

3.29 Ride Index

- 3.29.1 The maximum Sperling ride index shall not exceed 2.50 in new and worn wheel profile condition, both in the vertical and lateral planes, under tare and fully loaded conditions up to 90km/h, for all different types of vehicle of a train set. The tests will be performed using the standard new profile, and the fully worn profile. Drawings will be provided later. The sketch for fully worn profile for the Broad Gauge wheels shall be provided by the Contractor.



This page is left blank intentionally



EMPLOYER'S REQUIREMENTS

TECHNICAL SPECIFICATION

CHAPTER 4

VEHICLE BODY



CHAPTER 4: 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 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 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.

4.2 Mock-ups - General

- 4.2.1 Deleted.
- 4.2.2 Deleted.
- 4.2.3 Deleted.
- 4.2.4 Deleted.
- 4.2.5 The Contractor shall prepare and handover to the Engineer, 10 numbers of approximately 1:50 size true models of the DT car (non-working), with pedestal and casings.

4.3 Static Vehicle Profile (Kinematic Envelope)

- 4.3.1 The tenderer shall furnish a static vehicle profile together with a Kinematic Envelope as required by Clause 3.20.
- 4.3.2 The notional leading particulars of the driving trailer car, trailer car, and motor car are set out in Table 4.3.2.
- 4.3.3 It is preferred that a common body shell structure be adopted for all types of car as far as possible.

N.B. The vehicle shall remain within the Kinematic Envelope under all conditions.

Table 4.3.2 Principal Notional Vehicle Dimensions

Description	Dimension
Gauge	1673mm
Length over Body (T and M). DT car may be marginally longer	21 340mm
Maximum Width over Body	3 200mm
Minimum Passenger Saloon Headroom	2 050mm
Dropped down pantograph height for 25 kV a.c. cars from TOR at Car Centre Line	4250mm maximum



Height of floor from TOR	1130mm
Bogie wheel base (approximately)	2 400mm
Distance between bogie centres (approximately)	15 000mm
Wheel diameter (new)	860mm
Wheel diameter (fully worn)	780mm

4.4 Materials

- 4.4.1 The car body shall be constructed of austenitic stainless steel of grade SUS301L to JIS G4305 or any other internationally accepted equivalent standard. The Contractor shall bring to the notice of and take approval of the Engineer, if any of the components of the car body is intended to be of different material.
- 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 Delhi 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.
- 4.4.3 The exterior appearance of the car body 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 metre length, shall not exceed 1.0 mm. Any fluting, if offered, shall be shown to have advantages, and shall be subject to review by the Engineer. The roof, excluding the cantrail, may be either corrugated or smooth.
- 4.4.4 The finish texture shall be subject to approval by the Engineer, whether applied by machine or hand.
- 4.4.5 In the case of stainless steel cladding materials below 6mm in thickness, the side and end wall sections and underframe shall be manufactured from rolled sections, folded or pressed plates, or plain sheets.

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.

4.6 Car Body Strength

- 4.6.1 The mechanical strength of the car body structure shall comply with the requirements of UIC 566 except for the compressive load, which shall be 1200kN applied at the end of the car body at the centreline of the coupler, and shall be compatible in respect of crashworthiness. The tensile force shall be reduced in the same ratio as the compressive force in UIC 566.
- 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 underframe.
- 4.6.3 The number of passengers seated shall be taken as one per seat and standing as ten per square metre. The weight of each passenger shall be taken as 65kg, for the purpose of strength analysis.
- 4.6.4 The camber on the coach body under fully loaded condition shall be such that the structure shall not sag below the horizontal plane throughout the vehicle's 35 year life.
- 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 and cab-side doors.

- 4.6.6 The carbody, 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.

4.7 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 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 air conditioning apparatus, pantographs, VCB/HSCB, surge arrestor, 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.
- 4.7.3 The Contractor shall carry out a stress analysis of the carbody (including torsion mode) as well as for important structural components that affect safety or availability, using the Finite Element Method. Separate analyses shall be demonstrated and submitted for car bodies having different basic structures. The analysis shall demonstrate that all static and fatigue strength requirements of the carbody and equipment mounting are met.
- 4.7.4 Calculations of the moments of inertia of the carbody about its longitudinal and transverse axes shall be furnished, together with those of the carbody bending frequency.

4.8 Crashworthiness

- 4.8.1 The car structure and its supplemental energy absorption devices shall be designed to minimise accelerations transmitted to passengers, by absorbing collision energy, whilst not permitting one vehicle to over-ride another, nor to telescope one into another.
- 4.8.2 The car body design shall be suitable for an eight-car, six-car or four-car train and shall be such that it is capable of absorbing collision energy in a manner so as to localise structural deformation at low energy levels.
- 4.8.3 At high energy levels it shall ensure that collision energy is absorbed by progressive deformation of the vehicle end structure, thereby protecting the passengers and passenger area in the car. There shall be no structural deformation between the body bolsters.

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 eight-car train collides with an impact speed up to 10km/h.

- 4.8.5 Of particular concern is the cab front structure, which is required to protect the driver, and vital control and communications equipment in the event of a collision. The centre section of the cab is to be used as an emergency escape route, from cab to track.

The Tenderer shall submit his proposal as to the structural arrangement of the cab front and sides, and the manner in which members tie in with the underframe 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 vehicle :



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

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.

4.9 Under Floor Equipment Mounting

4.9.1 Equipment shall be mounted in accordance with IEC 61133 regarding weight distribution.

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 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.

Similarly, pneumatic and brake equipment shall be provided in a brake panel for easy access from the side.

4.9.5 The under-floor mounted equipment cases shall be constructed using materials 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 maloperation or failure, equipment will remain secure and within K.E.

4.10 Couplers and Draft-gear

4.10.1 General

The outer ends of the cars of each two-car unit shall be fitted with automatic couplers allowing automatic mechanical, electrical and pneumatic coupling and uncoupling of units. The inner ends of the unit shall be provided with semi-permanent couplers.

4.10.2 Coupling Requirement

The automatic coupler shall, in conjunction with the draft-gear automatically effect mechanical, electrical and pneumatic coupling. It shall also permit separation of units either manually from the track side or remotely from the cab. The coupler shall provide adequate support to the gangway with passengers. Alternative gangway support systems may be proposed. Full details shall be provided.



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. and Table 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 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 200m radius and vertical curves of 2500m radius.

4.10.3 Automatic Couplers : Protection

When uncoupled, auto-couplers shall be arranged so that electrical contacts and 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 and electrical 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

Means shall be provided for vertically aligning the couplers, at the intermediate ends, to facilitate coupling. After coupling, such means shall not limit normal operating movement of the coupler. This arrangement shall accommodate the full range of height variation between adjacent vehicles when being coupled. 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 electrical and pneumatic connections, and thus causing an instant emergency brake application.

4.11 Car Exterior

4.11.1 The appearance of the car exterior must be of a modern and aesthetically pleasing profile. The car exterior finish 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 DMRC/MRTS logo (to be advised after contract award) shall be applied on both sides of the car at both ends at a location to be advised later. The car number shall be applied on both



sides of each car at both ends, both externally and internally and also inside the cab to be easily visible to the train driver.

- 4.11.4 A longitudinal colour band 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 On each side of every car, at an appropriate location close to mid point of the vehicle but beyond the sweep of the passenger saloon doors, a Train Identification Indicator (ESD) shall be provided (See Chapter 13). The device shall be flush mounted with the exterior of the car body.
- 4.11.6 The cars shall be completely watertight and be able to withstand an agreed water test, simulating a train travelling at speed under severe climatic conditions of Delhi as well as passage through automatic wash plants.
- 4.11.7 The design of the car exterior shall generally be aesthetically pleasing, and shall minimise the build up of dirt.

4.12 Cab Front End Exterior

- 4.12.1 The cab front end is required to house the following features and devices :
Front end centrally Emergency Door (See chapter 7)

Windscreens for the driving position, and at the non- driving side (See 4.13.2), with windscreen wiper blades and windscreen washer nozzles, the washing medium being contained in reservoirs accessible from within the cab.

Train Identification Number indicators shall be located inside the non-driving side windscreen, and be visible from 20m ahead of the train. Full details of the proposed system shall be provided.

Head Light and Tail Light- See chapter 12.

The destination indicator shall be clearly visible at the top of the non-driving side windscreen. Alternatively, the destination indicator may be placed centrally above the emergency door/ramp, if the door/ramp mechanism allows it.

A pneumatic horn, operable from the driver's console shall be provided. See Clause 6.10.2.

Windscreen wipers shall be provided on both side screens operable from the driver's console.

- 4.12.2 The steps provided in the skirt portion of mask for entraining and detraining of train operators shall have anti slip surface. The material used should last at least for interval between major overhauls of car body.
- 4.12.3 The cab grab rail shall be brush finished with sufficient hand clearance for ease in holding.

4.13 Driver's Cab

4.13.1 Cab Layout

The Driver's Cab shall be the full width of the car, with the Driving side on the left in the forward direction of travel. It is required to house the Driver's console, including direct access to all the necessary telecommunications links, instrumentation, power and braking controls, and indirect access to miniature circuit breakers, fault indicator lights, sealed switches, etc.

The driving console shall include, arranged ergonomically, all necessary devices, incorporating a fore-and-aft quadrant power-brake controller with integral "dead-man" device. The proposed layout shall be incorporated into a mock-up. See Appendix TB.



4.13.2 Windscreens

Windows in the driving cab shall be constructed of laminated safety glass, and shall comply with the requirements of UIC 651.

The windscreen shall be sufficiently strong to comply with UIC 566, in addition to UIC 651.

4.13.3 Cab Front Non-Driving Side Cupboard

An emergency equipment cupboard shall be provided at the cab front, beneath the non-driving side windscreen, to house the portable bridging device, emergency door stowage devices, First Aid box, and safety equipment including fire extinguishers.

4.13.4 Destination Indicator

The train destination indicator shall be located at the top of, and immediately behind the non-driving side windscreen. A modern high resolution display in both Hindi and English is required. Full details of the data to be incorporated will be provided to the Contractor. Data input shall be from the driver's console as part of the setting up procedures. Access for maintenance and adjustment shall be from within the cab.

4.13.5 Driving Console Lighting

Lighting of the driver's console shall meet the requirements of UIC 651 OR which stipulates a minimum of 60 lumens/m² measured at the driving control desk (see chapter 12).

4.13.6 Driver's Seat

The driver's seat shall be cushioned, using non-flammable materials and filling, and fully adjustable in the longitudinal and vertical directions. The seat back may be made integral with the back wall. The seat squab shall be arranged to flip up, when weight is removed from it, providing a narrow lateral passageway between the centre of the cab and the side door.

4.13.7 Cab Side Doors

See Chapter 7.

4.13.8 Saloon-to-Cab Door

See Chapter 7.

4.13.9 Cab Air Conditioning and Ventilation

The driver's cab shall be provided with a dedicated air conditioning unit. (See Chapter 11).

4.13.10 Cab Floor

The cab 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 cab floor without damage to the floor or equipment.

4.13.11 Cab Lighting

The cab shall be provided with a ceiling lights, providing 200lux at 1m above floor level. It shall be operated automatically by the opening of either cab door, and extinguished manually from within the cab (see chapter 12).



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 driver aware of problems.
- (iii) External panelling, including the under surface of the car roof and all interior surfaces of car body side panels shall be coated with suitable anti-drumming compound, except where corrugated materials are used.

The body side and roof outer skin shall have a suitable thickness of approved acoustic insulating material bonded to their interior surfaces.

The design of interior fittings shall be safe under all conditions of passenger impact, during emergency braking and buffing under fully loaded condition.
- (vi) All non-metallic materials shall satisfy the requirements of flammability and smoke emission limitations.
- (vii) 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.
- (viii) All internal panel surfaces shall be smooth finished with modern low flammability, low smoke emission, and low toxicity materials. All internal panels shall be resistant to graffiti, scuffing, vandalism, and cleaning agents. Rounded corners or covings shall be provided wherever mutually perpendicular flat plane surfaces abut. Metal kicking strips of 150mm depth with radiused coving are required on all exposed vertical surfaces above floor level.
- (ix) As far as possible, fastening devices, fixings and securing screws shall not be visible from within the saloon.
- (x) Gaps between all interior lining panels, kick strips, seat shell, etc. shall be minimised. The effects of thermal expansion shall be taken into account and all unsealed gaps shall not exceed 1mm in depth where feasible. Suitable cushioning at panel joints shall be provided to suppress noise.
- (xi) The area between top of body side windows and the ceiling shall be utilised for advertising displays.
- (xii) The tenderer shall propose arrangements for map and advertisement holders in the saloon. He may also propose alternative and additional display systems which satisfy the above intentions.
- (xiii) Equipment cupboards for housing equipment for which access from the saloon is necessary, may be provided at the carbody ends.
- (xiv) Two 10kg fire extinguishers with dial type pressure gauge of the dry powder type shall be installed in each saloon, readily accessible, and notionally located beneath diagonally opposite seats.
- (xv) A dedicated space shall be provided in the Driving Trailer 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.



- (xvi) Each Saloon shall have at least one 230V, 5A socket and 2 fast charging USB ports on both ends. The sockets and USB shall be used for mobile & laptop charging.

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 (See 4.14.3 below) shall comprise double glazed, toughened, laminated glass separated by an air gap, permanently sealed against ingress of moisture. The inner pane need not be laminated.
- (iii) All windows shall be designed to minimise solar gain and provide a level of thermal insulation consistent with the requirements of the air conditioning 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 into the car in compliance with UIC 566.
- (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) Deflection at window and door openings under a compressive load of 1200kN and a tensile load of 1000kN shall not damage the window or door.
- (ix) Window seals shall be designed to prevent ingress of water to the inside of walls.

4.14.3 Passenger Saloon Doors

For details, see chapter 7.

4.14.4 Not Used

4.14.5 Seats

- (i) Longitudinal banks of seats shall be provided along the body-side between doorway draught-screens, and between draught-screens and body ends.
- (ii) The seats shall provide an adequate level of comfort, have a good appearance and be scuff and vandal resistant and their mountings shall be capable of withstanding the loads arising in service conditions.
- (iii) The seats shall provide some resistance to passenger movement longitudinally along the vehicle during acceleration and braking of the consist.
- (iv) Seats shall not be upholstered and shall not have sharp edges or protrusions that could cause injury to passengers or staff.
- (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) It is preferred that the seats be cantilevered out from the side wall, to provide a clear unobstructed car width floor, for ease and speed of cleaning.



4.14.6 Draught Screens

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.

Beyond the stand back area and at the end of the adjacent longitudinal seat a draught screen shall be installed. 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.

The strength of the draught screens shall be such that passenger loadings shall not produce any permanent deformation, damage or displacement.

4.14.7 Grab Poles and Rails

Stainless steel grab poles and rails shall be provided in the standing areas of the saloon for the comfort and safety of standing passengers.

Grab poles shall also be an intrinsic feature of the inner edges of all draught screens.

The grab poles and rails shall suffer no permanent deformation when subject to loading conditions arising in service, in accordance with UIC 566

Grab poles and rails shall be positioned such that 95% of Indian passengers can always access a pole or rail without having to reach more than 300 mm.

4.14.8 Interior Lighting

For details, See Chapter 12.

4.14.9 Floor

The non-skid floor structure shall be designed to minimise the life cycle cost of the floor over 35 years.

The floor, and its mounting structure, shall be designed to withstand any loads that may be applied over 35 years in normal operation of the consist.

The floor structure shall provide a high resistance barrier to fire and to noise generated beneath the vehicle. At all door openings, the floor shall make a weather-tight connection. No opening in the sub-floor is permitted.

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 design shall allow the floor covering to be removed without damage to the floor sub-structure.

The total floor structure shall provide an effective fire barrier for a minimum of 30 minutes as per EN 45545, Latest Editions. The tenderer shall provide, as an option an increase of this period to 45 minutes, highlighting any implications this may have. Fire resistance characteristics shall conform to international standards.

The sub-floor shall be insulated for anti-drumming and noise suppression.

Contractor shall demonstrate through design that no floor swelling or undulations shall occur during the design life.



4.15 Inter-Car Gangways

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) For cars coupled by auto-couplers the alignment and engaging of the gangway shall be actuated simultaneously with the action of the auto-coupler.
- (iv) The gangway structure shall lock securely at top and bottom. Locking and unlocking shall be by manual means.
- (v) The means of uncoupling a semi-permanently coupled pair of cars, in workshop conditions shall be described by the tenderer.
- (vi) All inter-car gangway structures shall be totally interchangeable with one another.
- (vii) To protect the interior of the vehicles when stabled as units, (i.e. not as a complete 4, 6, or 8 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.

The covers shall be lockable in position to withstand high wind conditions. The tenderer shall include in his price for **twelve** such covers.

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 panelling and shall ensure that no potential finger or dirt traps exist.
- (iv) It shall not be possible for a person to move apart parts of the gangway interior cladding in such a way as to gain access to the exterior of the vehicle between components of the gangway, under any circumstances

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 air conditioning requirements of the car body shall be provided.
- (v) Sealing of the gangway shall eliminate leakage of water into the saloon area.
- (vi) The elements of the gangway shall give a service life of fifteen years excepting those susceptible to deterioration, such as gangway flexible elements, which shall give a service life of 7.5 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:
- (iii) A differential pressure between inside and outside of the gangway of $\pm 2.5\text{kN/m}^2$.
- (iv) A concentrated perpendicular load, acting from within the gangway, of 1000N applied over an area of 0.1m² anywhere on the surface of the side walls.

4.16 Car Roof and Roof Mounted Equipment

4.16.1 Roof Structure

Every effort shall be made to make the structure of all cars, as nearly as possible identical. To this end, tenderers shall indicate what economies may accrue from making all car roofs to one standard design, having a recess capable of accommodating a pantograph, even though no pantograph will be fitted on the Motor Cars. Tenderers may offer what alternatives they consider appropriate.

4.16.2 Air Conditioning Equipment

Package air-conditioning 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, even in the event of the failure of one air conditioning unit (see chapter 11).

- 4.16.3 In Delhi 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.

4.16.4 Roof Drainage

The Contractor shall ensure adequate water drainage from the roof, such that no water shall be discharged into the vicinity of the passenger doorways.

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.



This page is left blank intentionally



EMPLOYER'S REQUIREMENTS TECHNICAL SPECIFICATION

CHAPTER 5

BOGIES



CHAPTER 5: BOGIES**5.1 General Requirements and Features**

- 5.1.1 The bogie shall be of a design which has worked satisfactorily in service on a metro or suburban railway, of similar traffic density for at least three years, irrespective of gauge.
- 5.1.2 It shall be constructed to continue in service, under normal operating conditions for at least 35 years, assuming normal wear and tear, and maintenance. During that period, there shall be no major rebuild, repair or strengthening of any bogie structural members.
- 5.1.3 The bogies shall be of the two axle bolsterless type incorporating a steel-and-rubber primary suspension system, and a secondary pneumatic suspension system, and with axle bearings outboard of the wheels. The use of helical coil steel springs will not be permitted. Calculations supporting the selection of axles and bearings shall be submitted for review by the Employer's Representative.
- 5.1.4 The bogies shall be identical. Driving trailer car bogies, trailer car bogies and motor car bogies shall have interchangeable components to the maximum extent possible.
- 5.1.5 Carbody and bogie construction tolerances and distortions shall be compensated by the incorporation of shims, welded into position, and which shall become a permanent fixture on the carbody and bogie respectively.
- 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 equipments shall be designed to minimise unsprung mass.
- 5.1.8 The bogies offered shall permit the cars to negotiate curves on plain track and through turnouts as shown below :-

Table 5.1.8 Bogie Performance on Curves

Track Gauge	Min. Rad. of Curvature Plain Track	Turnout Type	Min. Rad. of Curvature Turnout	Track Speed
1676mm	175m	1 in 8.1/2	175m	<25km/h
1676mm		1 in 12	350m	<40km/h

The bogies shall also be able to operate on a gradient of 3% without speed restriction, and on a gradient of 4% with speed restriction in depot, and on specified cant deficiencies and at specified speeds.

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 carbody. Bogie and body frequencies shall be suitably separated.
- 5.2.2 All vehicles shall be dynamically stable, and so designed that no part of the car shall infringe the Kinematic Envelope at any speed up to 90km/h.
- 5.2.3 The vehicle shall remain dynamically stable throughout the full speed range of the train under



all loading conditions in the event of either complete or partial deflation of the secondary suspension, the car shall operate safely up to the maximum design speed.

- 5.2.4 The bogie suspension, in conjunction with the carbody, shall be designed to enable cars to operate satisfactorily on track with the maximum specified track twist. The maximum off loading of any wheel shall not exceed 50% of nominal wheel load.
- 5.2.5 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 wheelset hunting.
- 5.2.6 The Contractor shall submit calculations to confirm that the derailment quotient Y/Q shall not exceed 1.0 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.

5.3 Bogie Construction: Bogie Frame

- 5.3.1 The bogie frames shall as a minimum be of fabricated, robust construction, using weather resistant high tensile carbon steel to 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.
- 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 fatigue strain gauge and suitable non-destructive tests on a pre-production bogie frame and submit the report. The strain gauge fixing locations and the application of forces for static as well as for fatigue testing shall be in place at the time of testing.
- 5.3.5 All fasteners for bogie mounted equipment or components shall be positively locked. The use of self-locking nuts alone is not acceptable.
- 5.3.6 Adequate corrosion protection shall be provided. Details shall be submitted. A corrosion protection control programme for the bogie shall be submitted.

5.4 Bogie Construction: Primary and Secondary Suspension

- 5.4.1 The Contractor shall submit a proposal for the primary suspension using steel-and-rubber springs, and shall declare the estimated mean service life for operation in the Delhi environment. The service life shall be not less than 6 years, and shall be warranted for 5 years.
- 5.4.2 Secondary air suspension shall be installed to provide automatic vehicle body to bogie height adjustment, functional for all vehicle loading conditions.
- 5.4.3 Vehicle height variation due to wheel wear and re-profiling shall be adjusted by packing. This shall be made possible without disconnection or removal of the carbody from the bogie.

The maximum floor height reduction on this account shall be for review by the Employer's Representative.

The minimum clearance of bogie mounted equipment from rail level for a fully loaded static car including full wheel wear on diameter shall not be less than 75mm.



- 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 be capable of safe operation up to the specified maximum speed with deflation of any or all of the air springs. In the event of one air spring becoming wholly or partially deflated, the complete air spring system of that bogie shall be correspondingly exhausted to ensure that the carbody remains level laterally, and can continue to operate safely.
- 5.4.5 Hydraulic dampers shall be provided as necessary to control and limit the vertical and horizontal oscillation of the carbody.
- 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.
- 5.4.7 The lateral stop shall be cushioned using a properly designed stiffness value.

5.5 Bogie Construction: Bogie to Body Connection

- 5.5.1 The carbody centre pivot shall be capable of permitting the full range of bogie movements without excessive restraint.
- 5.5.2 The bogie shall be attached to the carbody in such a way as to permit lifting of carbody 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.
- 5.5.4 Arrangements shall be made to exchange wheelsets with the minimum dismantling of bogie components being required.
- 5.5.5 The carbody shall be easily detached and lifted from the bogie. It is preferred that the Contractor may consider offering a design to permit access to one or more easily located fasteners, accessible from the side of the vehicle without the necessity for a pit between the rails.
- 5.5.6 The arrangement should allow the bogie to be mechanically disconnected, permitting the body to be lifted sufficiently far to provide access between body and bogie to disconnect traction motor cables, brake system flexible pipe connectors, and secondary suspension levelling valve linkages, etc.
- 5.5.7 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.
- 5.5.8 Body to bogie connection shall be easily accessible to facilitate exchange of bogies. An effective system of guiding shall be provided to assist the exchange of bogies following repair.

The target interval between major bogie overhauls shall be not less than 0.8 million kilometres of service operation. The Contractor shall propose how this requirement will be achieved.

5.6 Bogie Strength

- 5.6.1 The mechanical strength of the bogie frame shall comply with the requirements of UIC 615-4 and UIC 515-4 or latest version 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 or latest version.
- 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. The passenger weight for this calculation shall be taken as 65kg/person.

5.7 Body to Bogie Connection

- 5.7.1 The carbody 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 $\pm 3.0g$.

5.8 Bogie Mounted Equipment

- 5.8.1 Equipment mounted on the bogie frame shall withstand without permanent deformation the loads associated with the following accelerations acting on the mass of the item of equipment :

(i)	vertically	10g
(ii)	transversally	3g
(iii)	longitudinally	5g

- 5.8.2 Equipment mounted on the bogie frame shall have a fatigue life of not less than 10^7 cycles under loads associated with the following accelerations acting on the mass of the item of equipment :

(i)	vertically	$\pm 5.0g$
(ii)	transversally	$\pm 1.5g$
(iii)	longitudinally	$\pm 0.2g$

- 5.8.3 Equipment mounted on the axlebox shall withstand without permanent deformation the loads associated with the following accelerations acting on the mass of the item of equipment :

(i)	vertically	25g
(ii)	transverse	5g
(iii)	longitudinal	5g

- 5.8.4 Equipment mounted on the axlebox shall have a fatigue life of not less than 10^7 cycles under loads associated with the following accelerations acting on the mass of the item of equipment :

(i)	vertically	$\pm 10.0g$
(ii)	transversally	$\pm 3.0g$
(iii)	longitudinally	$\pm 0.5g$



- 5.8.5 The acceleration level specified in paragraphs 5.8.1 and 5.8.2, will be reviewed by the Employer's Representative, based upon International Standards or Norms followed by reputed metro railways.

5.9 Finite Element Analysis

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

5.10 Motor Suspension

- 5.10.1 The traction motor shall be bogie frame mounted, complete with suitable drive and suspension.
- 5.10.2 Traction motors and drives shall be easily removable in a workshop, after disconnection of cables and fixings without the need to disturb the axle.
- 5.10.3 Contractors are invited to offer as an alternative, a motor suspension arrangement which will permit a traction motor to be lowered onto a drop table from beneath a car elevated on a raised track or on jacks. The Contractor should indicate the extent of his past experience with such an arrangement.
- 5.10.4 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.

5.11 Gearbox and Coupling

- 5.11.1 Contractor shall provide flexible coupling between traction motor and drive gear.
- 5.11.2 The gearbox shall be compatible with the flexible coupling. 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 0.8 million kms.

- 5.11.3 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 km.
- 5.11.4 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 30°C and temperature shall be continuously monitored. The temperature shall not exceed the manufacturer's recommendations consistent with life between oil changes. Test shall be carried out in both the directions. Noise and vibration test shall also be performed along with this test. The Contractor shall submit a Test Procedure based on international practice for approval by the Engineer.

5.12 Wheels, Axles and Axle-boxes

- 5.12.1 The wheels shall be monobloc forged steel, complying with the requirements of EN 13262, grade ER8 Category 2. The type test (carried out according to table F1 of EN 13262) certificate shall be provided with the prototype deliveries.
- 5.12.2 The powered axles shall comply with EN 13104 or UIC Code 811-1 or any other internationally accepted equivalent standard. Manufacturing of axles shall be as per EN 13261. The type test (carried out in accordance with table J1 of EN 13261) certificate shall be provided with the prototype deliveries.
- 5.12.3 The non-powered axles shall comply with EN 13103 or UIC Code 811-1 or any other internationally accepted equivalent standard. Manufacturing shall as per EN 13261. The type



test (carried out in accordance with table J1 of EN 13261) certificate shall be provided with the prototype deliveries.

- 5.12.4 Wheels, axles, drive gears and axle bearings shall be assembled on axles by an interference fit method. Oil injection grooves shall be provided as appropriate.

- 5.12.5 The wheel tread shall be of the wear adapted wheel profile in accordance with RDSO Sketch No. 91146 (Alteration 2) for a track gauge of 1676mm (See Appendix TE).

The extreme maintenance limits for broad gauge wheels are as given below:

- (i) Minimum thickness of flange measured from wheel gauge face at 13mm from outer edge of the flange = 16mm
 - (ii) Maximum projection for flange of worn wheel measures from the tread at 63.5mm from the wheel gauge face = 35mm
 - (iii) Back-to-back wheel gauge distance = 1600mm $-1\text{mm} + 2\text{mm}$
 - (iv) Maximum clearance between flange and new rail = 22mm
- 5.12.6 Axle bearings shall be of a proven type. The roller bearings shall have a minimum life rating of 3 million kilometres when computed in accordance with the method given in ISO 281/1. 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.
- 5.12.7 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.
- 5.12.8 The Contractor will be required to provide recommended lubricants which shall have been proven in similar railway service for the axle bearings.

An alternative lubricant, manufactured in India shall also be identified by the Contractor, in conjunction with the bearing manufacturer, and the lubricant manufacturing industry.

5.13 Bogie Brake Equipment

- 5.13.1 Full details of the braking scheme are to be found in Chapter 6.

5.14 Automatic Train Control (ATC) Equipment Mounting

- 5.14.1 Full details of the Automatic Train Control System interface issues are given in Chapter 12 and Appendix TD.

5.15 Wheel Flange Lubrication Equipment

- 5.15.1 Dry type Wheel flange lubricators of a proven design in EMU metro application shall be provided in 25% of axles of each car. A suitable mechanism shall be provided to ensure that lubricators operate only in the leading position on the train. The functionality of the wheel flange lubrication mechanism shall be submitted for review of the Engineer.

5.16 Maintainability

- 5.16.1 Arrangements shall be made to exchange wheel sets with the minimum dismantling of bogie components being required. The procedure for dismantling shall be furnished.
- 5.16.2 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.

- 5.16.3 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.
- 5.16.4 Body to bogie connection shall be easily accessible to facilitate exchange of bogies.
- 5.16.5 The target interval between major bogie overhauls shall be not less than 0.8 million kilometers of service operation. The Contractor shall furnish inspection, maintenance and operational schedule of the bogies along with the intervals.
- 5.16.6 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.
- 5.16.7 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.



This page is left blank intentionally



EMPLOYER'S REQUIREMENTS TECHNICAL SPECIFICATION

CHAPTER 6

PNEUMATICS, AIR SUPPLY AND BRAKE SYSTEM



CHAPTER 6 : PNEUMATICS, AIR SUPPLY AND BRAKE SYSTEM

6.1 Overview

6.1.1 Each two-car unit shall be fitted with a complete "stand-alone" compressed air supply system.

6.1.2 The Pneumatic and Air Supply System (See Clauses 6.2 to 6.11 inclusive) shall consist of, but need not be limited to, the following :

- (i) Air compressor unit and drive motor
- (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 6.12 to 6.22 inclusive) design shall be subject to review, and shall consist of, but need not be limited to, the following :

- (i) Brake system
- (ii) Electric brake
- (iii) Electric/pneumatic brake blending
- (iv) Parking brake
- (v) Emergency brake
- (vi) Brake control system
- (vii) Wheel spin and slide protection

6.2 Air Compressor and 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 A proven air compressor operating from a 415V 3-phase 50 Hz power supply with an adequate free air delivery capacity for 2-cars shall be provided. One compressor shall have sufficient capacity to charge a completely empty 2-car unit within 7 minutes. Full air suspension inflation



shall be achieved in a further five minutes. The average duty cycle of each compressor without electric braking shall not exceed 50% during operation.

- 6.2.3 In the event of total failure of electric brakes and one air compressor on a fully loaded 4-car train, the remaining air compressor on the train shall have sufficient capacity to enable the train to remain in service for at least 3 hours.
- 6.2.4 While the quietness of the proven type of compressor is of importance, considerable emphasis is also placed upon reliability. The Contractor is therefore required to show that the reliability and maintainability of the compressor offered, has been established in actual EMU metro service. The Contractor should, *inter-alia*, submit letters from actual users indicating experience with the compressors on their system.
- 6.2.5 The motor compressor unit shall be 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 Delhi.
- 6.2.7 The compressor should preferably be splash lubricated to avoid the need for oil pump, filter, valve, etc.
- 6.2.8 A pressure switch shall control the cutting in and out of the compressor. A time relay shall be provided to monitor the state of health of the compressor and air delivery system.
- 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. If need be, a soft start feature shall be provided.
- 6.2.11 A safety valve shall be provided to protect the compressor against excess pressure.
- 6.2.12 The Contractor shall submit calculations to show that the compressor will meet the above conditions.

6.3 Auxiliary Compressor

- 6.3.1 A proven 110V d.c. operated compressor 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 d.c.. 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. Detailed proposals on the method and standards achievable for exclusion of water vapour, oil and water mist and particles, prior to delivery of air to the main reservoir, and the means of combatting the extremely hot, humid and dusty conditions prevailing in Delhi, shall be submitted.
- 6.4.2 The grade of filtration at rated pressure shall be minimally as follows:
- | | | | |
|-------|-------------------------------|---|--------------------------------|
| (i) | Particles removal down to | : | 1 micron |
| (ii) | Maximum remaining oil content | : | 0.01 mg/m ³ at 21°C |
| (iii) | Liquid water removal | : | > 95% |
| (iv) | Dew point depression | : | 40°C |

Under the ambient conditions prevailing in Delhi, no condensation shall take place.



6.4.3 A proven regenerative type of air dryer with suitable capacity shall be provided between the air compressor and the main reservoir. The air dryer shall be preceded by an automatic drain valve, preferably of the swirl type, which collects and discharges the bulk of the moisture in the compressed air, before it enters the air dryer.

6.4.4 Use of a desiccant that would improve the filtering standards of the above is preferred. Suitable means of oil separation, prior to the air dryer shall be provided if a desiccant drying agent is proposed. An inter-cooler and after-cooler of liberal capacity shall be supplied to ensure efficient operation of the air dryer. Full technical details of the proposed air dryer shall be furnished by the Contractor for review by the Employer's Representative.

6.4.5 All failures of the air dryer shall be displayed in the driver's cab.

6.5 Reservoirs

6.5.1 A main reservoir with a capacity adequate for a 4-car train shall be provided on each two-car unit. The reservoir 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 80km/h fully loaded. This shall be achieved without electric brake supplement and without air replenishment from the main reservoir.

6.5.3 Not Used

6.5.4 Reservoirs shall be manufactured from stainless steel. All reservoirs shall have a device for venting and draining of the contents of reservoirs.

6.5.5 A separate air suspension system reservoir of suitable capacity shall be provided.

6.6 Pressure Governors and Switches

6.6.1 Pressure governors and switches proven in railway rolling stock applications shall be provided for various control and monitoring functions.

6.7 Pipe System

6.7.1 All piping shall be of stainless steel conforming to the requirements of SUS 316L to JISG 3459 or any other internationally accepted equivalent standard with flare less double compression fittings. The pipe fittings shall conform to the requirements of DIN 2353.

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

6.7.3 All piping shall be of stainless steel with flareless compression fittings. The use of pipe fittings with rubber 'O' rings or similar types of seal is not acceptable.

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

6.7.5 All branches from the main reservoir pipe or control system shall be fed via cut-out cocks which may or may not be vented as appropriate. Strainers, reducing valves and check valves shall be incorporated as required.

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

6.7.7 Flexible hoses shall be kept to a minimum, and be proven in railway rolling stock service. The Contractor shall submit proposals to increase the integrity of the air supply system against



rupturing of inter-car flexible hoses. Burst hose protection shall be provided for hoses to each actuator.

6.7.8 Foreign matter shall be removed from all pipes prior to installation.

6.7.9 Suitable colour coding shall be applied to all pipework for identification.

6.8 Pressure Gauges

6.8.1 All driving cabs shall be fitted with a pressure gauge which indicates:

- (i) The pressure in the main reservoir pipe.
- (ii) The pressure in the brake actuators of the vehicle to which the gauge is fitted.
- (iii) Pressure in the brake reservoir.

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. It shall be possible to check the operational pressure of each brake actuator. The location of the test points shall be submitted to the Employer's Representative for review.

6.9 Air Suspension Equipment

6.9.1 A levelling control system shall be provided to ensure longitudinal and transversal control of body height under all conditions of load. In each bogie, one levelling system shall be provided to adjust air pressure in the air springs. 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 levelling system shall be taken from the main reservoir pipe.

6.10 Automatic Coupling Actuating Equipment

6.10.1 Control of the auto coupler operation shall be provided by air supplied from the main reservoir via an isolating cock, protection choke and solenoid operated valves.

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 together with a battery operated motor driven compressor, for the purpose of initial raising of the pantograph and closing of the vacuum circuit breaker.

6.11.2 A pneumatic horn, operable from the driver's console shall be provided, located at the front end of the cab, facing forwards. It shall be in accordance with the requirements of UIC 644 or latest international standards. Details of the loudness, tone and pitch shall be subject to review by the Employer's Representative.

6.12 Isolation of Defective Equipments

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.

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 train braking performance shall be as specified in Chapter 3, Clause 3.25.1.
- 6.13.2 The brake system shall be complete in each two-car unit, and shall consist of :
- (i) An electro-pneumatic (EP) service friction brake.
 - (ii) A fail safe, pneumatic friction emergency brake.
 - (iii) An spring applied air-release parking brake.
 - (iv) An electric regenerative service brake.
 - (v) Provision of smooth and continuous blending of EP and regenerative braking.
- 6.13.3 The EP brake is to be so designed that its control function can be taken over by the pneumatic control units even in the case of failure of individual electronic or electrical control elements.
- 6.13.4 Friction braking shall be achieved by bogie mounted brake actuator units operating on the EP system. The EP service and emergency brakes shall operate the same brake actuators. The brake actuator shall operate a tread brake.
- Parking brakes shall be incorporated on 50% of tread brake actuators. Parking brakes shall be capable of holding a fully loaded stationary train on a 4% gradient under all track conditions, indefinitely.
- 6.13.5 The friction brake system shall be proven and capable of achieving all performance requirements for a continuous round trip with maximum speed of 55 Km/h without the aid of electric braking.
- 6.13.6 With the train at standstill on a rising gradient, the brake application shall be retained (up to e.g. 6 km/h) while traction power is being applied, with a force sufficient to prevent the train from rolling backwards.
- 6.13.7 At station stops, the friction brake application shall continue at a level sufficient to prevent the train from moving. The brake shall be released only when a power command is given to start the train.
- 6.13.8 It shall be possible to isolate the friction brake system individually on each bogie. The isolation device shall be located on the underframe adjacent to the bogie and be readily accessible. The isolation shall be readily discernible to operations and maintenance staff.
- 6.13.9 All devices capable of isolating a portion of the brake system shall be located and protected to avoid inadvertent or malicious operation.
- 6.13.10 Brake friction materials shall not contaminate the wheels or rails adversely so as to affect train detection by the Signalling System.
- 6.13.11 Composite tread brake blocks shall contain no asbestos material. Heating by the brake block shall in no case cause the wheel to exceed its permissible temperature above which incipient thermal surface cracks appear.
- 6.13.12 Friction characteristics of the brake block material as tested on the Contractor's brake dynamometer, in both dry and wet conditions in the range of 0-110km/h under various designed brake forces and pressures shall be submitted.
- 6.13.13 The calculation for emergency braking distances under dry and wet conditions shall be



submitted.

6.13.14 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 on modular panels or frames to minimise pipe lengths.

6.14 Electric Brake

6.14.1 Priority shall be given to the electric brake whenever a brake command is initiated. The electric brake shall also be load weighed to ensure consistent performance. The use of electric brakes shall be maximised in all service braking modes, and shall make full use of the adhesive weight on all motor car axles.

6.14.2 The Contractor shall state the lowest possible electric brake application speed before instability occurs.

6.14.3 Deleted

6.14.4 In the event of failure of the electric brake, the friction brake shall be capable of carrying out full braking duty.

6.14.5 The tenderer shall submit brake effort v. speed characteristics showing the contribution of regenerative braking and electropneumatic braking separately over the entire speed range.

6.15 Electric/Pneumatic Brake Blending

6.15.1 The brake blending system shall ensure the priority of electric braking over pneumatic braking. If the demand declaration is not achievable solely by the motor cars' electric brakes, the pneumatic brake system on the trailer cars shall provide supplementary brake effort. The Contractor shall submit full proposals for review. Electric brake fade out shall not occur above 5km/h.

6.16 Parking Brake

6.16.1 The 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 cab 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 track level. Application of parking brakes shall also be controllable from the cab. (See also 6.12.4).

6.16.2 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.

6.16.3 Status of train parking brake shall be displayed in the active cab.

6.17 Emergency Braking

6.17.1 The Contractor shall furnish emergency braking distances to standstill, for a fully loaded train from speeds, starting from 10km/h to 90km/h in increments of 10km/h.

6.17.2 The friction brake system shall be rated to, and have sufficient thermal capacity to safely complete three successive acceleration and emergency brake cycles, with no interval between each cycle. Each cycle shall comprise a full acceleration from standstill to 80km/h followed by the application of emergency brake to standstill. On the completion of the five cycles, the brake system shall show no abnormalities.



- 6.17.3 Wheel slide protection shall be used 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 spin/slide system.
- 6.17.4 The electric brake shall be isolated during emergency braking.
- 6.17.5 Two emergency brake push-buttons shall be installed in each cab in the train. Activation of the buttons shall apply the emergency brakes under all conditions, including in-active cabs.
- 6.17.6 Unintended parting of the train shall result in an emergency brake application on both halves of the train.
- 6.17.7 Activation of the emergency brake by any means shall result in the propulsion system being disabled in a safe critical manner. The propulsion system shall not be re-enabled until the train is at zero speed and the emergency condition has been reset.

6.18 Brake Control System

- 6.18.1 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 demanded. 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 effort on more than one car. All circuits and controls essential for braking equipment 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.
- 6.18.2 A Deadman device shall be incorporated into the Master Controller Handle.
- 6.18.3 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.

6.19 Jerk Limitation for Service Brake

- 6.19.1 The build-up of pneumatic brake force shall be jerk limited (for changes in brake demand) to increase passenger comfort. The jerk limitation shall be as per chapter 3, table 3.25.1. This limit shall be respected at the time of final stoppage also.
- 6.19.2 Jerk rate control shall be applicable to braking as well as propulsion.

6.20 Brake Operating Timing

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

(i)	Service Brake Application	:	2.0s
(ii)	Emergency Brake Application	:	1.5s (max.)
(iii)	Service and Emergency Brake Release	:	2.5 s.
- 6.20.2 A malfunction of the brake control system shall result in an emergency brake application. At restart, the train shall be able to be controlled by normal brake operation system.
- 6.20.3 Brake Assurance Time (the time from initiation of the brake application signal, 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.



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

- 6.21.1 A BP controlled back-up system including a separate pneumatic control unit shall be provided in order to take over the control function in case of failure of electronic or electric control elements in the brake system. In case of such failure, the operator can continue to control braking by using the back-up brake. This system shall also be used to control brake system of dead train during rescue by a healthy train, transit of cars and shunting operation.
- 6.21.2 The back-up brake control unit shall be ergonomically placed on operator's console and shall have three positions for application, charging and lap modes.
- 6.21.3 During the operation of this mode, the dynamic brakes shall be isolated and the pneumatic brake application shall be resorted to.

6.22 Failure Management

- 6.22.1 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 Employer's Representative's review.

6.23 Wheel Slide Protection

- 6.23.1 Digital wheel slide protection with gradual slide correction shall be provided in all braking modes, on all cars. Slide detection shall be on a per axle basis with correction on a per bogie basis. The slide protection scheme provided shall be capable of detecting the severity of the slide and provide the appropriate level of slide correction.
- 6.23.2 Automatic wheel wear compensation shall be incorporated in the wheel slide protection scheme. The wheel slide system shall detect the onset of slide by either (a) an axle deceleration exceeding a pre-set parameter, or (b) detection of a difference between the relative speeds of the axles of any one bogie. Wheel slide indication shall be made available in the driving cab. The Tenderer shall submit full details of wheel slide protection scheme and equipment.

6.24 Monitoring

- 6.24.1 The performance of brake system shall be monitored by the train integrated management system (TIMS) and displayed in the driver's cab.
- 6.24.2 All components of the pneumatic system shall be tested in accordance with IEC 60077 or any other internationally accepted equivalent standard as set out in Chapter 15.

6.25 Brake Electronic Control Unit (BECU) Cards

- 6.25.1 Improved BECU cards with highest reliability shall be used to reduce failures of these cards being experienced by DMRC in the existing fleets.
- 6.25.2 The contractor shall propose the improvements carried out in BECU cards during design stage for Engineers review.



This page is left blank intentionally



EMPLOYER'S REQUIREMENTS TECHNICAL SPECIFICATION

CHAPTER 7

DOOR AND DOOR CONTROL SYSTEM



CHAPTER 7 : DOOR AND DOOR CONTROL SYSTEM

7.1 General

7.1.1 The train shall have following type of doors:

- (i) Passenger Saloon Door
- (ii) Cab Side Door
- (iii) Passenger Saloon to Cab Door
- (iv) Front end central Emergency Door

7.2 Passenger Saloon Door

7.2.1 General

- (i) Each car shall have eight pairs of externally hung, sliding bi-parting doors, four per side. The clear door opening width of each door pair shall be 1400mm or 1500mm. 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) Sheet metal shall be of ample gauge to provide adequate strength and rigidity. Joints and edges shall be thoroughly sealed against ingress of moisture with drain holes located at the bottom of the doors to allow drainage of condensate.
- (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 forces in compliance with UIC 566 or latest international standards.
- (vi) The door leaf design shall enable any portion of the door leaf or the car body visible to passengers to be cleaned.
- (vii) Each door leaf shall have a window of flat, double glazed toughened, laminated safety glass separated by an air gap, permanently sealed against ingress of moisture, positioned to avoid stress points resulting from any change in angle of the body side.
- (viii) 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. (See 4.13.2 (viii) above).
- (ix) Door windows shall be replaceable without removal of the door leaf.
- (x) No single defect or failure of any part of any door system shall produce a situation capable of causing injury to any door user.
- (xi) Door guides and supports shall be mounted within the section of doorway protected by the door seals and shall not allow ingress of dirt, debris, or any other foreign matter likely to result in excessive wear or incorrect operation of the door equipment.
- (xii) The materials used for the door track rollers and seals shall take into account of hygroscopic effects in high humidity tropical environments.
- (xiii) Sealing arrangements on external sliding door leaf shall meet the following requirements:
- (xiv) 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.

- (xv) Positive sealing along entire saloon door opening and door leaf inner surfaces to eliminate in-rush of tunnel air due to the piston effect.
- (xvi) Door sealing shall also be such that the saloon interior noise specification is satisfied when measured at doorways.
- (xvii) Door sealing arrangement shall be adequate to prevent water ingress due to torrential rain and car washing through automatic wash plant.
- (xviii) The sealing arrangement shall take into consideration of car body manufacturing tolerance and deflections under fully loaded conditions.
- (xix) The tenderer shall indicate the amount of time required to replace a door leaf on the car, adjust it, and test it.

7.2.3 Door Mechanism

Doors shall be electrically operated from 110V dc supply through train line. The door operating mechanism shall be of a proven design in service.

The door system shall continue to operate correctly with the car battery voltage supply range between 77V to 132V dc.

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.

7.2.4 Passenger Door Opening and Closing Times

- (i) Opening and closing time of the passenger doors shall be adjustable in the range of 1.5 to 4.5 seconds.
- (ii) The end of the closing stroke (say 100mm) shall be damped or cushioned to reduce impact and 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) An automatic feature shall be provided to detect and release obstructions with the gap between door leaf edges between 300mm and 50mm. With the gap greater than 300mm, if an obstruction is detected, the door shall continue to attempt to close.
- (vi) Between 300mm and 50mm gap, on sensing an obstruction, the door shall stop. The closing force of the obstructed door shall be removed. After a delay of 2s, the door shall attempt to close again. If an obstruction persists, each door leaf shall either open 25mm or the closing force of the obstructed door shall be removed. After a further delay of 2s, the door shall attempt to close again. Failure to do so shall be reason for the driver to arrange to isolate and lock the door closed, and take it out of action.
- (vii) On successfully closing, electrical interlocks prove the closed position of each door leaf, and a mechanical lock is caused to operate. Only then can traction enabling circuits be energised.



- (viii) Deleted.
- (ix) Deleted.
- (x) The above gaps and timings are notional, and shall be capable of being adjusted after experience in service has been gained. The initial settings shall be determined from an investigatory trial undertaken using the door mock-up, or the door test rig.

7.2.5 Passenger Door Operational Criteria

(i) 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.

(ii) Emergency Release of Doors

Two means of operating doors by staff, shall however be provided for emergency situations, operable from outside the vehicle from platform level or track-side.

On each side of every car, a mechanism shall be provided, close to the mid-point of the vehicle but beyond the sweep of the door leaf. This mechanism shall release the "locking" mechanism, on the adjacent door only.

The manual emergency release mechanism shall be unobtrusive, flush with, or recessed into, the car side, but readily available in an emergency. Once the door is opened, it shall be indicated to the train operator as an open door.

A second device shall be provided on diagonally opposite end panels of each car, to release the "locking" mechanisms on all the doors on that side of the car. Where not all of a train has been able to enter a station, this device will allow the orderly de-TRAINMENT of passengers from those cars at the platform.

Passenger saloon doors on both sides near drivers cab in case of 'DT+M' car/ Train shall be used for emergency egress for passengers & train crew. The contractor shall develop & implement suitable design to ensure safe and secure emergency egress to the walkway/platform at any location on the elevated, at grade and underground sections duly considering the curves and strictly in accordance with the relevant international standards.

(iii) Door Failure

Each saloon door shall be fitted with the means of isolating and locking both door leaves. The isolation shall require the use of a key at a location normally accessible from the platform. The keyhole location shall be subject to review by the Engineer.

When the isolation is activated, the door shall be mechanically locked in the closed position. Manually isolated doors shall be enunciated on the driver's cab visual display unit (VDU).

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.

In Door By Pass/Cut Out mode, in case Train Operator forgets to close the door i. e. forgets to push the relevant push button for closing of doors, the system should automatically generate door closing command and traction shall get enabled only after lapse of sufficient time (variable and operator settable) to ensure that doors are closed before the train achieves motion. Contractor shall submit the proposal for Engineers's review during design stage.



(iv) Interlocking

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.

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.

Irrespective of the operating mode, the train shall not be able to move unless all the saloon doors and cab side doors are proved closed and locked. A sealed cut out switch accessible to the driver in each cab, shall be provided to bypass the interlock, to enable a train to be taken to the next station prior to being taken out of service, to attend to the defective door. Operation shall be recorded by the Train Integrated Management System (TIMS).

(v) Door Controls : Driver's Controls

All door control panels in the driver's cab shall have an identical layout and shall be physically interchangeable.

All door control panels shall be located conveniently for operation of the doors that side of the train. The control devices located on each side of the cab shall only operate the doors on that side of the consist.

The doors shall be arranged for cab control operation. The control circuit shall be hardwired so that all the doors on either side may be operated automatically by either ATO command or manually. All door control panels in the operator's cab shall have an identical layout and shall be physically interchangeable.

The door control push buttons shall be illuminated with distinct colour light. The details and schematic shall be provided for the review of the Engineer.

The opening and closing of the door shall only be possible from an operative cab. The door controls shall be located on the operator's console and also near cab side door.

The cab side door control panels shall be located conveniently for operation of doors of 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.

A switch shall be provided, preferably at the back wall of the driving side of the cab. In ATO mode, the automatic door open command may be overridden by operating this switch. Operation of this switch shall be monitored by TIMS.

In case of unavailability/failure of door authorization signal from ATP system, adequate safeguard shall be provided and also incorporated in the control circuit to minimise the probability of error of opening of doors on wrong side (other than platform side) during revenue service.

The following additional control device is required :

- (vi) A chime shall sound over the PA system as the doors are opening, as a signal to the visually impaired. The chime shall stop when the doors are fully open.
- (vii) A door close announcement followed by a chime shall be triggered each time the "Door Close Announcement" button is pressed. The door close chime shall continue to play till the Doors achieve locked position. The chime shall warn the passengers inside the train as well as those on the platform about the door operation. Selection of the type and adjustment of volume of the chime shall be independent of the volume of the announcements.



- (vii) While chime is played over the PA system, any existing auto announcement shall be aborted.

7.3 Cab Side Doors

- 7.3.1 There shall be a cab side door on both sides of the cab. The doors shall be manually operated doors. It shall be possible to lock, unlock, open and close the cab side doors from track level.
- 7.3.2 The cab side doors shall be lockable from inside without the use of a key.
- 7.3.3 The cab side door shall be positively retained in the closed position under all operating conditions.
- 7.3.4 The assembly of the cab side door, including the mounting tracks, door retaining mechanism, cushioning bumper, stopper, etc., shall be of a robust design that can withstand rough handling including slam-open and slam-close by operation and maintenance personnel.
- 7.3.5 The doors shall be sealed against draughts, noise and water.
- 7.3.6 The door shall be positioned such that access to the cab is free from obstructions.
The clear door opening width shall be 650mm \pm 50mm.
- 7.3.7 Heavy duty locks with proven record in metro applications shall only be used.
- 7.3.8 The open/close and lock/unlock status of the cab side doors shall be monitored using reliable & suitable sensors. The train control logic shall be designed so that the train shall not be able to move unless all the saloon doors and cab side doors are proved, closed and locked.
- 7.3.9 The open/close and lock/unlock status of the cab side doors shall also be used to provide the status to TMS and also to actuate the cab lights.
- 7.3.10 Each cab side door shall contain a fixed window, which shall be flat and positioned to avoid stress points resulting from any change in angle of the body side.

7.4 Saloon-to-Cab Door

- 7.4.1 There shall be a solid door between the saloon and the cab. The clear door opening shall not be less than 1100 mm wide. In normal operation opening the door from the saloon shall require the use of a special key.
- 7.4.2 Opening the door from the cab shall only require the train operator to operate a handle. No key shall be required.
- 7.4.3 The door shall not be possible to be locked, bolted or wedged from either side of the door to prevent opening.
- 7.4.4 In emergency, it shall be possible for a passenger to gain access to the locking device, to permit access to the cab, for operation of the emergency end door.
- 7.4.6 A visual and audible alarm shall be activated in the event that the saloon-to-cab door in the unoccupied cab is opened.

7.5 Front End Central Emergency Door:

Between the front end windows, the front of the cab shall be fitted with a dual-purpose central door, flush with the exterior panels, to provide an aesthetically pleasing exterior, to provide emergency egress for train crews and passengers. It shall be arranged to provide either :

- (i) Deleted



(ii) Train to Track Mode

To move train crew and passengers from a defective train onto the track, it shall be arranged that the front door be released at the top, but leaving in position a hinge arrangement at the bottom, allowing the door to be pushed outwards unfolding into a two-section ramp, approximately 1100mm wide tread, the surface of which is faced with a high friction material, and the outside edges marked with fluorescent guide lines.

The assembly shall be complete with all necessary guide straps, which will enable the walkway to be lowered onto the track, while restraining the ramp from hitting the track bed and thereafter giving support to those negotiating the ramp.

Full details of the arrangement shall be given. The equipment necessary to return the door to its normally stowed position shall be provided. All necessary ancillary equipment to enable the train to be moved after emergency de-trainment shall be provided as parts of the scope of equipment under this clause.

For either of the above modes, simplicity of operation is imperative. Instructions shall be displayed to enable passengers, unfamiliar with the equipment to operate the emergency door, in either mode, when the driver is incapacitated.

(iii) Side Walkway

It should be noted that a side walkway nominally 800mm below the car floor level in the Rail Corridor, and within 50mm of the floor level in the Metro Corridor will be provided. This may play a part in emergency disembarkation of passengers. Tenderers may offer an alternative arrangement. Full details shall be provided.

7.6 Door Leaf Construction

- 7.6.1 All exterior doors shall have the same durability as the vehicle body. The interior finish shall be compliant with the visual design and withstand severe wear and tear. It shall not be possible for a door to become detached from the vehicle under any operating conditions, including heavy side load from standing passengers or sudden pressure transients.
- 7.6.2 The construction of the door shall be such that it is able to resist without deformation or damage a load equivalent to that which could occur on a crush loaded train. The door shall be as light and rigid as possible.
- 7.6.3 The door leaf edges shall be such that when the doors are closed they form a weather tight seal extending the full height of the door.
- 7.6.4 Any seal shall not require regular cleaning. Seals and sensitive edges (if used) shall be effective under all operating conditions from tare to crush loading and particularly shall be resistant to atmospheric and chemical deterioration and to vandalism.



This page is left blank intentionally



EMPLOYER'S REQUIREMENTS

TECHNICAL SPECIFICATION

CHAPTER 8

HV AND PROPULSION EQUIPMENTS



CHAPTER 8: HV AND PROPULSION EQUIPMENTS

8.1 Propulsion Configuration

- 8.1.1 The Propulsion System shall be suitable for operation at 25 kV ac single phase on the entire network. The tenderer may adopt 1800V as the nominal d.c. link voltage for the 25 kV system. The equipments, d.c. link, inverter and traction motors shall be common.

8.2 HV Power Collection

- 8.2.1 Power shall be drawn from the overhead line by pantographs. The pantograph for the 25 kV ac system shall be suitable for flexible auto-tensioned OCS consisting of catenary and contact wire on elevated/at grade sections as well as rigid catenary system provided in the tunnel section, for flexible OHE in the depot and in the event that the Metro routes may later be extended above ground.
- 8.2.2 The pantograph shall be capable of sustained operation and satisfactory current collection from 100mm above the collapsed pantograph level up to the full range of contact wire height, and at all operating speeds as specified.
- 8.2.3 A pantograph auto-drop function which shall drop the pantograph automatically when excessive height is detected shall be provided. An indication shall be provided to the train operator when this function has operated.
- 8.2.4 Pantograph controls shall be configured in the cab car such that any one pantograph, or all pantographs can be raised or lowered. When all pantographs are raised, there shall be a time delay function such that the instantaneous line current demand peak and inrush current characteristic are reduced to less than the operating limit of the traction power and OHL system.
- 8.2.5 Pantograph spacing shall, as nearly as is possible, be a minimum of two car lengths of all trains.
- 8.2.6 The contact wearing strips to be used on the pantograph shall be of carbon of proven design, arranged to cause least wear on the contact wire as well as to the strips themselves. The tenderer shall furnish the frequencies of replacement of strips in terms of kilometres earned by the car.

8.3 HV Protection & Distribution

- 8.3.1 A roof-mounted vacuum circuit breaker (VCB) of proven design shall be provided for the 25 kV ac system vehicles, located close to the pantograph. The VCB shall be of the single bottle type having a short circuit rating of 250MVA, and conforming to IEC 60056, in conjunction with IEC 60077 or any other internationally accepted equivalent standard.
- 8.3.2 A switch shall be provided, operable from inside the car, enabling each high voltage (HV) circuit to be earthed during maintenance. This switch shall be interlocked with the pantograph to prevent the pantograph being raised while the HV circuit is earthed and to prevent the HV circuit from being earthed while the pantograph is raised. It shall be possible to apply padlocks in the isolated and earthed position.
- 8.3.3 A suitably rated high voltage cable, shall connect the vacuum circuit breaker to the main transformer. The cable insulation and sheathing materials shall be halogen free, flame-retardant, and having low smoke emission as per the requirements of EN 45545, latest editions. The enclosure and termination of the cable shall be protected against flexure and wear. In the event of the breakdown of the cable insulation or the termination, there shall be no



risk of electrocution, or other hazards, to persons inside, or close to the outside of the car.

8.3.4 Deleted.

8.3.5 On the Rail Corridor a suitable arrangement shall be made to switch off the VCB automatically before a neutral section, resulting in the traction control equipment returning to OFF with no driver intervention. The VCB shall automatically re-close after the neutral section, causing traction control equipment to switch on again in the same operating mode, as before the switching off operation, without driver intervention.

8.3.6 The RS15 Contractor shall provide both the required way side/track-side equipment for one number of neutral section and trainborne equipment. The trackside equipment shall be installed by the RS15 Contractor in consultation with the Track Contractor, the OCS contractor and the cost to be borne by RS15 Contractor. The trainborne equipment shall be installed by RS15 Contractor. The Contractors shall liaise with one another for exchange of technical data and regarding testing and system integration.

8.4 Lightning Arrestor

8.4.1 Gapless type lightning arrestors of proven design in accordance with specification IEC 60099-4 shall be provided on the roof located as close to the pantograph as possible, for protection against line voltage transients caused by lightning or system switching.

8.4.2 The voltage and current ratings of lightning arrestors for 25 kV a.c. system shall be as follows:

Description	25 kV ac
Rated Voltage	42kV r.m.s.
Rated Current	10kA@8/20μs

8.5 25 kV Potential Transformer

8.5.1 A 25 kV Potential Transformer, to be mounted, on the roof, meeting the requirements of IEC 60044-2, for protection / measurement shall be supplied.

8.5.2 The Potential Transformer should be of Anti Burst Type of proven design and MCB protected.

8.6 AC Current Transformer

8.6.1 An AC Current Transformer, to be mounted along with 25 kV cable for protection and measurement, meeting the requirements of IEC-60044-1, shall be supplied.

8.7 Main Transformer

8.7.1 The main transformer shall have a service life of at least 35 years, demonstrable through design calculations to the satisfaction of the Employer's Representative.

8.7.2 The overall harmonic current level at the pantograph shall be restricted so that EMI with other equipments as well as Train Control & Signalling system Track Circuit frequencies are within the specified limits. The Contractor shall submit the harmonic current spectrum and overall harmonic current at pantograph level during design stage, which will be subjected to review by Employer's Representatives. The kVA rating of the transformers shall be specified at a line voltage of 22.5kV and shall be designed to deliver the power corresponding to the continuously rated traction motor currents, after accounting for the efficiency and the power factor of the traction motor, converter, inverter and auxiliary inverter.

8.7.3 The transformer shall be designed to conform to IEC 60310 and the temperature rise limits of windings and oil shall correspond to IEC 60310 limits.



- 8.7.4 The transformer shall be modular in construction, complete with oil pump, oil pump motor, radiator, conservator and protection equipment (e.g. Buchholz Relay) all assembled as a single module.
- 8.7.5 The transformer shall be silicon oil immersed, to ensure the minimum acceptable standard for fire load. Alternative coolants offering enhanced fire safety may be offered.
- 8.7.6 The transformer shall be under-slung and the mounting arrangement shall be described in detail by the tenderer.
- 8.7.7 Measures shall be included to monitor for, and protect against, traction transformer failure and leakage. The design shall minimise the fire load of the transformer.

8.8 25 kV Cable with HV Bushing and T-connector

- 8.8.1 Copper cable of adequate voltage rating and diameter shall connect the vacuum circuit breaker to the main transformer. The cable shall be laid in a stainless steel pipe. The cable insulation and sheathing shall be halogen free, flame retardant, and having low smoke emission in compliance with EN 45545, Latest Editions. The details for roof end and the transformer end terminations shall be provided for the Engineer's review.

8.9 Power Converter - Inverter

- 8.9.1 There shall be two converters and one inverter in each motor car. The power converter - inverter shall be a proven, four quadrant Revolution Intelligent Power Module (RIPM) based unit, with pulse width modulation control to ensure that the power factor is always lagging near unity at all speeds. The equipment shall conform to IEC 61287-1 or latest internationally accepted equivalent standard. Natural or forced air cooling may be offered, however natural cooling is preferred. However, if forced air cooling is deemed necessary, complete details of the arrangement, including the method of filtration shall be furnished.
- 8.9.2 The system shall be designed to minimise switching losses, switching noise, and weight, and improve heat dissipation.
- 8.9.3 The current rating of the RIPM should be such that the junction temperature has the minimum thermal margin of 10°C in the worst loading conditions taking into account the ambient conditions. The design calculations to establish the above margins in junction temperature, as well as margins available in voltage rating, shall be furnished.
- 8.9.4 The converter/inverter system and transformer shall be capable of withstanding the maximum short circuit under fault conditions.
- 8.9.5 The continuous rating of the converter shall be based on the continuous rating of the traction motor, inverter and rating of auxiliary converter after accounting for the efficiency and power factor of the traction motor.
- 8.9.6 24 V DC LED based lighting arrangement shall be provided in the CI box for maintenance purpose. Its fail safe interlocking with the box cover to be ensured. Contractor shall submit the detail document for Engineers' review during design stage.
- 8.9.7 Latest generation Gate Control Unit with individual Traction Motor Current and Temperature monitoring shall be provided with the Converter- Inverter.
- 8.9.8 Deleted
- 8.9.9 For maintenance purpose, there shall be additional by pass ground switch in CI box duely interlocked with safety locks. Contractor shall submit the proposal for Engineers's review during design stage.



8.10 AC Traction Motor

- 8.10.1 Three phase asynchronous traction motors, suitable for RIPM converter/inverter operation shall be offered. The motor shall have adequate built in margin to cater to the environmental conditions given in the specification. The motor shall be designed to suit ripples and harmonics from the inverter and shall have a high degree of reliability in service during motoring as well as regeneration. The traction motor shall be self ventilated, and shall comply with the requirements of IEC 60349 or latest internationally accepted equivalent standard and parts thereof.
- 8.10.2 Evaluation of the insulation system for sealing against moisture shall be made in accordance with IEEE 429 or latest internationally accepted equivalent standard. The insulation system shall be evaluated for thermal endurance in accordance with the requirements of IEC 60505 (1975) or latest internationally accepted equivalent standard, its draft supplement and IEEE 304.
- 8.10.3 Various ageing parameters viz., thermal and electrical stresses, ambient temperature, humidity, dust and mechanical stresses, vibration etc., should be used in the evaluation and the temperature index of the insulation system corresponding to an extrapolated life of 20 000 hours shall be established.
- 8.10.4 The temperature rise limit for the stator winding shall be the maximum temperature index of the insulation minus 70°C.
- 8.10.5 The traction motor shall be suitably rated to meet the most severe service requirements as specified in Clauses 3.25 and 3.26.

The motor bearing maintenance inspection interval (excluding lubrication if required) shall exceed 0.8 million kilometres and the bearing shall have a design life of 1.6 to 2.0 million kilometres. Lubrication of motor and gearbox bearings shall be accessible without the need of equipment removal. Calculations supporting the choice of bearings shall be submitted for review.

The motor shall be mounted on the bogie frame via flexible coupling and gear unit, which shall be totally enclosed and free from lubricant leakage.

8.11 Neutral Section Detector

- 8.11.1 A suitable arrangement shall be made to switch off the VCB automatically before a neutral section, resulting in the traction control equipment switching OFF without train operator's intervention. The VCB shall automatically re-close after the neutral section, causing traction control equipment to switch ON again in the same operating mode, as before the switching OFF operation, without train operator's intervention. The sequence of VCB closure shall be so planned that minimum numbers of cars in a train are affected. Sequential opening and closing of VCB shall be ensured to minimize the power loss. Back up operation (Both open and close) of VCBs of each unit shall be affected based on distance from previous station.
- 8.11.2 The control logic for the neutral section detector shall ensure that the power demand smoothly reduces on approach to overhead line neutral sections and smoothly increases the power demand immediately after the neutral section. Power ramping characteristics shall be submitted for review by the Engineer, and shall be validated by test.
- 8.11.3 Adequate redundancy shall be built in so that no single point failure can cause disruption. The status as well as failures of vital components shall be logged by TIMS.



This page is left blank intentionally



EMPLOYER'S REQUIREMENTS TECHNICAL SPECIFICATION

CHAPTER 9

AUXILIARY SUPPLY EQUIPMENTS

