cabs. Adequate controls shall be provided for necessary surveillance requirements and priorities.
- 17.11.5. In case of activation of 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 driver shall be able to select any other camera, as required.
- 17.11.6. Not Used
- 17.11.7. Full details shall be submitted for Engineer's review.
- 17.11.8. For the exterior platform passenger observation system, two camera shall be installed on the exterior of each side of the driver car near the operator's cab to observe the movement of passengers on the platforms at the station stops and safe position of doors before starting.
- 17.11.9. All recording shall have the associated camera unique identifier time and date information stamped and super imposed onto the video image. Facilities to recover any recordings using time and/or location request shall be implemented.

17.12. Interfaces

- 17.12.1. Appropriate interfacing with TMS shall be developed to carry out the abovementioned functionality. The interface shall include provision of single point downloading the data logs stored in the memory of all train based Communication Equipment using TMS interface.
- 17.12.2. See Volume 3: Employer's Requirements – Technical Specifications, Chapter 24–Clause 24.7 for full details of the division of responsibility between the Rolling Stock Contractor and Signalling Contractors.

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 Engineer / 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 Engineer, 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 Engineer 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.

18.5. Corrosion Protection

- 18.5.1. The Contractor shall address corrosion protection in the design review process, and intergraded into the maintenance manual.
- 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. Closed or inaccessible areas made of materials susceptible to corrosion, shall be internally covered with an adequate corrosion protection coating immediately after completion of fabrication.
- 18.5.4. 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. Fittings mounted on car body shall be adequately locked to prevent loosening in service. Under frame equipment mountings shall be able to withstand, without deformation, to cater shocks and vibrations, as per IEC 61373. Mounting arrangement bolts should not be under tension.
- 18.6.2. Items and equipment on the Bogie frame and axle box including their mountings shall be designed to withstand the forces associated with the acceleration according to CEN standards TC 256 WY13 Annex or equivalent standards.
- 18.6.3. ALL under-slung equipments should be mounted and fastened such that NO connecting bolts should be in tension.

18.7. Interchange-ability

- 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 Engineer, 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, which will be replaced or interchanged frequently among different locations after maintenance work. At the request of the Engineer, the Contractor shall provide demonstration on any specified equipment to show 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 Engineer considers such devices inadequate, the Contractor shall provide a non-interchangeable design to eliminate the risk of incorrect installations.
- 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 interchangeability 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 be considered priority to adopt stainless steel. Proprietary makes of high tensile or other types of screw may be used unprotected provided the Engineer 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 Engineer.
- 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 Engineer. 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. Screw threads shall be of ISO metric sizes.

18.8.23. All steel fasteners used in electrical equipment and/or exterior applications shall be of stainless steel, hot dip galvanised or cadmium plated.

18.8.24. Jointing of Aluminium:

- (i) Riveting of aluminium 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.

18.8.25. 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 Engineer 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 Engineer.
- (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 Engineer 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 Engineer 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 Engineer 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 other International 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 car body 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 (a), (b), and (c), 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, BS 8118 or other international standards) and the relevant fatigue load cases from the car Particular Specification, greater than 0.7 or in accordance with the agreed welding standard.
- (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 to the following either AWS Standards or

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 Engineer 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 Hindi, English and Bengali 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 Hindi, English and Bengali to be confirmed during design stage.
- 18.10.13. Submission: the Contractor shall submit the design of equipment identification labels during design stage.

18.11. Mountings and Enclosures

18.11.1. General:

- (i) 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 the front face of all equipment when mounted to the vehicle in the saloon area shall be sealed to IEC 60529 IP54. The remaining sides of the enclosure case shall be sealed to IEC 60529 IP20 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, such as cooling fan, traction or inverter inductor, and transformers 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 Engineer 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 (IP65).

- (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. 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.

18.11.9. Openings:

- (i) 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.

18.11.10. Roof Mounted Equipment:

- (i) 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.

18.11.11. Outside Mounted Equipment:

- (i) 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: Not Used

18.12.3. Rubbers:

- (i) Synthetic rubber, conforming to International Standards, shall be used for components exposed to sunlight or lubricants during Operation & Maintenance.

18.12.4. Fibreglass Reinforced Plastics:

- (i) Fibreglass reinforced plastics (FRP) may be used for non-structural parts, and applications as accepted by the Engineer. They shall be manufactured to an approved process and satisfy the flammability, toxicity and smoke generation limitations of BS 6853:1999, or the latest equivalent internationally accepted standard.

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.
- (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. Cables shall all comply EN 50264 or other international standards like approved by the Engineer. All cables should be of Copper material. Aluminium conductor is not allowed.

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 shall be fire resistant cables.

18.13.4. The system adapted 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 preferably 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 Engineer in design stage. For S&T control cable connections between equipment smaller cable sizes may be used as per the S&T system requirements.

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 Engineer.

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 cable terminations shall be of the crimped type and soldered connections shall not be used.

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:

- (i) Maker, Maker's Mark and Type Number.
- (ii) Cable size and stranding for which the cable lug is suitable.

18.14.6. The Engineer 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, are exempt from this requirement provided that the appropriate manufacturer's data sheets are submitted for information to the Engineer.
- 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 Engineer 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:

- (i) 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 Engineer 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 Engineer.

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 Engineer. 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:

- (i) 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 other terminals. All safety circuit cables shall be coloured yellow.

- (ii) The Engineer 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:

- (i) 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 labeled 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 Engineer 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. DELETED

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 Engineer 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 Engineer 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 color 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.
- 18.19.13. All jumper connections outside the car ready to be protected from dust and water. It must be IP65 compliance.

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 Engineer.

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 Engineer 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 Engineer 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 Engineer 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:

- (i) 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:

- (i) 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. However, the dry heat test temperature shall be for temperature up to **80°C** as against **70°C** specified in IEC/EN. LCD display units may be tested into **70°C**.

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.

- 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.
- 18.25.7. The Contractor shall furnish the following information in respect of printed circuit boards as a part of contract:
- (i) Voltage and/or waveform expected at each critical test point.
 - (ii) Instructions for carrying out testing and troubleshooting and the function of each circuit block.
 - (iii) Component layout of the printed circuit boards and assemblies.
 - (iv) Connection or interfacing diagrams for the printed circuit boards and assemblies.

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, with at least two levels of documentation above the source code level.
- 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 Engineer in design stage.
- 18.27.3. The Contractor shall submit his Software Quality Plan for review by the Engineer 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 Engineer 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 Engineer.

- 18.27.5. Sufficient software documentation shall be provided to give the Engineer 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.

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. Tenderers 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. Printed circuit board extenders shall be provided for test purposes.

"The Contractor shall provide detailed maintenance and troubleshooting procedures, including wave-forms at critical locations of the circuitry."

- 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 Engineer, 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 Engineer 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. Painted surfaces in the underframe shall have a service life of at least 15 years.
- 18.30.2. 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.

19. RAMS: Reliability, Availability, Maintainability, Safety

19.1. Reliability, Availability and Maintainability: General

- 19.1.1. The Contractor shall submit Reliability, Availability and Maintainability Management Plan as specified in 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.
- 19.1.2. The Contractor shall comply with the guidelines of IEC 60300-1, IEC 60300-2 and IEC 60571 for electronic equipment, and IEC 60300-3-5 in meeting the reliability, availability and maintainability requirements of equipment.

19.2. Reliability Requirements

- 19.2.1. Kolkata Metro Rail Corporation 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.
- 19.2.2. The Contractor shall demonstrate by quantitative methods achievement of the specified levels of reliability for the train and specific individual items of equipment.
- 19.2.3. An evolving reliability model consisting of reliability block diagrams and probability of success equations shall be developed and submitted to the Engineer 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.
- 19.2.4. Reliability apportionment and prediction analysis shall be in accordance with established techniques or standards, which will be submitted for acceptance by the Engineer. The analysis shall provide predictions for each major equipment and sub-system. Predictions shall be based on actual revenue service results for identical equipment operating under service conditions and duty cycles equivalent to KMRCL, 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.
- 19.2.5. Reliability Apportionment and Prediction Report shall be completed prior to build commencing and reports shall be submitted at this stage for acceptance by the Engineer, who reserves the right to require the Contractor to carry out field data collection to verify the reliability model.
- 19.2.6. Definitions :
 - (i) 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 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 Engineer these are attributable to rolling stock. The decision of the Engineer shall be final.

- (ii) 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 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.
- (iii) Service Failure: Any relevant failure or combination of relevant failures during revenue service operations, simulated revenue operations, or during pre-departure equipment status checkouts to determine availability for revenue service, which results in one of the following:
 - Non-availability of the train to start revenue service after successful completion of pre-departure checkout;
 - Withdrawal of the train from revenue services;
 - A delay equivalent to or exceeding 3 minutes.

The discretion of declaring a metro train as Not-available to start revenue service after successful completion of pre-departure checkout or withdrawing a train from revenue service on account of any relevant failure rests solely with the Employer and shall be final.
- (iv) 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 percentage predicted rate shall be as under:
 - (a) three or more relevant Service Failures of the same replaceable part, item or equipment in same manner in identical or equivalent applications occur at a rate which is at least 20 % higher than the predicted failure rate of the part, item or equipment and / or
 - (b) at least 20 % of the same replaceable part, item or equipment in the fleet has a relevant failure in the same manner in identical or equivalent applications during a moving 18 months window starting when the reliability demonstration starts and ending at the end of the Defect Liability Period, these failures will be classed as pattern failures.
- (v) Mean Distance Between Failure (MDBF): The MDBF is the ratio of the total operating distance accumulated by the total available fleet of the trains to the total number of Service Failures
- (vi) Mean Distance Between Component Failures (MDBCF): The MDBCF of a system is the ratio of the total operating distance accumulated by the total population of identical items in the available fleet of the trains to the total number of Service failures occurring within the population identical items.

19.2.7. Reliability Targets:

- (i) Reliability shall be monitored for the respective fleet for 6-car metro trains.
- (ii) The fleet average levels of MDBF, as specified in table 19.1, shall be achieved.

Table 19.1: Reliability Targets

Duration	Minimum fleet average MDBF
	6-Car fleet
After 6 months of start of revenue service	60,000
After 12 months of start of revenue service	100,000

Any train shall be counted as available for reliability calculations only after a stabilization period of 6 months after putting the train into revenue service.

- (iii) The achieved level of MDBCF of major systems shall be as proposed by the Contractor in the bid. The Tenderer shall submit MDBCF of the major systems as listed in table 19.2 along with the bid.

Table 19.2: MDBCF of major systems

S.N	System / Equipment	MDBCF (km)
(i)	Propulsion System	
	a) Shoe collectors	
	b) HSCB and Earthing switch	
	c) Traction Inverter	
	d) Traction Motor	
(ii)	Auxiliary Supply System	
	a) Auxiliary Converter	
	b) Battery Charger	
	c) Back-up Batteries	
(iii)	Air Supply and Friction Brake Equipment	
(iv)	Door System and Controls	
(v)	VAC 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)	DMS	

19.3. Reliability Demonstration

- 19.3.1. The Contractor shall be required to establish a personal computer based Failure Reporting and Corrective Action (FRACAS) System to demonstrate compliance with specified train and equipment reliability. The reliability demonstration of each train shall start after six months of that train in revenue service and shall continue till the end of the defects liability period. Reliability of the trains and of the identified major systems shall be demonstrated on fleet basis.
- 19.3.2. The Employer shall collect and maintain data on every Service Failure along with the TMS data indicating the probable failure. MDBF and MDBCF shall be calculated throughout the monitoring period. The Contractor shall collect all the relevant details from the Engineer and submit monthly Reliability Demonstration Reports.
- 19.3.3. In case the Contractor is not able to achieve specified/provided reliability target of MDBF/MDBCF, the Contractor shall take necessary corrective measures either by way of change of design of the relevant equipment/ component or software modification.
- 19.3.4. The Contractor shall analyze each and every failure/defect of components of various equipments to determine the cause of failure and to propose corrective measures, which would be reviewed by the Engineer.
- 19.3.5. A record shall be maintained for each and every defect/failure in accordance with FRACAS to be submitted by the Contractor and approved by the Engineer.
- 19.3.6. Reliability shall be monitored during revenue service operation of the trains. The Contractor shall collect and collate data on each and every deficiency and failure observed by both himself and the Engineer, from handing over the first train to the end of the Defect Liability Period. Each and every failure, whether of component, sub-system or system, during this period shall be subject to a failure analysis to determine the cause of failure? The Contractor shall submit investigation reports for review of the Engineer.
- 19.3.7. Correction shall be made to components or subsystems that either fail to attain predicted reliability levels or show Pattern Failure, at no additional cost to the Employer.

19.4. Availability Requirements

- 19.4.1. Availability shall be assessed by the following measure:

$$\text{Percentage Availability} = \left[\frac{1 - [DT(OPM) + DT(CM)]}{TotalTime} \right] \times 100$$

Where:

- (i) Total Time is the time in hours in the assessment period multiplied by the number of trains commissioned under the Contract.
- (ii) DT (OPM), or Down Time due to Other Preventive Maintenance, is the total down time in hours due to Preventive Maintenance other than service checks, summed over all sessions carried out on all trains commissioned under the Contract during the assessment period. The trains shall not be due for major overhauls at the time of demonstration and shall therefore be excluded from the assessment.
- (iii) DT (CM), or Down Time due to Corrective Maintenance, is the total down time in hours due to corrective maintenance, summed over all sessions carried out on the trains commissioned under the Contract during the assessment period. Any unreasonable delay in handing-over the train for repairs for reasons not attributable to

contractor shall be excluded. Time spent on train integrity inspections after train reformations arising from corrective maintenance work shall be included.

- (iv) The down time DT (OPM) shall be counted starting from the moment when the train becomes unfit for service or work is physically started on a train, whichever is earlier, and shall end when the train is restored to service condition. If the train is withdrawn from revenue service specially for preventive maintenance, time spent on withdrawing the train and sending back the train to revenue service, if any, shall also be included.
- (v) Down time DT (CM) shall be counted starting from the moment when the train becomes unfit for service or work is physically started on a train, whichever is earlier, and shall end when the train is restored to service condition. If the train is sent to revenue service after the corrective maintenance, the time spent on sending back the train to revenue service, if any, shall also be included.
- (vi) The down times DT (OPM) and DT (CM) shall also cover the full content of the maintenance work concerned, including safety precautions, inspections, servicing, replacement of equipment, defect detection and rectification, testing and restoration to service condition.

19.4.2. Availability Target: the trains supplied shall achieve a minimum availability of 95%.

19.5. Availability Demonstration

19.5.1. The average availability of the trains shall be assessed after 18 months from the start of revenue operation with the first train supplied under the contract, in a specified train Maintenance Depot. The total maintenance down times for all trains shall be collected by the Engineer on monthly basis, and the average availability during the preceding six months, shall be worked out from the above formula.

19.5.2. In the event that the availability target is not achieved due to Rolling Stock, the determination of availability achievement in the preceding six month period shall be continued at monthly intervals until the target is achieved.

19.5.3. In the event that the availability target is not achieved, the Contractor shall, at his own expense, take whatever action is deemed necessary to meet the availability requirement.

19.6. Maintainability Requirements

19.6.1. 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.

19.6.2. 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.

19.6.3. Those components, systems and assemblies which require routine maintenance, frequent attention or unit replacement, shall be easily accessible for in situ maintenance.

19.6.4. The Contractor shall develop a comprehensive maintenance programme for the trains.

19.6.5. 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.

- 19.6.6. 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.
- 19.6.7. 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 the ratio of cumulative time, including the access time expended during a time interval to the total number of relevant failures.
- 19.6.8. The objective of the maintainability program including corrective and preventive maintenance shall provide for:
- (i) Enhancement of Vehicle availability.
 - (ii) Minimisation of maintenance cost.
 - (iii) Minimisation of vehicle down time.
- 19.6.9. During the design stage, the Contractor shall furnish a list of Least Replaceable Units (LRU's) for the equipments, 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 tenderers 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.
- 19.6.10. The Tenderer shall submit the expected MTTR of the identified key systems as listed in table 19.6, along with the bid.

Table 19.6: MTTR of major systems

S.N	System / Equipment	MTTR (hours) Target
(i)	Propulsion System	2.5
	a) Third rail current collector	1.5
	b) HSCB & Earthing switch	2.5
	c) Power Converter – Inverter	3.0
	d) Traction Motor	3.0
(ii)	Auxiliary Supply System	1.7
	a) Auxiliary Converter	2.0
	b) Battery Charger	2.0
	c) Back-up Batteries	1.0
(iii)	Air Supply and Friction Brake Equipment	2.0
(iv)	Door System and Controls	1.2
(v)	VAC System	1.5
(vi)	Communication System	1.2
(vii)	Couplers and Draft Gear	2.2
	a) Automatic couplers	2.2

S.N	System / Equipment	MTTR (hours) Target
	b) Semi permanent couplers	2.0
(viii)	Bogies	2.0
	a) Drive gear and coupling	2.0
	b) Primary suspension	2.0
	c) Mechanical Parts & Components	2.0
	d) Secondary suspension	2.0
(ix)	Lighting System	1.0
(x)	DMS	1.5

19.7. Maintainability Demonstration

- 19.7.1. The Contractor shall carry out tests to demonstrate that all maintainability predictions provided are met. All such tests shall be completed within six months after the delivery of first train. In the event that any maintainability target is not achieved, the Contractor shall at his own expense take whatever action is deemed necessary to meet the maintainability targets.
- 19.7.2. The Contractor shall ensure that all the required information including the related Maintenance Work Instructions (MWI) etc. are available before the commissioning of the first train into revenue service to enable him to demonstrate the maintainability targets.

19.8. Vehicle Maintenance Program

- 19.8.1. The Contractor shall submit to the Engineer a maintenance program, within the period specified in the delivery schedule, in order to reach the reliability and availability level defined in the performance requirements.
- 19.8.2. During the design stage, the Contractor shall submit downtime and manpower requirements for the maintenance inspections and service checks considered necessary for maintaining the trains under normal operational conditions as per table 19.7. The service check sessions shall include all routine maintenance activities including inspections, cleaning, washing, pest and rodent control etc.

Table 19.7: Maintenance Inspections and Service checks

Session	Interval (Minimum)	Manpower and downtime requirements (Maximum)	
		Downtime	Expected staff (man days)
Service Check 1			
Service Check 2, if any			
Service Check 3, if any			
.....			
Service Check n, if any			

- 19.8.3. The Contractor shall also submit periodicity, downtime and manpower requirements for the maintenance activities as listed in table 19.8, for maintaining the trains under normal operational conditions, during the design stage.
- 19.8.4. For achieving lowest operation and maintenance costs, the metro trains shall be designed according to the following criteria:
- (i) Design for a life cycle of at least 35 years
 - (ii) Main mid life overhaul after 15 years
 - (iii) Interval for Revision / main inspection of traction and brake equipment and other safety relevant equipment about 500 000 km

Table 19.8: Maintenance Activities

Type of activity	Frequency (days or km)	Expected staff (man days)	Downtime	Specific tools required
A				
B				
C				
...				
Half-life overhaul				

- 19.8.5. The Corrective Maintenance time as indicated above shall include defect identification, replacement of defective LRUs and restoration to service condition
- 19.8.6. For all the life of the metro train, this plan shall include also :
- (i) maintenance concept (schedule, type of operation...),
 - (ii) maintenance documentation,
 - (iii) labour and infrastructure means,
 - (iv) tools and workshop equipment,
 - (v) spare parts (including wearing parts),
- 19.8.7. 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 Engineer.
- 19.8.8. Special tools shall be avoided wherever possible. If they are required, they shall be supplied by the Contractor in sufficient quantities to meet the maintenance requirements.
- 19.8.9. Equipment design shall be modular to minimise 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. Equipment covers shall be provided with secure, visible, latching arrangements for easy inspection from the side of trains
- 19.8.10. All under frame 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 under frame dimensions. All under frame equipment shall be arranged such that it is capable of being removed and replaced without disturbing any other equipment.

- 19.8.11. 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.
- 19.8.12. Removal and re-assembly of moving and wearing parts on bogies shall generally be carried out without the use of special tools.
- 19.8.13. 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. 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.
- 19.8.14. 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.
- 19.8.15. Lubrication points shall have button head type grease nipples, and shall be easily accessible from rail level and shall, where possible, be grouped together.
- 19.8.16. 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.
- 19.8.17. Should the electronic equipment be found to be faulty, the equipment shall enable fault finding to be carried out at module level.
- 19.8.18. 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.
- 19.8.19. 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.
- 19.8.20. Equipment to which access will be required for faultfinding shall be conveniently located. A list of such equipments and their location shall be supplied.
- 19.8.21. 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.
- 19.8.22. It shall be physically impossible for plug and socket connections and connections on safety-critical circuits to be mismatched.
- 19.8.23. The unit shall have standard test points on pneumatic systems. There shall be unrestricted access to facilitate checks during routine maintenance and fault diagnosis.
- 19.8.24. The above mentioned features shall be suitable reflected in the respective design documents, as applicable, during the design stage.

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 Engineer as specified in the Engineer'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 minimising 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 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.
- 19.9.5. During the Design Review process, the Contractor shall submit analyses for Engineer 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.

19.10. Hazard Analysis report

- 19.10.1. Safety performance shall be assessed by the Risk levels of individual hazards identified during the System Assurance process.
- 19.10.2. 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.
- 19.10.3. The Contractor shall take lead role in the interface Hazard Analysis for train borne equipment provided by other contractors.

- 19.10.4. 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.
- 19.10.5. 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 Engineer 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)
- 19.10.6. 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.
- 19.10.7. 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) VAC System.
 - (ix) Pneumatic System.
 - (x) Communication System.
 - (xi) HV and Propulsion System.
 - (xii) Auxiliary Power System.
 - (xiii) Control equipment.
 - (xiv) TMS.
- 19.10.8. All hazard resolution by procedural control shall be cross-referenced from the Critical and Catastrophic Items List to the appropriate manuals.
- 19.10.9. 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 30 days of Notice to Proceed(NTP) and the Preliminary Hazard Analysis shall be submitted within 6 months of Notice to Proceed(NTP). 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.

19.10.10. 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.

19.10.11. The following targets norms shall be employed for the Fault Tree Analysis These norms are subject to review by the Engineer 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.

19.10.12. Source of all failure rates employed to be indicated in the Hazard Analysis.

19.10.13. All hazard analyses submitted to the Engineer are to be standardized by the Contractor such that format and forms employed by all sub-contractors are the same.

19.11. Fire Safety Analysis Report

19.11.1. The Contractor shall prepare a Fire Safety analysis report for review and acceptance by the Engineer as required in chapter 3 of the Employer's Requirements - General Specification. Materials used in the cars shall conform to fire safety requirements of BS 6853: 1999 and NF F 16 101, NF F 16 102 or the latest edition of other equivalent international standards, subject to the acceptance of the Engineer.

19.11.2. Whichever Standard is selected for meeting the Fire Safety Criteria, then that standard shall be declared, and once accepted by the Engineer, its requirements shall be met consistently throughout.

20. INSPECTIONS, TESTS AND COMMISSIONING

20.1. General

- 20.1.1. The contractor shall furnish inspection, testing and commissioning plan and programs as prescribed in the Employer's requirements - General Specification (Chapter-4).
- 20.1.2. All the tests shall be carried out at the Contractor's cost, wherever performed, in the presence of and to the satisfaction of the Engineer, who reserves the right to witness any or all of the tests and to require submission of any or all test specifications and reports.
- 20.1.3. 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 Engineer, shall be devised.
- 20.1.4. 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 Engineer for review with the valid certificate from approved international agency for that particular system. The waiver of Type Test is entirely at the discretion of the Engineer.
- 20.1.5. The Engineer 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. Engineer may if considered necessary may call for conducting optional tests as per relevant standards without any additional cost to the Employer.
- 20.1.6. The results of all tests shall be submitted to the Engineer, who will record his conclusions as to whether or not the equipment being tested has passed satisfactorily.
- 20.1.7. Repeated rejections, at either the Contractor's or a sub-contractors' facilities, shall be cause for the Engineer to suspend inspection. In such case, the work in question shall also be suspended until satisfactory corrective action is taken by the Contractor.
- 20.1.8. 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 Engineer.

20.2. Test Procedure

- 20.2.1. 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:
 - (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.

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

- 20.2.2. As defined in the Employer requirements –General Specification (Chapter-4), following tests shall be conducted.

20.3. Obligatory Tests on Pilot Metro Train

- 20.3.1. The Pilot 6-car metro train shall be supplied as per the delivery schedule.
- 20.3.2. Clearance of the Pilot Metro Trains will be granted, only after successful completion of tests at the nominated place by the manufacturer, to the entire satisfaction of the Engineer. Should any modification/ alteration based on results of the tests on the pilot be required, contractor will be obliged to carry out necessary modifications at no additional charge on all trains.
- 20.3.3. The Contractor shall manufacture and supply complete six car train duly equipped with test and measuring equipment/measuring wheel and sensors, for carrying out the following tests, in addition to those specified in IEC 61133 or an accepted International Standard, on respective lines.
- 20.3.4. For introduction of a Rolling stock in revenue service, tests are required to confirm that the design meets all the specified safety and statutory requirements and the train is fit for revenue service.
- 20.3.5. The Metro Trains the KMRCL designated route shall satisfy the following maximum values:
- (i) Maximum R.I. for both vertical & lateral modes in inflated conditions = 2.5
 - (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 $\Delta Q/Q$ as per clause 10.2.10
 - (vi) Derailment coefficient < 1
 - (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.
 - (ix) Measurement of lateral forces on curves shall be carried out using measuring wheel to establish bogie performances as per clause 10.2.4

Note: The RI calculations will be done as per Para 2.1 of ORE –Report C116 using FFT method (Fast Fourier Transform method).

- 20.3.6. The oscillation trial 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 60 km/h for deflated conditions. Tests can be discontinued at lower speed if unsafe conditions are observed.
- 20.3.7. The test 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.

- 20.3.8. The performance of each type of car will be separately evaluated.
- 20.3.9. Besides the above statutory test following investigation test to confirm the safe behaviour of the coach will also be carried out
- (i) Measurement of natural frequency in Bouncing, pitching and
 - (ii) Rolling modes using a wedge of 18mm (Investigation test).
 - (iii) Bogie Rotational resistance (x-factor).
 - (iv) Damping Factors.
 - (v) Braking Distance Test.

Table 20.3 – The Limiting Values:

S. No.	Term	Conditions	Acceptable Value
1.	Damping factor (under tare 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.	To be determined in co-ordination with System Contractor.

- 20.3.10. KMRCL intends to appoint an independent and authorized certifier of Rolling Stock to supervise the trials and certifying the fitment of coaches for inductions in revenue service. The Engineer will also witness the trial
- 20.3.11. The instrumentation requirements and the manner of conducting the test etc will be decided by him jointly with the contractor and approved by the Engineer. The Contractor shall provide full instrumentation for this purpose.

20.4. Integrated Testing and Commissioning

- 20.4.1. 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 Engineer, the Contractor shall carry out all tests necessary to verify the functioning of his system with those of other Designated Contractors. These tests shall be carried out in various phases and for different sections, as the work progresses.
- 20.4.2. Tests and test procedures shall be submitted by the Contractor for acceptance by the Engineer or as required by him.
- 20.4.3. 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 Telecommunications

- (ii) Telecommunication
- (iii) Third rail Equipment
- (iv) Civil Constructions for underground sections
- (v) Track works
- (vi) Station Construction
- (vii) Depot Equipment Supply

20.4.4. 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 Engineer before the commencement of service trials.

20.4.5. On completion of the integrated testing and Commissioning, to the satisfaction of the Engineer the Contractor shall confirm in writing to the Engineer that the rolling stock provided by him is suitable for the purpose of service trials.

20.5. Service Trials

20.5.1. The pilot metro train and subsequent metro 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.

20.5.2. Service Trials for the Pilot Metro Train shall be carried out for a minimum of 2500 km and for other trains 750 km.

20.5.3. 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.

20.5.4. During the Service Trial period, the Contractor shall make the train set completely fit for introduction in revenue service.

20.5.5. 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.

20.5.6. During the pre-revenue operations, the Contractor and designated contractors will run trains subject to constraints of the ongoing construction activities.

20.5.7. Trains shall be inducted into 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.

20.5.8. Upon completion of Service trials the Contractor shall submit a statement confirming that the rolling stock is safe and ready for commencement of revenue service.

20.6. Special Tests

20.6.1. 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.

20.7. Vehicle Body Shell Tests

- 20.7.1. 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 chapter 6.10, as type test.
- 20.7.2. 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.
- 20.7.3. 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.
- 20.7.4. 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.
- 20.7.5. The strength of couplers and draught gear shall be carried out in accordance with international practice, also as a type test.
- 20.7.6. The car body shall also be subjected to a vertical deflection test. All side doors, including the cab side doors, on one side of the car shall be installed, complete with drive mechanisms, and all sealing and weather-stripping.
- 20.7.7. 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.
- 20.7.8. One shell out of every 4 bare shells, to be randomly selected by the Engineer, shall be subjected to water tightness test as per an agreed procedure based on IEC 61133.
- 20.7.9. For the floor, fire test as 9.10.9 TS, noise suppression test and endurance tests shall be carried out by the Contractor to establish the performance.

20.8. Bogie Tests

- 20.8.1. The bogie frame shall be subject to static as well as fatigue tests in accordance with UIC 515-4 for DT car bogie and UIC 615-4 for M car bogie, with the design load as specified in Chapter 10. This shall be a type test.
- 20.8.2. Tests for clearances in the bogie, and between bogie and body shall be carried out on straight track as a routine test.
- 20.8.3. Tests for clearances in the bogie, and between bogie and body shall also be carried out by rotating the bogie to simulate a 100 m radius curve. This shall be a type test.
- 20.8.4. 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.
- 20.8.5. A load deflection test and accelerated ageing tests shall be performed to demonstrate that the spring rate of the primary and secondary suspension system and the creep rate for the materials used are within the design limits.
- 20.8.6. These tests shall prove that the primary and secondary 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.

20.8.7. Wheel disc and axle shall be subjected to type tests and routine tests as per UIC standards 812 and 811.

20.8.8. Gear box and coupling shall be type tested as per clause 10.9.4.

20.9. Passenger Saloon Door, Type Tests

20.9.1. The body side doors shall be tested for strength as required in Chapter 8, for relevant parameters which are required to be met.

20.9.2. 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

20.9.3. Vibration test shall be carried out as defined in IEC 61373.

20.10. Passenger Saloon Door, Routine Tests

20.10.1. 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.

20.11. Seats

20.11.1. 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.

20.12. Cab Side Door and Saloon to Cab Door Type tests

20.12.1. The Pilot Metro Train Cab Side door and 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.

20.13. Air compressor and Motor Test

20.13.1. 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.

20.13.2. 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.

20.13.3. 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.

20.14. Brake Equipment Type Tests

20.14.1. Disc 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 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.

20.14.2. 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, Axle disc brake) under dry and wet conditions, maximum temperature attained during braking, rate of wear etc. as per UIC Standard.

20.14.3. 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.

20.15. Complete Brake System, Type Tests

20.15.1. A complete set of brake equipment comprising all items of equipment forming the Brake System shall be assembled. These shall include the Brake Controller and interface with ATO equipment and a transceiver to measure force at the callipers 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.

20.15.2. 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 Engineer.

20.15.3. 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 and wet rail conditions. The Contractor shall submit detailed Test Procedure for review by the Engineer.

20.15.4. The Pilot Metro Train shall be used for carrying out emergency braking distance trials under tare and loaded conditions of the train as per IEC 61133.

20.15.5. The contractor shall obtain clearance from CRS (Commissioner of Railway Safety)/CMRS after successful test and trial on safety standards.

20.16. Complete Brake System, Routine Tests

20.16.1. All reservoirs shall be tested to an appropriate international pressure vessel standard and necessary test certificates shall be provided from a recognised test agency.

20.17. Propulsion System Type Tests

20.17.1. 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 TMS 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.

20.17.2. 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.

20.18. Auxiliary Systems, Type Test

20.18.1. 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.

20.18.2. Type tests shall be carried out on the lighting system including performances.

20.18.3. 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.

20.19. TMS Type Test

20.19.1. The Contractor shall perform tests on the TMS system to verify designed capacity of the systems, functional requirements and correct interfaces. The real interface hardware and software should be used where possible.

20.20. Roof Mounted VAC Package Unit Type Tests

20.20.1. The following tests shall be carried out at the manufacture's works or a reputed testing laboratory on the Pilot Metro Train unit in the presence of the Engineer.

- (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 20.1)

Table 20.1 VAC unit test criteria:

Weather Conditions	External temperatures	Internal Conditions
Summer	Dry Bulb 35.2°C Wet Bulb 26.°C	Dry Bulb 25°C 60 % RH
Monsoon	Dry Bulb 28°C Wet Bulb 26°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 VAC unit at 100% cooling at ambient temperature up to 55°C. and the pressure should not exceed 2850 kpa. High pressure trip setting may be adjusted accordingly.

20.20.2. The power input to the module, as well as to each of the motors shall be recorded.

20.20.3. Insulation Resistance Test: insulation resistance tests under all weather conditions shall be undertaken on all equipment, in the following conditions :

- below 300 volts: Minimum 2 megaohms at 500V d.c.
- equal or above 300 volts: Minimum 5 megaohms at 1kV d.c

20.20.4. Dielectric Test: the equipment shall withstand a high potential difference of 2kV for a duration of one minute.

20.20.5. Vibration and Shock Tests: this test shall be done as per IEC 61373.

20.20.6. EMC Test: EMC test shall be carried out in accordance with EN 50121-3-2 : 2000 on one unit

20.20.7. Testing of Emergency Inverter: the Emergency Inverter unit shall be tested in accordance with IEC 61287 and IEC 61373.

20.20.8. 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.

20.21. Complete Car VAC System Type Tests

20.21.1. 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.

20.21.2. The extent of such test shall be decided by the Engineer , 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.

20.22. Car VAC System Routine Tests

20.22.1. Every VAC package unit shall be subjected to routine test at the manufacturer's works as given below:

- (i) Dimensional & Visual inspection.
- (ii) Conditioned air-delivery test.
- (iii) Fresh air quantity test.
- (iv) Measurement of power.
- (v) Electrical test.

20.23. Rescue Operation

20.23.1. After delivery of two trains, the ability of one healthy train to rescue a disabled train shall be tested.

20.24. Noise and Vibration, Verification

20.24.1. The Contractor shall perform noise and vibration type tests on complete 6 car metro trains to demonstrate compliance this document. All test procedures, data and results shall be submitted to the Engineer for acceptance.

20.25. Fire Performance Verification

20.25.1. Type tests according to the relevant 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 Engineer at his sole discretion.

20.26. System Safety Verification Tests

20.26.1. 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.

20.26.2. 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;

20.27. EMC Testing

- 20.27.1. The Contractor shall perform measurements to demonstrate EMC requirements specified in this document et seq. have been achieved. Demonstration of EMC compliance shall be considered a type test requirement.

20.28. Testing with Signalling and Telecommunications Contractors

- 20.28.1. Integrated testing of each car shall comply with the accepted international standards agreed between the Contractors as agreed with the Engineer. Integration testing shall be done at the rolling stock factory and main line to ensure satisfactory performance of all train control and telecommunications interfaces. The test certificate subsequently shall be issued jointly by the Rolling Stock, Signalling and Telecommunications Contractors.
- 20.28.2. In case of ATO, the Integration test between the Rolling Stock, and Signalling and Telecommunications Contractors shall include tests on mainline to confirm the realisation of demanded acceleration and deceleration rate by the ATO under various conditions.

20.29. Car Weight:

- 20.29.1. 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 5%. In addition, bogies of Pilot Metro Train. i.e. DTC and MC each shall be weighed separately. Certified weight tickets shall be submitted to the Engineer and copies thereof included in the car record book. Vehicle weight balance in tare condition shall follow the requirements of IEC 61133".

21. 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 KMRCL, 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 Engineer'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 21.1 to 21.11.
- 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 Engineer 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 21.1 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 aluminium and aluminium-alloy die forgings, hand forgings, and rolled ring forgings

Table 21.2 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	1006	Methods of test for colour fastness of textiles and leather
BS	1571 : Pt. 2 1992	Methods for Simplified Acceptance Testing of Air Compressors and Exhausters: Part 2: Simplified testing of reciprocating and rotating types, including permissible deviations pressure and temperature measurements and arrangement of tests, form of test report and gives adjustment of test result to guarantee conditions.
BS	2618	Specification for electric traction equipment
BS	3100	To be checked

Standard Organization	Standard Reference Number	Title or Description of the Standard
BS	4568-1 1987	Specification for steel conduit and fittings with metric threads of ISO form for electrical installations - steel conduit, bends and couplers
BS	4579	To be checked if existing
BS	5000 part 11 2005	Machines électriques rotatives de types particuliers ou pour applications particulières - spécification - partie 11: moteurs et génératrices électriques de faible puissance
BS	6853 1999	Code of Practice for Fire Precautions in the Design and Construction of Railway Passenger Rolling Stock. Gives advice on the choice and testing of materials for use in the interiors of passenger rolling stock, includes advice on the provision of fire barriers, and on the means of achieving safe evacuation from a train on fire.
BS	7608 1995	Code of practice for fatigue design and assessment of steel structures
BS	7671 2001	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

Table 21.3 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 21.4 German Standards / Deutsches Institut für Normung

Standard Organisation	Standard Reference Number	Title or Description of the Standard
DIN	2353 : 1998	Compression fittings and couplings
DIN	5510 1/2/4/5/6	Preventive fire protection in railway vehicles
DIN	6700 1 to 6	Welding of railways vehicles
DIN	7500-1 2007	Case hardened and tempered thread rolling screws for metric iso thread - part 1: types, designation, requirements
DIN	7500-2 1984	Thread rolling screws for iso metric thread; guideline values for hole diameters
DIN	53387	Testing of plastics and elastomers; artificial weathering or exposure to filtered xenonarc radiation

Table 21.5 Euro Norms

Standard Organisation	Standard Reference Number	Title or Description of the Standard
EN	3-7	Portable Fire Extinguishers
EN	286 1	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 1994	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	287-1 : 2006	qualification test of welders - fusion welding - part 1: steels
EN	288-9	Specification and approval of welding procedures for metallic materials - welding procedure test for pipeline welding on land and offshore site butt welding of transmission pipelines
EN	571-1 1997	Non-destructive testing - penetrant testing - general principles
EN	573 1/2/3/5 2004	Aluminium and aluminium alloys - chemical composition and form of wrought products
EN	755-1 to 9 1997	Aluminium and aluminium alloys
EN	779 2002	Particulate air filters for general ventilation - determination of the filtration performance
EN	895 1995	Destructive tests on welds in metallic materials - transverse tensile test
EN	970	Non-destructive examination of fusion welds - visual examination
EN	1011-1 2003	Welding - recommendations for welding of metallic materials - part 1: general guidance for arc welding
EN	1011-2 2003	Welding - recommendations for welding of metallic materials - part 2: arc welding of ferritic steels
EN	1011-4 2003	Welding - recommendations for welding of metallic materials - part 4: arc welding of aluminium and aluminium alloys
EN ISO	1234 1997	Split pins
EN	1435 2003	Non-destructive testing of welds - radiographic testing of welded joints
EN	1714	Non-destructive testing of welds - ultrasonic testing of welded joints
EN	10025-1 to 5 2004	Hot rolled products of structural steels - corrosion resistance
EN	10293 2005	steel castings for general engineering uses
EN	10210 2006	Hot Finished Structural Hollow Sections of Non-Alloy and Finer Grain Structural Steels.

Standard Organisation	Standard Reference Number	Title or Description of the Standard
EN	12663	Structural requirements for Railway Vehicle Bodies“.
EN	12681 2003	Founding - radiographic examination
EN	13103 2001	Railway applications - wheelsets and bogies - non-powered axles - design method
EN	13104 2001	Railway applications - wheelsets and bogies - powered axles - design method
EN	13129-1 2002	Railway applications - air conditioning for main line rolling stock - part 1: comfort parameters
EN	13129-2 2002	Railway applications - air conditioning for main line rolling stock - part 2: type tests
EN	13452-2 2004	railway applications - braking - mass transit brake systems - methods of test
EN	13261 2001	Railway applications - wheelsets and bogies - axles - product requirements
EN	13 262 2004	Railway applications - wheelsets and bogies - wheels - product requirement
EN	13 272	Railway applications - electrical lighting for rolling stock in public transport systems
EN	13452-1	Railway applications - braking - mass transit brake systems - part 1: performance requirements
EN	14750-1	Railway applications - air conditioning for urban and suburban rolling stock - part 1: comfort parameters
EN	14752 2005	railway applications - bodyside entrance systems
EN	14813	Railway applications - air conditioning for driving cab
Pr EN	15227	Railway applications — Crashworthiness requirements for railway vehicle bodies
EN	23270 1991	Paints and varnishes and their raw materials - temperatures and humidities for conditioning and testing
EN	50085-1/2.1/2.3 2005	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 – Rolling Stock
EN	50124	Railway applications - insulation coordination
EN	50125 1999	Railway applications - testing of rolling stock after completion of construction and before entry into service
EN	50126-1 (2006-05)	Railway Application – The specification and demonstration of reliability, availability, maintainability and safety (RAMS) Part 1: Basic requirement and generic process
EN	50126-2	Railway Applications – Dependability for Guided Transport System - Pt. 2 : Safety
EN	50128 2001	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

Standard Organisation	Standard Reference Number	Title or Description of the Standard
EN	50155 2007	Railway applications - electronic equipment used on rolling stock
EN	50163 2007	railway applications - supply voltages of traction systems
EN	50264	Railway Application- Railway Rolling Stock cables having special fire performance
EN	50286 2.4	Specification for conduit systems for cable management - part 2-4: particular requirements for conduit systems buried underground
EN	50347 2001	General purpose three-phase induction motors having standard dimensions and outputs
EN	60249-1 1994	Base materials for printed circuits - part 1: test methods
EN	60529 2007	Specification for Degrees of Protection Provided by Enclosures (IP Code).
EN	61000	electromagnetic compatibility (emc)
EN	61010-1 2002	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	61 386 1/21/22/23 2004	Conduit systems for cable management
EN ISO	10007 1996-08	Quality management – Guidelines for configuration management
EN ISO	4892-2 2006	Plastics - methods of exposure to laboratory light sources - part 2: xenon-arc lamps
EN ISO	4759-1 2000	Tolerances for fasteners - part 1: bolts, screws, studs and nuts - product grades a, b and c
EN ISO	1478 1999	Tapping screw thread
EN ISO	1479 1994	Hexagon head tapping screws
EN ISO	7049 1994	Cross recessed pan head tapping screws
EN ISO	7050 1994	Cross recessed countersunk (flat) head tapping screws (common head style)
EN ISO	7051 1994	Cross recessed raised countersunk (oval) head tapping screws
EN ISO	7045 1994	Pan head screws with type h or type z cross recess - product grade a
EN ISO	7046 1994	Countersunk flat head screws (common head style with type h or type z cross recess) - product grade a - part 1: steel of property class 4.8
EN ISO	7046-2 1994	Cross recessed countersunk flat head screws (common head style) - grade a - part 2: steel of property class 8.8, stainless and non-ferrous metals
EN ISO	7047	Countersunk raised head screws (common head style)

Standard Organisation	Standard Reference Number	Title or Description of the Standard
	1994	with type h or type z cross recess - product grade a
EN ISO	7042 1997	Prevailing torque type all-metal hexagon nuts - property classes 5, 8, 10 and 12
EN ISO	7719 1997	Prevailing torque type all-metal hexagon nuts, style 1 - property classes 5, 8 and 10
EN ISO	9000	quality management systems - fundamentals and vocabulary
EN ISO	9001 2000	Systems : Model for Quality Assurance in Design, Development, Production, Installation and Servicing
EN ISO	9934-1 2003	Non-destructive testing - magnetic particle testing - part 1: general principles
EN ISO	15614	specification and qualification of welding procedures for metallic materials - welding procedure test

Table 21.6 International Electro-technical Commission

Standard Organisation	Standard Reference Number	Title or Description of the Standard
IEC	60349-1 1999	Electric traction - rotating electrical machines for rail and road vehicles - part 1: machines other than electronic convertor-fed alternating current motors
IEC	60349-2 2002	Electric traction - rotating electrical machines for rail and road vehicles - part 2: electronic convertor-fed alternating current motors
IEC	60349-3 1995	Electric traction - rotating electrical machines for rail and road vehicles - determination of the total losses of convertor-fed alternating current motors by summation of the component losses
IEC	61082 2006	Preparation of documents used in electro-technology, requirement.
IEC	60034 (1 to 26)	Rotating Auxiliary Machines :
IEC	60051 (1 to 9)	Direct acting indicating analogue electrical measuring instruments and their accessories
IEC	60068 (1 and 2)	Environmental Testing
IEC	60077-1 1999	Railway applications - electric equipment for rolling stock - part 1 - general service conditions and general rules
IEC	60077-2 1999	Railway applications - electric equipment for rolling stock - part 2: electrotechnical components - general rules
IEC	60085 2007	Electrical insulation - thermal classification
IEC	60115 (Part 1 to 9)	fixed resistors for use in electronic equipment
IEC	60228	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) 1986	Dimensions of mechanical structures of the 482.6 mm (19 in) series
IEC	60300-1	Dependability Management – Pt. 1 Dependability

Standard Organisation	Standard Reference Number	Title or Description of the Standard
	(2003-06)	Management System.
IEC	60300-2 (2004-03)	Dependability Management – Pt. 2 Guide lines for Dependability Management.
IEC	60300-3-1 (2003-01)	Dependability Management – Pt. 3 Application Guide Sct. 1 Analysis Techniques for Dependability. Guide on Methodology
IEC	60300-3-2 (2004-11)	Dependability Management – Pt. 3 Application Guide Collection of Dependability Data from the Field.
IEC	60300-3-3 (2004-07)	Dependability management - part 3-3: application guide - life cycle costing
IEC	60300-3-5 (2004-07)	Dependability Management – Pt. 3 Application Guide Sct. 5 Application guide- reliability Test Conditions and Statistical test principles.
IEC	60310 2004	Railway application Traction Transformers and Inductors on board Rolling Stock.
IEC	60319 1999	Presentation of Reliability Data for Electronic Components.
IEC	60321 (1 to 3) 1970	Guidance for the design and use of components intended for mounting on boards with printed wiring and printed circuits
IEC	60326 (2 to 12)	Printed boards
IEC	60332 (1 to3) 2004	Tests on electric and optical fibre cables under fire conditions
IEC	60502 (1/2/4) 2004	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	60529 2000	Degrees of protection provided by enclosures (IP code
IEC	60571 2006	Electronic equipment used on rail vehicles
IEC	60617-2/34/5/6/7/8/9/10 (1996-06)	Graphical Symbols For Diagrams :
IEC	60623 2001	secondary cells and batteries containing alkaline or other non-acid electrolytes - vented nickel-cadmium prismatic rechargeable single cells
IEC	60631 1978	characteristics and tests for electro-dynamic and electro-magnetic braking systems
IEC	60664 (1-5) 2007	insulation coordination for equipment within low-voltage systems
IEC	60747 (1-16) 2004	semiconductor devices
IEC	60749-1 2002	semiconductor devices - mechanical and climatic test methods
IEC	60754 (1-2)	Test on gases evolved during combustion of electric cables
IEC	60850 2000	Railway applications - supply voltages of traction systems
IEC	60947 (1-8)	low-voltage switchgear and control gear

Standard Organisation	Standard Reference Number	Title or Description of the Standard
	2007	
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 (1-2) 1991	Power Electronic Capacitors
IEC	61133 2006	Electrical traction-Rolling stock - testing of rolling stock on completion of construction and before entry into service
IEC	61287-1 2005	power converters installed on board rolling stock – pt. 1 characteristics and test methods
IEC	61373 1999	railway applications - rolling stock equipment - shock and vibration tests
IEC	61377-1 2006	railway applications - rolling stock - part 1: combined testing of inverter-fed alternating current motors and their control system
IEC	61508 1999	functional safety of electrical/electronic/programmable electronic safety-related systems.
IEC	61881 1999	Power Electronic Capacitors used on Rolling Stock

Table 21.7 International Standards Organisation

Standard Organisation	Standard Reference Number	Title or Description of the Standard
ISO	272 1982	Fasteners - hexagon products - widths across flats
ISO	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	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

Standard Organisation	Standard Reference Number	Title or Description of the Standard
ISO	272 1982	Fasteners - hexagon products - widths across flats
ISO	1217 1996	Displacement compressors - acceptance tests
ISO	9329-4	seamless steel tubes for pressure purposes
ISO	9330-6	welded steel tubes for pressure purposes

Table 21.8 Japanese standards

Standard Organisation	Standard Reference Number	Title or Description of the Standard
JIS	4305	

Table 21.9 French Standards (Normes Françaises)

Standard Organisation	Standard Reference Number	Title or Description of the Standard
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 fire fighting - design arrangements
NF	X 35002 1982	Anthropometric models of the male and female population

Table 21.10 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 21.11 International Railway Union

Standard Organisation	Standard Reference Number	Title or Description of the Standard
UIC	510-2	Conditions concerning the uses 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	553	Heating, ventilation and air-conditioning in coaches
UIC	560 OR	Doors of coaches and luggage vans

Standard Organisation	Standard Reference Number	Title or Description of the Standard
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	615-4 OR	Motive power units - Bogies and running gear – Bogie frame structure strength test
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	813 O	Technical Specification for the Supply of Wheelsets for Tractive and Trailing Stock : Tolerances and Assembly
UIC	854	Battery

22. CAR BODY MOCK-UPS

A full-scale driving cab and first door way with one row of bench each side engineering mock-up of DTC car is to be provided for the train end, driving cab and the passenger saloon of the DTC. 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 Alarm device allowing two-way speech channel to be established with train operator.
- (xi) 3D modelling should also be a part of Mock up for DTC, MC .

22.2. Car-body Engineering Mock-up

22.2.1. A Car-body Engineering Mock-up shall be provided for review by the Engineer 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) Access to Passenger Information Display system.
- (vii) Gangway to car-end interface.
- (viii) Access to Electrical control (relay and MCB etc.) panels

22.3. Cab Mock-up

22.3.1. 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) Location and access to cab VAC unit.
- (xiii) Colour and form of the cab internal finish.
- (xiv) Space / enclosure for keeping train operator's kit, manuals and log books etc.
- (xv) Location of front end PSSS camera.
- (xvi) NOT USED

22.4. Cab Front End Mock-up

22.4.1. 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.

22.4.2. The mock-up shall be mounted for easy transportation to Kolkata and shall be suitable for public display.

23. ABBREVIATIONS

23.1. General

23.1.1. Various abbreviations used in this document are set out in alphabetical order in Table 23.1

Table 23.1: Abbreviations.

Appendix	Appendix to tender means the completed pages entitled appendix to tender which are appended to and form part of letter of tender
ASHRAE	American Society for Heating , Refrigeration and Air-conditioning Engineers
ATO/ATP	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 Engineer for final acceptance at the end of the warranty period and possible extension of each metro train.
KMRCL	Kolkata Metro Rail Corporation Ltd
BCE	Brake Control Electronics
BCU	Brake Control Unit
CELENEC	European Committee for Electro-technical Standardisation
Contract	Means the Contract agreement, the Notice to Proceed, the letter of tender, these conditions, the Specification, the Drawings, the schedule, and further documents (if any) which are listed in the Contract agreement or in the Notice to Proceed
Contractor	Means the Contractor of the present metro train and associated services supplying contract
CCTV	Closed Circuit Television
CTC	Centralized Train Control
DIN	German Industry Standard
DIS	Depot Information System
DLP	Defect Liability Period
DTC	Driving Trailer Car
DMS	Dead man system
EMC	Electromagnetic Compatibility
EMI	Electro-magnetic Interference
Engineer	Means the person named as Representative of KMRCL
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
GSM	Global System for Mobile Communication

VAC	Ventilation and Air Conditioning
HSBC	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
LRU	Least Replaceable Unit
Metro car	One metro car part of a metro train
Metro train	Fixed composition of metro cars composed by several metro cars
DTC	Driving Trailer car. Trailer car equipped with a driving cab
MC	Motor car without out driving cab
MCB	Miniature Circuit Breaker
MDBF	Mean Distance Between Failures (MDBF)
MDBCF	Mean Distance Between Component Failures
MTTR	Mean Time To Repair
NFPA	National Fire Protection Association
OCC	Operation Control Centre
PEA	Passenger Emergency Alarm
PA	Public Address (System)
PIS	Passenger Information System
PLC	Programmable Logic Control
PAS	Public Address System
PC	Personal Computer
PPHPD	Persons per Hour and per Direction
PSSS	Passenger Saloon Surveillance System
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
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 Engineer for preliminary acceptance of a metro train when the metro train is declared as "suitable for revenue service".
TMS	Train Integrated Management System
TOR	Top Of the Rail
Train ID	Train Identification Number
TV	Television
UIC	International Union of Railway (Union Internationale des Chemins de Fer)
VDU	Video Display Unit

24. INTERFACES

24.1. General

- 24.1.1. The Rolling Stock Contractor shall be responsible for all interfaces for the design, manufacture, supply, testing, commissioning and integration of the Metro Trains with ALL other Designated Contracts as defined in the General Conditions of Contract. The Contractor shall keep the Engineer fully informed in respect of such interfaces, in the form at such intervals as stated in the Contract or as required by the Engineer.

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 Chapter 24.
- 24.2.2. This Chapter 24 shall be read in conjunction with the relevant clauses of the Employer's Requirements of the 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 works and throughout the execution of works, 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 after the commencement of the Works and throughout the execution of the Works 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.
- 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 summary table 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 work.
- 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 works required. The Plan will define the interface works necessary to complete all the works in this contract and may not be limited to those listed in the summary table attached.

- 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 Notice to Proceed(NTP) 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 Engineer, in a preliminary form, as per schedule furnished in table 2-A of the Employer's Requirements of the General Specifications. Thereafter, the IMP shall be updated by the Contractor at regular intervals, agreed with Designated Contractors and submitted to the Engineer. Should it appear to the Engineer that the progress of the Works, 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 reflect the progress of the Works and 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 Engineer of any amendments to the summary table required in the process of his works. Unless such requests are reviewed without objection by the Engineer, the rolling stock Contractor shall design and construct the rolling stock works in accordance with the provisions outlined in this Appendix and the attached summary table.

24.3. Scope of Work of Integrated 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 summary table. 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 liaison with the rolling stock Contractor in the design, installation, testing and acceptance of the rolling stock Works.
- 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 summary table 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 Engineer for review and shall copy the same to the Designated Contractors.

24.4. Interface with PSD/PSG Contractors.

Passenger doors shall be of bi-parting, power operated sliding doors. The two door panels at each passenger doorway shall be synchronously controlled and shall provide a door clear opening width of 1400mm. The passenger door pitch shall be approximately equally spaced to provide the smooth passenger flow. The passenger door pitch shall be compatible with that of passenger pitch of the PSD/PSG being installed in the stations.

The design of the passenger door control system shall ensure that the passenger doors open before the PSD/PSGs open. The design of the passenger door control system shall ensure that the passenger doors open before the PSD/PSG's open. The operation of the "Door Close" pushbutton shall broadcast an audible warning in each saloon, signifying that both the passenger doors and PSD/PSGs shall subsequently close.

After the pre-set time, adjustable between 0 and 5 seconds, following the finish of the audible warning, the control system shall synchronously "Close and Latch" all the passenger doors and PSD/PSGs on the corresponding side. The design of the passenger door control system shall ensure that the passenger doors close in unison with PSD/PSGs.

The Rolling Stock Contractor is responsible for interfacing with the Signalling Contractor with determining the integral functionality for PSD/PSG's

24.5. Interface with Power Supply Contractors

24.5.1. For the total KMRCL E-W line, the 750 V DC traction power, receiving, traction & auxiliary substation equipment, switchgear, auxiliary power equipment, power cables and SCADA are planned to be within one contract.

24.5.2. The details of these contracts and contractors shall be made available during the execution of the contract.

24.5.3. A detailed design consultant may be engaged by KMRCL for the design of power supply works.

24.5.4. These shall include the following but not limited to:

Item No.	Item Description	RS Contractor	Power System Contractor
1	Rolling stock electrical and physical characteristics	<p>a. Shall provide the following data to the Power Supply Contractor:</p> <ul style="list-style-type: none"> • AW0, AW3 and AW4 car weights for motor and trailer cars. • Length and frontal area for motor and trailer cars. • Maximum line speed limit. • Maximum acceleration and deceleration rates. • Train resistance coefficients • Train auxiliary power requirements. • Cut-off traction motor voltage. • Maximum traction motor voltage during regenerative braking. • Traction effort versus speed curves at various line voltages. • Electric braking effort versus speed curves at various line voltages. • Motoring current versus speed curves at various line voltages. • Braking current versus speed curves at various line voltages. 	<p>a. Shall use data to perform a traction power simulation study and for the preliminary design of the traction power supply system.</p>
2	Rolling Stock harmonic characteristics	<p>a. Shall provide harmonic current spectrum during motoring and regenerative braking.</p>	<p>a. Shall use data to perform harmonic study and EMI/EMC study.</p>
3	Electrical and mechanical	<p>a. Shall provide drawing showing the Rolling Stock kinematic envelope.</p>	<p>a. Shall incorporate in the design of third rail</p>

Item No.	Item Description	RS Contractor	Power System Contractor
	clearances between third rail support assemblies and collector shoe		system.
4	Rolling stock collector shoe/ third rail interaction	a. Shall design the shoe gear in accordance with third rail installation details. b. Shall provide drawing showing mounting arrangement, dimension, and maximum/minimum working heights of the shoe gear.	a. Shall provide installation drawings showing third rail dimensions, tolerances, and gap details for the design of Rolling Stock shoe gear. b. Shall confirm suitability of shoe gear design details.
5	Sectioning arrangement of third rail system.	a. Shall provide information to the PS Contractor regarding the requirement of bridgeable or non-bridgeable third rail gaps based on the traction/auxiliary load requirements of the train.	a. Shall incorporate the RS Contractor requirements for the design of third rail gaps.

24.6. Interface with Track Contractors

24.6.1. For the line, detailed design consultants, if any and construct contractors for the tracks works for the elevated line and underground line shall be advised during the execution of the contract. KMRCL may also procure Head Hardened Rails and Fastenings etc.

24.6.2. The details of these contracts and contractors shall be made available during the execution of the contract.

24.6.3. These shall include the following but not limited to:

Item No.	Item Description	Rolling Stock Contractor	TW (Track Work) Contractor
1	Structure gauge	a. Shall provide kinematic envelope	a. Take into account for checking the infringement at construction stages
2	Buffer stops	a. Shall provide details of Rolling Stock	a. Shall consider these details for design, supply and installation of buffer stops.
3	Integrated testing & commissioning	a. Shall provide results of test runs including those pertaining to track conditions.	a. Shall associate during integrated testing & commissioning and carry out necessary rectification of track.
4.	Track Hardness	a. Shall incorporate in his	a. Shall provide information to

Item No.	Item Description	Rolling Stock Contractor	TW (Track Work) Contractor
		design.	RS Contractor.
5.	Track Design drawings	a. Shall incorporate in his design.	a. Shall provide information to RS Contractor

24.7. Interface with Signalling and Telecommunication Contractors

24.7.1. General:

- (i) The Signalling and Telecommunications 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 ATO/ATP and radio on-board cab equipment and antennae etc. to be mounted on the rolling stock shall also be provided, as applicable. However the preliminary list of on board signalling equipments including weight and size of the equipment with drawings has been attached in Appendix C.
- (ii) The Signalling and Telecommunications Contractor shall deliver to the Rolling Stock Contractor's factories, all train-borne ATO/ATP and radio equipment, as applicable, and data to enable fitting and testing.
- (iii) The Signalling and Telecommunications contractor shall supply at Rolling Stock Contractor's factory pre-wired equipment racks with appropriate connectors for all wiring terminating inside ATO/ATP, including wiring between ATO/ATP racks. The Telecommunications Contractor shall similarly supply all the train radio equipments including the Train Radio Control Panel at the at Rolling Stock Contractor's factory. The Signalling and Telecommunications 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.
- (iv) For compatibility, the rolling stock and the train detection system (track circuits), shall conform to EN 50238.
- (v) Interfacing wiring for each module provided by Signalling and Telecommunications Contractors including the interfacing wiring between Signalling and Telecommunications contractors' equipment shall terminate in a quick disconnect robust plug connector suitable for traction applications and brake applications, with direct cable connection with direct cable connection as far as possible. All cable connectors shall be identified within the cubicle using robust cable markers with distinctive colours for identification of e.g. safety function cables.
- (vi) For all relay contact interfaces Signalling and Telecommunications Contractors 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.
- (vii) Signalling and Telecommunications Contractors shall provide Rolling Stock Contractor with the number of wires required between cars of a 6-car trainset and between trainsets to transmit signals from one end of the rake to the other end through an automatic electrical coupler.
- (viii) Rolling stock contractor shall provide necessary video ports, appropriate connectivity (switch/router) for BBRs System, power points and space for monitoring video camera installed in the saloon area from OCC/BCC. For this necessary liaison shall be made with telecommunication contractor.

- (ix) Vehicle control circuits shall be developed by the RS Contractor. All the vehicle control circuits incorporating the identified interfaces shall be provided to the S&T Contractor, as applicable. The RS Contractor shall suitably incorporate the S&T data in the design.
- (x) Specific Interface requirement of Signalling with Rolling Stock Contractors are provided in Appendix C.

24.7.2. Rolling Stock Characteristics to be used by Signalling and Telecommunication Contractor

- (i) The size and location of track circuits for determining the ATP blocks shall be designed to meet the headway requirements of 6-car trains, based on the characteristics of the vehicles to be furnished (Appendix-B Table 26-1) and the track geometry. The back-up (line-side) signalling (in cut out mode) shall use the same track circuits as designed for the ATP working. Signalling & Telecommunication contractor must co-ordinate with Rolling Stock Contractor to fine-tune the block 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.
- (ii) When operating in ATP Mode, a delay of 3s (programmable) shall be provided for the train operator to acknowledge a reduction in speed and begin to apply the brakes.
- (iii) The model for calculating the safe braking distance (SBD) shall identify and take into account various systems' response times and train drivers' reaction times. The design of ATP blocks shall also take into account the effect of track geometry on the traction and braking characteristics. The Rolling Stock Contractor shall furnish the guaranteed braking rate at the normal braking efficiency, and at the lowest braking efficiency permitted in service, including brake deterioration, to control the Signalling and Telecommunications Contractor. RS Contractor shall provide the speed / acceleration and speed / tractive effort curves, for all loading conditions.
- (iv) The Rolling Stock Contractor shall furnish as a minimum the rolling stock parameters to be used by the Signalling and Telecommunications Contractor for designing the target distance based ATP system, as set out in the attached Table. 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.

24.7.3. Signalling and Telecommunication Details to be Used by Rolling Stock Contractor:

- (i) The following data shall be provided :
 - The maximum power consumed by the Signalling and Telecommunications Contractors' equipment from the 110V d.c. supply under all specified operating conditions.
 - The number of train wires required, and the function of each.
 - All control logic outputs.
 - Electrical characteristics of the interconnection cabling and wiring.
 - Sensitivity levels and frequencies which must be avoided.
 - The specific heat load for air conditioning purposes.
 - The EMC/EMI requirements including the limiting value of psophometric current, to obviate interference in the operation of telecommunication equipment
 - Details of the provisions required to enable the transference of data from the train to the OCC.

24.7.4. ATC and Radio Equipment Cubicles:

- (i) The Rolling Stock Contractor shall supply the ATC and Train Radio equipment cubicle enclosure(s). All supports, braces, mounting holes, cabling apertures, etc. required for mounting the cubicle and its equipment shall be properly co-ordinated between by the Signalling and Telecommunications Contractors' and the Rolling Stock Contractor to ensure secure mounting, and access. The cubicle(s) shall be resiliently mounted.
- (ii) To achieve the ATC control functions, the Signalling and Telecommunications Contractor shall identify any interfacing circuits specifically required for ATC operation and liaise with the Rolling Stock Contractor. These include but not are limited to start, door control, motoring, coasting, braking and emergency brake commands.
- (iii) For train control circuits the Signalling and Telecommunications Contractors' 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 contractors shall co-ordinate to agree on levels and protocols for each such signal.
- (iv) As a minimum, all electronic equipment to be mounted on rolling stock, including those provided by the Signalling and Telecommunications Contractors shall comply with IEC 60571: 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.

24.7.5. Antennae:

- (i) The Signalling and Telecommunications Contractors' shall identify and supply 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.
- (ii) The Signalling and Telecommunications Contractors' 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.
- (iii) The Rolling Stock Contractor shall provide the antenna mounting brackets, conduits, support or clamping arrangements to ensure security and reliability.
- (iv) 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.
- (v) The RS contractor shall provide to the S&T contractor all data needed to compute the displacement of the measurement device (for the purpose of speed and distance measurement) including gradient /curvature, wheel slip/slide/or wear in wheel diameter.

24.7.6. Speed Measurement Devices:

- (i) For each ATO/ATP equipment set (per driving cab), the Signalling and Telecommunications Contractor shall supply to the Rolling Stock Contractor for installation, axle mounting speed measurement devices and couplings, to be configured, and the data from them processed in such a way as to achieve the objectives described below in fail safe manner. The speed measurement devices shall be mounted on one axle for each driving cab, which shall be:

- non-powered/powering as proposed by the Signalling and Telecommunications Contractor
 - not used for service brake application and;
 - used for emergency brake application, whenever required.
- (ii) The Signalling and Telecommunications Contractor shall ensure that the speed measurement devices produce a signal which reflects the true displacement of the train (within 3 cm) under any operational, weather and track conditions including gradient, curvature, wheel spin/slide and error in the speed measurement due to wear in wheel diameter.
- (iii) The Signalling and Telecommunications 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 S&T contractor will supply all associated mechanical fixing items.
- (iv) The Rolling Stock Contractor shall provide for each speed measurement device mounting brackets, support or clamping arrangements to ensure security and reliability.
- (v) The Signalling and Telecommunications Contractor shall furnish the zero velocity detection apparatus (ZVR relay).
- (vi) The Signalling and Telecommunications Contractor shall provide speedometer indicating the actual speed, and with maximum safe speed. The design shall be acceptable to the Engineer.
- (vii) 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.
- (viii) 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% (compensated) gradient under all track conditions, indefinitely.
- (ix) The Signalling and Telecommunications Contractor shall furnish the Rolling Stock Contractor with full mounting details, apertures, fixing holes, etc.

24.7.7. Train driver's Display:

- (i) Indications to the train driver shall be displayed on the ATO/ATP Cab Display supplied by the Signalling and Telecommunications Contractor. The train operator's display will be composed of an integrated LCD screen of approximately 10" size. It shall incorporate as a minimum, but need not be limited to the following information :
- Train description, (ID) including crew identification.
 - Target Distance.
 - Target Speed.
 - Service and Emergency Brake Initiation.
 - Train docked.
 - Train hold status.
 - Station dwell time available.

- Departure order.
- In ATP zone or not.
- ATP/ATO failure indications.
- Skip Stop indication.
- DOOR OPEN Indication.
- Maximum Permissible Safe Speed (MSS) in ATP and ATO Modes.
- Train stopped outside of expected stopping window.
- Depot indication, when the train is identified as being in a depot.
- Axle locked indication, for axles on which ATO/ATP speed sensors.
- Door release available; indicating on which side(s) of the train the doors may be opened.
- Operating Mode

24.7.8. Interface Between TMS and Train Equipments:

- (i) The Rolling Stock Contractor shall provide an on-board Train Information Management System (TMS), to log the information from the ATP/ATO and Train Radio equipments supplied by the Signalling and Telecommunications Contractors' , in addition to the information shown in the Rolling Stock specification.
- (ii) Data stored in the TMS shall be password protected. Levels and protocols shall be agreed between the Contractors. Software for downloading the data from TMS to maintenance terminal shall be provided by the Rolling Stock Contractor. The Signalling and Telecommunications Contractors' as applicable, shall provide Windows compatible software for maintenance terminals for viewing the data logged in TMS.
- (iii) All the vital commands by the on-board ATP and ATO systems, to Rolling Stock equipment and the responses of the rolling stock equipment to these commands, shall also be recorded in TMS.
- (iv) The signals to be supplied from the TMS to the equipment of the Signalling and Telecommunications Contractors' shall be decided jointly between the Contractors.
- (v) TMS shall be able to communicate data to OCC using a data link supplied by the Telecommunications Contractors'. The data shall contain identified train alarms. The Rolling Stock and the Telecommunications Contractors shall interface to make the data available to its destination in OCC.
- (vi) The interface shall ensure that TMS receives necessary inputs from the on-board ATP system to enable TMS to synchronize its clock with the system master clock. All the microprocessor/ micro-controller based on-train systems shall synchronize respective clocks with TMS clock.

24.7.9. Power Supply and Earthing Arrangements:

- (i) Rolling Stock Contractor will provide two 110 VDC battery level power feed to the ATC rack, one 110 VDC power feed to the train driver Display unit (ADU) and one for Train Radio Equipment. The battery range shall be 77 to 135 VDC. The ATC shall use this power feed for powering the ATC rack equipment and for driving battery level ATC outputs. To avoid voltage fluctuations, signalling contractor requires dedicated circuit breakers from the vehicle battery power supply to its ATC rack and ADU. These power feeds are not to be shared with any other equipment. Rolling Stock

Contractor will also supply the circuit breakers as per the S&T system requirement for Vehicle to ATC Interface to provide power to the ATC system.

- (ii) The Rolling Stock Contractor shall provide dedicated earthing arrangements for the train borne ATO/ATP and radio equipment. The Signalling and Telecommunications Contractors shall specify the earth impedance required.
- (iii) The power supply cable between the train power supply and the ATO/ATP and radio train borne equipment power equipment shall be segregated, as short as possible and directly connected to the supply without any intermediate connection.

24.7.10. Telecommunications:

- (i) The Telecommunications Contractors' shall furnish the Rolling Stock Contractor with the interface required between:
 - a) Train Radio system and the on-train public address system in order to implement requirements of clause 17.1 and followings.
 - b) Train Radio system and the on-board CCTV system in order to implement to requirements of clause 7.9.4 and clause 17.10.
- (ii) 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.
- (iii) The Rolling Stock Contractor shall provide Train ID to train radio through TMS-Train Radio interface.
- (iv) The Telecommunications Contractors' contractor shall furnish the Rolling Stock Contractor with the interface required between the train radio system and the TMS for recording the initiation, termination, and success or failure of emergency calls initiated by the train driver 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.
- (v) RS Contractor shall share all API (Application Programming Interface) / SDK (Software development Kit) documentation with the S&T Contractor for necessary interface designs between the onboard CCTV system and Radio System, as in the case of train management system.

24.7.11. Factory Installation and Testing:

- (i) All the special equipment associated with the train borne ATO/ATP and radio system, including the interface cables / wires between the train borne ATO/ATP and Train Radio shall be designed and supplied by the Signalling and Telecommunications Contractors' , as applicable, to the Rolling Stock Contractor's factory. Each contractor shall be aware of the locations of manufacturing plants, which could concurrently be manufacturing cars.
- (ii) The Signalling and Telecommunications Contractors' shall be responsible for providing all data and training of Rolling Stock Contractor's staff in all aspects of ATO/ATP and train radio installation and testing where applicable. The first set of ATO/ATP equipment and also Train Radio equipment shall be installed by Rolling Stock Contractor, under the supervision of the Signalling and Telecommunications Contractors.
- (iii) The Rolling Stock Contractor shall be responsible for installing wiring and equipment, and it's testing on each car to the functioning standard agreed with the Signalling and Telecommunications Contractors.

- (iv) Testing of each car shall comply with the accepted international standards agreed between the contractors as agreed with the Engineer. 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 and telecommunications between OCC/BCC/SCR and Train which will be required to be done jointly by the Rolling Stock and Signalling and Telecommunications Contractors at site in Kolkata. The test certificate subsequently shall be issued jointly by the Rolling Stock, Signalling and Telecommunications Contractors.
- (v) The Rolling Stock Contractor shall provide facilities including test track for comprehensive static, dynamic, and interface tests between the Rolling Stock, Signalling and Telecommunications systems at his premises. The Signalling and Telecommunication Contractors shall be responsible for the provision of special test equipment and instrumentation.
- (vi) In case of ATO, the Integration test between the Rolling Stock and the Signalling and Telecommunications Contractors shall include tests on mainline to confirm the realization of demanded acceleration and deceleration rate by the ATO under various conditions.
- (vii) 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 for work involving scope as identified in clause above.

24.7.12. EMC/EMI Interface:

- (i) Regarding electromagnetic interference, The Signalling and Telecommunications Contractors shall provide a list of frequencies and other sensitive 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 emission wherever required.
- (ii) The Rolling Stock and Signalling and Telecommunications Contractors shall ensure that the emission and immunity level of their respective equipment meet the requirements of the set of EN50121 standards.
- (iii) 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 and Telecommunications Contractor.
- (iv) The contractors shall also jointly develop a test plan for verification of electromagnetic compatibility of traction, signalling and telecommunications systems. The contractors shall work together to assure that all electronic and electrical equipment on the rolling stock works properly without interfering with signalling, or telecommunications sub-systems.
- (v) The cable layout of the signalling and communication system in the cable ducts provided by the Rolling Stock Contractor shall be jointly agreed. The separation between signalling and communications cables and power cables of 750 V d.c, 415 V three phase a.c., 230 V a.c. single phase, 110 V d.c. rating shall be in accordance with accepted international practice and jointly agreed.
- (vi) 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.

24.7.13. Division of Responsibility:

24.7.14. The Signalling and Telecommunications Contractors 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 Cl.24.7.15.

24.7.15. These shall include the following but not limited to:

Item No.	Item Description	RS Contractor	S&T Contractor
1	On board ATP/ATO equipment.	To provide space in the vehicle design for fixing and installation and interfaces at the manufacturers facility by the RS contractor under the supervision of S&T Contractor to achieve overall system functionalities.	To supply the equipment to the RS contractor.
2	Antennae for ATP, ATO and TWC.	Installation by RS Contractor	To supply the equipment to the RS contractor.
3	Speed measuring sensors and speedometer.	Installation by RS Contractor	To supply the equipment to the RS contractor.
4	ATC cab displays (Driver's MMI)	Installation by RS Contractor	To supply the equipment to the RS contractor.
5	On-board Radio / BBRs/TETRA equipment	Provide cubical, fixing to comply with IEC60571	To supply the equipment to the RS contractor.
6	Antenna for train radio / BBRs/TETRA equipment.	Installation by RS Contractor	To supply the equipment to the RS contractor.
7	Power supply and earthing for on-board ATP/ATO and train radio / BBRs/TETRA equipments.	To provide the required Voltage and current levels and earthing requirements.	Furnish required Voltage and current levels and earthing requirements to RS Contractor.
8	Logging of on-board information from ATP / ATO & train radio.	Provide the on board data logger TIMS.	S&T Contractor to co-ordinate with RS Contractor for signal levels and protocols.
9	Interface between ATP/ATO with train braking and propulsion systems for automatic braking,	Rolling Stock Contractor shall co-ordinate with the S&T to agree on levels and protocols for interface signals.	ZVR (zero velocity Relay) & EBR (Emergency Brake Relay) are to be supplied by the S&T contractor.

Item No.	Item Description	RS Contractor	S&T Contractor
	acceleration and deceleration.		
10	System master clock	RS Contractor to synchronise its clock with master clock.	S&T Contractor to provide necessary inputs.
11	On-board announcement from OCC/BCC	Shall provide for necessary hardware interface, to display for on-board P.A. system inside the cars.	Shall provide necessary signals on-board to RS
12	On-board equipment for CCTV image transmission to Cab / OCC / BCC.	R S contractor shall provide necessary on-board cameras, display equipment and inter connections, NVRS (network Video Recording System) and appropriate interface / protocols for S&T equipment.	S&T contractor shall provide necessary on-board equipment to R S contractor for image transmission to OCC / BCC
13	Data transmission link from one end of the rake to other end.	RS Contractor shall provide car/train lines and auto-coupler spare pins. Hardware RS level & protocols agreed between RS & S&T	S&T contractor must coordinate.
14	Climatic requirements for on-board ATP /ATO and Radio / BBRs/TETRA equipments	Shall provide ventilation and air conditioning design parameters of the cab and plan proper layout to install ATP/ATO and Radio / BBRs equipments.	S&T to specify the climatic requirements for on-board ATP/ATO and Radio/BBRS equipments and also advice the heat load details of the equipments.
15	EMI / EMC Interface between S&T and R S	Shall co-ordinate and ensure the compatibility of Rolling stock equipment with ATC and telecommunication equipments. Cable layout – ducts by RS to be jointly agreed. Duct to be earthed accordingly. Identify all interfacing circuits. Identify volt free contacts (ATP equipment and Train Borne). Safety Cut-out switches (SCS) to be provided by RS.	Shall advise the EMI/EMC plan for ATP / ATO and radio / BBRs equipments and co-ordinate with Rolling stock contractor to avoid interferences from rolling stock equipments.

24.8. Interface with Depot Detailed Design and Construct Contractor

- 24.8.1. Engineer with experience and help of DDC will design the facilities in depot and workshops. This interface is to improve it further to meet the requirements.

Item	Subject	Rolling stock (RS) contractor's Responsibilities	Engineer / Depot Design Contractor's Responsibilities
1	Requirement for commissioning and testing of cars	Review the planning by Engineer and DDC and define the minimum facilities required for commissioning and testing the cars in the depot.	Based on Engineer's broad design and review of RS, DDC shall design the infrastructure facilities for commissioning and testing of cars in nominated Depot(s).
2	Metro train	Shall furnish the maintenance schedules	DDC shall design the Depot

Item	Subject	Rolling stock (RS) contractor's Responsibilities	Engineer / Depot Design Contractor's Responsibilities
	Maintenance requirement	and equipment requirement for complete cars, assemblies and subassemblies systems and sub systems.	maintenance facilities including all depot buildings, to suit RS requirement
3	Plant and Machinery, test panels, tools and instruments etc.	Supply all special tools/test panels suitable for the rolling stock to be supplied.	Engineer shall design and develop specification for supply and commissioning of General-purpose plant and machinery, tools and instruments at Depot.
4	Store facilities for important items of Rolling Stock.	Shall furnish the special requirements for storage and the quantities for storage.	DDC shall design the store facilities for assemblies, sub assemblies, capital spares etc. at Depot.

24.9. Interface with Other Contractors

24.9.1. Besides the 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.

24.9.2. The details of these contracts and contractors shall be made available during the execution of the contract.

24.9.3. These shall include the following but not limited to:

Item No	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.

25. TENDERER'S SUBMISSIONS (Technical Specifications)

25.1. Documents Required for Technical Evaluation

The following paragraphs list the minimum documentation that shall be supplied by the Tenderer to enable technical evaluation of the Tender. The Tenderer shall include any further information necessary to demonstrate the suitability of his proposal.

Volume 3: Employer's Requirements – General Specifications (Refer Appendix 9)

- i. Outline Project Management Plan
- ii. Sub-Contractor/Vendor List
- iii. Outline Interface Management Plan
- iv. Outline Works Management Plan
- v. Outline Quality Assurance Management Plan
- vi. Outline System Safety Assurance Management Plan
- vii. Outline Reliability, Availability and Maintainability Assurance Management Plan
- viii. Outline Site Safety Management Plan
- ix. Outline Software Quality Assurance Management Plan
- x. Outline Environmental Management Plan
- xi. Outline Inspection, Testing, Commissioning and Integration Management Plan
- xii. Training Proposal
- xiii. Proposal for Use of Site and Site Management

Volume 3: Employer's Requirements – Technical Specifications (Refer Chapter 25)

- xiv. Technical Capability of Manufacture of Cars in India
- xv. Service Experience of Cars and Equipments
- xvi. Tenderer's Detailed Technical Proposal (Clause by Clause Commentary)
- xvii. Deviations (Clause by Clause Compliance)
- xviii. Design Parameters - Design Data of Cars and Equipments
- xix. Design Details Including Drawings
- xx. Proposed Works Program
- xxi. Proposed Design Submission Program
- xxii. Other Submissions under the Tender Documents

25.2 Technical Capability of Manufacture of Cars in India

For manufacture of cars in India, the Tenderer shall include complete details of Indian partner including details of technical capability. Details of the Indian partner shall include, but not limited to, the following:

- MOU indicating scope of work
- Procedure for assuring Quality Standards
- Detailed plan for deployment of Contractor's personnel in Indian partner's works
- Qualification procedures for key personnel including welders, crimpers, fitters etc.
- Detailed method statements for each activity including supply, manufacture, testing and commissioning.
- Inspection procedures (stage as well as final) for sub-systems and complete car.

- Details of Infrastructure and Facilities for Manufacturing and Testing.
- Availability of Machinery & Plant (M&P), jigs & fixtures etc.
- Details of transfer of Engineering and manufacturing drawings and process sheet.
- Safety certificate like ISO 9001 and Environment Certificate 14000
- Any other documents desired by Employer.

25.3 Service Experience of Cars and Equipments

(Refer also to Pro-Forma Tables A.1 to A.8, in Appendix - A)

25.3.1 The Tenderer is required to provide satisfactory evidence to Employer of the proven experience (Volume 2: GCC – Clause 1.1.6.14, for previous Design, Manufacturing, Testing, Commissioning and Integration of Metro Trains and sub-systems, of which comply to the functionality, performance and safety requirements within this Technical Specification.

25.3.2 The Tenderer shall furnish the information related to service experience of complete cars and main equipment/sub-systems with similar design specifications and ratings, as far as possible. The information may be restricted to two Projects concluded within last 10 years, and where the Cars/Equipments have at least, earned five years experience in revenue service as required and in the format given in the following Tables in Appendix A;

- (i) Table A-1: Service Experience of Cars and Equipment
- (ii) Table A-2: MDBF of Major Sub-systems
- (iii) Table A-3: MTTR of Major Sub-systems

25.3.3 Information related to service experience of the specific sub-systems as per the requirement of the Volume 3: Employer's Requirements - Technical Specification, and in the format given in Appendix A,

- (i) Table A-4: Integration of completed vehicles to metro system
- (ii) Table A-5: Carbody,
- (iii) Table A-6: Bogie
- (iv) Table A-7: Propulsion Equipment, and
- (v) Table A-8: Performance data of cars respectively,

This information shall be used as one of the inputs for evaluating the service reliability of the various equipments/sub-systems offered by the Tenderer.

25.4 Tenderer's Detailed Technical Proposal (Clause by Clause Commentary)

25.4.1 The Tenderer must provide a valid and fully compliant and Detailed Technical Proposal for the metro cars as detailed in the Employer's Requirements. As a minimum the Tenderer must demonstrate clear understanding toward the Employer's Requirements and present the proposal in such a way as to demonstrate the Technical Proposal offered by the Tenderer shall be compliant to the Schedule of Dimensions (SOD), functionality, performance and safety requirements by reflecting on the prior stated factors of Service Proven Design and with similar reliability and availability characteristics as afore said in the Tenderer's Service Experience submissions.

25.4.2 For preparing the Detailed Technical Proposal, the Tenderer may submit a detailed clause by clause commentary on all the clauses of the Volume 3: Employer's Requirements – Technical Specification.

Tenderers shall note that their comments to the clause by clause commentary wherever given shall only be in the following form:

- a) Complied: "Complied" shall be indicated by the Tenderer where the Tenderer is able to comply with the clause.
- b) Noted: Where a clause merely provides information, and no other comment is necessary, "Noted" will suffice.
- c) Not Complied: Where the Tenderer is not able to comply fully with certain clauses or has any observation or proposes an alternative design, "Not Complied" shall be indicated and comments if any of the Tenderer shall be indicated in detail. All Clauses with status as "Not Complied" shall be included in the statement of Deviations (**Form of Tender: Appendix FT- 6**) and shall be priced in the Pricing Document: **Appendix I**.

25.5 Deviations (Clause by Clause Compliance)

Tenderer shall also note that any comment by the Tenderer in the Clause by Clause Commentary, other than either of "Complied" or "Noted" shall be treated as "Not Complied".

- a) ***Any "Not Complied" comment by the Tenderer in the Clause by Clause Commentary which has not been included in the Statement of Deviations (Appendix FT- 6 to Form of Tender) shall be treated as "Complied".***
- b) ***Any "Not Complied" comment by the Tenderer in the Clause by Clause Commentary which has also been included in the Statement of Deviations (Appendix FT- 6 to Form of Tender) but has not been priced in Appendix I of the Pricing Document shall be treated as null and void and deemed to have been unconditionally withdrawn.***

25.6 Design Parameters and Data:

(Refer also to Pro-Forma Tables A.9 to A.23, in Appendix - A)

- 25.6.1 Tenderer is required to confirm the proposed Metro Train Design will comply with specific design parameters of the KMRCL Metro System and also submit specific design data that is in **absolute compliance** (mandatory) with this Technical Specification. Tenderer **must comply** with the following information about cars and items of equipment as required and in the format given in Tables A-9 to A-23. In the case this is provided for in the Detailed Technical Proposal, the Tenderer must provide reference to such clause and/or drawings within the Tenderer's Detailed Technical Proposal.

25.7 Proposed Work Program and Design Submission Program

- (a) The proposed Work Program and Design Submission Program shall show how the Tenderer proposes to organize and carry out the Work and to achieve Stages and complete the whole of the Works by the given Key Dates. Detailed requirements of the work program are described in Volume 3: Employer's Requirements - General Specifications: Work Management Plan (Chapter 2) and Design Submission Program (Chapter 3).
- (b) The Tenderer's attention is drawn to the Key dates specified in Form of Tender: Appendix FT-1 to Form of Tender. The Tenderer shall prepare logic diagrams providing the philosophy for interface with other designated contractors & availability of track, electrification and signalling system to be available and submitted as part of his Tender. These logic diagrams shall be developed and submitted along with the Work Programs as submitted during the course of the Work.

- (c) All programs shall include design, procurement periods of major materials, off-shore production, production in India, despatch, transport, interface periods for system-wide, and adjacent contractors, testing and commissioning (including integrated testing & commissioning) along with any other training and service trial running information.

26. CONTRACTOR'S TECHNICAL SUBMISSIONS (PROPOSED)

26.1 General

- 26.1.1 The Contractor's Submissions is a compilation of the items required by each section of these Technical Specifications
- 26.1.2 The Contractor shall submit the documents listed for review by the Employer, and/or any third party deemed appropriate by the Employer, in time to be available for review sessions during which the subject documents will be discussed.
- 26.1.3 The Contractor's Submissions list provided is NOT exhaustive and may be increased or decreased at the discretion of the Engineer.
- 26.1.4 The Contractor's Submissions list shall be reviewed and modified with agreement of the Contractor and Engineer during the Preliminary and Detail Design, in line with the Contractor's Management Plan, Works Program, Design Submission Plan and Inspection, Testing and Commissioning Plan.

26.2 Contractor Submissions

The Proposed Contractor's Submissions as a minimum is shown in Appendix B: Table B-1 below;

APPENDIX- A : TENDERER'S TECHNICAL SUBMISSIONS

The following Tables A-1 to A-23 must duly completed and submitted as part of the Technical Submissions within the Technical Package. (These Tables are Compulsory Submissions for Technical Evaluation).

NOTE: *Failure to submit the attached Tables A-1 to A-23 (Duly Completed and Compliant), with the Technical Submissions, will deem the Tender as Non-Responsive and as such the Tenderer shall be disqualified.*

Table A-1: Service Experience of Cars and Equipment

S.N	Parameter	Technical Specification Requirement	Tenderer's Data	
			Project 1	Project 2
(i)	No. of cars supplied for 750 V D.C.Third rail system.	cl. 25.3		
(ii)	Name of the user Railway/Metro System, where in operation.	cl. 25.3		
(iii)	No. of years in revenue service.	> 10 years		
(iv)	Scope of participation of each member of the Tenderer's Constituents in respect of following :	cl. 25.3		
	Design and manufacture of complete car			
	a) Car body			
	b) Bogie			
	c) Traction propulsion equipment and controls			
	Testing of fully integrated cars			
(v)	a)Formation of each train in terms of Motor and Trailer Cars	cl. 25.3		
	b) No. of train sets supplied.			
	c) Power (in kW) of the Motor Car.			
(vi)	Mean distance Between Failures (MDBF) of complete train attributed to Rolling Stock failures only.	cl. 25.3		
(vii)	Percentage availability of trains in revenue service daily to total train fleet size	cl. 25.3		
(viii)	MDBCF (Mean Distance Between Component Failure)and MTTR (Mean Time To Repair) of major sub - systems	cl. 25.3	As per Table A-2 and Table A-3	

Table A-2: MDBCF of major sub-systems (Service Experience) (TS Cl.25.3):

S.N	Parameter	Tenderer's data					
		Project 1			Project 2		
		Make & design type	MDBCF		Make & design type	MDBCF	
			Actual	Guaranteed		Actual	Guaranteed
(i)	Propulsion System						
	a) Current collector System						
	b) High Speed Circuit Breaker						
	c) Traction Inverter including controls						
	d) Traction Motor						
(ii)	Auxiliary Supply System						
	a) Auxiliary Converter						
	b) Battery Charger						
	c) Back-up Batteries						
(iii)	Air Supply and Friction Brake Equipment						
(iv)	Door System and Controls						
(v)	VAC 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)	DMS						

Table A-3: MTTR of major sub-systems (Service Experience) (TS Cl. 25.3):

S.N	Parameter	Tenderer's data					
		Project 1			Project 2		
		Make & design type	MTTR		Make & design type	MTTR	
			Actual	Guaranteed		Actual	Guaranteed
(i)	Propulsion System						
	a) Current collector System						
	b) High Speed circuit Breaker						
	c) Traction Inverter including controls						
	d) Traction Motor						
(ii)	Auxiliary Supply System						
	a) Auxiliary Converter						
	b) Battery Charger						
	c) Back-up Batteries						
(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)	DMS						

Table A-4: Service Experience for Integration of Completed Metro Trains to New Metro Systems (TS Cl. 25.3):

Tenderer Name:								
Consortium details:								
Criteria for technical qualification of the Tenderer.		1. The Tenderer should have experience of Integration of completed vehicle into new Metro system, of a similar technology and complexity as proposed for this tender.						
		2. The Tenderer should provide “Proven Design” as defined in cl.1.1.6.14, Volume 2-GCC.						
	Details of reference							
Consortium members	Country (origin of manufacture)	Country (Other)	Participation in JV/Consortium	No of Trains	Train Formation	Date of Commissioning of 1st Metro Train***	Date of Commissioning of last Metro train***	Years in service

*** Tenderers shall submit certificate on letter head of the owner indicating details of commissioning of cars in the pro-forma attached

Table A-5: Service Experience of Carbody constructed (TS Cl. 25.3)

Tenderer Name:							
Consortium details							
Criteria for technical qualification of the Tenderer for manufacture of carbody:		1. The Tenderer should have experience of design, manufacturing, testing and commissioning of car body of similar technology and complexity as proposed for this tender.					
		2. The Tenderer should provide "Proven Design "as defined cl. 1.1.6.14, Volume 2 - GCC					
		Carbody Material:		Stainless steel			
		Jointing method :		Welding			
Details of reference							
Consortium members	Country (origin of manufacture)	Country (Other)	Participation in JV/Consortium	No of cars	Date of Commissioning of 1st Metro Train***	Date of Commissioning of last Metro Train***	Years in service

*** Tenderers shall submit certificate on letter head of the owner indicating details of commissioning of cars in the pro-forma attached

Table A-6: Service Experience of the Bogie (TS Cl.25.3):

Tenderer:							
Bogie Manufacturer		Name and Address					
		Is Bogie manufacturer a consortium partner?					
Criteria for technical qualification of the Bogie Manufacturer		1. The Tenderer should have experience of design, manufacturing, testing and commissioning of Bogies of similar technology and complexity as proposed for this tender. 2.The Tenderer should provide "Proven Design as defined cl. 1.1.6.14, Volume 2 - GCC					
Reference details							
Consortium members	Country (origin of manufacture)	Country (other country)	Participation in JV/Consortium	No of cars	Date of commissioning of Metro Train***	Date of commissioning of last Metro Train***	Years in service

*** Tenderers shall submit certificate on letter head of the owner indicating details of commissioning of cars in the pro-forma attached

Table A-7: Service Experience of the Propulsion Equipment (TS Cl. 25.3):

Tenderer:							
Propulsion Equipment manufacturer		Name and Address					
		Is Propulsion manufacturer a consortium partner?					
Criteria for Qualification of Propulsion equipment manufacturer		<p>1. The Tenderer should have experience of design, manufacturing, testing and commissioning of propulsion system of similar complexity and technology as proposed for this tender.</p> <p>2. The Tenderer should provide "Proven Design" as defined cl. 1.1.6.14 , Volume 2 - GCC.</p>					
Reference details							
Consortium member	Country (origin of manufacture)	Country (other)	Participation in JV/Consortium	No of cars	Date of commissioning of 1st metro train***	Date of commissioning of last metro train***	Years in service

*** Tenderers shall submit certificate on letter head of the owner indicating details of commissioning of cars in the pro-forma attached

Table A-8: Performance Data of Cars supplied - Proven Design (Service Experience)

Metro						
SN	Project Details		No of cars	Operational Data		Performance
	Name	Date Commissioned		Availability %	Reliability %	MDBF

Table A-9: General:

S.N	Parameter	TS requirement	Tenderer's Compliance	Tenderer's Proposal Reference Clause
(i)	Will the metro train be 6 cars configuration	cl.1.1.3 DTC+MC+MC+MC+MC+DTC	Yes/no	
(ii)	Will the cars be interchangeable	cl.1.1.6	Yes/no	
(iii)	Will the metro train be designed for a service life of 35 years	cl. 1.1.2	Yes/no	

Table A-10: Operational Environment:

S.N	Parameters	TS requirement	Tenderer's compliance	Tenderer's Proposal Reference Clause
(i)	Confirm Maximum & Minimum ambient temperatures	cl. 2.1.1, & as per ASHRAE	Yes/no	
(ii)	will metro train cater minimum radius of curvature of tracks	cl.2.3.1	Yes/no	
(iii)	will the current collector system be as per TS clause and IEC standards	cl. 2.5.1 IEC 60850	Yes/no	
(iv)	will the metro train satisfy the kinematic envelope as per TS clause	cl. 2.8.1 SOD	Yes/no	

Table A-11: Operational performances:

S.N	Parameter	Technical Specification Requirement	Tenderer's compliance	Tenderer's Proposal Reference Clause
(i)	will the total power of metro train achieve the operation performances specified in TS	cl. 3.1.1 (vii)	Yes/no	
(ii)	Are the traction & braking effort calculated with wheel rail adhesion ratio as per TS	cl. 3.1.1 (viii), 18% in tunnel and 16% at grade & super-elevation	Yes/no	
(iii)	will the metro train perform in dense crush load AW4, with minimum commercial speeds of 34 km/h on KMRCL alignment	cl. 3.2.1 curves & alignment as per Alignment Drawings in Volume 5	Yes/no	
(iv)	state the Passenger capacity of metro train proposed	cl.3.4.3 Dense crush load AW4: Seats: ≥286 Standeers: ≥1782 Total: ≥2068	Yes/no	
(v)	Are Wheel chairs provided in proposed metro train	cl.3.4.4 One wheel chair at each cab end & in both DM Cars	Yes / no	
(vi)	Is Traction & Braking effort curves submitted as per TS a) Train resistance formula: -at grade & elevated corridors -underground corridors b) total traction energy consumed c) total auxiliary energy consumed d) total regenerative energy fed back into system e) net energy consumed	cl.3.5 & 3.11 Davis or as per International standards	Yes/no	
(vii)	will the metro train satisfy acceleration & braking performances as per TS a) Average acceleration rate from 0 to 30 km/h b) Jerk c) average service deceleration from 80 to 0 km/h d) minimum average emergency deceleration	cl.3.6 cl.3.7 1 m/s ² ± 5% 0.7 m/s ³ ± 0.05 1 m/s ² ± 5% 1.3 m/s ²	Yes / no	
(viii)	State expected interior noise levels, when tested as per ISO3381, Train stationary: Saloon Driver cab Saloon Train running: Saloon Driver cab	cl.3.13.4 75 dBA in tunnel 72 dBA in tunnel 68 dBA in other field condition 70 dBA in other field condition 77 dBA 74 dBA	Yes/no	

S.N	Parameter	Technical Specification Requirement	Tenderer's compliance	Tenderer's Proposal Reference Clause
(ix)	State expected Exterior noise levels, when tested as per ISO3095. Stationary Train running	cl.3.13.7 69 dBA 86 dBA	Yes/no	
(x)	Will the metro train satisfy the fire safety standards	cl.3.14, - BS 6853 (class B1) or - NFPA 130 or - DIN 5510 or - NFF 16101 (cat. A1) and 16102	Yes/no	
(xi)	will the total fire load of potentially flammable materials on car satisfy the maximum values of 28000MJ for each above and below floor levels	cl.3.14.3	Yes/no	

Table A-12: Vehicle Driving Modes:

S.N	Parameter	Technical Specification Requirement	Tenderer compliance	Tenderer's Proposal Reference Clause
(i)	Will the train design comply automatic train driving	cl. 4.1.1	Yes / no	
(ii)	Provide descriptions and details of the ATC system offered		Yes/no	

Table A-13: Vehicle Design & Architecture:

S.N	Parameter	Technical Specification Requirement	Tenderer compliance	Tenderer's Proposal Reference Clause
(i)	State the following dimensions of metro train: a)total train length, over body b)distance between bogie centres c)car body width d)height (rail top to roof top)	cl.5.3.6 130 m 14700+250 mm 2880 mm Maximum 3873 mm Maximum		
(ii)	Has the Tenderer submitted drawings showing train profiles, dimensions, cross sections,	cl.5.3.7	Yes / no	
(iii)	State axle load , under AW4 load conditions	cl.5.4.3, 16 tons maximum		
(iv)	Has the Tenderer submitted the weight distribution as defined in IEC	cl. 5.4.6, IEC 61133	Yes / no	

Table A-14: Vehicle Car Body:

S.N	Parameter	Technical Specification Requirement	Tenderer compliance	Tenderer's Proposal Reference Clause
(i)	Will the car aesthetics be of modern & pleasing profile	cl.6.2	Yes /no	
(ii)	State the car structure materials: a)car side wall, roof, end wall structure & panels b)under frame, head stock, body bolster c)driver cab front end	cl.6.3 ASTM 301L & 304L, JIS 4305 S355J2G3, EN 10025 Or equivalents FRP	Yes /no	
(iii)	Will be car body construction be welded or any other Has the Tenderer submitted the service records for alternative construction methods, if offered	cl.6.4. welded	Yes / no	
(iv)	Will the car body satisfy the sealing requirement as per standards	cl.6.4.4 IEC 61133	Yes / no	
(v)	will the car body strength comply EN standards	cl. 6.10.1 EN 12663 PIII or equivalent	Yes / no	
(vi)	Will the car body ends comply crashworthiness as per EN standards	cl. 6.11, EN 15227	Yes / no	
(vii)	Will the cars be provided with Lifting & jacking points	cl.6.13	Yes / no	
	Couplers & Draft gear:			
(viii)	Has the Tenderer supplied layout of couplers in metro train configuration	cl.6.14	Yes / no	
(ix)	Will automatic coupler be fitted on outer ends of metro train and also in the middle between two M Cars	cl. 6.14.2	Yes / no	
(x)	Will the intermediate ends and trailer ends be fitted with semi-permanent coupler	cl.6.15.1	Yes / no	
(xi)	Will both ends of all cars be provided with electrical jumper cables	cl.6.15	Yes / no	
(xii)	Provide following details of both automatic & semi-permanent couplers proposed: a)name and address of manufacturer b)type no c)steel material used d)name of previous MRTS projects on which same type of couplers were provided by OEM e)descriptive catalogues along with specifications		Tenderer shall submit details	
(xiii)	Provide the following details of Electrical Jumper coupler proposed: a)name and address of manufacturer		Tenderer shall submit details	

S.N	Parameter	Technical Specification Requirement	Tenderer compliance	Tenderer's Proposal Reference Clause
	b)type no c)steel material used d)name of previous MRTS projects on which same type of couplers were provided by OEM e)descriptive catalogues along with specification			

Table A-15: Train Driver Cab:

S.N	Parameter	Technical Specification Requirement	Tenderer compliance	Tenderer's Proposal Reference Clause
(i)	Has the Tenderer supplied layout of ergonomic design of cab and its controls & instruments	cl.7.1.1 & 15.3.1	Yes / no	Tenderer's Proposal Reference Clause

Table A-16: Passenger Saloon Doors:

S.N	Parameter	Technical Specification Requirement	Tenderer compliance	Tenderer's Proposal Reference Clause
(i)	State the following: -clear opening width -clear opening height	cl.8 1400 mm 1900 mm		
(ii)	Does the saloon door comply EN standards	cl.8.1.1, 8.5.1, EN 14752	Yes / no	
(iii)	Has the Tenderer submitted calculations for boarding and detraining of passengers	cl.8.1.2	Yes / no	
(iv)	Has the layout of saloon doors on metro train comply PSD /PSG requirement	cl. 8.2.4	Yes / no	
(v)	Provide the following details of saloon door proposed: a)name & address of manufacturer b)type of door c)rated voltage for drive d)rated current for drive e)time required for --replacing door leaf on car --adjustment of door settings --testing of door functioning f)door opening time from initiation of open command g)door closing time (including locking) from initiation of close command h)name of previous MRTS projects on which same design doors were provided by the OEM i)Provide description, specification and catalogues		Tenderer shall submit details	

Table A-17: Saloon Interior:

S.N	Parameter	Technical Specification Requirement	Tenderer compliance	Tenderer's Proposal Reference Clause
(i)	Has the Tenderer submitted the layout of interior	cl.9.1.1	Yes / no	
(ii)	Has the Tenderer submitted the proven record of floor covering proposed	cl.9.10.5	Yes / no	
(iii)	Has the Tenderer submitted layout of Inter-car gangway	cl.9.11	Yes / no	
(v)	Provide the following details of proposed inter-car gangway: a)name & address of manufacturer b)type c)clear head room d)clear width e)name of previous MRTS projects on which same design doors were provided by the OEM f)Provide description, specification and catalogues		Tenderer shall submit details	

Table A-18: Bogies:

S.N	Parameter	Technical Specification Requirement	Tenderer compliance	Tenderer's Proposal Reference Clause
(i)	Type of proposed bogie-- Bolster or Bolster-less	cl.10.1.1	Yes /no	
(ii)	will the bogie operate satisfactorily on curves- a)main line , minimum b)depot, minimum	cl.10.1.3 120 m 100 m	Yes / no	
	Confirm the following:			
(iii)	bogie rotational resistance (X factor) at rotational speed of 0.8 degrees / second	cl. 10.2.6 ≤0.08	Yes / no	
(iv)	ride index for new wheel, vehicle suspension parts with inflated air springs on existing KMRCL track upto maximum designed speed.	cl.10.2.5 ≤2.50	Yes / no	
(v)	ride index for new wheel, vehicle suspension parts with deflated air springs on existing KMRCL track upto maximum designed speed.	cl.10.2.5 ≤3.0	Yes / no	
(vi)	vertical acceleration	cl.10.2.9 ≤0.27 g	Yes / no	
(vii)	lateral acceleration	cl.10.2.9 ≤0.27 g	Yes / no	
(viii)	derailment quotient	cl. 10.2.4 ≤1.0	Yes / no	
(ix)	Provide layouts of both motor bogie & trailer bogie along with		Tenderer shall	

S.N	Parameter	Technical Specification Requirement	Tenderer compliance	Tenderer's Proposal Reference Clause
	descriptions, details, dimensions and salient features		submit details	
(x)	Provide the details of :		Tenderer shall submit details	
	Primary Springs:			
	a) Name and address of manufacturer (OEM)			
	b) Type			
	c) Name of previous MRTS projects on which similar design of primary springs were provided by the OEM			
	Secondary Springs:			
	a) Name and address of manufacturer (OEM)			
	b) Type			
	c) Name of previous MRTS projects on which similar design of secondary springs were provided by the OEM			
	Axle roller bearings			
	a) Name and address of manufacturer (OEM)			
	b) Type			
	c) Life rating calculations of axle roller bearings			
	d) Name of previous MRTS projects on which similar design of bearings were provided by the OEM			
	Dampers			
	a) Name and address of manufacturer (OEM)			
	b) Type			
	c) Name of previous MRTS projects on which similar design of dampers were provided by the OEM			

Table A-19: Pneumatic, air supply & Brake Equipment:

S.N	Parameter	Technical Specification Requirement	Tenderer compliance	Tenderer's Proposal Reference Clause
(i)	Will the brake system satisfy the requirements as per TS clause	cl.11.2.4	Yes / no	
(ii)	Will the emergency brake system satisfy the requirements as per TS clause	cl.11.3	Yes / no	
(iii)	Will the Electro-pneumatic friction brake system satisfy the requirements as per TS clause	cl.11.4	Yes / no	
(iv)	Will the Electro-dynamic brake system satisfy the requirements as per TS clause	cl.11.5	Yes / no	
(v)	Will the parking brake satisfy the requirements as per TS clause	cl.11.6	Yes / no	
(vi)	Provide the following details of the proposed Pneumatic & brake systems: a) Name and address of manufacturer (OEM) of brake system b) Type c) Name of previous MRTS projects on which similar type of brake system was provided by the OEM d) Layouts of brakes on all cars e) Descriptions, details, specifications, and catalogues of all equipments		Tenderer shall submit details	

Table A-20: High Voltage and Propulsion Equipment:

(a) Traction Motor

S.N	Parameter	Technical Specification Requirement	Tenderer compliance	Tenderer's Proposal Reference Clause
(i)	Will the traction motor be designed and manufactured to International standards	cl.12.4 IEC 60349-1 & 2	Yes / no	
(ii)	will the electrical equipments proposed comply the testing requirements as per IEC standards	cl.12.1.1 IEC 61133	Yes / no	
(iii)	will all underframe mounted electrical equipment comply to IP65 as per the TS clause	cl.12.1.7	Yes / no	
(iv)	will the traction system proposed satisfy the requirements as per TS clause	cl.12.2	Yes / no	
(v)	Provide the following details of Traction motor proposed:		Tenderer shall submit details	
	Name and address of the manufacturer			
	Motor type			

S.N	Parameter	Technical Specification Requirement	Tenderer compliance	Tenderer's Proposal Reference Clause
	Continuous rating for operation:			
	a) power (kW) output at shaft			
	b) voltage			
	c) current			
	d) frequency			
	e) slip at full load			
	f) power factor			
	g) efficiency			
	h) speed (rev/min)			
	One hour rating for operation:			
	a) power (kW) output at shaft			
	b) voltage			
	c) current			
	d) frequency			
	e) slip at full load			
	f) power factor			
	g) efficiency			
	h) speed (rev/min)			
	Maximum frequency			
	Gear Ratio			
	Class of Insulation			
	Temperature Index of winding insulation			
	Permissible temperature rise of winding			
	Type of cooling			
	Air gap			
	Weight of traction motor			
	a) with pinion, gear case and flexible coupling			
	b) without pinion, gear case and flexible coupling			
	Provide the descriptions, specifications dimensions and catalogues			
	Name of previous MRTS projects on which Traction Motors of similar design were provided by the OEM.			
	Coefficient of adhesion			

(b) Traction Inverter:

S.N	Parameter	Tenderer compliance	Tenderer's Proposal Reference Clause
(i)	Provide the following details of proposed Traction Inverter:	Tenderer shall submit details	
	Name and address of the manufacturer		
	Type of control		
	Number of inverter sets per motorcar		
	Is the Inverter unit of modular design – (Yes/No)		
	a)DC link		
	b)Ripple voltage (during regeneration)		
	Inverter :		
	a)Output voltage		
	b)Output current braking		
	c)Output current powering		
	d) Output frequency		
	e)Number of diodes per set		
	f)Number of IGBT per set		
	g) Modulation frequency		
	Efficiency of Inverter		
	Power Factor at Rated Power		
	Power rating of Inverter		
	Type of cooling		
	Total weight including reactors, capacitors & switch gear		
	Overall Dimensions		
	No. of harmonic filters		
	Type of harmonic filters		
	Noise level in dB		
	Voltage ripple value during regeneration		
	Current ripple value		
	Name of previous MRTS projects on which Power Converter-Inverter of similar design was provided by the OEM.		

(c) Third rail current collector:

S.N	Parameter	Technical Specification Requirement	Tenderer compliance	Tenderer's Proposal Reference Clause
(i)	will the third rail current collector comply TS clause	cl.12.12	Yes / no	
(ii)	will the current collector be spring applied type & top collector system	cl.12.12.3 cl.12.12.7	Yes / no	
(iii)	Will the current collector be within the kinematic envelope specified	cl.12.12.8	Yes / no	
(iv)	Provide:		Tenderer shall submit details	
	Name and address of the manufacturer			
	Type			
	Rated voltage			
	Rated current capacity			
	Maximum recommended operating speed			
	Material of current collector shoe			
	No of current collector per car MC			
	The expected frequency for replacement of collector shoe			
	Name of previous MRTS projects on which same type of current collector were provided by the OEM.			

(d) Traction power supply in workshop:

S.N	Parameter	Technical Specification Requirement	Tenderer compliance	Tenderer's Proposal Reference Clause
(i)	Has submitted the layout showing the electrical receptacles on all cars as per TS clause	cl.12.13	Yes / no	
(ii)	Provide the description, specification / catalogue of receptacles proposed.		Tenderer shall submit details	

(e) High speed circuit breaker:

S.N	Parameter	Tenderer compliance	Tenderer's Proposal Reference Clause
(i)	Provide the following details of proposed high speed circuit Breaker	Tenderer shall submit details	
	Name and address of the manufacturer		
	Type		
	Rated voltage		
	Rated current		
	Maximum permissible operating voltage		
	Rated short time current		
	Total fault clearing time		
	Making and breaking capacity		
	Impulse voltage withstand		
	Control circuit voltage		
	Number and rating of auxiliary contacts		
	Over-all dimensions and weight		
	Name of previous MRTS projects on which same type of VCBs were provided by the OEM.		

Table A-21 Auxiliary Supply Electrical Equipment:

(a) Auxiliary Inverter (IGBT based or latest):

S.N	Parameter	Technical Specification Requirement	Tenderer compliance	Tenderer's Proposal Reference Clause
(i)	Will the design comply IEC standard	cl.13.2.5 IEC 61287-1	Yes / no	
(ii)	Will the auxiliary inverter maintain outputs as per TS clause	cl.13.2.7 IEC 60085	Yes / no	
(iii)	Provide the following details of the proposed Auxiliary inverter ;		Tenderer shall submit details	
	Manufacturer's name and address			
	Power rating (kVA).			
	No. of IGBT used with ratings			
	Type of control			
	Switching frequency converter			
	Switching frequency inverter			
	Input voltage			

S.N	Parameter	Technical Specification Requirement	Tenderer compliance	Tenderer's Proposal Reference Clause
	Output 1:			
	a) Voltage			
	b) No. of phase and wiring			
	c) Rated capacity			
	d) Rated frequency			
	e) Output voltage distortion factor			
	Output 2:			
	a) Voltage			
	b) No. of phase and wiring			
	c) Rated capacity			
	d) Rated frequency			
	e) Output voltage distortion factor			
	Output 3:			
	a) Voltage			
	b) No. of phase and wiring			
	c) Rated capacity			
	d) Rated frequency			
	e) Output voltage distortion factor			
	Power Factor at Rated Power			
	Harmonic frequencies and amplitude			
	Overall efficiency			
	Type of cooling			
	Noise level in dB			
	weight			
	Descriptions, specifications and catalogues			
	Name of previous MRTS projects on which Auxiliary Converter of similar design was provided by the OEM.			

(b) Battery Charger

S.N	Parameter	Tenderer compliance	Tenderer's Proposal Reference Clause
(i)	Provide the following details of the proposed battery charger:	Tenderer shall submit details	
	Name and address of battery charger manufacturer		
	Type		

S.N	Parameter	Tenderer compliance	Tenderer's Proposal Reference Clause
	Capacity and rating		
	Is Battery charger a part of Auxiliary Converter? If No, also furnish the following information:		
	Descriptions, specifications and catalogues		
	Weight		
	Name of previous MRTS projects on which battery charger of similar design was provided by the OEM.		

(c) Battery

S.N	Parameter	Technical Specification Requirement	Tenderer compliance	Tenderer's Proposal Reference Clause
(i)	will the rating & testing comply IEC standards	cl.13.4.1 IEC 60623 IEC60993		
(ii)	Will the battery capable of operating between 110V d.c. +25% -30%	cl. 13.4.10		
(iii)	Provide the following details of the proposed battery:		Tenderer shall submit details	
	Name and address of battery manufacturer			
	Type of the battery			
	Number of cells			
	Ampere hour rating			
	5 hours discharge rate			
	Frequency of topping-up of electrolyte			
	Descriptions, specificaitons and catalogue			
	Weight			
	Leakage current			
	Name of previous MRTS projects on which battery of similar design was provided by the OEM.			

Table A-22: Ventilation and Air Conditioning:

S.N	Parameter	Tenderer compliance	Tenderer's Proposal Reference Clause
(i)	Provide the following details of proposed VAC:	Tenderer shall submit details	
	Name and address of VAC unit manufacturer		
	Compressor:		
	a) Type		
	b) Rating		
	Condenser coils and fans:		
	a) Type		
	b) Rating		
	Evaporator coils and fans:		
	a) Type		
	b) Rating		
	Main unit		
	a) Type		
	b) Rating		
	Emergency Inverter		
	a) Make		
	b) Type		
	c) Rating		
	d) Input voltage		
	e) Output voltage		
	Refrigerant used		
	Frequency of cleaning:		
	a) Fresh air filter		
	b) Return air filter		
	c) Condenser and evaporator coils		
	weight		
	Description, specifications and catalogues of various equipments		
	Name of previous MRTS projects on which same type of VAC units were provided by the OEM.		

Table A-23: Design details & Drawings

S.N.	Description	Clause no.	Tenderer compliance	Tenderer's Proposal Reference Clause
(i)	Layout of Metro train (of 6 cars) configuration with dimensions and cross sections	cl.1.1.3	Yes / no	
(ii)	Kinematic Envelope	cl.2.8.1	Yes / no	
(iii)	Details of Typical round trip and speed time of fully loaded train	cl.3.2.3	Yes / no	
(iv)	Operation performance characteristics including degraded condition	cl.3.0	Yes / no	
(v)	Software package for commercial speed	cl.3.3	Yes / no	
(vi)	Estimated Specific energy consumption	cl.3.11	Yes / no	
(vii)	Quality specification of the re-generated energy including Harmonics	cl.3.11	Yes / no	
(viii)	Drawings of cars showing all dimensions, profiles and cross sections	cl.5.3.7	Yes / no	
(ix)	Drawings of cars showing all underframe mounted equipments with cross sectional details	cl.6.8	Yes / no	
(x)	Drawings of cars showing all roof mounted equipments with cross sectional details	Cl.6.9	Yes / no	
(xi)	Aesthetics alongwith drawings & isometric sections	cl.6.2.4	Yes / no	
(xii)	Predicted values towards crashworthiness of cars.	cl.6.11.5	Yes / no	
(xiii)	Estimation of Time required for replacement of door leaf.	cl.8.2.14	Yes / no	
(xiv)	Details of locking device for door leaves	cl.8.7.4	Yes / no	
(xv)	Layout of seating arrangement & calculations of seats proposed	cl.9.1.1	Yes / no	
(xvi)	Brake calculations – friction,dynamic, rheostatic and parking brakes.	cl.11	Yes / no	
(xvii)	Full details of Wheel slip/slide scheme & equipments.	cl.11.17	Yes / no	
(xviii)	Operational detail of VAC, setting etc.	cl.14.5 & 14.6	Yes / no	
(xix)	TIMS system architecture	cl.16.2.2	Yes / no	
(xx)	Proposed standards on Data protocols	cl.16.2.7	Yes / no	

APPENDIX- B: CONTRACTOR'S TECHNICAL SUBMISSIONS (PROPOSED)

The following Table 26-1 is for Reference Purpose Only and is NOT required to be submitted for Tender Evaluation).

NOTE: *The Contractor's Technical Submissions should be considered within the Tenderer's submission of outline Project Management Plan, Outline Works Management Program, Outline Design Submission Program and Outline Inspection, Testing and Commissioning Program.*

Table 26-1 Proposed Contractor's Submittals: (to be confirmed with Contractor)

Note: TS refers to Technical Specification

S.N.	Description	TS clause reference
	Operational Environment:	
1	Kinematic envelopes for both inflated and deflated conditions of springs along with detailed calculations	cl. 2.8.3 & 2.8.4
	Operational Performances- operational plan requirements:	
2	Total power, specific energy of 6 car metro train along with calculations	3.1.1 (vii)
	Commercial speed requirements:	
3	Typical round trips and speed time of fully loaded train as per clause	3.2.3
	Software packages:	
4	Software package employed for calculations of round trips and speed time	3.3.1
	Passenger capacity:	
5	Calculations of number of seats in each car and layout of same	3.4.3
	Traction & Braking efforts performances:	
6	Traction & Braking effort curves along with Formula used	3.5.1
	Degraded condition:	
7	Inter-station running time for 2 degraded conditions	3.10.1
	Electro-Magnetic compatibility performances;	
8	Outline environmental plan for EMC / EMI	3.12.1
	Noise & vibration performances:	
9	Outline environmental plan for Noise & Vibration	3.13.2
	Fire protection performances:	
10	Fire safety design management plan	3.14.1
11	Life cycle cost plan	3.15.1
	Vehicle car body- Aesthetics:	
12	Drawings, renderings, isometric sketches, photographs, artists impressions of proposed aesthetics of car	6.2.4
	Materials:	
13	Details of FRP elements for driver cab front end	6.3.2
	Vehicle body construction:	
14	Details of technology proposed for vehicle body construction	6.4.2
	Car body strength:	
15	Stress analysis (FEA) of car body	6.10.7
16	Tests for stresses as per EN 12663 & EN 15227.	6.10.8
	Crashworthiness:	
17	Detail technical analysis for maximum & minimum collision speeds & absorption of collision energies	6.11.5
	Passenger saloon doors -Passenger Alarm & Emergency system:	
18	Details of passenger alarm & emergency systems	8.8
	Saloon Interior – General:	
19	Proposals / layouts for saloon interior - seats, supports & handles incorporating modern aesthetics	9.1.1
	Disable people:	

S.N.	Description	TS clause reference
20	Detail -Doorway flap or ramp for wheel chair	9.7.1
	Interior Illumination system:	
21	Layout of saloon illumination system fittings & controls	9.12.1
	Bogies - Dynamic requirements:	
22	Calculations of ride index	10.2.5
23	Calculations of Bogie rotational resistance factor	10.2.6
24	Analysis & Model for suspension parameters of bogie	10.2.8
	Bogie Frame:	
25	Analysis & tests for fatigue stresses in welded zones on bogie structures	10.3.4
26	Finite Element Analysis & strain gauge test for bogie frame	10.3.6
	Primary & Secondary suspension:	
27	Dynamic model of bogie to demonstrate performance characteristics	10.5.16
	Bogie mounted equipments:	
28	Finite Element calculations on bogie mountings for various equipments	10.7.7
	Motor suspension:	
29	Calculations for natural frequency of Traction motor suspension	10.8.3
	Wheels, wheel sets, Axles & Axle boxes:	
30	Wheel tread profile	10.10.2
31	Drawings of wheel set assembly, wheel diameter & details, axle details	10.10.7
32	Design calculations for axle, wheel and noise damping measures	10.10.7
33	Procedures for testing of a free-standing assembled wheel set and testing a wheel set in site under a vehicle	10.10.9
34	Maintenance limits of wheels	10.10.14
35	Two numbers of laser based wheel profile measuring & recording system	10.10.14
36	Wheel re-profiling program	10.10.15
37	Wheel set Bearing life calculations	10.10.18
38	Details of wheel truing interface	10.10.27
	Pneumatics, Air supply & Brake system:	
39	Descriptions of brake application modes & performances	11.2.2
40	Calculations for Emergency Braking Distances under dry & wet conditions	11.2.6
41	Calculations for Normal service braking with electric brake blending	11.2.6
	Electro-dynamic Braking:	
42	Dynamic brake curves, speed / traction curves for a 6 car metro train composition	11.5.6
	Parking Brakes:	
43	Calculations for parking brakes performances	11.7.10
	Brake Control Unit:	
44	Design of failsafe Brake Control Electronics	11.9.1(iii)
	Air compressors:	
45	Calculations for capacity of air compressors on a metro train	11.10.3
46	Calculations of duty cycle, charging times, temperatures in motors, etc..	11.10.8
47	Certificates from user railways indicating experience with compressors on the	11.10.14

S.N.	Description	TS clause reference
	system	
	Reservoirs:	
48	Calculations to substantiate sizing of reservoirs on brake system	11.12.2
	Wheel slip & slide protection:	
49	Full details of wheel slide / slip protection scheme & equipment	11.17.3 (iii) & (vi)
	High Voltage Electrical Equipment – DC/AC Traction Inverter:	
50	Demonstration for limits of electrical and thermal rating of all power components	12.3.6
	Energy measurement:	
51	Means to record usage of energy	12.11.1
	Third rail current collector:	
52	Expected frequency for replacement of shoe	12.12.12
	Traction power supply in workshop:	
53	Protection scheme for Electrical receptacles on cars	12.13.3
	EMI:	
54	Protective measures to prevent EMI from all equipment on board	12.14.1
55	Design data, test specifications ,reports and all tests to prevent EMI	12.14.2
	VAC - passenger saloon:	
56	VAC system design, layouts, sizing & selection, etc..	14.1.5
	Design criteria:	
57	Cooling load & heat load estimates, power requirements, weights, etc.	14.2.3 & 14.2.4
58	Details of air velocities in VAC	14.2.9
	Smoke detection:	
59	Proposal for Smoke detection system	14.4.1
	Roof mounted VAC units:	
60	Calculations for inside conditions with one AC unit out of operation	14.5.5
61	Weight of AC unit & details of handling	14.5.12
	VAC control & temperature settings:	
62	Location / layout of AC control equipments	14.6.4
63	Pressure switch settings for VAC	14.6.11
	Compressor / condenser section:	
64	Overheating & overloading protection arrangement for compressor motors	14.7.2
	Condensate drainage:	
65	Sizing & arrangement of condensate drainage	14.10.1
	Electrical & control equipments – cab equipments:	
66	Details of system configuration and components	15.10.1 (iv) & 15.10.2
	Train Management System (TMS) – Architecture:	
67	Proposed TM System architecture along with applicable standard	16.2.2 & 16.2.7
68	Details of Communication protocols, along with hardware / software tools	16.2.8

S.N.	Description	TS clause reference
	Train Operating Aids:	
69	List of proposed system & sub-systems to be monitored & displayed by TMS with their interface details	16.4.2 (i)
	Equipments Control and Monitoring:	
70	Data management strategy to define design concepts defect handling	16.5.1 (iii)
71	Detailed list of features proposed to be controlled through TMS	16.5.1 (iv)
	Maintenance support:	
72	Proposed critical performance detection scheme	16.6.1 (ii)
	Man-Machine Interface (MMI):	
73	Proposed MMI detail document	16.8.4 (i)
	Communication system:	
74	Vehicle health data required to be transferred from train to OCC/BCC	17.2.1 (ii)
75	Interface between radio link & TMS	17.2.1 (iii)
76	Interface to enable OCC/BCC to passengers announcements	17.2.2
	DVAS & PAS:	
77	Details of different modes of communication	17.3.5
78	Details of loud speakers & power amplifiers – numbers, positions, etc.	17.3.18
	Automatic Digital Voice Announcement system unit:	
79	Details of Automatic Voice Announcement system	17.5.1 (ii)
80	Details (format, frequency, etc.) of messages to be triggered manually	17.5.1 (vi)
81	Details of commercial / general audio and / or visual messages in between announcements, playing and displaying of such advertisements	17.5.1 (viii)
82	Hardware and software (of voice announcements & text messages) for editing and modification & route database	17.5.1 (x)
83	Details of memory storage capacity to store Route Database	17.5.1 (xii)
	Cab to Cab Intercom:	
84	Procedure of two way communication system	17.6.6
	Emergency Intercom:	
85	Details of Intercom system	17.7.10
	Passenger Information Display System (PIDS)	
86	Detail location of all displays in PID System	17.9.2
	Internal / External Cameras:	
87	Details of Internal / External cameras in PSS System	17.11.7
	Materials & Workmanship: Standards:	
88	Copies of all alternative standards proposed	18.2.5
	Welding:	
89	Details of critical welds on all structures marked on relevant drawings	18.9.5
90	Non Destructive Testing program & procedures	18.9.9 (ii)
	Labels & Rating plates:	
91	Design of equipment identification labels	18.10.13
	Cables:	
92	Types of cables for different applications & specifications of cables	18.13.6

S.N.	Description	TS clause reference
	Cable Joints & Construction:	
93	Samples of types of crimped lugs / terminations	18.14.5
	Cable runs:	
94	Layout & wiring arrangement	18.17.1 (vi)
	Protection & Earthing:	
95	Complete Earthing scheme	18.19.7
	Electronic Equipments:	
96	Information in respect of Printed Circuit Boards	18.25.7
	Software:	
97	Software Quality Plan	18.27.3
	RAMS:	
98	RAMS plan	19.1.1
99	Reliability Demonstration	19.3.1
	Maintainability requirements:	
100	Furnish list of LRUs	19.6.9
101	Expected MTTR of identified key systems	19.6.10
	Maintainability Demonstration:	
102	Tests to demonstrate maintainability predictions	19.7.1
103	Maintenance Work Instructions (WMI)	19.7.2
	Vehicle Maintenance Program:	
104	Maintenance Program	19.8.1
105	Downtime & Manpower requirements for the maintenance, Inspections & Service checks	19.8.2 & 19.8.3
	Safety Assurance:	
106	System Safety Assurance plan	19.9.2
	Hazard Analysis:	
107	Hazard Analysis report	19.10.2
108	List of critical & catastrophic items identified	19.10.7
109	Schedule of Hazard Analysis submissions	19.10.9 (v)
	Fire Safety Analysis:	
110	Fire Safety analysis report	19.11.1
	Inspections, Tests & Commissioning:	
111	Inspection, Testing & Commissioning Plan	20.1.1
112	Proposal for waiver of Type tests of certain items	20.1.4
113	Detailed Test procedures for each equipment / sub-system / system	20.2.1
	Integrated Testing & Commissioning:	
114	Tests & Test procedures for Integrated Testing of Train on KMRCL alignment	20.4.2 & 20.4.3
	Service Trials:	
115	Service trials procedures to fit train into revenue service enlisting various operability & maintainability aspects	20.5.3
	Complete Brake System. Type tests:	
116	Proposal to combine test of individual items with the system test	20.15.2

S.N.	Description	TS clause reference
117	Detail test procedures to establish designed performance of Brakes including wheel slide protection system	20.15.3
	Noise & Vibration – verification:	
118	All test procedures, data & results for noise & vibration	20.24.1
	International Standards:	
119	List of International standards	21.1.1
120	Proposed equivalent Standards	21.1.5
	Car Body Mock-up:	
121	Full scale mock-ups of all cars at project site	22
122	Car Body mock-up, two full seating bays as per clause & 3 D model	22.1.1
123	Car Body Engineering mock-up at manufacturing facility	22.2.1
124	Mock-up of Cab with all controls & indications	22.3.1
125	Mock-up of Cab Front end	22.4.1
	Interface:	
126	Interface Management Plan	24.2.8
127	Various data, as per clause 24.5.4 (1) to Power Supply contractor	24.5.4 (1)
128	Harmonic current spectrum during motoring & regenerative braking (to PS contractor)	24.5.4 (2)
129	Drawing showing RS Kinematic envelope (to PS contractor)	24.5.4 (3)
130	Drawing showing third rail current collector (to PS contractor)	24.5.4 (4) & (5)
131	Details / drawings of buffers on RS (to Track contractor)	24.6.3 (2)
132	Test runs results on Integrated testing & commissioning (to Track contractor)	24.6.3 (3)
133	RS characteristics to S & T contractor	24.7.2 (i)
134	Guaranteed braking at Normal braking efficiency and at the lowest braking efficiency (to S & T contractor)	24.7.2 (iii)
135	RS parameters to be used by S & T contractor	24.7.2 (iv)
136	On board TMS to log information from ATP/ATO & train Radio equipments	24.7.8 (i)
137	Maintenance schedules & equipment requirement for complete cars, assemblies, etc.	24.7.8 (ii)
138	Special requirements for storage & quantities of storage	24.7.8 (iv)

APPENDIX C: Vehicle ATC System Description

One set (redundant pair) of Vehicle Automatic Train Control (ATC) onboard cab systems is installed on every six-car formation vehicle. Kolkata East- West Metro Rail Project vehicle consists of the mainly following Signalling equipment's supplied by Signalling contractor.

On board Signalling Equipment's list	Weight # (In Kg)
• Two modular MicroCab II ATC Equipment Racks, one per cab end	175*
• Two Aspect Display Units (ADU), one per cab end	3.4
• Four Pick-Up Coils (PUC), two per cab end	4.5**
• Eight Pick-Up Coil Mounting Clamps, two per PUC	
• Two Pick-Up Coil Junction Boxes, one per cab end	3
• Two Single Active Speed Sensors (SASS), one per cab end	0.06
• Two Electro-Optical Speed Sensors (EOSS), one per cab end	2.5
• Two AFO-IIC/TWC Antennas, one per cab end	4.27
• Two Cut out switch counter, one per cab end	0.028
• Two junction Box, one per cab	3

#Weight listed only for unit quantity otherwise stated specifically.

* Weight listed includes the weight of the ATC rack and does not account for the weight of Mating Connectors, mounting hardware, or vehicle cabling.

** weight listed only includes the weight of one pick up coil and two mounting clamps, and does not account for the weight of hardware or vehicle cabling.

Vehicle Emergency Brake Logic and ATC Interface:

Signalling contractor recommends and will provide a double-break battery +/- feed to control breaking a vital train line loop (up to 2 Amps).

The following requirements must be met for this interface:

1. The train line loop that Signalling controls shall be vital, that is, in all vehicle control modes (except ATC Cutout), when the master ATC equipment removes energy from this line, the vehicle must apply EB.
2. No other vehicle EB dumping mechanism (e.g. EB switch) can be disabled by the ATC holding energy on its EB interface. That is, all EB switches (emergency button) in all Cars must also drop the EB when depressed, no matter the state of the ATC EBL lines.
3. Conversely, no other EB dumping mechanism's logic can inhibit the ATC EB interface from requesting EB, except when the train is in ATC Cutout mode.
4. Vehicle Bypass logic must deactivate the ATC's ability to demand EB by energizing the EB loop. With the vehicle in ATC BYPASS, the ATC is isolated from the EB loop.
5. Any inductive loads shall be snubbed.

The ATC detects the state of the Emergency Brake circuit by monitoring the EB circuit (EBC) signal. With this, the ATC can detect when some other EB mechanism has commanded EB.

Emergency Brake (EB) Use:

The ATC controls the Emergency Brakes via its vital EB Loop (EBL) output. The ATC closes the EB Loop by energizing EBL. When the EB Loop is closed, the Emergency Brake Relay Bus (EBRB) is energized, which in turn energizes the EB Vital Relay in the ATC Rack. When the EB Relay is energized, power is fed through its contacts to the Emergency Brake Valves, which removes the brakes and permits vehicle motion. The ATC applies the Emergency Brakes by de-energizing EBL, which in turn de-energizes the EBRB and removes power from the EB valves.

Vehicle Interconnecting Cables:

The cabling requirements (maximum limits) for the inter-connecting cables (for pickup coils and AFO-IIC/TWC Antenna) provided by the Vehicle Contractor are as follows:

- Resistance: 9.63 Ohms/1000 ft. or 31.6 Ohms/km.
- Capacitance between conductors: 60 pF/ft or 200 pF/meter
- Capacitance between one conductor and other conductors connected to shield: 90pF/ft or 300 pF/meter
- Maximum total resistance of cabling (including couplings): 10.5 Ohms.
- Maximum total capacitance of cabling (between conductors): 15,000 pF.

On board ATC equipment installation drawings:

KMRC-26017-02a-02

KMRC-26017-02a-03

KMRC-26017-02a-04

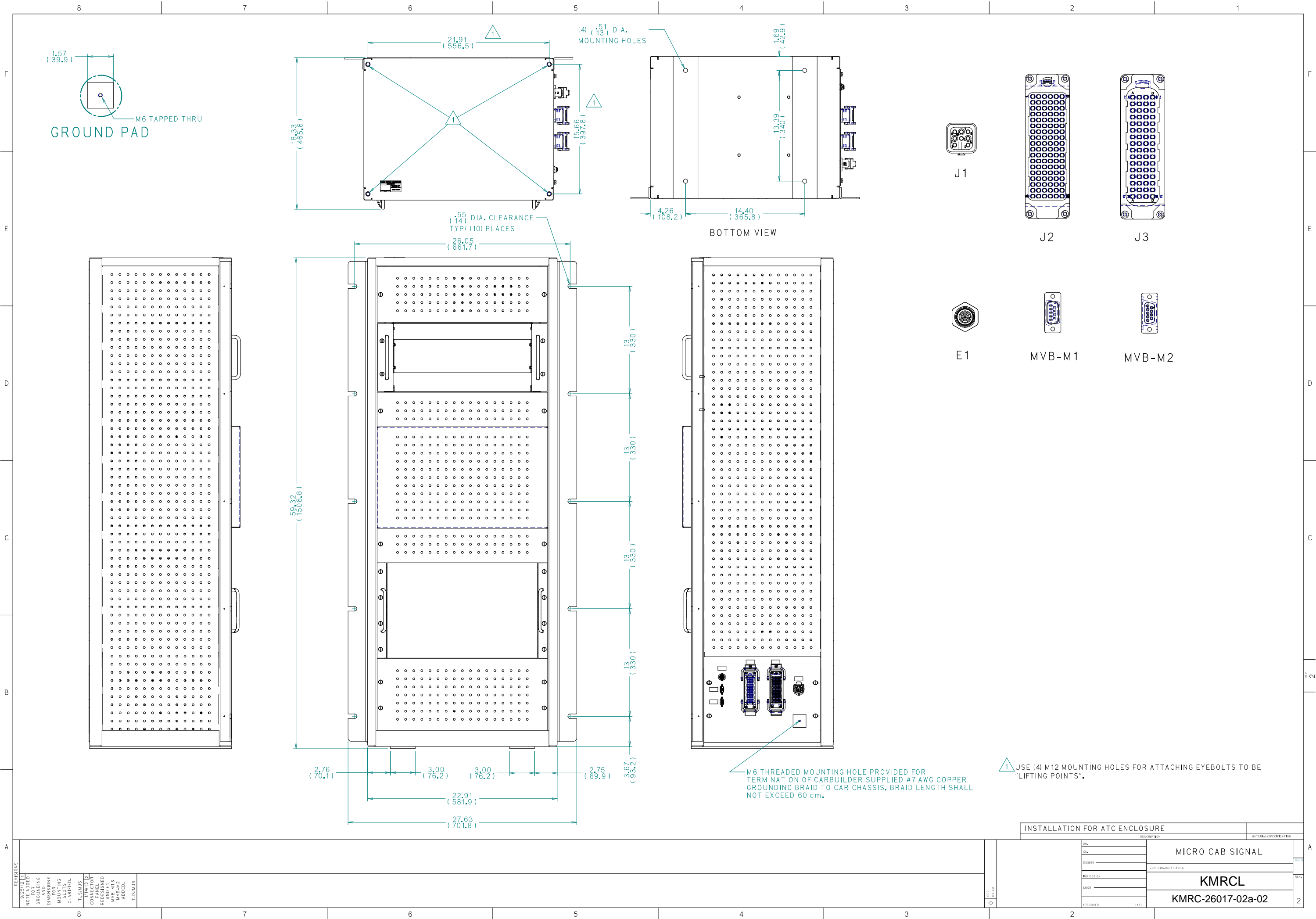
KMRC-26017-02a-05

KMRC-26017-02a-06

KMRC-26017-02a-07

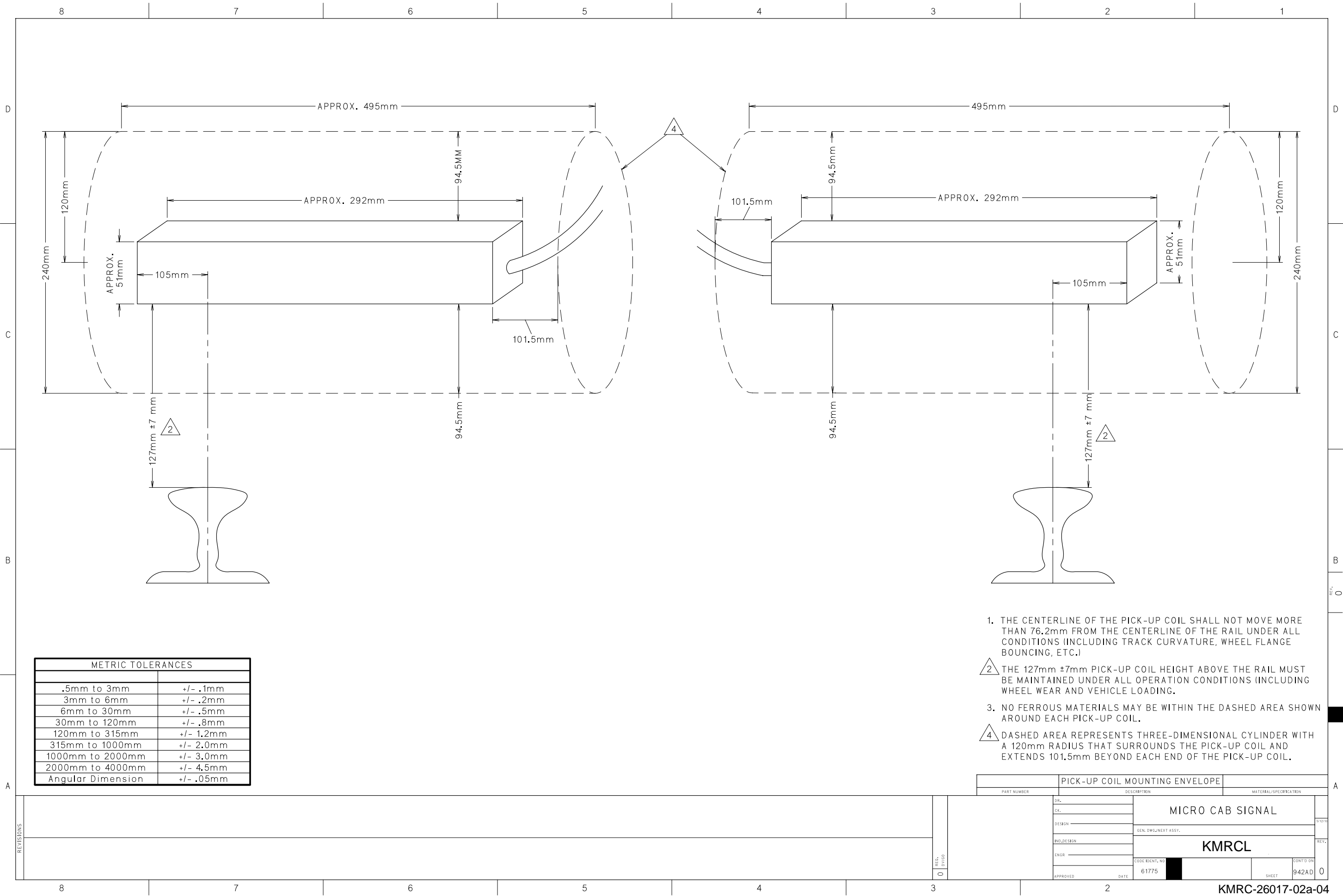
KMRC-26017-02a-08

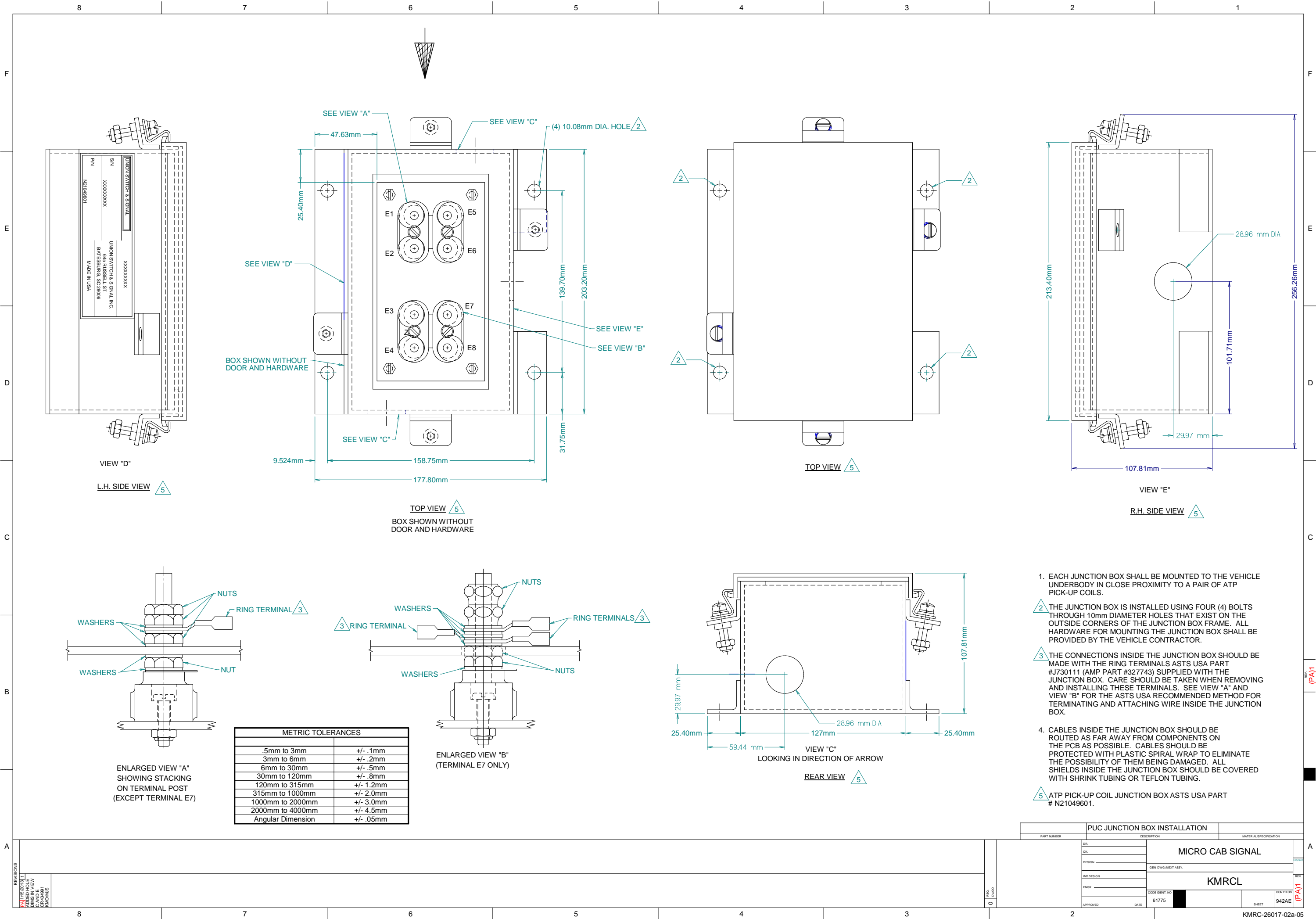
KMRC-26017-02a-09



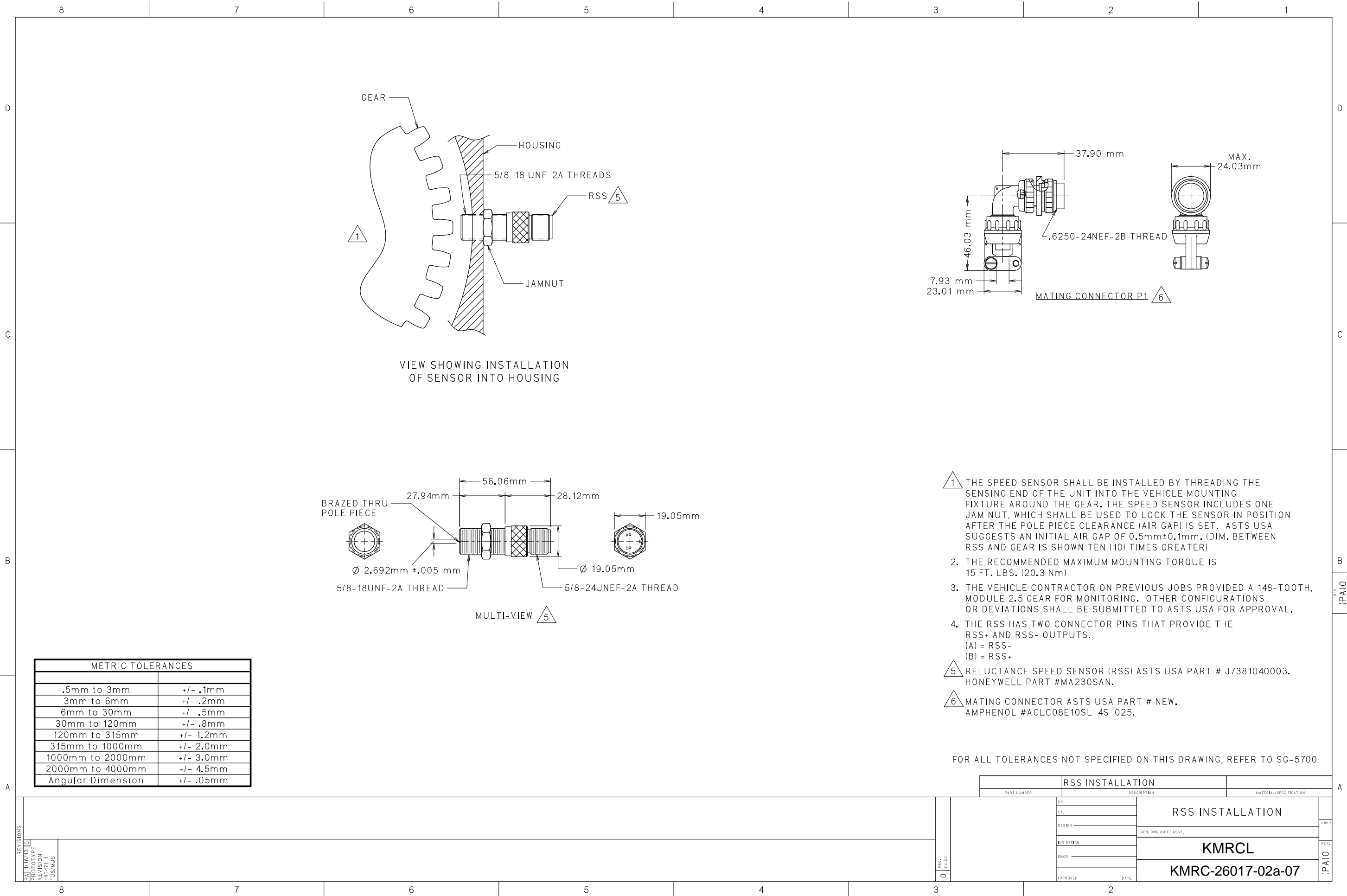
REVISIONS	
NO. 1	FOR ADDITIONAL DIMENSIONS FOR MODIFICATION SLOTS CLARIFIED.
NO. 2	CONNECTOR REDESIGNED AND E1, MVB-M1 & MVB-M2 ADDED.
NO. 3	TJ2/MJUS

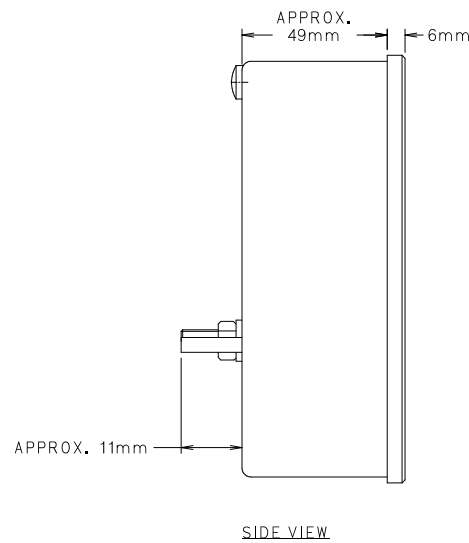
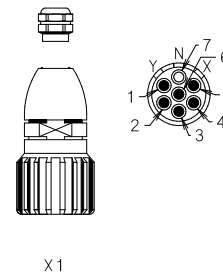
INSTALLATION FOR ATC ENCLOSURE	
DESCRIPTION	MATERIAL SPECIFICATION
DRG.	
CHK.	
DESIGN	
ENG.	
APPROVED	
MICRO CAB SIGNAL	
GEN. DWG. NEXT ASSY.	
KMRCL	
KMRC-26017-02a-02	





		PUC JUNCTION BOX INSTALLATION			
PART NUMBER		DESCRIPTION		MATERIAL SPECIFICATION	
	DR	MICRO CAB SIGNAL			350015
	CK				
	DESIGN	GEN. DWG. NEXT ASSY.			REV.
	IND. DESIGN	KMRC L			
	ENGR				
	APPROVED	DATE	CODE IDENT. NO. 61775		
		SHEET			





1. THE ADU SHOULD BE MOUNTED ON THE EMERGENCY DRIVE CONSOLE (EDC) TO PROVIDE THE OPERATOR WITH ACCESS TO THE VISUAL SPEED DISPLAY AND OTHER VISUAL ASPECTS. ALSO, THE OPERATOR SHALL BE ABLE TO PHYSICALLY REACH THE ADU SO THAT THE KEYPAD CAN BE CONTROLLED.
2. FOUR (4) MOUNTING HOLES SIZED FOR M5 HARDWARE (AM5DIN74) SHALL BE USED TO MOUNT THE ADU TO THE EDC. ALL HARDWARE FOR MOUNTING THE ADU SHALL BE PROVIDED BY THE VEHICLE CONTRACTOR.
3. THE ADU DISSIPATES HEAT PASSIVELY (VIA HEAT SINKS). THE VEHICLE MOUNTING LOCATION MUST ALLOW FOR HEAT DISSIPATION OF THE ADU. THE ADU REQUIRES AIR CIRCULATION TO ADEQUATELY DISSIPATE UP TO 30W. FORCED AIR COOLING IS RECOMMENDED.
4. A GROUND STUD WITH NUT (M6 HARDWARE) LOCATED ON THE BACK SIDE OF THE ADU SHALL BE CONNECTED TO VEHICLE CHASSIS GROUND USING A GROUND STRAP PROVIDED BY THE VEHICLE CONTRACTOR. THE GROUND STUD IS MARKED WITH A GROUND SYMBOL (\perp), THE GROUND STRAP SHALL BE NO LONGER THAN ONE (1) METER IN LENGTH, AND ITS CROSS SECTIONAL AREA SHALL BE AT LEAST 10mm².
5. ALL SHIELDS FOR THE ADU SHALL BE GROUNDED AT THE ADU EQUIPMENT END ONLY. NO OTHER EQUIPMENT OR WIRE ACCESS POINT SHALL GROUND AN ADU SHIELD. ALL ADU SHIELDS MUST BE CARRIED THROUGH THE VEHICLE CONTRACTOR'S INTERCONNECTING VEHICLE WIRE.
6. FOR MATING CONNECTORS X4 AND X5, THE VEHICLE CONTRACTOR MUST ATTACH MVB CABLE SHIELDS INSIDE CONNECTOR CABLE CLAMPS. FOR DETAILED INSTRUCTIONS, REFER TO TYCO ELECTRONICS AMP INSTRUCTION SHEET 408-6609 (AMPLIMITE CONNECTOR HD-20 SHIELDED CABLE CLAMP KITS).
8. OPERATING TEMPERATURE: -25°C TO +70°C.
9. NOT CONNECTED TO VEHICLE WIRING.

METRIC TOLERANCES	
.5mm to 3mm	+/- .1mm
3mm to 6mm	+/- .2mm
6mm to 30mm	+/- .5mm
30mm to 120mm	+/- .8mm
120mm to 315mm	+/- 1.2mm
315mm to 1000mm	+/- 2.0mm
1000mm to 2000mm	+/- 3.0mm
2000mm to 4000mm	+/- 4.5mm
Angular Dimension	+/- .05mm

		ADU INSTALLATION			
PART NUMBER		DESCRIPTION		MATERIAL SPECIFICATION	
DR.		ADU INSTALLATION		UNIT	
CK.					
DESIGN		GEN. DWG/INSTR. ASSY.			
IND. DESIGN		KMRCL		REV.	
ENGR					
CORRECTION		KMRCL-26017-02a-09		(PA10)	