

A2.4 Inside car temperature shall be maintained at 25°C. Contractor to note that the car inside temperature before opening of the saloon doors at each station shall be within 25° C.

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

A2.6 Loading Condition: Heat load of AW2 numbers of persons as per EN 14750-1, throughout the round trip including the terminal turnaround time.

A2.7 Doors opening and closing as per scheduled to and fro run on the route.

A2.8 For terminal stations, 2 times opening as well as closing of doors shall be considered.

A2.9 Contractor shall submit the efficiency value of Auxiliary Converter-Inverter and calculation sheets for:

- i) Cable losses between Auxiliary Converter-Inverter and HVAC with size and length of cables.
- ii) Efficiency curve of Auxiliary Converter-Inverter.
- iii) Cable loss between Auxiliary Converter-Inverter and main transformer.
- iv) Efficiency curves of Main Transformer during run, turnaround and during dwell time.

Submission of above data shall be a prerequisite for accomplishment of milestone A11 (Pre-final design completion) as specified in cost center 'A' of Annexure- PBS to Price Bid Submission Sheet and associated key date i.e. KD No. 3.1 as specified in attachment to Appendix-FB-1 to Form of Bid.

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

B. Validation of Specific Energy Consumption:

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

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

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

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

B1.1.1 The test protocol shall be prepared in detail and got approved from the Engineer before commencement of the test. In the "Combined Test Bed", all original relevant equipment such as Main Transformer, CI, Traction Motor and Auxiliary Converter-Inverter shall be considered. Type test results including efficiency curves at different loads for Main Transformer, Gear Case, CI and Auxiliary Converter-Inverter shall be considered for finalizing the test protocol.

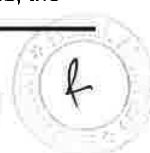
For measurement, CT and PT of accuracy class 0.1 or better as in IEC 60044 shall be used. Energy meter of accuracy 0.15% or better shall be used.

B1.1.2 The declared auxiliary load (D_{Aux}) multiplied by the total round trip time (corresponding to DSSP as per clause 3.22.2) shall be added to the measured value while calculating specific energy consumption in the combined test bed set up. This value shall be the SEC_{P-A} Stage 1.

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

B1.2.1 The value of ' $SEC_{P-declared}$ ' shall also be validated in actual line run - round trip of a 6 car train set from "Dahisar East to Mandala" (under ATO/UTO mode of operation) as per conditions stated in para 3.24(A1) above. This measured value during field trial shall be the SEC_{P-A} Stage 2.

B1.3 Tenderers shall note that, to determine compliance of the total specified ' SEC_s ' value, the



actual values determined on "Combined Test Bed" (B1.1) as well as the actual measured value in the line run test-round trip under ATO/UTO mode of operation (B1.2) would be considered.

B1.4 To determine compliance, higher of the determined Specific Energy Consumption values on the combined test bed i.e. $SEC_{P-A-Stage\ 1}$ and measured value in actual line test i.e. $SEC_{P-A-Stage\ 2}$ shall prevail. The higher of the two values ($SEC_{P-A-Stage\ 1}$ and $SEC_{P-A-Stage\ 2}$) shall be considered as SEC_{P-A} (Achieved SEC_P).

B1.5 Deleted.

B1.6 Combined Test Bed test for validation of ' $SEC_{P-declared}$ ' shall be conducted and concluded during the design stage and before dispatch of the prototype train set. Completion of Combined test bed validation shall be a pre-requisite for accomplishment of milestone for delivery of prototype train set and related key date i.e. KD No. 4.

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

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

B2.2 Validation of ' $SEC_{H-declared}$ ' value shall be done in a climatic chamber as per conditions specified in 3.24 (A2).

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

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

B2.5 Doors shall be opened and closed as detailed for a round trip and passenger load throughout the Round Trip (including terminal detention) shall be AW2.

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

B2.7 The Tenderers shall note that the ' $SEC_{H-declared}$ ' value validation test shall be carried out only after ensuring compliance of "Air Flow" and "Cooling Capacity test" exactly in line with the relevant standards and specifications of this tender.

B2.8 Energy Consumption for HVACs for the car under test shall be multiplied by the number of cars in a train (i.e. 6 cars) to determine the Energy Consumption of HVACs for one train (" SEC_H " Wh/GTKM).

B2.9 Deleted.

B2.10 Completion of Climatic Chamber test shall be a pre-requisite for accomplishment of milestone for delivery of prototype train set and related key date i.e. KD No.4.

B2.11 In case, the round trip time i.e. RTT_{FT} during field trial for measurement of SEC_P is higher than the declared round trip time by the Tenderer during Bid submission (as per clause 3.22.2) i.e. RTT_{DSSP} , the adjustment (i.e. increase) in the achieved specific energy consumption of HVAC (SEC_{H-A}) on pro-rata basis shall be made. For example, say the round trip time declared by the Tenderer during Bid submission is 50 minutes and during actual run, the round trip time was found to be 55 minutes.

$$RTT_{DSSP} = 50 \text{ minutes}$$

$$RTT_{FT} = 55 \text{ minutes}$$

Achieved value of SEC_H i.e. $SEC_{H-A} = 17 \text{ Wh/GTKM}$ (say)

Then, the adjusted value of SEC_{H-A} shall be

$$SEC_{H-A-\text{adjust}} = (SEC_{H-A} / RTT_{DSSP}) \times RTT_{FT}$$

$$SEC_{H-A-\text{adjust}} = (17/50) \times 55 = 18.7 \text{ Wh/GTKM}$$

However, if the round trip time i.e. RTT_{FT} during field trial for measurement of SEC_P is lower than the declared round trip time by the Tenderer during Bid submission (as per clause 3.22.2) i.e. RTT_{DSSP} , no adjustment will be made in the achieved specific energy consumption of HVAC (i.e. SEC_{H-A}) calculated as specified in para A2 above.

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

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

- (i) If the achieved value of ' SEC_P ' on combined test bed and/or during field trial is 26.11 Wh/GTKM, the value would be considered as 26.2 Wh/GTKM.
- (ii) If the achieved value of ' SEC_H ' is 16.89 Wh/GTKM, then value would be considered as 16.9 Wh/GTKM.

For validation, the energy measured with external energy meter during field trials shall prevail.

Contractor shall submit calibration certificate for the energy meters used for measurement from an independent laboratory and such certificate shall not be more than 3 months old.

B3.1 Measurements to be made for:

S.No.	Description	Symbol
1.	Energy Consumption input at pantograph during 'Non-braking' (Traction & Coasting)	E_{231}
2.	Energy consumption at input of SIV (Auxiliary Converter-Inverter) during 'Non-braking'	E_{221}
3.	Energy consumption at Converter-Inverter unit during 'Non-braking'	E_{211}
4.	Energy consumption input at pantograph during 'Braking'	E_{131}
5.	Energy exported during 'Braking' at pantograph	E_{132}
6.	Energy Consumption at SIV (Auxiliary Converter-Inverter) from Line during 'Braking'	E_{121}
7.	Regenerated Energy for input of SIV (Auxiliary Converter-Inverter) during 'Braking'	E_{122}
8.	Regenerated Energy at Converter-Inverter input during 'Braking'	E_{112}

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

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

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

$$\text{Regeneration Output } (E_{OP}) = E_{132}$$



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

Notations are explained below:

E_{xyz}

Where,

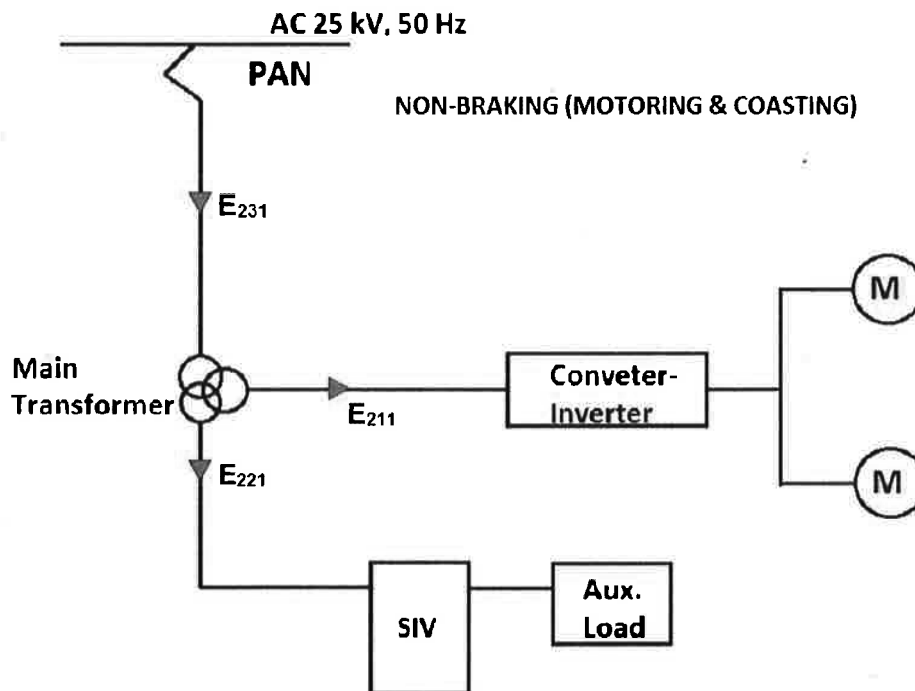
x specifies the mode of operation;

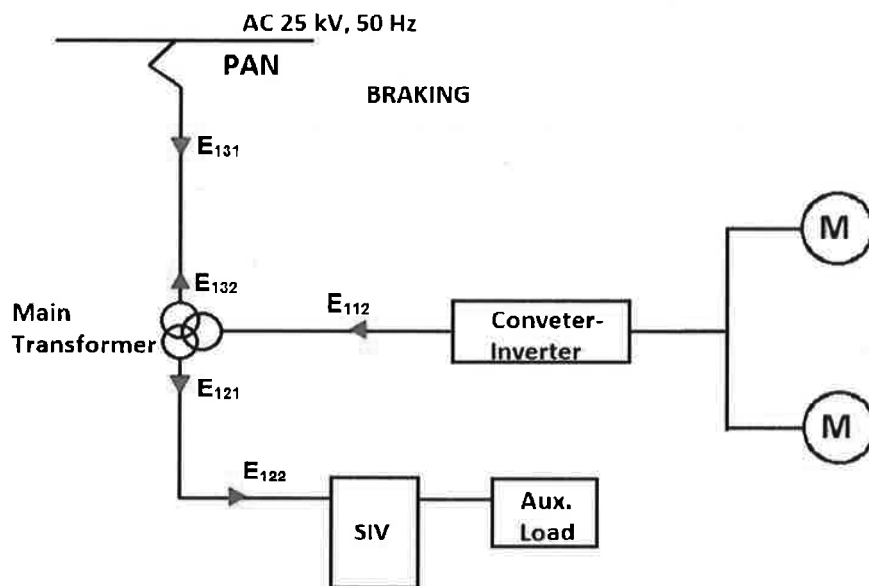
y specifies the equipment under consideration; and

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

Subscript	Value	Description
x	1	Braking mode
	2	Non-Braking mode
y	1	Converter-Inverter unit
	2	SIV (Auxiliary Converter-Inverter)
	3	Pantograph
z	1	Energy consumed from line
	2	Energy regenerated

The above parameters may be visualized in the following diagrams for understanding only:





C. Penalty in case of NON-COMPLIANCE by the Contractor:

Contractor shall further note that in case the total achieved Specific Energy Consumption (SEC_A) is higher than the specified Specific Energy Consumption (SEC_s) value (i.e. 47.5 Wh/GTKM), the penalty shall be imposed for the excess energy consumption.

The Penalty (P) shall be calculated as under:

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

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

- 'P' : Calculated Penalty for non-compliance of " SEC_s "
- ' SEC_s ' : Specified Specific Energy Consumption i.e. 47.5 Wh/GTKM
- ' SEC_A ' : Achieved total Specific Energy Consumption value [$SEC_{P-A} + \{SEC_{H-A}$ or $SEC_{H-A-adjust}$ (as applicable)]]
- SEC_{P-A} : Achieved of SEC_P
- SEC_{H-A} : Achieved value of SEC_H
- $SEC_{H-A-adjust}$: Adjusted value of SEC_{H-A} as per B2.11 above
- 'NRT' : Number of round trips considered per day (considered as '3')
- 'T' : Electricity Tariff per unit (considered as INR 7- per unit)
- 'NT' : Total number of trains (considered as '63' trains)
- 'L' : Life of the stock in years (considered as '35' years)
- ' D_y ' : No. of days in revenue operation in a year (considered as 345 days)
- 'E' : $D_y \times NRT \times L \times T \times NT = 345 \times 3 \times 35 \times 7 \times 63 = 15,975,225$
- 'W' : Gross weight of train under loading condition of 114 passengers/car (296.5 T)
- 'RTD' : Round trip distance in line-2 i.e. 83.01 km



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

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

Achieved value of SEC_P i.e. SEC_{P-A} = 29 Wh/GTKM

AND

Achieved value of SEC_H i.e. SEC_{H-A} = 19.5 Wh/GTKM

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

SEC_A = 29+19.5 = 48.5 Wh/GTKM

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

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

$P = [(48.5 - 47.5)/1000] \times 15975225 \times 296.5 \times 83.01$

P = INR 39,31,89,666

C1.2 In case, the contractor fails to establish the compliance of SEC_s during combined bed test and climatic chamber test, the penalty amount shall be deducted in equal proportions from the amount payable under the cost center 'B'/'C' (as applicable) for delivery of the trains.

C1.3 In case, the contractor established the compliance during combined bed test and climatic chamber test but fails to establish the compliance of SEC_s during field trial, the penalty amount shall be deducted in equal proportions from the balance amounts payable to the contractor under any cost center and if still not recovered, it shall be adjusted by encasing the balance amounts from the Performance Bank Guarantee.

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

C1.5 The maximum amount of penalty calculated as per this clause 3.24 'C' shall however not exceed 10% of the total contract price.

3.25 Deliverables

3.25.1 The Contract deliverables (tools/equipment/software etc.) required to be supplied by the Contractor under this Chapter of ERTS are listed below:

S.No.	Clause No.	Tools/Equipment/Software	Quantity
1.	3.22.9	One complete set of software(s) package and associated hardware as per Clause 3.22.9	One complete Set

Note:

1. The above mentioned list of deliverables is non exhaustive and only meant for the convenience for the Contractor and the Engineer.
2. The cost of these deliverables is deemed to be included in the quoted price of contract.

4.0 VEHICLE BODY**4.1 General**

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

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.

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

- 4.1.3 Design of car body shall be such that sealants are not used as a primary protection for ingress of rain water.

The car body structure shall be constructed so that fixed or mobile jacks can be used to lift the car body, with or without bogies.

- 4.1.4 Additionally, arrangements shall be made to permit the use of portable jacks in a restricted space to re-rail a car after derailment.

- 4.1.5 Full details shall be provided of the arrangements made to provide seating for jacks and body stands, both for normal and emergency applications.

- 4.1.6 Engineer's approval shall be taken for finalizing carbody shape and aesthetics.

- 4.1.7 Employer envisages supply of trains with unpainted stainless steel car body against this tender.

4.2 Mock-ups - General

- 4.2.1 The Contractor shall make available for review at specified locations, the mock-ups specified in Appendix TB. The Contractor may combine various aspects into one or several mock-ups, so long as a clear demonstration is possible of each of the aspects or functions set down in the Appendix. Complete car body as mock-up will be preferred. Digital model alone shall not be acceptable except for the roof layout. The mock-up shall be manufactured with non-inflammable items only so that this can be placed safely within the closed space for training or public view.

- 4.2.2 The mock-ups shall demonstrate the proposed design and design options, and shall progressively increase in detail and level of finish as the design progresses. The mock-ups shall be constructed at the Contractor's facilities. The Contractor shall allow a minimum of two formal reviews by the Employer (4 members). Employer shall depute a team of Engineers (around four) to Contractor's/Sub Contractor's/Vendor's premises for a minimum of two formal reviews. Total expenditure including air tickets as per entitlement and boarding charges shall be borne by the contractor. In such case, Contractor shall provide office facilities at their own cost.

- 4.2.3 After each review, the Contractor shall incorporate the Engineer's comments into the mock-ups prior to the following scheduled review. The mock-ups shall be updated to include prototype/pre-production examples of major equipment such as seats, doors, driving console, etc.

- 4.2.4 The final mock-up shall be maintained at the Contractor's premises till the first train is introduced in revenue service. Subsequently, at the sole discretion and instructions of the Engineer, the completed mock-up shall be delivered to the Employer at site. In case, mock up is not required by the Employer at site then the payable amount under milestone no. A15 will be reduced by 10%.

- 4.2.5 After the final review of the mock-up, and within two months of receipt of prototype, the Contractor shall prepare and handover to the Engineer, 20 numbers miniature approximately 1:50 size true models of the DM-car (non-working), with pedestal and casings. Sample of the model shall be got approved from the Engineer.

- 4.2.6 The Contractor shall prepare and handover to the Engineer, one true model of stainless steel (non-working) of a 6 car train DM-T-M-M-T-DM, approximately 1:20 size, duly equipped with representative track, OCS, interior-exterior furnishings, internal illumination, headlight, marker light and flasher light, display boards, pedestal and casings. All lights in the model shall be functional. Suitable stand (duly approved by the Engineer) shall be provided with the model. The same shall be delivered along with the delivery of the prototype train. Sample of the model shall be got approved from the Engineer.

4.3 Static Vehicle Profile

- 4.3.1 The Tenderer shall design the cars duly considering the Kinematic Envelope provided by the Employer.
- 4.3.2 The notional leading particulars of the driving motor car trailer car and motor car are set out in Table 4.1.

Table 4.1: Principal Notional Vehicle Dimensions

Description		Dimension
Gauge		1,435 mm
Maximum length over Body (including end-fairings)	DM car	22,010 mm
	T and M cars	22,010 mm
Maximum Length over couplers for all cars		23,000 mm
Maximum Width over Body		3,200 mm
Minimum Passenger Saloon Headroom		2,050 mm
Locked down pantograph height for 25kV AC cars from rail level at Car Centre Line		4,048 mm
Maximum Floor height above rail level of any unloaded vehicle		1,130 mm
Minimum Floor height above rail level of fully loaded vehicle		1,100 mm
Maximum height of coupler above rail level for unloaded vehicle		815 mm
Minimum height of coupler above rail level for fully loaded vehicle		740 mm
Bogie wheel base	Maximum	2400mm
	Minimum	2200 mm
Distance between bogie centres	Maximum	15,100 mm
	Minimum	14,400 mm
Wheel diameter	New	860 mm
	Fully worn	780 mm
Maximum axle load		17 Tonne(including all tolerances as per IEC 1133-1992)

- 4.3.3 The addition of two cars as mentioned in clause 1.1.5 shall not increase the average axle load not exceeding 17 Tonne and keeping weight as per IEC-1133-1992.
- 4.3.4 Common body shell structure shall be adopted for all types of car.
- 4.3.5 The design shall ensure that the vehicle remains within the Kinematic Envelope under all conditions (both in tunnel as well as on at-grade and via-duct). The carbody shall be optimized to maximize use of permissible Kinematic envelope.
- 4.4 Materials**
- 4.4.1 The car body shall be constructed of austenitic stainless steel of grade SUS301L to JIS G4305 or equivalent international standard. The Contractor shall bring to the notice and take prior approval of the Engineer, if any of the components of the car body is intended to be of different material. Intermix of Aluminum & Stainless Steel shall not be permitted.
- 4.4.2 Throughout the design life of 35 years, the car body material shall not corrode or be etched by the environmental conditions (See also Clause 3.10.1) that exist in Mumbai 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. During the design life, there shall never be serious mechanical failures of bearings, gears, motor or wheel set which may lead to unsafe conditions/ blocking of operational line during service unless due to neglect of maintenance by employer, accident or misuse. There shall be no structural failure or fatigue cracking of carbody, bogies or underframe load carrying brackets or fixtures during the design life.
- 4.4.3 The exterior appearance of the car body with stainless steel shall be smooth (not corrugated) unpainted metal without the use of filler or other similar material, such that the maximum variation from the required car profile, over any one meter length, shall not exceed 1.5 mm. Any fluting, if offered, shall be shown to have advantages, and shall be subject to review by the Engineer. The roof, excluding the cant rail, may be either corrugated or smooth.
- 4.4.4 Complete coach including underframe of the coach shall be of Austenitic stainless steel except end

underframe / body bolster which may be of Light Alloy High Tensile (LAHT) steel. Preventive measures to prevent galvanic corrosion at dissimilar metal contacts to be ensured.

4.4.5 Deleted.

4.4.6 The finish of the texture shall be subject to approval by the Engineer whether applied by machine or hand. The employer shall approve the finish and approved finish texture shall conform to ASTM A480 or relevant standard: Finish of stainless steel sheets and strip.

4.4.7 In the case of stainless steel cladding materials below 6mm in thickness, the side and end wall sections and under frame shall be manufactured from rolled sections, folded or pressed plates, or plain sheets.

4.4.8 All welds including spots welds marks shall be passivated with acceptable procedure to protect against any visible rusting/chemical deposits/blackening etc.

4.4.9 Non-stainless steel surfaces below the floor of the carbody shall be primed with epoxy coating and then finish painted with two coats of an approved polyurethane paint.

4.5 **Car Weight and Passenger Capacity**

4.5.1 The tare weight of the cars, passenger capacity and weight of passengers are detailed in Chapter 3 (clause no- 3.21.3 and 3.21.4).

4.6 **Car Body Strength**

4.6.1 The mechanical strength of the car body structure shall comply with the requirements of EN 12663 Category PIII. The Contractor shall carry out stress analysis of car body as well as for important structural components which affect safety and availability using the finite element method. However, the strength of the car body shall be decided during design stage by meeting EN 15227 & EN 12663 with exceptional passenger load of 10 passenger/m².

4.6.2 The vehicle shall withstand an evenly distributed downward vertical load equal to 1.1 x the weight of the vehicle complete with all its equipment and supplies, but no passengers, with the body supported at the lifting points provided by the Contractor close to the ends of the body bolsters in the under frame.

4.6.3 For the purpose of strength analysis, the number of passengers seated shall be taken as one per seat and standing as ten per square meter and the weight of each passenger shall be taken as 65kg.

4.6.4 For a welded construction, the camber on coach body under loaded condition with 10 persons/m² shall be such that the structure shall not sag below the horizontal plane throughout the vehicle's 35 years life. However, for shells fabricated with modular elements, the coach shall be built with a suitable camber under tare condition. It shall be ensured that the downward deflection of the coach in fully loaded condition (with 10 person/m²) shall be within the permitted deflection throughout the service life of thirty five years to ensure proper operation of doors under all loading conditions. Detailed calculations shall be submitted by the contractor for the expected deflection so as to confirm that the deflection is within permissible limits under all conditions throughout the life of the coach. 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.

4.6.5 Vertical deflection of the car body structure, up to the fully laden condition, shall not hinder the normal operation of the passenger doors.

4.6.6 The car body, and any equipment mounted on, beneath or within it shall be designed to withstand the fatigue loads that the car body structure will encounter over a period of 35 years in service, in accordance with the criteria described herein. The fatigue life assessment of body structure shall be carried out using recognised techniques and shall be submitted by the Contractor for review by the Engineer.

4.6.7 Suitable acoustic insulation shall be provided on the body side and roof sheet to minimise the effect of reflected noise into the saloon. The carbody shall be designed to have high thermal insulation to reduce the heat loss and heat transfer coefficient (K value) of the carbody excluding glazing/windows shall be kept within 1.6W/(mK). The calorific value of the insulation material used as well as the material used for fixing the insulation shall be bare minimum.

4.7 **Equipment and Equipment Mounting**

4.7.1 All equipment, mountings and fasteners of components shall withstand the forces and impacts as specified in UIC 566/EN 12663 without any part of the equipment becoming detached, and without



any permanent deformation to the car-body.

- 4.7.2 The roof structure shall be designed to support the HVAC equipment, pantographs, VCB, surge arrester, ducts, conduit, lighting fixtures, headlining, stanchions and other equipment, and shall, in addition, have sufficient strength to support, without permanent deformation, concentrated loads of 1000N, applied by personnel working on the roof at increments of 750mm apart. The minimum thickness of roof sheet shall not be less than 1.0mm.

There have been cases of roof getting damaged due to stray wires dropping on the live OHE and flashing through roof sheet. Details can be seen at Clause 4.16.1. In order to avoid puncturing of roof sheet, minimum thickness of roof sheet shall not be less than 1.0 mm.

- 4.7.3 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. The analysis shall demonstrate that all static and fatigue strength requirements of the car body and equipment mounting are met.
- 4.7.4 Calculations of the moments of inertia of the car body about its longitudinal and transverse axes shall be furnished, together with those of the car body bending frequency.

4.8 Crashworthiness

- 4.8.1 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. The overall design shall conform to EN 15227. Energy absorbing tubes (anti climber) shall also be provided in between the cars to reduce the risk of overriding within the vehicle after coupler failure.

EN 15227 states that Crashworthiness validation shall be done at 25 kmph for identical metro train units, which shall be assumed to be equal to train colliding a rigid wall with 12.5 kmph. Contractor shall analyse such scenarios during design stage and safety at survival space and structural integrity of the occupied areas shall be maintained in this scenario.

The car structure design shall meet the criteria laid down in EN15227 at 25kmph collision.

- 4.8.2 The car body design shall be suitable for a six-car train 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.
- 4.8.3 A suitable proven energy absorption feature with associated collapse features shall be incorporated into the coupler draft gear. The coupler shall sustain no permanent damage when a fully loaded six-car train collides with an impact speed up to 10 kmph with another stationary fully loaded six-car train with braked (maximum parking brake) and un-braked conditions.
- 4.8.4 At high energy levels it shall ensure that collision energy is absorbed by progressive deformation of the Coupler structure, Anti Climber at driving car end as well as in between the cars and the vehicle end structure, thereby protecting the passengers and passenger area in the car. There shall be least deformation between the body bolsters.
- 4.8.5 Of particular concern is the driving car front structure, which is required to protect the train operator, and vital control and communications equipment in the event of a collision. The Front part of the driving car is to be used as an emergency escape route from driving car to track
- The Tenderer shall submit his proposal for the structural arrangement of the driving car front and sides, and the manner in which members tie-in with the under frame and roof structure.
- 4.8.6 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 6 car train colliding with another fully loaded braked and unbraked stationary 6 car train:
- (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.
- 4.8.7 The detailed proposal shall also specify the measures taken in the design to achieve the above

objectives and the proposed verification to satisfy the effectiveness of the design.

4.8.8 Deleted.

- 4.8.9 One train shall be fitted with strain-gauged and instrumented couplers so as to be able to measure compressive and tensile loads being experienced by different couplers under different conditions of operation & testing (during commissioning) on main line.

Adequate provisions shall be made to monitor the data from these strain gauged couplers on TCMS. It shall be the responsibility of the Contractor to validate the instrumented couplers and to demonstrate that the loads being experienced by these couplers are within design limits, under different operating scenarios detailed by DMRC. Details shall be discussed during design stage.

4.9 Under Floor Equipment Mounting

- 4.9.1 Equipment shall be mounted in accordance with IEC 1133: 1992 regarding weight distributions.
- 4.9.2 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.
- 4.9.3 Equipment box covers shall be provided with simple secure locking devices, with easily visible markings to indicate locked position. The covers may be of stainless steel/Aluminum. The size and weight of the cover shall permit removal and manipulation by one person.
- 4.9.4 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 catches 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.
- Pneumatic and brake equipment, isolating valves shall be easily accessible from the side.
- 4.9.5 The under-floor mounted equipment cases shall be constructed using materials (e.g. stainless steel/Aluminium) requiring no corrosion protection throughout the life of the car.
- 4.9.6 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.
- 4.9.7 All equipment mountings must be designed such that in the event of mal-operation or failure, equipment will remain secure and within K.E.
- 4.9.8 Mounting arrangements shall ensure that under no circumstances the equipment would fall on line during operation. Contractor shall establish during design.
- 4.9.9 Design of carbody underframe and equipment layout shall consider quick re-railing of the car specifically in case of derailment at points and crossings. Re-railing points shall be located at suitable locations and detail re-railing procedure with normal Lucas tools shall be advised and validated. It shall be possible to place the jack(s) beneath the coupler at agreed location for lifting and moving the car for re-railing purpose.

4.10 Couplers and Draft-gear

4.10.1 General

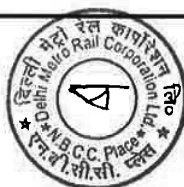
The basic composition is six-car train. The cars shall be provided with automatic couplers and/or semi-permanent couplers as specified in Chapter 1.

4.10.2 Coupling Requirement

The automatic coupler shall, in conjunction with the draft-gear automatically effect mechanical and pneumatic coupling. It shall also permit operation (both couple/uncouple) manually from the track side or remotely from the driving console and saloon.

The coupler shall provide adequate support to the gangway with passengers. Alternative gangway support systems may be proposed. Full details shall be provided.

In order to meet emergency requirements of clearing a disabled train by a healthy train, the couplers in the proposed train shall be totally compatible for effecting safe mechanical and pneumatic coupling.



The coupler and draft-gear shall, in conjunction with the inter-car gangway, be capable of gathering, engaging and coupling units on all track conditions detailed in Chapter 3, Clause 3.14. 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.

The automatic coupler shall be equipped with a integral self-centring device to prevent the coupler from swinging transversely when uncoupled. However, the gathering range of the mechanical coupler shall be suitable for horizontal curves of 100m radius and vertical curves of 1500m radius.

Both coupling and uncoupling arrangements shall be fool proof and shall utilise both the hands with built in safety precautions against possible hazards.

The coupler shall not generally require any maintenance upto intermediate overhaul. Any greasing if required shall be in-situ only.

4.10.3 Automatic Couplers: Protection

When uncoupled, auto-couplers shall be arranged so that pneumatic connections shall be automatically protected from the ingress of water and extraneous foreign matter.

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 atleast 2 years.

4.10.4 Semi-Permanent Couplers and Draft-gear

Semi- Permanent coupler should not sag in uncoupled condition and it should be possible to couple two halves of semi- permanent coupler without any external assistance. 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. The pneumatic connection between the cars of a unit shall be through the semi-permanent coupler.

Electrical end connections shall be semi-permanent. 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.

4.10.5 Draft-gear Design and Energy Absorption Requirements

The draft-gear shall meet the requirements specified in Clause 4.8.

4.10.6 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.

4.10.7 The weakest portion for parting shall be at the junction of the two coupler heads, interrupting pneumatic connections, and thus causing an instant emergency brake application.

4.10.8 All the couplers (Auto, semi-permanent) shall have the shear-off functionality. Wearing parts/plates of the couplers shall give a service life of minimum fifteen years.

4.11 Car Exterior

4.11.1 The appearance of the car exterior must be of a modern and aesthetically pleasing profile and shall minimize the built up of dirt. Approval of the Engineer shall be obtained for car exterior. The car exterior finish with stainless steel body shall not require paint for protection.

4.11.2 Proposals for measures that will maintain the original appearance of the car exterior from undue deterioration, staining or streaking, including appropriate chemical cleaners shall be submitted.

4.11.3 The Project Owner's 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 driving console to be easily visible to the train operator and maintenance personnel.

4.11.4 A longitudinal colour band and /or other branding image shall be provided along each side of each car. The colour scheme shall be agreed upon during the design review of the cars.

4.11.5 Deleted.

4.11.6 The cars shall be completely watertight, without using any sealing compound, and be able to withstand rain water protection test, as approved by the Engineer, simulating a train traveling at speed under severe climatic conditions of Mumbai as well as passage through automatic wash plants. If considered unavoidable, only weld-through sealants shall be provided. The external

sealants shall not be exposed to direct sunlight. The sealants life shall match with the life of the car body and detailed literature/catalogues shall be submitted to the Engineer and approval obtained prior to undertaking manufacture of car body.

- 4.11.7 The design of the car exterior shall generally be aesthetically pleasing, and shall minimize the build up of dirt.

4.12 Driving car Front End Exterior

- 4.12.1 The driving car front end is required to house the following features and devices:

- (i) Windscreens (See 4.13.2) along with sun-blinds,
 - (ii) Train Number Indicators (See Chapter 13)
 - (iii) Destination Indicator (See Chapter 13).
 - (iv) Head- and tail-lights (See Chapter 12).
 - (v) Flasher Light (See Chapter 12).
 - (vi) An electric horn, operable from the train operator's console (See Chapter 12).
 - (vii) Windscreen and Detrainment Door wipers (See Chapter 12).
 - (viii) Detrainment Door
 - (ix) Front and Rear Cameras (See Chapter 13)
- 4.12.2 Suitable step arrangement at first door for entraining and detraining of train operators shall be provided and shall have anti slip surface. The material used should last at least for interval between Periodic overhauls of car body.

- 4.12.3 Deleted.

4.13 Train Operator's Driving console

- 4.13.1 Driving console Layout

- (i) Driving console layout and facilities shall be designed to meet all possible modes of operation including UTO/non UTO, Manual Driving in line/depots/stabling yards etc.
- (ii) Suitable driving console shall be provided at each end of the train to manually operate the train. In addition, a suitable foldable seat for Train Operator shall also be provided under the driving console, which shall be used initially for running the train under GoA2 mode as well as in case the train operating under UTO is required to be driven by the TO under emergency conditions. A removable saloon to driving console partition shall be provided for each Driving Motor (DM) Car in all trains irrespective of mode of operation. The removable partition shall be of the full width of the car with a provision of access door between saloon side and driving console side with a suitable arrangement of locking mechanism (Refer ERTS 7.5).

It shall be possible to remove these partitions without disturbing the interior aesthetics. It shall also be possible to reinstall these partitions in the train, if required. The design shall be finalized by the Engineer during design stage.

- (iii) UTO shall be the predominant mode of train operation. In case the Employer does not engage UTO for any reason, the train operator will be onboard to drive the train under ATO or Manual Mode (under ATP). During such operations, the train operator shall be responsible for train safety and operation of the train as per the Employer's operating instructions and time tables.
- (iv) During UTO operation the driving console shall be concealed by an aesthetically matching cover (with car interiors). The cover shall have sufficient structural strength, vandalism proof, compatible with fire performance and suitably locked and secured. During the non UTO operation only authorised personnel can open the cover which shall be recorded and transmitted to the OCC.

Space for placing the covers shall be ensured when manual operation is required during UTO operation. Emergency detrainment door ramp (in folded condition) shall be suitably covered from inside of driving console and space for keeping this detrainment door cover shall be ensured.

- (v) In order to release maximum space when the saloon to driving console partition is removed during UTO and also to enhance the effectiveness of operation, the control equipment shall be installed at distributed locations without affecting the safety, maintainability and reliability of train operation. During the design and in the physical mock-up it shall be demonstrated that the removal of the



temporary partitions and other temporary fixtures shall be easily possible and space released for commuters giving good visibility of the driving console front.

4.13.2 Windscreen

The Windscreen including glass of the detainment door shall be constructed of toughened, laminated safety glass, and shall comply with the requirements of UIC 651, IS 2553 (Part-1 and 2), ECE Regulation-43, EN 15152, and UIC 566. The inner and outer surfaces of the windscreens shall be scratch resistant.

4.13.3 Cab Front Cupboard

An emergency equipment cupboard shall be provided at suitable location and equipped with first Aid box, safety equipment including fire extinguishers (5 Kg capacity) etc.

4.13.4 Destination and Train No. Indicators

The train destination and Train no. indicator shall be located at the top of and immediate behind windscreen at appropriate location (See Chapter 13).

4.13.5 Driving Console Lighting

LED based lighting of the train operator's console shall meet the requirements of UIC 651 OR and EN 13272. The driving console area shall be provided with a ceiling lights harmonised with saloon lights and console lights (See Chapter 12).

4.13.6 Train Operator's Seat (Removable)

The train operator's seat shall be cushioned, non slippery, ergonomically designed with back/lumber support using non-flammable materials and filling, and fully adjustable in the longitudinal and vertical directions. When operating in GoA3/4, this train operator seat shall be removed and suitable provision shall be made in the floor to ensure that no permanent marking remain on the floor. In addition, a suitable foldable seat for Train Operator shall also be provided under the driving console, which shall be used in case the train operating under UTO is required to be driven by the TO under emergency conditions.

4.13.7 Not Used.

4.13.8 Saloon-to-Driving console Door

There shall be a removable temporary door in the removable partition between the saloon and the driving console. (See Chapter 7).

4.13.9 Not Used.

4.13.10 Driving console Floor

The driving console floor shall be clear of all discontinuities, and shall not incorporate access panels to underfloor mounted equipment, junction boxes and cable ducts. It shall be possible to undertake water washing of the driving console floor without damage to the floor or equipment. The driving console floor material, the floor covering and general design shall be similar to the saloon interior floor (See clause 4.14).

4.13.11 Not Used.

4.13.12 Not Used.

4.13.13 Suitable 15A and 5A socket with suitable protection device shall be provided in the console and at both ends of the car for charging emergency light, use of cleaning machines etc.

4.13.14 Brush finished grab rails shall be provided at appropriate (more than one location) locations in the driving console.

4.13.15 An openable window on either side shall be provided in driving console area.

4.14 Saloon Interior

4.14.1 General Considerations

- (i) The Contractor shall propose vehicle interior layouts, which incorporate a modern aesthetic approach with considerations to optimise passenger comfort, safety and security as well as to minimise noise in the saloon.
- (ii) 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, LED lighting, air conditioning outlet grilles, passenger information displays, public address loud speakers, and passenger alarm devices to permit passengers to make the train operator aware of problems.
- (iii) The body side and roof outer skin shall have a suitable thickness of approved acoustic and thermal insulating material bonded to their interior surfaces.
 - (iv) The design of interior fittings shall be safe under all conditions of passenger impact, during emergency braking and buffing under fully loaded condition.
 - (v) All non-metallic materials shall satisfy the fire property requirements of flammability, toxicity, smoke emission limitations etc. specified in EN45545 Part 1 to 7 latest editions or better equivalent international norms/standards applicable for similar metro operations.
 - (vi) All interior surfaces must be finished with good blending and good slow ageing properties to provide a pleasant, high-quality interior and for ease of cleaning and maintenance. No material shall degrade or stain when exposed to food, drink, graffiti, or any cleaners used by the Maintenance Personnel. No material shall produce any odour that would be noticeable or irritating to passengers.
 - (vii) All internal panel surfaces shall be smooth finished with modern low flammability, low smoke emission, anti-graffiti, and low toxicity materials. All internal panels shall be resistant to graffiti, scuffing, vandalism, and cleaning agents (properties of cleaning agent shall comply with the Anti-graffiti Protection Standard NFF 31-112). Rounded corners or covings shall be provided wherever mutually perpendicular flat plane surfaces abut. Metal sticking strips of 150mm depth with radiused coving are required on all exposed vertical surfaces above floor level.

All panels shall conform to ASTM D2563- level 1 and NFF 01-281 standards. The colour shall not fade or discolour with time, or change due to rubbing. Vacuum infusion process with in-mould heating, Non-Crimp Fabric with Phenolic or FR Grade Vinylester Resin (confirming to EN 45545-2), shall be used to get light weight panels having 60% or more fabric by volume.

Additives, fillers, monomers, catalysts, activators, pigments, fire retardants, and smoke inhibitors shall be added to the resin mixes to obtain finished products with the required strength requirements and the flammability requirements as mentioned in EN 45545 Part 2(Category 4-A, Hazard level HL3) latest editions. Antimony Trioxide shall not be used. Mineral filler shall not exceed 30 percent of the finished weight for any preformed matched die molding process.

To obtain desired colour with good surface finish, finished exposed gel-coated surfaces with a minimum gloss value of 85 when measured with a 60 degree gloss-meter as per EN ISO 2813, high scratch resistance and anti-graffiti properties, gel coat with layer of surface tissue be used in the moulds. The gel coat shall have a minimum thickness of 0.4 mm and a maximum thickness of 0.75 mm. Painting of panels shall not be permitted unless specifically approved by the Engineer. Hand laying process shall not be acceptable, unless specifically approved by the Engineer.

Alternatively, Contractor with the approval of Engineer may use Prepreg panels subjected to meeting the requirements of flammability, toxicity and smoke emission limitations etc. with suitable surface finish, scratch resistance and anti graffiti properties.

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

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

Contractor must furnish details for different panels but not limited to properties such as Glass Content, Ultimate Tensile Strength, Tensile Modulus, Ultimate Flexural Strength, Flexural Modulus, Compression Strength, Compression Modulus and Impact Test complete with the test methods in compliance of relevant ISOs.

Contractor shall also submit 200 mm x 250 mm samples of each proposed material, indicating material finishes.



- (viii) As far as possible, fastening devices, hinges, fixings and securing screws shall not be visible from within the saloon.
- (ix) Gaps between all interior lining, panels kick strips, seat shell, etc. shall be kept to bare minimum. Suitable cushioning at panel joints shall be provided to suppress noise.
- (x) The area between top of body side windows and the ceiling shall be utilised for advertising displays. Ceiling shall be of honeycomb panel to minimise noise transmission inside the saloon.
- (xi) The Contractor shall propose arrangements for Line route maps, system route maps and advertisement holders in the saloon that are unobtrusive and easy to maintain. He may also propose alternative and additional display systems, which satisfy the above intentions.
- (xii) Equipment cupboards for housing equipment, for which access from the saloon is necessary, may be provided at the car body ends.
- (xiii) At least two fire extinguishers of the dry powder type of approximately 10 kg capacity shall be installed in each saloon, readily accessible and flush mounted on panel diagonally.
- (xiv) A dedicated space shall be provided in the Driving Motor car, near the first door of the car, 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.
- (xv) The Contractor shall provide all interior and exterior signages required by the Engineer for approval. All interior /exterior stickers/ signages strips / logo etc used in any location shall conform to international norms and must be in use in more than 5 different metros worldwide. The safety related signages shall be fluorescent. The signage used for marking wheel chair shall be placed on floor as per the standard signage. The Adhesion value of the signages after 24 hours of application shall be 1450-1500 gm/2.5cm. Contractor shall prepare detail plan for signages and stickers as followed in the metros worldwide for engineer's approval. The signages for emergencies shall be fluorescent types.
- (xvi) Each saloon shall have at least one 230V & 5A socket and two USB ports on both ends. Additionally, availability of two no. of USB ports at suitable location shall also be ensured at the unreserved seats which shall be finalized during design stage. These sockets and USB ports shall be used for mobile and laptop charging.
- (xvii) Space released due to GoA4, shall either be provided with seats or/and lumber support for standees.
- (xviii) Suitable fire and smoke detection system shall be provided inside the saloon as per ERTS clause 2.20.

4.14.2 Windows

- (i) Saloon windows shall be provided and be flush mounted with the exterior of the car body.
- (ii) All windows, including those in Passenger Saloon Doors shall consist of the following as a minimum:
 - Inner tempered glass (minimum 5mm thick);
 - Air gap (6mm);
 - Double glazed laminated glass with PVB coating between them.
 - Minimum total thickness shall be 18 mm with noise attenuation shall be 33 dBA.
- (iii) All windows shall be designed to minimise solar gain and provide a level of thermal insulation consistent with the requirements of the HVAC system.
- (iv) Window units shall be modular units, and shall be replaceable with minimum disturbance to the rest of the vehicle.
- (v) Large window openings are preferred to permit standing passengers a wider view. The size of the windows shall be subject to review by the Engineer
- (vi) 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.
- (vii) All side windows shall transmit less than 5% of the incident ultra violet radiation. All windows shall transmit between 50% and 55% of incident visible light.



(viii) Deleted.

(ix) Window seals shall be designed to prevent ingress of water to the inside of walls. Use of rubber extrusions is preferred to make the mounting watertight. The sealing material shall be so selected that it lasts at least for the interval between major overhauls of car body.

4.14.3 Passenger Saloon Doors

Each car shall have eight pairs of electrically operated, externally hung, sliding bi-parting doors, four per side (See Chapter 7).

4.14.4 Seats

(i) For all cars including 'First Class' Car, the seating arrangement shall be discussed during design and shall be maximised by avoiding cubicles in the saloon space. The seats shall be designed to ensure they are:

- Comfortable with lumbar support & aesthetically pleasing.
- Easily cleanable, repairable and changeable and will not be adversely affected by normal cleaning agents.
- For all cars except 'First Class' Car, Durable, stainless steel/ SMC (Sheet Moulding Compound) with PIMC (Powder in-Mould Coating) FRP, light weight, fire resistant, anti graffiti, scratch and vandalism proof seats shall be used. In case of FRP seats, high level of anti-scratch resistance as per NF T51-113 & EN438-2 should be followed and according to EN438-2, minimum rating of 3 for scratch resistance and above shall be preferred. Graffiti shall be easily cleaned off from the seats by using approved cleaning agents. Details of such agents shall be furnished and validated. Additional mineral fillers may be added to enhance fire retardant property, flex modulus and surface finish. In case of FRP seats, the colour shall be uniform throughout its thickness and shall have same top surface colour so that the scratches are generally not visible. Additional anti-scratch protection may be provided. Contractor shall get specific approval of fiber reinforcement and polymer matrix materials from the Engineer.
- Mountings shall be capable of withstanding the loads arising in service conditions.
- Sitting surface may be metal/non-metal. In case of metal surface, seat shall be made of anti-slip bucket type stainless steel.
- Provide some resistance to passenger movement longitudinally along the vehicle during acceleration and braking.
- The proposed seats should have been in use in similar metros worldwide.

(ii) The colour scheme and design shall be selected by the engineer during design.

(iii) Behaviour of seats at static, fatigue, vibrations, impact stress shall be tested as per NFF 31-119 and indentation test shall be tested as per ISO 2439. The indentation hardness shall be similar to industry standards. The indentation hardness and depth shall be measured first be tested initially and then at 80,000 cycle intervals.

The natural frequency of the seat system (including seated passengers, each weighing 65 kg) shall be greater than 1.4 times the natural frequency of the carbody natural bending frequency.

(iv) Unpainted seats shall be used. A very high order gloss level shall be achieved and permitted gloss level shall not be less than 80 measured as per the relevant standard. The seats shall be subjected to endurance tests up to 300,000 cycles. In order to release space in the driving console area, auxiliary equipment /panels etc. may have to be placed under the seat. The equipment heat shall not affect the seat and suitable arrangement shall be made for its dissipation. The seat/its base shall be provided with arrangement with 'Sealed for life' hydraulic jack to easily lift by one person it for maintenance purpose. Seating passengers can block the air flow into these equipment/panels. Care shall be taken in design of ventilation/cooling arrangement of these equipment.

(v) 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.

(vi) Seats in 'First Class' DM car shall have improved passenger comfort, including in the areas of seat bottom and back angles, seat width, lumbar support, entry/egress from the seat. The foam selected for the seat back and bottom cushions shall be of fire retardant-treated type. The Contractor shall submit details of seating which will be finalized by the Engineer during design stage.

(vii) Equipment requiring periodic maintenance shall not be installed underneath seats.

(viii) **Submittals**



- All drawings and calculations necessary to evaluate and manufacture all the types of complete seat assemblies used in the car shall be provided.
- One sample of each type of seat shall be provided.
- Seat layout drawings showing the location of all seats in the car for each car type.
- Inspection procedure for the inspection of seat assemblies and components to ensure compliance with the Specification and the requirements outlined in the part and assembly drawings of all seating components.
- A2 Size (420 mm x 594 mm), color, three-dimensional photo-realistic renderings of each type of seating assembly shall be provided before any engineering drawings are provided. The renderings shall be updated and resubmitted after the seat outline drawings are approved by the Engineer.

4.14.5 Draught Screens

- (i) 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.
- (ii) Beyond the stand back area and at the end of the adjacent longitudinal seat a draught screen shall be installed.
- (iii) 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. Bump support/Lumber support arrangement shall be at suitable location as decided by the Engineer.

Draught Screen shall be adequately supported and the packing material used should not come out during the service life.

- (iv) The strength of the draught screens shall be such that passenger loadings shall not produce any permanent deformation, damage or displacement.
- (v) Deleted.

4.14.6 Grab Poles and Rails

- (i) Stainless steel grab poles and rails shall be provided in the standing areas of the saloon for the comfort and safety of standing passengers.
- (ii) Grab poles shall have not less than three vertical arms for increased accessibility. However, space between the vertical arms shall be limited to ensure that no entrapment of any part of the body is possible.
- (iii) Sufficient margin shall be available in the top guide so as to ensure that under extreme loading conditions, the grab poles shall not become free.
- (iv) The grab poles and rails shall suffer no permanent deformation when subject to loading conditions arising in service, in accordance with UIC 566/EN 12663. The mounting of grab poles considers the movement of floating floor for passenger load of 10 passenger/m² and shall ensure free movement in the worst possible scenario.
- (v) Grab poles and rails in the DM and T/M car shall be provided to cover maximum number standing passengers. As a minimum 3 rows of longitudinal bars shall be provided throughout the saloon. The bars shall be suitably contoured in the door area to facilitate easy flow of passengers. The layouts shall be proposed by contractor during design and shall be decided during mock up. The decision of engineer shall be final. Stainless steel grab handles (sample shall be got approved from Engineer during Mock up review), widely used in at least five metros worldwide, shall be used.

Stainless steel grab handles with minimum five handles per meter of grab rail shall be provided. Additional Stainless steel grab rails shall also be provided at the entrance (both sides) of each door and also near gangway as decided by the engineer during Mock up review.

- (vi) Grab rails and stanchions in saloon area shall be brush finished.
- (vii) The Contractor shall incorporate his proposals into the mock up, for consideration. Detailed arrangements shall be finalized and got approved from the Engineer during the mockup finalization



stage. The decision of the Engineer shall be final and binding.

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

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

- (ix) Grab rails shall be so designed that they do not hinder passengers view of door/PEA(Passenger Emergency Alarm) device in CCTV.

4.14.7 Interior Lighting

See Chapter 12 for details.

4.14.8 Floor

- (i) The non-skid floor structure shall be of floating floor type. Aluminium honeycomb sandwiched type floating floor with suitable noise, vibration and heat insulation, duly supported on rubber cones will be preferred. Alternatively, the floor may comprise of ply board with cork inlay/Plymetal, rubber cushion, glass wool insulation and floor covering subject to its conformance with EN45545 part 1 to 7 Latest editions to achieve low noise level inside the cars and less weight. The floor shall be designed to minimise the life cycle cost of the floor over 35 years. Subject to submission of complete details and approval by the Engineer & for better noise attenuation level of the floor and conformance to EN45545 part 1 to 7 Latest editions or better equivalent international standard as specified in ERTS 2.5.8, any suitable alternate design of floating floor can also be considered.
- (ii) The floor, and its mounting structure, shall be designed to withstand specified loads that may be applied over 35 years in normal operation of the consist. The minimum thickness of the floor structure shall be 80 mm. There shall be no hatches in the floor or passenger areas. Floor hatches in driving console shall be avoided.
- (iii) The floor structure shall provide a high resistance barrier to fire and to noise generated beneath the vehicle. Test reports shall be submitted. At all door openings, the floor shall make a water-tight connection. No opening in the sub-floor is permitted.
- (iv) The floor covering shall be anti-slip, waterproofed and sealed, non-skid, resistant to wear and staining shall not trap dust, and shall be easily cleaned using conventional floor cleaning machines/methods and media. The floor covering shall meet the requirements of EN45545 part 1 to 7 Latest editions in respect of fire, smoke and toxicity. The Contractor shall ensure even, uniform and gapless joints. The width of the roll shall be selected to ensure the joint, if any, is only to the farthest from centre of the car. Due to heavy dusty environmental conditions, lot of abrasive dust gets accumulated on the floor within short time and gets stick to it making it difficult to clean by normal means. Contractor shall propose suitable cleaning machines and liquid (with suitable local equivalent) and demonstrate the cleaning procedure to the satisfaction of engineer and without any damage to flooring on long term basis. At least three sets of Machines and shall be supplied by the contractor without any extra cost for each depot. The flooring shall have high abrasion resistance as per ISO-4649 and shall be compliant with relevant EN/ISO standards. It shall also have provision for inlaid logos for handicapped persons etc.
- (v) The floor design shall allow the floor covering to be removed without damage to the floor sub-structure.
- (vi) The total floor structure shall provide an effective fire barrier for a minimum of 30 minutes to be validated as per EN45545 part 1 to 7 Latest editions or better equivalent standards applicable for similar metro operations.
- (vii) The sub-floor should be insulated for anti-drumming and noise suppression.
- (viii) Floor covering shall have a design life of not less than 20 years.



4.15 Inter-Car Gangways

Single piece/Double piece, single skin/double skin with interior panel gangway suitably protected from heat and dust (subject to Engineer's approval) with suitable clamping and jointing arrangement on both ends with saloon end walls shall be provided within the unit. The attenuation of outside noise through the gangway shall not be less than 33 dB. In case of separation of cars the gangways shall have securing arrangement and shall not get damaged or de-shaped. Suitable form of guiding pin/plate etc. shall be provided so that the coupling /uncoupling of gangways can be carried out by one person.

4.15.1 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. The levers shall not be easily accessible to commuters.
- (iv) The means of uncoupling a semi-permanently coupled pair of cars, in workshop conditions shall be described by the Contractor.
- (v) All inter-car gangway structures shall be totally interchangeable with one another.
- (vi) To protect the interior of the vehicles when stabled as units, (i.e. not as a 6-car rake), 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. The Tenderer shall include in his price for twelve such covers.
- (viii) The location of drain holes in the frame shall be such that water does not fall and corrode the junction box or coupler beneath.

4.15.2 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 through at least 1400mm.
- (iii) The interior design shall be fitted with smooth and aesthetically pleasing finish 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 locking arrangement shall not be accessible to the commuters.

4.15.3 Gangway Floor

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

- (vi) The rubber/elastomer elements of the gangway shall give a service life of minimum eight years. However, bellows shall give the service life of minimum fifteen years.

4.15.4 Gangway Strength

- (i) The gangway floor shall be designed to meet the same strength requirements as the rest of the car floor.
- (ii) 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.

4.15.5 Deleted.

4.16 Car Roof and Roof Mounted Equipment

4.16.1 Roof Structure

- (i) Carbody roof shall be curved to suit aesthetics and shall be got approved from engineer. Roof shall be constructed of stainless steel sheets of minimum 1 mm thickness. The 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.
- (ii) In Mumbai area, incidences of stray wire being dropped by birds etc are quite frequent. In many cases this has fallen on OCS and roof equipment mounted on the body. These resulted not only in interrupting train running and power supply system but also withdrawal of rakes from revenue service and also puncturing of roof sheets. To obviate these problems, suitable design arrangements for provision of suitable insulation (for 25 kV single phase) of all live parts on the roof (excepting pantograph pan) shall be provided and methodology shall be finalized during Pre-Final Design Stage with the approval of Engineer.
- (iii) Sometimes these wires are long enough to bridge OCS and body of cars. Design shall ensure that puncturing of the roof is avoided to the maximum extent possible. In such cases, non metallic cab mask is found to experience severe damage. Suitable design provisions shall be made to minimise such instances.
- (iv) Roof design shall be such that there shall be no possibility of water stagnation at any part of the roof.
- (v) All sub components of the roof or roof & equipment bases, shall be continuously welded/brazed to ensure that there is no ingress of rain water between any joints on the roof. Use of water sealant putty alone for water sealant is not acceptable. However, such putty of proven make can be used along with the continuously brazed/welded joints, if required.
- (vi) The Contractor shall submit proposals for review and approval by the Engineer.

4.16.2 HVAC Equipment and Duct

Package units shall be mounted at each end of the car roof, housed in suitable watertight wells in the car roof structure. The wells shall be provided with adequate, double sealed connections to the main conditioned air ducting, electrical supply and condensate drains. Conditioned air shall be fed into thermally insulated ducting. The duct shall be split diagonally from end to end to distribute air evenly throughout the length of the car. In the event of the failure of one HVAC unit conditioned air shall be made available throughout the length of car including driving console in DM car. The design of the duct shall comply with the requirements laid down in ERTS Chapter 11.

Suitable arrangement shall be provided for providing sufficient quantity of conditioned air in the driving console area as well as in the front console and cubicles. The temperature in the driving console area shall be same as achieved in the saloon.

Suitable arrangement shall be provided to drainout the condensate water from the lowest point of the HVAC unit. Service life of the drain holes shall be minimum 35 years. The drain arrangement shall be robust and of adequate size, shall be designed to prevent choking and shall be easy to clean and design shall be finalised during Pre-Final Design Stage. Under no circumstances, the condensed water shall spill inside the saloon or on the platform.

HVAC covers in the roof except for grill of condenser fan shall be of sufficient strength and no restriction shall be placed for movement of maintenance personnel on the HVAC roof.



Deposition of dust in the duct shall be avoided to the maximum extent. It shall be possible to easily clean the duct. Cleaning of the duct shall be simple and Contractor shall suggest necessary equipment required for dust removal and sanitization against fungal growth etc. Contractor shall provide minimum two sets of duct cleaning equipment in each Depot. Thermal insulation and sealing of duct shall have zero calorific value. Tapes and other adhesive materials used in ducts shall have minimal calorific value and shall be fire retardant.

4.16.3 Roof Drainage

The Contractor shall ensure adequate water drainage from the both ends of the roof, such that no water shall be discharged into the vicinity of the passenger doorways. The water shall not accumulate in the rain gutters and shall be easily discharged through adequate sized pipes at levels below the floor level and sufficiently away from the track. Hose/Rubber fittings are not preferred in the discharge pipe and steel pipe fittings shall be preferred. In case, rubber pipe connections are unavoidable due to tolerance clearance issues, they can be used only at one location provided the life of rubber used shall be more than 15 years and suitable window arrangement on the carbody for its replacement shall be available.

The rain gutter shall be so mounted on the car body such that there is no possibility of water seepage from gutter on the body.

The rain gutter stainless steel sheet shall be of same finish as side wall. The joints shall be designed such that no water seepage shall be possible at joints. The surface finish criteria for rain gutter shall be same as applicable for the side wall.

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.

4.17 Design of Exhaust Air Path

Exhaust air exit path shall be provided through openings below the seats, allowing the interior air to pass through the gap between the inner and outer layers of side walls and discharging to atmosphere from outlets provided on the roof at centre and as well as at the ends. Exhaust airpaths/ducts should be metallic, constructed of stainless steel or Aluminium, and having anti-corrosion coatings. They should be sloped to drain any condensate water to the outside of the car. Gravity dampers and water eliminators should be provided at exhaust air outlets to prevent air back flow and water ingestion from rain or car washer. Exhaust grills should be located on the car body areas where the outside static pressure disturbances are minimum, so as to prevent large fluctuations of the car interior static pressure on train runs. The design of exhaust chimney shall be suitably designed to prevent water ingress inside saloon area and between the inner and outer layers of side walls.

4.18 Obstruction Deflection & Derailment Detection Device (ODD)

4.18.1 At the front of the DM car, an obstruction deflection & derailment detection device shall be installed to push away objects on track to avoid derailment along with derailment detection functionality. The actuation of the obstruction deflection & derailment detection device due to impact of the object, shall initiate the emergency brake and shall be recorded by the TCMS. The design of obstacle deflection & derailment detection device and its mounting arrangement shall be proven and should be in use in similar metro applications.

4.18.2 The Contractor shall submit the detailed calculation of design proof load, installation arrangement, safety against derailment, energy absorbing capabilities etc. during detailed design.

4.18.3 Obstruction deflection & derailment detection device mounted on the leading bogie shall be preferred. Detailed arrangement shall however, be discussed during the detailed design and approval of the Engineer shall be obtained. Engineer decision shall be final and binding.

4.19 Deliverables

4.19.1 The Contract deliverables (tools/equipment/software etc.) required to be supplied by the Contractor under this Chapter of ERTS are listed below:

S.No.	Clause No.	Tools/Equipment/Software	Quantity
1.	4.14.8 (iv)	Conventional floor cleaning machines.	At least three sets of Machines for each depot.
2.	4.16.2 & 11.2.8	Duct cleaning equipment.	Minimum two sets of duct cleaning equipment in each Depot.

Note:

1. The above mentioned list of deliverables is non exhaustive and only meant for the convenience for the Contractor and the Engineer.
2. The cost of these deliverables is deemed to be included in the quoted price of contract.



5. BOGIES**5.1 General Requirements and Features**

- 5.1.1 The bogies proposed to be supplied against the tender shall be of proven design principles. Similar bogies as proposed for this tender, shall have been in use and have established their satisfactory performance and reliability on at least three mass rapid transit systems in revenue service over a period of three years or more (in each MRTS) either outside the country of origin or in Indian Metros. The Tenderer should submit performance certificate on the letterhead of metro operator, confirming that the supplied bogies have completed satisfactory performance for more than five years. Tenderers must submit following information with their offer
- (i) Statement indicating commissioning dates of bogies and numbers, duly certified by the metro operators.
 - (ii) Details of the designer and manufacturer (complete address) of the supplied bogies.
 - (iii) Following details of the metro systems where the bogies are in operation:
 - No. of stations with details of inter-station distances
 - Average annual kilometers earned (duly certified by the metro operators)
 - Details of sharp curves (minimum radii)
 - The Tenderers shall submit the details in the proforma specified in 'Annexure TBS-3' of 'Technical Bid Submission Sheet'.
 - In case, the Tenderer is not the manufacturer of bogies and intends to procure the bogies proposed to be supplied against the tender from a sub-contractor, the proposed sub-contractor for the bogie shall meet the eligibility requirements stated above. Further, during contract execution, the manufacture of the bogies by the sub-contractor shall be required to be inspected and certified by a reputed Third Party Inspecting Agency engaged by the Contractor having sufficient previous experience of similar nature. The contractor's proposal for engaging Third Party Inspecting Agency with detailed terms of reference (TOR) indicating detailed scope of work shall be submitted to Engineer for the approval not later than six (06) months from the commencement date. However, maintaining the quality standards, ensuring performance requirement and timely delivery shall be the sole responsibility of the contractor.
- 5.1.2 It shall be manufactured to continue in service, under all 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.
- 5.1.3 The bogies shall be of the two axle bolster less type incorporating a primary suspension system of proven helical coil steel-springs. Vertical damper shall be provided with primary suspension. Calculation supporting the selection of axles and bearings shall be submitted for review and approval by the Engineer. Bogie body connection shall preferably be through resilient transmission bar arrangement.
- 5.1.4 The bogies for all trains under this contract shall be identical to the maximum extent possible. DM, T and M car bogies shall have interchangeable components to the maximum extent possible. The bogie components and suspension components shall be common for all bogies.
- 5.1.5 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 carbody.
- 5.1.6 The design shall provide means for easy compensation for wheel wear and loss of height in the bogie resulting from other causes.
- 5.1.7 The bogie and bogie mounted equipment shall be designed to minimize unsprung mass.
- 5.1.8 The bogies offered shall permit the cars to negotiate curves on plain track and through turnouts as per parameters given in chapter 3.
- 5.1.9 The bogies shall be provided with optimised suspension. Suspension would not be acceptable if bogie shows tendency to hunt up to the maximum test speed.
- 5.1.10 All Rubber/ rubber-metal-moulded items used in suspension shall be type tested for specified temperature and humidity conditions.

5.1.11 The bogie shall be capable of negotiating Depot curves of 100 m radius and main line curves of 110 m radius, turnout up to 1 in 7 & 190m radius. 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 do not lead to excessive rail wear, wheel flange wear and noise, but shall be sufficient to obviate bogie or wheel set hunting.

5.1.12 The design life of the car and the bogie shall not need any rebuilding, repair or strengthening of structural members.

The service life of rubber bonded metal components shall not be less than 8 years and shall be warranted for the same.

5.2 Dynamic Requirements

5.2.1 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.

5.2.2 All vehicles shall be so designed that no part of the car shall infringe the Kinematic Envelope at any speed up to 90 kmph.

5.2.3 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 offloading of wheels ' $\Delta Q/Q$ ' shall not exceed 60% of nominal wheel load for bogie twist and vehicle body twist as per EN 14363 in both inflated and deflated conditions.

5.2.4 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.

5.2.5 The Contractor shall submit calculations to confirm that the derailment quotient Y/Q shall not exceed 1.0 at rail-wheel level 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.

5.2.6 The bogie rotational resistance (X factor) test under inflated and deflated air spring conditions would be carried out at the manufacturer's works under AWO and AW3 conditions, the value of which should not exceed 0.1 at rotational speed of 1 degrees/second.

5.2.7 Vehicle Dynamic Analysis of Bogie:

A Dynamic Analysis, to evaluate the running behavior of the vehicle with the proposed bogie design, shall be carried out by means of theoretical calculations applying multi-body simulation techniques. Proven validated software shall be used. 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.

The Contractor shall submit a proposal covering the scope of the analysis and the model for review by the Engineer.

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

5.3 Bogie Construction: Bogie Frame

5.3.1 The bogie frames shall be of fabricated, robust construction, using high tensile carbon steel to EN10025/ JIS G3114 or an approved international standard, capable of withstanding heavy duty,



the design incorporating adequate safety margins. The bogie frame construction shall be consistent with good mechanical design, be as light as possible. Use of cast steel inserts of acceptable grade in fabrication with specific prior approval of the Engineer in the bogie may be permitted.

- 5.3.2 The Contractor shall submit for review detailed calculations, including a finite element analysis under different boundary conditions, to demonstrate that the strength of the bogie frame is adequate for the specified loading.
- 5.3.3 The bogie frames for all the cars shall be identical unless justified otherwise.
- 5.3.4 The Contractor shall undertake full static load test, fatigue load test 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 these tests shall be approved by the Engineer before starting the testing. These tests have to be done as per UIC 615 and UIC 515 or EN 13749.
- 5.3.5 All fasteners for bogie mounted equipment or components shall be positively locked. Use of self locking Nuts alone shall not be acceptable. However, self locking nuts with lock washers would be acceptable.
- 5.3.6 Adequate corrosion protection shall be provided. A corrosion protection control programme for the bogie shall be submitted. This shall comprise of paint protection system of external surfaces. The internal areas of the frame shall be completely sealed to avoid moisture ingress after the internal surfaces are protected from corrosion by suitable corrosion resistance substance or any other alternative measure. The corrosion protection plan shall be submitted and got approved during detail design.

5.4 **Bogie Construction: Primary and Secondary Suspension**

- 5.4.1 The Contractor shall submit a proposal for the primary suspension system of proven helical coil steel springs. Vertical damper shall be provided with primary suspension and secondary pneumatic suspension system, and contractor shall declare the estimated mean service life for operation in the Mumbai environment. Quality of dampers used shall be very high and guaranteed against any oil leakage/oozing.

Use of Chrome vanadium grade Steel as per EN10089 for helical coil primary suspension system design shall be ensured.

- 5.4.2 Secondary air suspension shall be installed to provide automatic vehicle body to bogie height adjustment, functional for all vehicle-loading conditions. The Contractor shall submit complete details and calculations of the proposed suspension (asymmetrical/symmetrical) during Pre-Final Design Stage for review and approval of the Engineer.
- 5.4.3 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. Leveling of the car once adjusted, shall not get disturbed during operation or otherwise and shall not require any adjustment except for usual adjustments due to wheel wear and placement of shims. The maximum floor height reduction on this account shall be for review by the Engineer. The load sensors shall be placed at the farthest end towards the side wall.

The minimum clearance of bogie-mounted equipment from rail level for a fully loaded car under worst conditions*(*worst condition means wheels with maximum tread wear and primary springs with maximum deflection) shall not be less than 65 mm in static condition and 50 mm in dynamic condition.

The minimum clearance of car body-mounted equipment from rail level for a fully loaded car under worst conditions*(*worst condition means wheels with maximum tread wear and primary springs with maximum deflection) shall not be less than 102 mm in static condition.

- 5.4.4 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 90 kmph) 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. The safe speed at which the train can operate will be determined through oscillation trials to the same safety and statutory limits as per clause 15.5, with either complete (full coach) or partial deflation (one bogie) of the secondary springs.
- 5.4.5 Hydraulic dampers of suitable capacity shall be provided symmetrically to control and limit the vertical and lateral oscillation of the car body. The damping factors are to satisfy the provisions given in table 15.1B. The damping factor in vertical mode, by wedge test, when tested using a



wedge of 18mm thickness should be between 0.20 and 0.25. The damping factor in lateral mode when measured by "quick release side pull test" should be between 0.30 and 0.40. Suspension will not be considered acceptable if maximum acceleration and spring displacements do not decay within 2-3 cycles.

No leakages of any kind shall be permitted. The life of the dampers shall be minimum 10 years.

- 5.4.6 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. Air pressures of all the four air springs (per car) shall be taken accurately to determine the actual average load.
- 5.4.7 The lateral stop shall be cushioned using a properly designed stiffness value. The lateral stops shall be sourced from Vendors having proven experience. Specific approval shall be obtained from the engineer.
- 5.4.8 The air springs shall have over inflation protection. The maximum permissible increase in height will be decided during detailed design stage.
- 5.4.9 Deleted.
- 5.4.10 The design life of secondary suspension air bags (all inclusive) shall not be less than 12 years. The air bags and its components shall not crack/shear/balloon/ burst or deteriorate in its performance during its design life.

5.5 Bogie to Body Connection

- 5.5.1 The car body bogie connection shall be capable of permitting the full range of bogie movements without excessive restraint.
- 5.5.2 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.
- 5.5.3 Traction linkage(s) shall be provided, and located such that the ride characteristic of the vehicle is devoid of any pronounced fore- and-aft and pitching motion. Single traction link (Mono-link) is preferable.
- 5.5.4 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 $\pm 3.0g$.
- 5.5.5 Bogie and car body connection shall be designed to avoid the transmission of noise and vibration.

5.6 Bogie Strength

- 5.6.1 The mechanical strength of the bogie frame shall comply with the requirements of UIC 615-4, UIC 515-4 and EN 13749 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.
- 5.6.2 The bogie frames shall be able to withstand a longitudinal shock load of 5g without failure. This shall be taken as occurring simultaneously with the fully laden vertical load.
- 5.6.3 The axle shall be designed in accordance with UIC 515-3/EN 13103/EN 13104.
- 5.6.4 The number of seated passengers shall be taken as one per seat, and standing passengers as 10/m² for all the above-mentioned strength analyses except for fatigue test. The fatigue load shall be decided based on actual loading which shall correspond to AW2 loading conditions. The loading cycles shall be as specified in respective UIC. There shall not be any crack at the end of any stage of loading cycles. The passenger weight for this calculation shall be taken as 65kg/person.

5.7 Bogie Mounted Equipment

- 5.7.1 The train equipment shall conform to IEC 61371/IEC61373 in respect of shocks and vibrations including the endurance limits. These shall be incorporated in the type test of the equipment.

5.8 Finite Element Analysis



- 5.8.1 Finite element analysis shall be demonstrated using validated software, and detailed calculations submitted for the above-mentioned strengths (including static and fatigue loads).

5.9 Motor Suspension

- 5.9.1 The traction motor shall be bogie frame mounted, complete with suitable drive and suspension. Mounting arrangement shall ensure that under no circumstances traction motor would fall on line during operation. Contractor shall establish during design.
- 5.9.2 Traction motors and drives shall be easily removable in a workshop, after disconnection of cables and fixings without the need to disturb the axle.
- 5.9.3 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.

5.10 Gearbox and Coupling

- 5.10.1 Contractor shall provide flexible coupling between traction motor and drive gear.
- 5.10.2 The gearbox shall be compatible with the flexible single stage/double stage coupling. The motor and the gearbox shall be proven for the proposed gear ratio selected by the Contractor. Gearbox movement 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 1.2 million kms. No sensor shall be installed in the gear case. Comprehensive, flexible and fully automatic test bench(s) shall be provided to test an overhauled/newly assembled gear case with transmission arrangement and duly mounted on the wheel set. The specification shall be got approved from the Engineer.
- 5.10.3 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 200,000 kms. The sight glass shall be of prismatic or better. Suitable arrangement shall be provided in the gear case to trap magnetic impurities in the gear case lubricant.
- 5.10.4 The gearbox shall be subjected to a test based on the actual duty cycle on a specified Corridor with the specified torque and speed conditions. Testing shall start with gearbox at temperature of at least 46°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. The Contractor shall submit a Test Procedure based on international practice for approval by the Engineer.
- 5.10.5 The RPM considered for design and testing shall conform to maximum design speed with fully worn wheels.
- 5.10.6 The torque value considered for design of gears and coupling shall correspond to maximum tractive effort requirement for worst duty cycle. The torque value shall be taken with new wheel diameter. The temperature for type test shall be taken as 46°C i.e. ambient + 10°C proximity effect. The design value of gear box drive and coupling shall correspond to high tractive effort mode of operation and the design shall conform to the requirements of ERTS clause 3.22.7, 3.23, 8.1.9 and 8.9.9(iii).

5.11 Wheels, Axles and Axle-boxes

- 5.11.1 The wheels shall be monobloc-forged steel, complying with the requirements of UIC Code 812-3/EN 13262, grade R8 (for 1435 gauge) having the hardness value of 250-320BHN or equivalent international Standard. However final selection of the grade shall be based on suitability for the type of brake system proposed and the head hardened rails used by the Employer and shall be decided during design review.
- 5.11.2 The powered axles shall comply with UIC Code 811-1/EN 13261
- 5.11.3 The non-powered axles shall comply with UIC Code 811-1/EN 13261
- 5.11.4 Wheels, axles, drive gears and axle bearings shall be assembled on axles by interference
- 5.11.5 The wheel tread shall be of the wear adapted wheel profile in accordance with RDSO sketch no. 91146 (Appendix–TH). Wheel Profile Measurement Gauge (mechanical as well as non contact laser guided Calipri tool or equivalent with accessories, to be finalized by Engineer during Pre-Final Design Stage) with tolerance of 0.1 mm shall be supplied for each depot. The cost of these tools shall be deemed to be included in the quoted price.

- 5.11.6 The Contractor shall furnish the extreme maintenance limit for wheels. The maintenance limits for wheels shall be within limits recommended in UIC 510-2 OR and SOD adopted by Engineer.
- 5.11.7 Axle bearings shall be of a proven type. The roller bearings shall have a minimum life rating of 3 million kilometers when computed in accordance with the method given in ISO 281/1. The Contractor shall provide adequate training to the Project Owner's Maintenance Personnel for overhauling of the axle bearings and shall also provide two sets of the special tools required for overhauling in each depot. The cost of such tools shall be deemed to be included in the quoted price. Details to be finalized during design stage.
- The passenger load as described in Clause 5.6.4 shall be taken for the design of the wheels, axles and axle bearings. Bearings shall be arranged not to carry any traction return current.
- 5.11.8 Natural frequencies of the wheels, axles, axle boxes and other unsprung equipment shall have sufficient separation between natural frequencies with the track structure to avoid resonance.
- 5.11.9 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.
- 5.11.10 Squeal noise shall be measured for at least one sharpest curve by placing microphone at 7.5m distance from rail centre at 3.5m height from rail top toward the direction of both inner rail and outer rail at elevated section (beyond the parapet wall by fixing the microphone on suitable height pole/mast etc.) or at grade, with normal vehicle operating conditions (i.e. TOR, WFL, Wheel Dampers as available in operating condition) including all installed assets, environmental and track conditions as per ISO 3095 at normal operational speed. Sound measuring time shall be the train pass by time (from train head passing time to train tail passing time) as per ISO 3095. A squeal noise shall be evaluated on basis of tone to noise ratio method/prominence ratio method as per Annex A of ANSI S1.13-2005.
- 5.11.11 Deleted.
- 5.11.12 Contractor shall provide at least one system each in each of the Depots for the automated wayside wheel profile measurement and temperature monitoring of axle box bearing. The cost of these systems shall be deemed to be included in quoted price. Details shall be finalized during design stage.
- 5.12 Bogle Brake Equipment**
- 5.12.1 Tenderer shall provide Tread Brake units in all cars. Appropriate Provision shall be made to minimize Rail Contact fatigue incidences (RCF) and consequential need for reprofiling. Wheel reprofiling shall generally not be required below 0.25 million Kms on account of RCFs.
- The Tenderer shall submit detailed comprehensive proposal on the Brake system along with the proof of provenness for similar metro applications and shall also include operator's comments on the proposed system.
- Full details of the braking scheme are given in Chapter 6.
- 5.13 Automatic Train Control (ATC) Equipment Mounting**
- 5.13.1 Full details of the Automatic Train Control System interface issues are given in Appendix TD.
- 5.14 Wheel Flange Lubrication (WFL) Equipment**
- 5.14.1 Oil type Wheel flange lubricators of a proven design in EMU/ metro application shall be provided only at both driving ends of each train or Dry type Wheel Flange Lubricators on 50% axles of each train. The final decision shall be taken during design stage. A suitable mechanism shall be provided to ensure that lubricators operate only in the leading position on the train actuate suitably during traversing of the curves automatically and shall be effective for all wheels, the purpose of the WFL shall be to reduce wear of wheel and track/rail and reduce noise in the curves.
- 5.14.2 The design of WFL system shall ensure precise & cyclic application of lubricant on the flange of the wheel(s) so that the lubrication application is uniformly distributed on the flange surface without any excess deposition on the contact surface. There shall be no flow of lubricant on the tread/braking surface under any circumstance. The system shall be designed to minimize oil and air consumption.



Single tube system shall be preferred. The nozzles shall be designed to protect against choking /clogging due to dust. There shall be no movable part in the nozzle. The design shall permit optimized control of oil spray in straight and curved track by suitably modulating the spraying cycles and quantity of oil in the spray. The spray cycle as above shall be programmable and shall be fine tuned during field trials and performance of wheels during DLP. The programming tools shall be supplied to Employer (one set each line).

5.14.3 The spray of oil shall be time controlled as well as distance controlled. The actuation and spray cycle and quantity shall be decided by the location and degree of the curve which shall communicated to the system by a centrifugal force sensor, coordinates and parameters of curves informed by the vehicle or/and through GPS. Status of WFL shall be available in TCMS. It shall be possible to isolate the equipment through TCMS in case of any defect/malfunctioning.

5.14.4 Provision shall also be made in bogies to permit fitment of dry type flange lubricator on 50% axles in a train. The complete arrangement shall be provided by the Contractor. The cost of the stick shall be borne by Project Owner/Employer. Details shall be discussed during design and got approved from the Engineer.

5.15 Maintainability

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

5.15.2 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 leveling valve linkages, etc.

5.15.3 The bogie frame shall have a suitable arrangement for lifting the bogie frame from the wheels and for lifting the complete bogie during maintenance in the workshop. Restraints to prevent loading of axle, primary suspension etc. in case of lifting by cranes/rerailments of the cars by jack or any means shall be provided. Dampers shall not get loaded/damaged in this exercise. The Contractor shall provide necessary restraint.

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

5.15.5 The target interval between bogie overhauls shall be not less than 1.2 million kilometers of service operation. The Contractor shall furnish inspection, maintenance and operational schedule of the bogies along with the intervals.

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

The Contractor shall submit the detail of ultrasonic testing of powered & non- powered axles. The detail shall include the testing procedure and pattern used as reference for this test, which shall be used by Employer's maintenance staff/personal.

5.15.6 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.

5.15.7 In addition, the design of the bogie frame shall incorporate horizontal and vertical pads at diagonal positions for re-railing operations following derailments.

5.15.8 Re-profiling on an under-floor wheel lathe shall be often performed in remote workshops without dismantling parts.

5.15.9 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.

5.15.10 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.

5.15.11 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



5.16 Deliverables

5.16.1 The Contract deliverables (tools/equipment/software etc.) required to be supplied by the Contractor under this Chapter of ERTS are listed below:

S.No.	Clause No.	Tools/Equipment/Software	Quantity
1.	5.11.5	Wheel Profile Measurement Gauge	For each depot
2.	5.11.7	Special tools for overhauling of the axle bearings.	Two sets in each depot.
3.	5.11.12	Tools for the wayside wheel profile measurement.	At least one tool each in each of the depots.
		Tools for the temperature monitoring of axle box bearing.	
4.	5.14.2	Programming tool for spray cycle of WFL System.	One on each line.

Note:

1. The above mentioned list of deliverables is non exhaustive and only meant for the convenience for the Contractor and the Engineer.
2. The cost of these deliverables is deemed to be included in the quoted price of contract.



6. PNEUMATICS, AIR SUPPLY AND BRAKE SYSTEM**6.1 General**

6.1.1 Each 3 car unit shall be fitted with a complete "stand-alone" compressed air supply system. In case the train configuration is changed to 8 car (if required), the compressor of one 3 car unit shall be capable of catering the compressed air supply requirement for additional (T+M) unit also.

6.1.2 The Pneumatic and Air Supply System (See Clauses 6.2 to 6.12 inclusive) shall consist of, but need not be limited to, the following:

- (i) Air compressor unit and 3-phase 415V induction motor drive
- (ii) Auxiliary Compressor and 110V DC motor drive
- (iii) Air drier and filtration components
- (iv) Reservoirs
- (v) Pressure governors and switches
- (vi) Pipe system
- (vii) Air suspension equipment
- (viii) Automatic coupling actuating equipment
- (ix) Pantograph actuating equipment
- (x) Ancillary pneumatically driven devices.

6.1.3 The Brake System (See Clauses 6.13 to 6.22 inclusive) design shall be subject to review, and shall consist of, but need not be limited to, the following:

- (i) Electro-pneumatic friction brake system (EP)
- (ii) Electric-regenerative brake system
- (iii) Provision of smooth and continuous blending of EP and regenerative braking
- (iv) Spring applied air-release parking brake system
- (v) Electro-pneumatic friction emergency brake system
- (vi) Extended EP and Emergency brake during rescue operation. Refer ERTS 6.20
- (vii) Wheel spin and slide protection
- (viii) Microprocessor based brake control system
- (ix) Emergency brake push buttons.

6.2 Air Compressor and 3-phase 415V induction motor Drive

6.2.1 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.

6.2.2 Reciprocating air compressors proven in EMU metro operations for at least 2 years, operating from a 415V 3-phase 50 Hz power supply with an adequate free air delivery capacity for three-cars shall be provided. One compressor shall have sufficient capacity to charge a completely empty six-car train including full air suspension inflation within 30 minutes. The average duty cycle of each compressor without electric braking shall not exceed 45% during operation. The Contractor shall submit calculations to show that the capacity of the compressor will meet the worst conditions.

6.2.3 In the event of total failure of electric brakes and one air compressor on a fully loaded six as well as eight car train, the remaining air compressor on the train shall have sufficient capacity to enable the train to remain in service for at least four (4) hours. An "intelligent air compressor management" (with option of forced start) shall be provided to ensure that both the compressors on a six as well as eight car train are operated during fill-up and both the compressors in the train are operated alternatively thereafter, to avoid moisture condensation in the compressor due to low duty cycle.

6.2.4 The Contractor shall convincingly establish that the reliability and maintainability of the compressor offered, has been established in actual EMU metro service. The Contractor shall, inter-alia, submit letters from actual users indicating experience with the compressors on their system.



- 6.2.5 The motor compressor unit shall be a compact unit consisting of compressor, motor drive, coupling and inter and after cooler, resiliently mounted to minimise the levels of vibration transmitted to the car body.
- 6.2.6 The intake air shall be directed through a properly designed filter, suitable for the dusty atmospheric conditions prevailing in Mumbai. Filters shall be easy to clean and shall be easily accessible for cleaning and replacement. Since dust & humidity protection of the intake air is very crucial, specific measures shall be taken to ensure under no circumstance the dust/moisture enters in the compressor.
- 6.2.7 A pressure switch shall control the cutting in and out of the compressor.
- 6.2.8 Safety valves shall be provided to protect the system from over pressure.
- 6.2.9 A non-return valve shall be provided between the compressor and the main reservoir supply line.
- 6.2.10 The compressor shall not be made to start against back pressure. A soft start feature as a built in part of SIV or direct on line shall be provided.
- 6.2.11 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 IP55 protection.
- 6.2.12 The Contractor shall by calculations or otherwise establish that the compressor will meet the above conditions.
- 6.2.13 The compressor shall be designed to achieve a minimum of 12000 hours of running time between overhauls. Routine maintenance shall not be required at a frequency more than once per year.
- 6.2.14 Correct functioning and running hours of compressors shall be monitored and recorded by TCMS.

6.3 Auxiliary Compressor

- 6.3.1 A proven 110V DC operated compressor (oil free) shall be provided for operation of pantograph and VCB during start-up of the train. The compressor shall work satisfactorily within voltage range of 77V to 138V DC Minimum protection class should be IP 55.

6.4 Air Dryer and Filtration

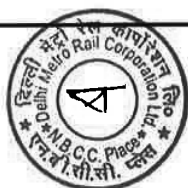
- 6.4.1 The air delivered to the pneumatic system shall be clean and dry and shall conform to the air quality specified in ISO 8573. An air dryer and filtration unit proven on rolling stock application suitable for extremely hot, humid and dusty conditions prevailing in Mumbai, shall be provided.
- 6.4.2 The grade of filtration at rated pressure shall be minimally as follows:
 - (i) Particles removal down to : 1 micron
 - (ii) Liquid water removal : > 95%
 - (iii) Dew point depression at 10kg/cm²: minimum 25°C.

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

- 6.4.3 A proven regenerative type of air dryer using desiccant and of a suitable capacity shall be provided between the air compressor and the main reservoir. The air dryer shall be preceded by an automatic drain valve, which collects and discharges the bulk of the moisture in the compressed air, before it enters the air dryer. The air dryer shall have IP65 protection.
- 6.4.4 Suitable means of dust separation, along with automatic drain valve prior to the air dryer shall be provided. An inter-cooler and after-cooler of liberal capacity shall be supplied to ensure efficient operation of the air dryer. A humidity indicator showing the condition of the outlet air through change of colour shall be provided. Full technical details of the proposed air dryer shall be furnished by the Contractor for review by the Engineer. Interval for replacement of desiccant in the dryer unit shall be furnished.
- 6.4.5 All failures of the air dryer shall be displayed in the TCMS/OCC

6.5 Reservoirs

- 6.5.1 Main reservoirs with adequate capacity shall be provided on each three-car unit to distribute the air to various systems. The reservoirs shall incorporate a safety valve and an automatic drain valve. The Contractor shall provide calculations to substantiate correct sizing of the reservoirs.



- 6.5.2 The brake service reservoir shall have sufficient capacity for three consecutive full service brake applications with a train speed of 80 kmph fully loaded. This shall be achieved without electric brake supplement and without air replenishment from the main reservoir.
- 6.5.3 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 286-3:1994.
- 6.5.4 Separate reservoirs of suitable capacity shall be provided for satisfactory operation of other on-train pneumatic systems.
- 6.5.5 Reservoirs shall be provided with manual draining arrangement which shall normally be automatically locked and secured.
- 6.6 **Pressure Governors and Switches**
- 6.6.1 Pressure governors and switches proven in EMU metro applications shall be provided for various control and monitoring functions.
- 6.7 **Pipe System**
- 6.7.1 A main reservoir pipe shall run continuously throughout the train.
- 6.7.2 All piping shall be of stainless steel conforming to the requirements of Duplex Steel or equivalent with flare less bite type double compression fittings generally conforming to the requirements of DIN 2353.
- 6.7.3 Sharp bends shall be avoided and standard connections shall be used as far as possible. All pipe lines shall be suitably colour coded. The proposed colour coding shall be reviewed during the Under Frame Equipment Layout Mock-up review.
- 6.7.4 All branches from the main reservoir pipe or control system shall be fed via self-locking cocks (coloured according to the corresponding pipe colour) with or without vent and electrical switches as appropriate. Magnet valves, reducing valves, check valves, silencer and drain plugs etc. shall be incorporated as required.
- 6.7.5 Quick release coupling test points made of stainless steel, with blanking plugs shall be provided. They shall be located in easily accessible positions.
- 6.7.6 Flexible hoses shall be kept to a minimum, and be proven in EMU metro service. Burst hose protection shall be provided to increase the integrity of the air supply system against rupturing of inter-car flexible hoses. Armoured hoses shall be provided in the flexible connections in the parking brake piping.
- 6.7.7 Foreign matter shall be removed from all pipes prior to installation.
- 6.7.8 Deleted.
- 6.7.9 All pipes shall be installed by means of clamps with integral, moulded vibration damping inserts to prevent any rattling in service. Clamps shall not be welded to the pipe.
- 6.7.10 Where piping pass 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.
- 6.7.11 In the event of leakage from the Pneumatic circuit/system, it shall be possible to isolate the effected part of the circuit by train operator (remote isolation during GoA3/GoA4) and reach up to destination station. Isolation arrangement shall be simple and shall not require more than square key normally carried by Train Operator. Contractor shall submit detail plan during design for engineer's approval. The isolation arrangement shall preferably be in the saloon and shall be secured and monitored alternatively the isolation arrangement may be through magnet valves.
- 6.8 **Pressure Gauges**
- 6.8.1 All driving consoles shall be fitted with analogue pressure gauge with life of more than 15 years which indicates:
- The pressure in the main reservoir pipe.
 - The pressure in the brake reservoir and brake cylinder pipe.
- 6.8.2 On all cars, test points, onto which test gauges may be connected, shall be provided in the vehicle brake and air supply system. The location of the test points shall be reviewed by Engineer and shall be demonstrated during the review of Underframe Equipment Layout Mock-up. The tests points shall be provided, at the minimum, to measure the pressure of the following:



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

6.9 Levelling Valve System

6.9.1 A leveling control system shall be provided to ensure transversal control of body height under all conditions of load. In each bogie, one leveling system shall be provided to adjust air pressure in the air springs. In the case of failure of one air spring, the other should quickly bleed out so that the carbody is lowered to its stable position. The air supply for the leveling system shall be taken from the main reservoir pipe and a separate reservoir shall be provided with each air suspension bellow. However, an alternate proven design meeting the functional requirements may be proposed by the Contractor for approval of the Engineer. Load sensing valve shall be provided. Antiroll bars shall be provided with air suspension units.

6.9.2 Levelling valves shall be installed as far as possible outside the wheel in the bogie so that the dynamic load changes are addressed appropriately.

6.10 Front Automatic Coupling Actuating Equipment

6.10.1 Control of front auto coupler for rescue operation shall be from the driving console. The Isolating cocks for MR for extension of air supply through the coupler shall be located in the driving console. Any other operation required necessary for coupling shall be from the driving console only. There shall be a provision to connect the two trains to facilitate communication between the two trains.

6.11 Ancillary Pneumatic Devices

6.11.1 Pantograph actuating equipment shall be fed by air supplied from an auxiliary reservoir, suitably located in each unit with auxiliary compressor, for the purpose of initial raising of pantograph and closing of VCB.

6.12 Isolation of Defective Equipment

6.12.1 Isolating valves and switches shall be provided to enable parts of the system to be isolated.

6.12.2 All isolating valves that require operations by train crew in normal operation or in emergencies shall be easily accessible either from within the car or from track level as appropriate. The location shall be finalized during Pre-final Design Stage. The isolating valves shall be colour coded.

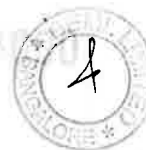
6.12.3 Isolating cock handles shall lie parallel to the pipe in which it is installed, in the normal operational (Open) position, and perpendicular to the pipe in the isolated (Closed) position, and shall operate in the horizontal plane only. Cable ties shall provide a ready means of identification of a cock, which has been operated.

6.13 Brake System

6.13.1 The brake system and components shall be proven, state of art and widely used in modern metro rolling stock. The brake components, valves etc. shall have been in use and have established their satisfactory performance and reliability on at least three mass rapid transit systems in revenue service over a period of last three years or more (in each MRTS) outside the country of origin in three different countries or in an MRTS in India. The options for brake system have been specified in clause 5.12.1. Train braking performance shall be as specified in Chapter 3, Clause 3.22.1 and shall be designed for 90 kmph. The operational speed shall be 80 kmph. The system shall generally conform to EN13452.

Brake valves shall be designed and validated for heavy duty cycles required for intensive brake blending. No change of valves or components except rubber items shall be required for at least 15 years beyond DLP. Contractor shall assess the cyclic load under worst service conditions appearing together and validate the same on a test bench.

6.13.2 The brake system shall be complete in each three-car unit, and shall consist of:



- (i) An electro-pneumatic friction brake system (EP).
 - (ii) An electric regenerative brake system.
 - (iii) Provision of smooth and continuous blending of EP and regenerative braking.
 - (iv) A spring applied air-release parking brake.
 - (v) A fail safe, electro pneumatic friction emergency brake system.
 - (vi) Extended EP & Emergency brake during rescue operation. Refer ERTS 6.20
 - (vii) Emergency brake push buttons
In case of addition of one (T+M) unit (if required), the brake system of additional unit shall interface with that of 6 car train to meet the braking performance requirement of complete train.
- 6.13.3 The EP brake shall be so designed that its control function can be taken over by the other redundant control elements in the case of failure of individual electronic or electrical control elements.
Redundant power supply and processor card for hot stand by in the control unit and spare slots for I/O cards shall be ensured. However, any other suitable design for redundancy of EP Brake control function may be proposed by the Contractor subject to approval of the Engineer.
- 6.13.4 The friction braking shall be achieved by bogie mounted brake actuator units operating on the EP system. The EP service and emergency brakes shall be applied by the same brake actuators.
- 6.13.5 Roll Back protection shall be provided to ensure that the train moves only bare minimum standing on gradient with power on. The direction of wheel movement with respect to master controller position shall be compared and protection shall be applied in case of conflict.
- 6.13.6 The friction brake system shall be proven and capable of independently achieving all performance requirements for a continuous round trip with maximum speed of 50Kmph with AW2 load case without the aid of electric braking.
- 6.13.7 When a train is at standstill there shall be sufficient retention of brakes (holding brake) such that the train does not roll back on a 4% gradient. The brake application shall be retained while traction power is applied and the train takes forward movement.
Specific provision shall be made in the software to ensure that the train safely starts on the gradient, the roll back if any is nominal.
- 6.13.8 It shall be possible to isolate the friction brake system individually on each bogie. The isolation device [Bogie Isolation Cock (BIC)] shall be located inside the passenger saloon area (duly protected by a lockable cover) and also on the under frame adjacent to the bogie (either side) and be readily accessible. The isolation shall be readily discernible to operation and maintenance staff and shall be displayed on HMI. Isolation of any bogie shall popup an alarm in TCMS VDU/OCC for information and acknowledgement in both operation mode as well as in maintenance mode. The isolating cock for leading Bogie for DM car shall be in the Driving console. For all other bogies, it shall preferably be in the cubicles. Contractor shall also refer ERTS 6.7.11 during design of isolation arrangement. Separate magnet valve shall be provided for remote operation to isolate the friction brake system individually on each bogie.
- 6.13.8.1 In case of isolation of bogies, a suitable speed restriction shall be applied in compliance with Metro Railways General Rules (MRGR).
If no. of bogies isolated is more than the minimum bogies required to achieve Guaranteed Emergency Brake Requirement (GEBR), then traction block shall be applied. However, it shall be possible to override the traction block and a speed restriction of 10 kmph (configurable) shall be applied. Speed restrictions shall be finalized during design stage.
- 6.13.8.2 In case more than 50% bogies are isolated in a train, then the traction block shall be applied and it shall not be possible to override the traction block.
- 6.13.9 If due to any reason parting of train is being perceived without actual taking place, the emergency brakes of the portion of the train which perceived parting shall automatically get applied. It should be possible to move the train further by isolating the bogie brakes of this portion of the train. In such situation, the control system shall automatically impose restriction on the maximum speed. The level of the speed will be decided during the design stage.
- 6.13.10 All devices capable of isolating a portion of the brake system shall be located and protected to avoid inadvertent or malicious operation. The operation of such isolation device shall be clearly visible to maintenance staff once operated.



- 6.13.11 Brake friction materials shall not contaminate the tracks and other underframe mounted equipment adversely so as to affect train detection by the Signalling System.
- 6.13.12 Brake pads shall be of composite material and shall contain no toxic material. Heating by the brake pad shall in no case cause any damage to the wheel tread.
- 6.13.13 The brake pad shall be proven in EMU metro application. The friction characteristics of the brake pad material shall be tested on brake dynamometer, in both dry and wet conditions in the range of 0-90 kmph under various designed brake forces. The test scheme and acceptance criterion shall be submitted for review by the Engineer. The Tenderer shall furnish brief description of the proposed brake system along with the expected life of brake pads based upon experience of other Metro Railways.
- 6.13.14 The Brake calculations under all the service operating conditions including wheel-rail interaction study, adhesion calculations and for emergency braking distances under dry and wet conditions shall be submitted. Braking distances for normal service braking with electric brake blending shall also be submitted.
- 6.13.15 All the pneumatic control equipment and valves for one car shall be mounted in the enclosed lockable boxes, made of stainless steel/Aluminium (anodized).
- 6.13.16 The air supply and distribution systems shall be arranged such that any single type failure can be readily isolated such that full performance capabilities are maintained.
- 6.13.17 Deleted.
- 6.13.18 It shall be possible to test the functioning of brake system while at standstill at depot or at termination station.
- 6.13.19 The system shall provide adequate protection against brake binding and give indication to the TCMS/OCC.
- 6.13.20 Following minimum SIL levels at train level shall be complied for the brake system

Emergency brakes	SIL 3
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The contractor shall submit relevant certifications for the SIL levels as above.

- 6.13.21 The speed measurement devices and couplings required for measurement of train speed in a fail safe manner by the Signaling and Train Control Contractor shall be installed on one non powered axle in each 3 car unit (DM+T+M) which shall be:

- (i) Not used for service brake application and;
- (ii) Used for emergency brake application, whenever required.

This shall be finalized by the Contractor during finalization of interface with signaling Contractor. In case signaling Contractor is not yet finalized by Employer then the design shall be finalized in consultation and with the approval of the Engineer.

The train braking system shall meet the specified braking performance requirements with the above considerations.

6.14 Electric Regenerative Brake and Electric/Pneumatic Brake Blending

- 6.14.1 Priority shall be given to the electric regenerative brake whenever a brake command is initiated. The electric regenerative brake shall also be load weighed to ensure consistent performance. The use of electric regenerative brakes shall be maximized in all service braking modes, and shall make full use of the adhesive weight on all motor car axles.
- 6.14.2 Brake blending logic shall ensure priority of electric regenerative braking over pneumatic braking. If the demanded brake effort is not achievable solely by the electric regenerative brakes, the pneumatic brake system on the T cars shall provide supplementary brake effort. The Contractor shall submit full proposal for review. Electric regenerative brake fade out shall not occur above 5 kmph. For the given Brake demand signal, the Brake effort achieved shall be same during the transition from ED to friction Brake. After the speed is reduced to a very low speed, holding brakes shall be applied to prevent the train from rolling backwards at station stops and gradient.
- 6.14.3 The electric regenerative brake shall be independent for each Motor Car and faults on one car should not adversely affect the braking performance on the other. Each Car shall have independent Brake Electronics with wheel slide control.



- 6.14.4 In the event of failure of electric regenerative brake or during fading, the friction brake shall be capable of carrying out full braking duty. Smooth and safe changeover from regenerative to EP brakes in case of failure of regenerative brakes or during fading shall be ensured.
- 6.14.5 The Contractor shall submit brake effort vs. speed characteristics showing the contribution of regenerative braking and electro-pneumatic braking separately over the entire speed range and at different loading conditions of the cars.
- 6.14.6 Deleted.
- 6.14.7 Regenerative braking shall be actuated and applied only in the event of the train exceeding the set speed (settable between 20 to 35 kmph) since last stop. For train speed up to the set speed since last stop, only friction brakes shall be applied.

6.15 Parking Brake

- 6.15.1 Parking brakes shall be incorporated on 50% or more of brake actuators of DM, T and M cars. Parking brakes shall be capable of holding a fully loaded stationary train on a 4% gradient under all track conditions, indefinitely. Inadvertent/unintended application of parking brakes due to air leakage or otherwise will be detected and displayed on TCMS as fault indication. It shall be possible to isolate the parking brake unit and release the traction interlock. The control of parking brake shall be through hardwire.
- 6.15.2 Parking brakes shall be applied in the event of loss of the main compressed air supply. The parking brakes shall be capable of release from within the driving console when the compressed air supply is present. With no compressed air supply available, it shall be possible to release individual parking brake actuators manually from saloon or from platform level. Application of parking brakes shall also be controllable from the driving console and remotely from OCC. The design shall be such that the parking brakes will take effect prior to fade off of service brake and shall ensure that the combined brake effect of the pneumatic brake and parking brake is never less than the full brake effort of the parking brake alone. Parking brakes shall be directly actuated by MR pressure.
- 6.15.3 Status of train parking brake shall be displayed in the active driving console and remote control centre.
- 6.15.4 In the event of air leakage from the air feed to parking brake/within the unit and consequential application of parking brake/traction block, arrangement shall be provided for isolation and manual release of Parking Brake(s) so that traction block is released and train is operable as usual. The parking brake manual release arrangement shall be provided in each car or at platform level and it shall not be accessible to the passengers. If manual release arrangement for parking brake is provided at platform level then special tools shall be provided for accessing it from platform level when train stops at any position with respect to Platform Screen Doors (PSD). Two (2) no. of such tools shall be provided in each train. Separate Isolating cocks (PIC- Parking Isolation Cock), adjacent to the Isolating cocks (BIC) shall be provided in each car. For DM cars, these shall be in Driving Console. No traction block shall occur on account of parking brakes, after the same has been isolated.

6.15.5 Deleted.

6.16 Emergency Braking

- 6.16.1 Emergency braking shall be applied by de-energisation of an emergency magnet valve as a consequence of brake in emergency brake loop wire. The break can be caused by the Train Operator 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. Both brake loops shall be controlled by separate feeder MCB.
- 6.16.2 Emergency brake is applied by friction brake system. Electric regenerative brake shall be isolated during emergency braking. The Emergency braking shall be load weighed. Emergency braking rate as specified in clause 3.22 shall be achieved from 80 kmph to 0 kmph up to fully loaded train on level tangent track.
- 6.16.3 Emergency brake push-button shall be installed in each driving console in the train. Activation of the buttons, shall apply the emergency brakes under all conditions. Movement with Emergency push button activated shall be possible only after by passing the Brake loop with a cutout switch provided in the driving console(s). Activation of the EPB shall not result in opening of VCB and /or lowering of Pantograph.

In the event of mal-operation of emergency brakes from working driving console, it shall be possible to operate train from either driving console (to be decided during design) in either direction at restricted speed.

- 6.16.4 Parting of the train shall result in an emergency brake application on both halves of the train.
- 6.16.5 Wheel slide protection shall be available during emergency braking. Any failure in the wheel slide protection in emergency braking shall result in the application of full brake force and deactivation of the slip/slide system.
- 6.16.6 Activation of the emergency brake by any means shall result in the propulsion system being disabled in a safe critical manner. The Emergency condition shall not get reset till the train has achieved zero speed (i.e. train at stand still). The propulsion system shall not be re-enabled until the train is at zero speed and the emergency condition has been reset.
- 6.16.7 The Contractor shall furnish emergency braking distances to standstill, for a fully loaded train from speeds, starting from 10 kmph to 80 kmph in increments of 10 kmph.
- 6.16.8 The friction brake system shall be rated to, and have sufficient thermal capacity to safely complete two successive acceleration and emergency brake cycles, with no interval between each cycle. Each cycle shall comprise a full acceleration from standstill to 90 kmph followed by the application of emergency brake to standstill. On the completion of the two cycles, the brake system shall show no abnormalities. The requirement shall be demonstrated during testing.
- 6.16.9 The Contractor shall furnish the maximum braking distance from a speed of 80 kmph to stop, under emergency brake application. The guaranteed maximum braking distance shall satisfy the requirements specified in table 15.1.B emergency brake application. The guaranteed maximum braking distance shall satisfy the requirements specified in table 15.1.B emergency brake application.
- 6.16.10 The Contractor shall provide the guaranteed emergency brake de-acceleration rate to signaling Contractor during interface. The Guaranteed Emergency Brake rate shall be decided on the basis of minimum initial adhesion of 6% on the Mumbai Metro network, one car brake isolated and with maximum 15% emergency brake distance extension (for adhesion from 8% to 6%) due to wheel sliding.
- In case of adhesion being below 6% and actual emergency brake rate is found lower than the guaranteed Emergency Brake Rate, it shall be the Contractor's responsibility to prove to the satisfaction of the Engineer that the initial adhesion is below 6%. For determining the adhesion, UIC 541 shall be followed. The system diagnostic shall record all relevant signals and shall be retrievable for analysis. The necessary software/hardware tools shall be given to each depot.
- 6.16.11 Complete friction brake system shall be tested on Brake dynamo-meter and validated during field tests.
- 6.17 Brake Control System**
- 6.17.1 A high integrity fast response closed loop digital brake control system shall be provided with the brake regulation rate at $\pm 5\%$ of the deceleration demand. The closed loop is formed by the dynamic brake and the pneumatic brake: use of dynamic brake is maximized, achieved dynamic brake information is provided to pneumatic brake control, and this control applies to the remaining need of brake in order to reach the total demand. The Contractor shall ensure that the brake system is so designed that failure of any single control component shall not result in loss of braking performance of the train. All circuits and controls essential for braking equipment shall be a fail safe, double break circuits, and shall have high integrity 'hard wire' feeds and inputs. These feeds and inputs shall be duplicated. A microprocessor based brake control system shall be offered.
- 6.17.2 The Contractor shall submit the details of the brake control system interfaces with the vehicle control circuits, The Propulsion system, the Master Controller, PWM generator/ Digital Control and ATP/ATO etc. The brake control system logic shall have adequate redundancy and back-up. PWM data from PWM generator or digital data and ATO shall be hard wired but shall also be received through TCMS as back-up. The system design shall also define the fail back mode operation when PWM data/digital data is not available from both the PWM generator/ Digital Control and TCMS back-up, because of any reason.
- 6.17.3 A Deadman device shall be incorporated into the Master Controller Handle. Activation of the same shall cause emergency brake application. Ergonomic Design of Master Controller shall ensure minimum strain on Train Operator's arm. Twist type Master Controller shall be preferred. Overall design shall specifically be got approved from Engineer.
- 6.17.4 A Load Weighing Signal, proportional to the passenger load shall be applied to the control systems for the rates of acceleration and braking, and for ensuring correct adjustment of the car body by the secondary air springs.
- 6.17.5 A sufficient degree of redundancy without adversely affecting system reliability may be used to



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achieve the degree of fail-safe operational required.

6.17.6 The Brake control unit shall have provision for logging of selectable parameters/signals (by the Employer/Project Owner) and faults with related data. The memory shall be extendable. Provision shall be available for continuous logging or logging triggered by a particular event of User selectable parameters (up to 20 at a time) for a period of up to 24 hrs. The memory shall be adequate to store the above data including additional minimum 20000 incidents. Provision shall be available to download the stored data. Supply of any special tools complete with requisite software (one set for each depot) required for the above shall be included in the quoted cost. Training shall be organized by the OEM trainer in India for adequate duration before the commissioning of first 10 trains and cost of training is deemed to be included in quoted price of contract.

6.17.7 The diagnostic tools for brake system shall include complete graphical & analytical tools, recording of events, data of brake system and interface signals etc. It will also have facility to add on the necessary signals as requires during fault investigations.

6.18 Jerk Limitation for Service Brake

6.18.1 The build-up of pneumatic brake force shall be jerk limited (for changes in brake demand) to increase passenger comfort. The jerk limitation is 0.75m/s^3 . This limit shall also be respected at the time of final stoppage also.

The Rolling Stock Contractor as well as Signalling Contractor shall comply EN 13452-1 or equivalent international standards for jerk determination and methodology shall be finalized during design stage with the approval of Engineer.

6.18.2 Jerk rate control shall be applicable to braking as well as propulsion.

6.18.3 Removal of power and application of brakes under emergency braking conditions shall not be jerk limited.

6.18.4 Removal of power and brake effort under wheel slip conditions shall not be jerk limited. The reapplication of power and brake effort shall be jerk limited.

6.19 Brake Operating Timing

6.19.1 The following maximum brake operating timing shall be achieved on all cars of a train. The maximum time for a brake application from initiation of brake application command from BECU to 90% of full Brake Cylinder Pressure (BCP) and for brake release from initiation of brake release command from BECU to 10% of BCP shall not exceed the following:

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

The Contractor shall provide the timing diagram during design stage.

6.19.2 Any Malfunction of brake control system, which can cause an unsafe operation, shall result in an emergency brake application. In case of single point failure in brake control system, which can be automatically isolated and fully compensated without affecting the train performance, the application of emergency brake should be avoided.

6.19.3 Brake Assurance Time (the time from initiation of the brake application signal from TO/VATO, to achievement of the retardation rate requested), shall be provided. Full details shall be given. This feature will require close liaison with the Signalling Contractor.

6.19.4 In case, full compensation of brake control system is not available, the train control system shall impose a suitable speed restriction so that the braking distance is not exceeded.

6.20 Brake control under rescue operation

During the rescue operation of pushing/pulling of a defective train loaded with passengers, the healthy train shall ensure simultaneous brake application in both healthy and defective train. Release of parking brake/holding brake of the defective train shall be possible from healthy train after mechanical and pneumatic connections.

For brake application purpose, the contractor shall:

Provide extension of EP brake and emergency brake lines from healthy train to defective train through a suitable jumper cable which can be connected manually during such eventualities. The



extended EP brake lines shall be in form of coded hardwires brake lines. The jumper connection shall be easily accessible, flexible and self lockable after connection. The connector housing shall have protection level not less than IP65 and shall be designed to automatically protect the connector against dust and water. The cover shall harmonise with the external finish. One set of jumper cable shall be kept in each driving console duly secured. The hardware lines as well as jumpers shall be with 100 % redundancy with one jumper connector on each side of the driving console front. The system shall ensure the integrity of these lines by built-in self test and also their isolation in case of extension of feed to the faulty brake lines of the defective train.

Details shall be discussed during design stage.

6.21 Failure Management

- 6.21.1 It shall be possible to recover a dead 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 locomotive. The emergency brake application of the dead train shall be possible by its operator. The detailed scheme shall be subject to the Engineer's review during design finalisation.

6.22 Wheel Slide Protection (WSP)

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

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

- 6.22.3 6-car train shall be subjected to complete type test as per UIC 541-05 and may have to be validated on more than two trains. Slide protection scheme shall include suitable measures for condition involving simultaneous slide in all 4 axles of any car.

The type test protocol shall be agreed with the engineer and shall be in line with ERTS 15.15.4.

- 6.22.4 Deleted.

6.23 Monitoring

- 6.23.1 The performance of brake system shall be monitored by the Train Control & Management System (TCMS) and displayed in the train operator's driving console.

6.24 Documentation

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

The contractor shall supply animation of complete pneumatic system, covering all pneumatic valve operations etc., demonstrating the complex pneumatic system for training purpose, which shall help in fault finding during maintenance period.

- 6.25 Engineer shall be able to adjust/change Brake cylinder pressure and other output parameters of Brake System. 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. Nominated Representative of the Engineer shall be fully trained and made fully conversant by the Contractor for this purpose.



6.26 Deliverables

6.26.1 The Contract deliverables (tools/equipment/software etc.) required to be supplied by the Contractor under this Chapter of ERTS are listed below:

S.No.	Clause No.	Tools/Equipment/Software	Quantity
1.	6.16.10	The necessary software/hardware tools shall be given to each depot for determining the adhesion as per UIC 541.	To each depot.
2.	6.17.6	Supply of any special tools complete with requisite software as per clause 6.17.6	One set for each depot
3.	6.25	Hardware/software tool to adjust/change Brake Cylinder Pressure.	One set at each depot.

Note:

1. The above mentioned list of deliverables is non exhaustive and only meant for the convenience for the Contractor and the Engineer.
2. The cost of these deliverables is deemed to be included in the quoted price of contract.

7. DOOR AND DOOR CONTROL SYSTEM

7.1 General

7.1.1 Door system shall generally be compliant with EN14752:2015 or latest unless otherwise specified.

7.1.2 The train shall have following type of doors:

- (i) Passenger Saloon Door
- (ii) Front End Emergency Door
- (iii) Deleted
- (iv) Passenger Saloon to Driving Console Door
- (v) Passageway Sliding Door for 'First Class' Car.

7.2 Passenger Saloon Door

7.2.1 General

- (i) Each car side shall have minimum four pairs of externally hung, sliding bi-parting doors. The clear door opening width of each door pair shall be minimum 1400mm and a clear height of at least 1900mm. The doors shall be electrically driven.
- (ii) 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.
- (iii) Stainless steel Sheet metal of similar finish, as adopted for sidewall shall be of ample gauge to provide adequate strength and rigidity shall be used for outer sheet. Specific approval shall be obtained from the Engineer during design stage. 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. However, inside door leaf of Aluminium or stainless steel with matching shade good quality paint can be acceptable. Further details shall be discussed during design stage by the Engineer.
- (iv) Doors shall be vibration free and 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.
- (v) 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.
- (vi) The door leaf design shall enable any portion of the door leaf or the car body visible to be cleaned.
- (vii) Each door leaf shall have a window.
- (viii) Overlapping of central seals of door leaves during door closed condition shall be minimum 10mm to 15mm. Both type of seals viz. End Seals and Central Seals shall be labyrinth type and not only adhesive type. Suitable profile of seals shall be ensured so that it shall not come out during service life.
- (ix) In respect of solar gain, thermal insulation, replacement criteria, strength, resistance to pressure, and the transmission of light, and solar heat gain, these windows shall be identical with those of the saloon windows.
- (x) Door windows shall be replaceable without removal of the door leaf.
- (xi) No single defect or failure of any part of any door system shall produce a situation capable of causing injury to any door user.
- (xii) Door guides and supports shall be mounted within the section of doorway protected by the door seals and other suitable means from inside and outside ensuring that no ingress of dust, debris, or any other foreign matter likely to result in excessive wear or incorrect operation of the door equipment. Proposed design shall be maintenance friendly and cleaning interval of the guide shall not be less than 1 year. At least four no. of special tools in each depot for cleaning of the guides shall be provided and cost of such tools is deemed to be included in quoted price of contract. The proposed design for sealing of the guides shall be got approved from the Engineer



- during design stage.
- (xiii) The materials used for the door movement and seals shall take into account of hygroscopic effects in high humidity tropical environments.
- (xiv) Sealing arrangements on external sliding door leaf shall meet the following requirements:
- 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.
 - Positive sealing along entire saloon door opening and door leaf inner surfaces to eliminate in-rush of tunnel air due to the piston effect.
 - Door sealing shall also be such that the saloon interior noise specification is satisfied.
 - Door sealing arrangement shall be adequate to prevent water ingress due to torrential rain and car washing through automatic wash plant.
 - The sealing arrangement shall take into consideration of car body manufacturing tolerance and deflections under fully loaded conditions.
 - All gaskets provided in the doors shall be so designed that there is no possibility of their getting loose during service. Life of the gaskets/seals shall be minimum 12 years.
 - The gap between the carbody exterior and interior leaves of the door panel shall not exceed 6mm (4+ 2, - 0) and packing used shall have service life of atleast 35 years.
 - Adequate care shall be taken to ensure no part of door machinery is visible from inside / outside the saloon.
- (xv) The Tenderer shall indicate the amount of time required to replace a door leaf on the car, adjust it, and test it.
- (xvi) A microprocessor based saloon Door Controller Unit (DCU) shall control each pair of saloon door and shall be an integral part of door control assembly. The door controller unit of a proven design shall be equipped with self-diagnostic functions and shall communicate with TCMS. Power supply to DCUs shall be in such a loop that the redundancy can be ensured in case of breakage of any one wire. The Contractor shall ensure that the system shall not be affected in single point failure. Details shall be submitted for review of Engineer.
- (xvii) DCU Hardware and Software support:
- It shall be possible for the Engineer to modify/change the parameters or closure/opening logic of door's circuit and implement the same as required by DMRC based on their operational and maintenance requirements. Full access to the software for the purpose above shall be provided.
 - Any hardware/software tool required for this purpose shall also be provided free of cost (2 sets for each depot).
 - The documentation including but not restricted to flow charts (for complete software), signal flows, and interpretation of signal etc. shall be provided.
 - Training shall be provided by the OEM experts to DMRC personnel to the complete satisfaction of the Engineer.
 - Single point uploading of software and downloading of faults/data on unit and train basis shall be ensured.
- (xviii) Design of doors and threshold plate shall ensure the specified requirement of maximum permissible platform gap as per Chapter 2 of Schedule of Dimension is satisfactorily met.
- The maximum permissible horizontal clearance between edge of the platform coping and edge of the carbody floor threshold plate with door open shall be 75 mm in underground corridor and 85 mm in elevated corridor.
- (xix) Specific measures shall be taken to maximise noise attenuation through doors. Door leaf shall be provided with honeycomb sheets or PU foam throughout. The doors assembly on the cars shall include carefully engineered sealing arrangement to reduce noise transmission into the cars. Details of thermal and noise insulation of doors shall be submitted for review by the Engineer.
- (xx) Limit switches used shall be of high reliability and with IP 65 protection. Life of the limit switches shall be at least 15 years. The Contractor shall furnish details during Pre-Final Design Stage.
- (xxi) The door position measurement and detection shall be accurate and real time measurement of

the distance moved by each leaf. Details shall be discussed and finalized during design stage. Also, Door closed position shall be double checked through two independent arrangements.

- (xxii) Door System shall be at least SIL 2 compliant at train level for all the safety related functions including the following:

- Door opening when train not at standstill,
- Door opening at standstill on track side,
- Train departure with an open door,
- Non opening of two doors in case of emergency;

including but not limited software, hardware and control functionality etc.

The Contractor shall submit relevant certifications for the SIL levels as above. The SIL levels as above shall be validated and shall ensure that the train shall not move from a station unless the doors are closed and locked unless intentionally permitted by the Engineer. Details shall be worked out during design stage.

- (xxiii) The operation of saloon doors shall be under train operator/attendant in the active driving console when the trains are driving in non-UTO mode. However, under UTO mode, the normal operation of saloon doors shall be under Signalling system.

7.2.2 Door Mechanism

- (i) Doors shall be electrically operated from 110V DC supply through train line. The door operating mechanism shall be of a proven design in service.
- (ii) The door system shall continue to operate correctly with the car battery voltage supply range between 77V to 132V DC.
- (iii) 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.
- (iv) All such fasteners, which can cause safety and/or adjustment, operational disturbances if loose during service, shall be provided with Nord lock arrangement. Contractor shall submit comprehensive proposal for Engineer's approval during design. Use of shims during installation or commissioning or adjustments shall not be acceptable, however if unavoidable use of shims shall be restricted to minimum which shall be discussed during design stage.

7.2.3 Passenger Door Opening and Closing Times

- (i) Opening and closing time of the passenger doors shall be adjustable in the range of 2.0 to 4.5 seconds.
- (ii) The end of the closing and opening stroke (say 100mm) shall be damped or cushioned to reduce impact and/or minimise possible injury to passengers.
- (iii) All doors on the train shall fully open within 2.0 to 2.5 seconds from initiation of the open door command.
- (iv) All doors on the train shall fully close within 2.5 to 3.5 seconds from the initiation of the close door command.
- (v) The doors shall not lock and permit a door-closed indication if an obstruction is detected. The obstruction detection feature shall not permit the doors to lock either when a 15 mm wide by 100 mm long flat plate is held between the door panels or when a 19 mm diameter bar is held between the door panels. If an obstruction is detected, the door shall stop. The closing force of the obstructed door shall be removed. The door shall reopen by 50 mm (minimum 25 mm each door leaf) when an obstruction is detected. After a specified delay (adjustable between 0 and 5s), the door shall attempt to close again. If an obstruction persists, each door leaf shall stop again and the closing force of the obstructed door shall be removed. After the specified delay, the door shall attempt to close again. If the obstruction is still present the door shall reopen by 50 mm (minimum) 25 mm each door leaf) and remain stationary, reporting a fault to the TCMS.

The system shall have the provision of reclosing the door(s) without opening all doors in case of obstruction detection.



- (vi) Successfully closing of doors should be confirmed by mechanical locking. Interlocks should prove the closed and locked position of door system and then application of traction power should be enabled.
- (vii) The force required for closing/opening of any door leaf, when fully connected with the driving gear shall not exceed as mentioned in EN 14752:2015 or latest.
- (viii) The push back feature shall be operative after the door leaves have been closed and 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. However final value shall be decided during design. Expected door gap to be created by push back during intentional operation should not exceed 15mm. (the final gap shall be decided during detail design stage of the door). Every operation of push back shall be recorded with time stamp and message shall pop up in cab HMI. The complete scheme shall be of proven type in worldwide metros.
- (ix) All the above settings 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.

7.2.4 Passenger Door Operational Criteria

7.2.4.1 Reliability and Safety

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.

7.2.4.2 Door Failure

- (i) Each saloon door shall be fitted with the means of isolating and locking both door leaves both from inside and outside. 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. It shall also be possible to isolate any closed and locked door from the driving console by the train operator using TCMS interface as well as remotely from OCC.
- (ii) When the isolation is activated, the door shall be mechanically locked in the closed position. Manually isolated doors shall be enunciated on the train operator's cab visual display unit (VDU).
- (iii) 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.

7.2.4.3 Interlocking

- (i) No spurious electrical signals shall cause any door to be released or opened. The Contractor will be required to provide a comprehensive Safety Audit to prove this point to the satisfaction of the Engineer.
- (ii) 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.
- (iii) The door controls shall be interlocked with the train's zero speed circuitry so that the doors cannot be opened until the train is stopped. However, loss of ATC power at zero speed shall not inhibit door operation. Zero speed signal shall be hard wired.
- (iv) Irrespective of the operating mode, the train shall not be able to move unless all the saloon doors are proved closed and locked. Separate Door closed and locking shall be proved for each door leaf. Separate close and locking switches shall be provided for each door leaf. The train line circuit performing this interlock shall be a failsafe, fully redundant circuit to provide maximum protection against erroneous door locked signal. A sealed cut out switch accessible to the train operator 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 Control Management System (TCMS).

In the event the train operator has operated the cut out switch to by-pass the door closed interlock, the system shall ensure that the doors are in closed condition before actuation of traction command.

- (v) At the centre of each door, (both exterior as well as interior) suitable dual colour LED indication lamp, duly approved by the Engineer shall be provided to indicate door status (including isolated state). The lamp shall flash yellow during opening/closing and shall glow yellow during open condition. The lamp shall glow red during isolated condition.
- (vi) 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.
- (vii) 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. However, the TO shall be able to open the doors by operating suitable switches in the event of the train not being inside the stopping window without involving the ATP cut-out mode.
- (viii) 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.
- (ix) Both Door close and lock switches shall be hard wired.
- (x) All relevant door relays shall have paralleling of its contacts. Sealed type Mors-Smit relay (BK-400) shall only be used for door system. If any other proven relay is proposed, design details of the same shall be submitted for the Engineer's approval and may be provided only after Engineer's approval.

7.2.4.4 Door Controls : Train operator's Controls

- (i) The doors shall be arranged for driving console control operation in non-UTO and from OCC in case of UTO. The control circuit shall be hardwired so that all the doors on either side may be operated automatically by either ATO command or manually.
- (ii) Door Control Push Buttons:

Push button used in the door circuits shall have feature of flashing e.g. door open push button shall flash when door authorization is received and glow continuously when door is opened. The details and schematic shall be provided for review and approval of the Engineer during design stage.
- (iii) The opening and closing of doors shall only be possible from an operative driving console. The door controls shall be located on train operator's console and on respective door side, suitably located on side wall between the first door & front end. This control Push Buttons shall be suitably encapsulated during GoA4. The location shall be decided during mock up review.
- (iv) The driving console side control panels shall be located conveniently for operation of the doors on that side of the train. The control devices located on each side of the cab shall only operate the doors on that side of the consist.
- (v) All door control panels in the train operator's cab shall have an identical layout and shall be physically interchangeable.
- (vi) A switch shall be provided, preferably at the side of the driving console. In ATO mode, the automatic door open command may be overridden by operating this switch. Operation of this switch shall be monitored by TCMS.
- (vii) In case of unavailability/failure of door authorization signal from ATP system, adequate safeguards shall be provided and also incorporated in control circuit to eliminate the probability of error of opening of doors on wrong side (other than platform side) during revenue service. Manual opening/closing of the doors from the cab shall be possible by simultaneous operation



of Two Push Buttons on door control panel on respective side using both hands.

7.2.5 Interfaces

7.2.5.1 With TCMS

The door controller unit shall have communication link with TCMS. TCMS shall also be interfaced with the related circuits and interlocks so that all the door related status and commands are logged.

7.2.5.2 With ATP/ATO

See Appendix 'TD' for full details of the division of responsibility between the Contractor and Signalling Contractors.

7.2.5.3 With On-board Public Address System

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

- (i) A chime with car based control 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 controlled preferably by the DCU (scheme to be finalized during design stage) shall be triggered each time the "Door Close Command" is initiated. The door close chime shall continue to play till the Doors achieve locked position. The chime shall also play in case an obstruction is detected. The chime shall warn the passengers inside the train as well as those on the platform about the door operation using identical chime sound for both internal and external speaker. It shall be possible for depot to adjust the volume of speakers easily as per the need. Selection of the type and adjustment of volume of the chime shall be independent from announcements. It shall also be possible to separately adjust the volume of the internal and external chimes.
- (iii) While chime is played over the PA system, any existing auto announcement shall be aborted.

7.2.6 Emergency Release of Doors

Three means of operating doors by staff shall however be provided for emergency situations as described below:

- (a) On each side of every car, a device (Emergency Access Device - EAD) shall be provided. The location of EAD shall be finalized through interface with the PSD Contractor during design stage with the approval of Engineer. This device shall be operable from outside the vehicle from platform level or track-side. Operation of this device shall release the "locking" mechanism on the adjacent door. Manual emergency release device shall be unobtrusive, flushed with, or recessed into, the car side, but readily available in an emergency. The manual emergency release device shall be provided with spring loaded cover to ensure water tightness. This shall require a special key so that only authorised personnel can operate the same.
- (b) A second device (one for each side) shall be provided inside the driving console. This device shall be operable from inside the driving console. Operation of this device shall release the "locking" mechanism on adjacent passenger saloon door of the DM car. This device shall be unobtrusive, flushed with, or recessed into the side wall / interior panel.

Any operation of the above mentioned manual door release devices shall be indicated to the train operator on TCMS/to OCC along with the position of the door(s) as open or close.

- (c) Third device shall be provided inside each saloon door coving. Operation of this device shall release the locking mechanism of the respective door. The device shall be accessible only to authorized DMRC personnel.
- 7.2.7 During detail design stage, all events that shall trigger recording of data in the DCU shall be finalized. Various parameters, that shall be available for display shall be selectable. For each event, the complete data for minimum previous 300 secs shall be recorded & retrievable. The data shall include each input output & status of different parameters. Adequate memory shall be available for recording of at least 100 records. Complete diagnostic tools (software/hardware) shall be provided.

Provision shall also exist to monitor all inputs/output ON LINE on a maintenance device. Unless the data is viewable on a laptop loaded with maintenance software (to be supplied by contractor for each depot) the contractor shall provide two sets of maintenance devices and diagnostic tools for each involved depot.

- 7.2.8 Accessibility of EAD with provision of PSD shall be properly interfaced with designated Contractor.

7.3 Front End Emergency Door/ Detrainment Door

- 7.3.1 Arrangement for emergency egress of passengers from the front shall be provided on the cab front. The door arrangement shall be aesthetically designed ensuring seamless clear view of the track from driving car. The door shall aesthetically harmonize with the lookout glass and driving car front and shall not block the front view giving a look of single front glass. The glass of Front End Emergency Door shall meet the specifications of the windscreen Glass (ERTS 4.13.2). The visibility of the joint between the front door and look out glass shall be bare minimum. The detrainment door system shall be SIL2 compliant and shall be provided with a sealed cover door actuating mechanism. The clear width of the door way and ramp when operated shall not be less than 1100mm with a headroom not less than 1900mm so that two files of passengers can be simultaneously detrained without supervision.

- 7.3.2 During design stage, Contractor shall provide all details to the Engineer of the metros where such options can be seen and overall design is decided. If required, the contractor shall facilitate visit of Employers representatives to such metros. Suitable arrangement for ensuring safe detrainment of passengers from saloon to the track plinth (both elevated and underground sections) shall be provided. The folding ramp shall be simple in operation and should be operable by passengers without assistance during emergency. The ramp shall have full length longitudinal handrail and fluorescent material marking on both sides. The detrainment door ramp shall be designed for load of 500 kg/m² or more and it shall not sag during evacuation process. The ramp angle shall not be more than 16.5 degree. The ramp shall also be suitably supported on the track to ensure no tilting of the ramp on straight as well as on curved sections. Retrieval of the ramp shall be easy. Contractor shall demonstrate safe use of the emergency door and ramp in the elevated and tunnel section on different radius curves specified in the specifications. The door design shall be consistent with the latest applicable fire safety standards. Further details shall be decided during design.

- 7.3.3 The door shall be vibration free and sealed against water ingress and sound transmission. It shall be provided with a safe, simple and secure locking mechanism which shall throughout be unaffected by single point failure.

- 7.3.4 The opening of the detrainment door & ramp shall be possible by one person. The retrieval and stowage of ramp should be easily accomplished by a single trained staff without dismantling any equipment. Any tool, if required, for manual operation by single person shall be provided in the driving console area. In addition to manual arrangement operable by one person, suitable portable power operated devices for stowage of door and ramp shall also be provided in each train at suitable location. If battery of Portable power is weak, stowage of door shall be operated manually. All necessary ancillary equipment to enable the train to be moved after emergency detrainment shall be provided as parts of the scope of equipment under this clause.

- 7.3.5 For operation of the door, simplicity of operation is imperative. Multilingual (regional language(s) and English and/or Hindi) Instructions shall be displayed to enable passengers, unfamiliar with the equipment to operate the emergency door, in either mode, when the train operator is incapacitated.

- 7.3.6 There shall be two operation modes, emergency operation mode and depot/maintenance mode. While in emergency operation mode complete deployment shall not take more than 1 minute. Deployment and stowage timings shall be reviewed by the Engineer.

- 7.3.7 The door status shall be interlocked with the train control circuit so that once the door is found unlocked and open:

- (i) Driving console light, Head lights and Flasher lights are automatically lit and CCTV camera automatically operated.
- (ii) Emergency brakes are applied on the train.
- (iii) Such event is logged in TCMS.

