

CHAPTER 9: AUXILIARY SUPPLY EQUIPMENTS

9.1 Auxiliary Supply System

- 9.1.1 The auxiliary power supply shall consist of a static inverter -converter together with back-up batteries and battery charger. The auxiliary static inverter - converter will receive its power from from a separate winding in the traction transformer. The auxiliary converter shall be Silicon Carbide switching Device based with microprocessor and pulse width modulation control. The three output voltage shall be as follows:

- | | | |
|-------|-----------|---------------------------|
| (i) | Output 1: | 415V 50Hz 3 ϕ 3 wire |
| (ii) | Output 2: | 230V 50Hz 1 ϕ |
| (iii) | Output 3: | 110V d.c. |

None of the above shall be accessible by passengers.

Industrial 415V 50Hz 3 ϕ socket outlets with spring loaded covers, capable of accepting a shore supply shall be provided on each vehicle at sole-bar level, on both sides. Each shall be accompanied by a red lamp, to warn of live sockets, when a shore supply is plugged in.

Internal 230V 50Hz 1 ϕ socket outlets for vacuum cleaners, and scarifiers shall be provided in each car.. 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.

- 9.1.2 The output circuits are galvanically isolated from the input and each other. The auxiliary converter shall provide power supply to all auxiliaries including ventilation blower motor, air-conditioning units, air compressor, doors, light equipments, control units and low voltage loads.
- 9.1.3 The supply shall be regulated within $\pm 5\%$ of the nominal voltage and total harmonic disturbance shall be limited to 8% under all operating conditions. The converter shall otherwise comply with the provisions of IEC 61287-1 or latest internationally accepted equivalent standard. The control shall ensure that the converter power factor is always lagging near unity at all loads.
- 9.1.4 The auxiliary converter shall be continuously rated to provide full auxiliary load on one unit (1M+1T). Full auxiliary load shall include charging a discharged battery to 80% full charge within 4 hours.
- 9.1.5 Protection against single phasing and short circuiting shall be incorporated into the auxiliary converter feeding 415V, 50Hz auxiliary drives.

Control circuit logic shall permit testing and monitoring of the operation of the auxiliary power supply system when running. Appropriate test equipment shall be supplied.

The auxiliary power control system shall carry out self-tests to ensure the integrity of the equipment. Sufficiently detailed status, fault and diagnostic information shall be transmitted to the train integration management system (TIMS), to enable protective or corrective action to be taken immediately, when necessary.

The train operator from the cab shall be able to isolate any defective auxiliary power supply equipment.

All auxiliary power equipment shall be easily accessible for inspection, testing and maintenance. Contactors shall be rated for maximum current capacity and overload interruption capability.

- 9.1.6 The SIV box shall be of Painted Aluminium with rivetting. Contractor shall submit detail document during design stage for Engineers' review. Necessary type/routine tests shall be performed in accordance with the latest accepted international norms.
- 9.1.7 For maintenance purpose, there shall be separate by pass ground switch in SIV box duely interlocked with safety locks. Contractor shall submit the proposal for Engineers's review during



design stage.

9.2 Back-up Batteries

- 9.2.1 Batteries having a nominal voltage of 110V comprising of cells of nickel cadmium type with cell casings of stainless steel or other alternative robust flame- retardant material. They shall meet the requirements of IEC 60623 and IEC 60993 respectively or latest internationally accepted equivalent standard.
- 9.2.2 The back up battery shall be adequately rated be provided to:
- (i) maintain full d.c. loads when the train runs over neutral sections of the overhead line in case of 25 kV ac system.
 - (ii) supply emergency load for at least 60 minutes in case of failure of battery charger or its supply with the battery charged to 80% of its full capacity. Non-essential load shall be shed after 30 seconds of failure of battery charge supply.
- 9.2.3 Emergency loads shall include, but need not be limited to :
- (i) Emergency lighting.
 - (ii) All exterior lights.
 - (iii) Ventilation fans, but not air conditioning.
 - (iv) Communication systems including public address, emergency help points, surveillance system and train radio.
 - (v) Propulsion and brake controls.
 - (vi) Door controls.
 - (vii) TMS.
 - (viii) Cab console indicators, lighting and interlocking.
 - (ix) ATP train borne equipment.
 - (x) Data recorder.
 - (xi) Safety proving circuit.
- 9.2.4 The design and control of the battery shall ensure that there is sufficient capacity left under all conditions to raise all the pantographs simultaneously. Adequate circuit protection shall be provided to ensure the battery load shall be disconnected when the battery voltage has dropped below 70% of the nominal voltage and when the auxiliary load is re-connected, the initial battery load shall not cause the battery output to oscillate.
- 9.2.5 Battery electrolyte capacity shall be such that the batteries will not require to have distilled water added more than once in every 90 days. The battery terminal voltage shall float on the 110V DC output of the auxiliary power supply of which the output voltage shall have fine adjustments and good stability to avoid over or undercharging of the battery.
- 9.2.6 Two sets of battery electrolyte automatic topping up devices shall be provided. These devices shall be portable and easily operated by one person. They shall incorporate a feature to cut-off



the electrolyte automatically when it has reached the correct level. The Contractor shall submit details of this device for acceptance.

- 9.2.7 The control elements taking power from the battery shall be capable of operating between 77V and 137.5V d.c.

9.3 Battery Charger

- 9.3.1 The battery shall be charged from the local (two-car unit) static battery charger. The battery charger with automatic control shall be capable of providing a high rate float charge compatible with the characteristic of the Ni-Cd batteries. The battery charger voltage and current output shall be monitored for diagnosis and generation of fault with respect to auxiliary power system output availability.

9.4 Battery Box

- 9.4.1 The box for battery shall be such that to avoid any corrosion throughout the service life on any account and the box shall last for the lifetime of the cars. Within the battery box, the battery shall be mounted in roll out trays to allow for easy maintenance.
- 9.4.2 The roll out system shall be corrosion resistant, and shall be provided with the necessary stops and locks to limit the travel of the battery box and retain it in both extreme positions. When rolled out, the entire top of the battery shall be exposed. All the battery terminals, including battery positive and negative main connections shall be easily accessible for maintenance work.
- 9.4.3 The box interior / the roll out trays shall be lined with a non-flammable, electrolyte proof, insulating material of suitable thickness. The box shall be ventilated to preclude the possibility of built-up of any gas.
- 9.4.4 The battery box shall be sized to have at least 10% extra space to accommodate augmented capacity battery. Extra space shall be suitably packed.



This page is left blank intentionally



EMPLOYER'S REQUIREMENTS TECHNICAL SPECIFICATION

CHAPTER 10

TRAIN INTEGRATED MANAGEMENT SYSTEM



CHAPTER 10: TRAIN INTEGRATED MANAGEMENT SYSTEM

10.1 GENERAL

10.1.1 The Train Integrated Management System (TIMS) shall be of latest version (in case of 'DT+M' car) complete, integrated system for the control and monitoring of train functions, systems and subsystems. The system shall provide for real-time distributed control and modular processing of subsystems in a redundant manner with high reliability and availability in the adverse operating environment of a railway.

It would be desirable for the train control data bus and the control processor to be duplicated.

10.1.2 The design shall consider the train as a complete system. The train shall monitor all its subsystems' operation and fault status, fault data logging, incident investigation and reporting. Real-time diagnostic information shall be accessible on the console display to assist drivers to operate the train safely, quickly, efficiently, and to rectify faults or failures that are resettable.

A proven train data communication link, which is immune to EMI and harmonics generated by traction equipments, will be provided between the cars. The tenderer shall list the subsystems that are to be monitored or controlled by the TIMS with their interface details.

10.1.3 The scheme proposed shall differentiate between faults which are not potentially life threatening, (e.g. air conditioning failure), and other system faults which could be life threatening (e.g. failure of the brake system).

10.2 TIMS Architecture

10.2.1 The system shall be made up of subsystem processing nodes interconnected through a train data communication link. Both subsystems processing nodes shall be redundant to increase system reliability and availability.

Diagnostic capability incorporated in the system shall detect node or line section failure rapidly to ensure no impairment of normal control and monitoring functions. The tenderer shall submit proposed system architecture.

10.2.2 The TIMS shall be of a fault tolerant distributed control system architecture.

10.2.3 The TIMS shall be modular in functional design at all levels with at least 10% spare capacity for expansion.

10.2.4 The TIMS unit shall incorporate built-in self-test diagnostic functions.

10.2.5 The hardware system shall conform to IEC 60571

10.2.6 Data protocols and standards should be to international and railway industry standards. The Tenderer shall advise the standards he intends to apply, for review.

10.3 Microprocessor Control and Diagnostic System

10.3.1 A Microprocessor/Micro-Controller based control system shall be adopted to cover control, protection, fault diagnostic display and data acquisition requirements.

10.3.2 A suitable physical bus interface, to ensure error-free and high speed data transmission shall be provided. It is desirable that the majority of control and monitoring functions are implemented by software, so as to reduce hardware and cables.

10.3.3 The microprocessor should perform the task of fault diagnostics and display, in addition to



performing the control task. The microprocessor should be capable of monitoring the status of the equipments continuously and occurrence of faults. The microprocessor should also cause appropriate action to be taken, and wherever necessary shut down equipments.

- 10.3.4 The fault data reading system shall be connected to the Train Integrated Management System (TIMS) via the Car Data Bus and Inter-Car Data Bus.

Fault data shall be displayed in the "live" driving console on a VDU.

- 10.3.5 Fault occurrences should also be stored in the memory of the microprocessor and it should be possible to transmit the output by means of a serial interface to a printer or a personal computer. The various important parameters of the equipments at the time of occurrence of faults should also be recorded with a view to enabling proper fault analysis. Adequate redundancy should be built into the microprocessor.

- 10.3.6 The tenderer shall furnish detailed technical features of the control system including control methods and strategy adopted in the design.

- 10.3.7 The monitoring functions, control functions and the fault diagnostics rules of TIMS shall be subjected to the review & change by Engineer upto the defect liability period. Since supplier of TIMS for 'RS15' has been specified same as that of 'RS1'/RS6'/RS13' as defined in Annexure TG of this Technical Specifications, all modifications and changes as advised by Engineer for 'RS1'/RS6'/RS13' and 'RS15' TIMS within the available hardware capacities shall be carried out at no extra cost upto the defect liability period. RS15 TIMS shall have reverse compatibility with 'RS1'/RS6'/RS13' TIMS.

Necessary onshore training shall be imparted to Engineer's representatives upto the full satisfaction of Engineer, to utilise the available capacity of TIMS and the required modification of the TIMS software.

10.4 Driving Console

- 10.4.1 Each Driving Console shall be provided with a VDU to display real time information to the driver. The display screen shall be of the liquid crystal display (LCD) type. The VDU shall display information of equipment operating status, faults and failure of both auxiliary and control functions. The VDU shall also display recommended remedial actions in the event of alarms or faults occurring on the train.

- 10.4.2 A communication port on each car to interface with a notebook computer shall be provided and all information on the VDU shall be accessible on the notebook computer. In addition, other diagnostic access by maintenance staff via the notebook computer shall also be provided.

A minimum of Five laptop (notebook) computers, together with all associated accessories and software necessary for all diagnostic functions for all train-borne equipment shall be provided. Two copies in approved non-volatile memory of all the softwares uploaded in the notebook computers shall also be provided separately.

- 10.4.3 The notebook computer shall provide full testing of and interaction with the on-board TIMS at both train and car level.

- 10.4.4 The following minimum capabilities shall be provided:

- System monitoring, fault data retrieval and analysis.
- Viewing and processing of logged TIMS data.
- Uploading facilities for new operating software and parameters.
- Uploading facilities for new train configuration data (e.g. wheel diameters, etc.).
- Downloading of fault and usage information in Depot.
- Exercising and checking of digital inputs and outputs.
- Checking of train and subsystem serial links.



- (i) Checking of train data bus set-up and configuration.
Retrieval of equipment identification numbers.
Initiating function testing of onboard equipment.

10.4.5 A seven-digit odometer display shall be incorporated into the VDU display on each driving console. It shall record cumulative distance run, irrespective of direction, and shall be non-resettable.

10.5 User Interface

10.5.1 A high-speed suitable communication port on each car to interface with a notebook computer shall be provided and all information on the TIMS shall be accessible on the notebook computer. It shall be possible to download the desired data for the entire train including data logged in its sub-systems through any one of these ports.

10.5.2 In addition, other diagnostic access by maintenance staff via the notebook computer shall also be provided.

10.5.3 The level of access to distinct functionalities shall be controlled for the maintenance personnel. At least three levels shall be defined which shall be user name and password protected. The details shall be reviewed by the Engineer.

10.6 TIMS Software

10.6.1 The software and communication protocols used throughout the TIMS and the interfaces to subsystems shall be to a common standard or standards.

10.7 TIMS Labelling

10.7.1 The type, location and identification of all hardware, software interconnections, cabling and terminals shall be determined on a coherent hierarchical system basis. Labelling or identification shall use appropriate English language based mnemonics or abbreviations. The Contractor shall submit proposal for review.

10.8 Energy Measurement

10.8.1 Energy meter shall be provided with facility to display energy consumption for each journey as well as cumulative in each motor car. Facility shall be available to key in the driver and train identification number.

10.8.2 The control system shall be designed to ensure accurate energy measurements. The integrity of measurements with the unit & train shall be ensured, recorded and retrievable. The employer intends to use the data for getting carbon credits. The measurements shall include both during traction, coasting and regeneration at pantograph, converter and aux converter level. The system shall ensure the followings:

Net energy drawn at panto with both the components viz. motoring (including coasting) & regeneration with time & kilometers travelled stamp shall be displayed on HMI when required. The integrated & cumulative values at any time shall be available and recorded with date, time stamp & net kilometers travelled.

All energy measurements shall have accuracy within $\pm 3\%$. This shall be validated during type tests.

Further details shall be discussed and finalized during design. The contractor shall also provide suitable analytical tools to screen and analyze the data for optimization of energy regeneration, coasting, right manner/energy saving manner of driving, educating train operators and indentifying the areas where energy can be saved etc. Contractor shall submit the proposal for Engineers's review during design stage.



This page is left blank intentionally



EMPLOYER'S REQUIREMENTS

TECHNICAL SPECIFICATION

CHAPTER 11

HEATING, VENTILATION AND AIR-CONDITIONING



CHAPTER 11: HEATING, VENTILATION AND AIR-CONDITIONING

11.1 General

11.1.1 The Heating, Ventilation and Air-conditioning (HVAC) System shall be installed on each car to provide full control of interior temperatures automatically, over the full range of heat loads associated with passengers, miscellaneous electrical equipment, lighting, heat transmission and solar gain.

11.1.2 HVAC units shall be roof mounted package type. Two identical units per car shall be suitably located to achieve specified conditions.

The Contractor shall submit proposals relating to measures to be incorporated to prevent unloading of air-conditioning units under the conditions of stoppage of train at the platforms and inside the tunnels due to high condenser temperature.

11.1.3 The units shall continue to operate at maximum capacity at condenser inlet temperatures up to 50°C and derated capacity up to 58°C.

11.1.4 The refrigerant used in the air-conditioning system shall be in accordance with the requirements of the Montreal Protocol. Environment-friendly R407C/R134 refrigerant shall be used.

11.1.5 The proposed HVAC system shall be service proven in a rail-borne application, and shall achieve a reasonable degree of comfort for minimum weight and life cycle cost.

11.1.6 The estimated weight, power requirements and heat load calculations giving the parameters adopted, shall be submitted by the Contractor. The specific measures taken to minimise energy consumption of the HVAC unit shall be detailed in the tender.

11.1.7 Deleted.

11.2 Design Criteria – Cooling and Heating Capacity of the Unit

11.2.1 The HVAC unit shall be designed to achieve internal conditions as listed in table 11.2 for the indicated external conditions

Table 11.2 external/internal conditions for HVAC

Weather Conditions	External temperatures	Internal Conditions
Summer	44°C Dry Bulb, 33% RH	25°C Dry Bulb, 60% RH
Monsoon	35°C Dry Bulb, 65% RH	25°C Dry Bulb, 60% RH
Winter	4°C	18°C

11.2.2 The fresh air intake may be taken as 2.3 litre/sec. for 380 passengers should give CO₂ level of below 2600 PPM inside saloon at ambient CO₂ of around 450 PPM.

11.2.3 Heat gains to be considered for each car shall be mainly as follows:

- Car lighting and electrical loads (including evaporator fan motors).
- Passenger loading @ 380 passengers/T and M car and 360 passenger for DT car.
- Carbody heat transmission with an assumed 10 kmph relative exterior velocity.
- Fresh air heat load.



384000

000437

- (v) A solar load representing direct and diffused radiation, convection and radiation from window surfaces, and absorbed heat gain from the glazing and carbody structure.
- 11.2.4 The system shall automatically control the temperature and relative humidity throughout the passenger area up to 25°C and relative humidity of 60%RH respectively, for ambient temperatures of 35°C 65% RH and 44°C 33% RH.
- 11.2.5 Failure of one of the HVAC units on a car shall not adversely affect operation of the other unit. The Contractor shall submit calculations for the inside conditions with one HVAC unit out of operation.
- 11.2.6 The HVAC system shall be designed to achieve the following:
- (i) Air Discharge Velocities: The air discharge velocities at any outlet grille shall not exceed 4m/s. The air velocities at specified points in the car, as proposed by contractor and reviewed by Engineer, shall not exceed those set out in EN13129/EN14750. The air velocity at any point in the car shall not exceed 0.75 m/s. The air velocity within ducts shall not exceed 8m/s, shall not cause noise or air movement discomfort to passengers, and shall generally follow internationally accepted practices. The air intake velocity at the re-circulation and exhaust grilles shall not exceed 3m/s. Details of the Contractor's proposals shall be submitted.
 - (ii) Temperature Distribution: Temperature difference among all points in the same horizontal plane over full car length shall commensurate with best international practices. The Contractor shall submit proposal for review of the Engineer.
 - (iii) Saloon Pressure: The ventilation shall pressurize the car with all doors closed and car stationary. The proposed value of pressure shall be submitted.
- 11.2.7 In the event of the failure of both HVAC on a car, an emergency ventilation system shall operate automatically to admit fresh air directly into car to maintain the required oxygen level in the fully laden car, in accordance with ASHRAE. The outside fresh air shall not be less than 18m³/h/person, under fully loaded train conditions. Contractor shall submit minimum fresh air required as per ASHARE. The emergency ventilation fans in the saloon shall be fed from the 110V d.c. supply in the event of non availability of 415V ac supply from their individual inverters.
- 11.2.8 Fresh air should be filtered for human comfort and safety, in accordance with internationally accepted norms. The filter element shall be provided before the fresh air damper and fixed in a metallic frame and shall be easily replaceable from inside the car. Even with extremely dusty and humid environment prevailing in Delhi, the cleaning of the filters shall not be required before 5000 kms of train run. The filter shall have sufficient efficiency to ensure that dust deposition in the air duct is bare minimum and cleaning of duct is not required in between major overhaul. Cleaning of the duct shall be simple and contractor shall suggest necessary equipment required for dust removal and sanitization against fungal growth etc. The method for cleaning the filters and expected life of filter shall be furnished during detail design stage. Minimum expected life of filter provided shall be 100,000 kms. Better alternatives may be suggested during design.
- Tenderers shall indicate the type of filters proposed to be used by them in the bid. The expected pressure drop across the filter shall be furnished. Details of suitable tools, used for measurement of pressure drop shall be provided in the bid. Two sets of such tools shall be supplied by the contractor in each depot. Each type/ size of filter shall be interchangeable with the RS1/RS6 or RS13 fleet.
- 11.2.9 Provision shall be made to shut off the fresh air intake and re-circulate the internal air of the saloon, during an emergency condition, such as fire outside the train causing excessive heat and smoke to be drawn into the vehicle. Full details of the system proposed shall be given.
- 11.2.10 Provision of reheating may be provided for dehumidification as required to achieve the



specified humidity conditions. The Contractor shall give technical write-up explaining as to how they will control the humidity inside the car giving details with respect to psychometric charts and type of arrangement envisaged.

11.2.11 The HVAC units fed by one Auxiliary Power Supply Equipment shall have staggered starting in a sequence to reduce the inrush current load due to simultaneous starting of air-con motors. This may be achieved through Programmable Logical Controller of the units and TIMS.

11.2.12 The HVAC unit shall have optimized capacity control depending on the number of commuters inside the car.

11.2.13 Employer expects that energy efficient system comparable with the best available in the market shall be provided. Contractor shall furnish energy efficiency ratio (EER) for the offered system. In cooling mode the Coefficient of performance (COP) of HVAC shall not be less than 2.5 for both summer and monsoon outdoor and indoor conditions specified in table 11.2. Energy Efficiency Ratio (EER) of minimum 2.5 is to be proved during Type Test (if there is any design change) for summer and monsoon conditions with fresh air damper open. Cooling capacity test has to be done as per latest version of IS 8148 or any equivalent ASHRAE or international standard. The contractor shall submit the record of proven system already functional in metros with the specified COP.

11.2.14 Deleted.

11.2.15 In case of grounding in any HVAC unit, it shall be possible to isolate the defective HVAC unit without affecting the static inverter operation. Contractor shall submit the proposal for Engineers's review during design stage.

11.3 Heating System

11.3.1 The car shall be electrically heated by a Thermostatic Control System using evaporator fan / heater unit. The system shall be designed to provide an inside temperature of 18°C with an external ambient temperature of 4°C.

11.3.2 The heater shall be installed in the evaporator unit, downstream of the evaporator coils, to condition the fresh air intake and for reheating to control humidity under partial cooling operation of the cooling equipment.

11.3.3 The control circuit shall not allow the heaters to be powered unless the evaporator blowers are operating. Heater element over temperature protection shall be provided. Self-resetting thermostats shall be installed adjacent to the heaters to open the contactors when excessive temperatures are detected. A positive interlock shall be provided to open heater contactors in the event of failure of the Auxiliary Power Supply Equipment.

11.4 Roof Mounted Package Units

11.4.1 Two package type HVAC units, with all equipments required for satisfactory functioning of the system, shall be provided on each car.

11.4.2 Each unit shall be arranged on an integral stainless steel frame with bottom plate of SUS 316L and SUS 304L body, removable from the car as a single complete module. The integral frame housing of the unit shall be constructed such that to avoid any corrosion in service on any account and the box shall last for the lifetime of the HVAC unit without needing any attention. HVAC frame/cover shall be suitable for free movement of maintenance personnel without any consequential damage to covers/equipment. The finish of the frame shall match and will be in harmony with the car body finish. The HVAC unit supplied with RS15 stocks shall be completely interchangeable with existing HVAC of RS1/RS6/RS13 stocks.

11.4.3 The complete operation to remove and replace a unit should be simple. The Contractor shall



000487

000487

declare the weight of the complete unit including specialized mechanical handling equipment. All electrical connections shall be fitted with quick disconnection fittings, at easily accessible locations.

- 11.4.4 The frame housing shall be designed and constructed so that access for inspection and routine maintenance is from roof hatches, hinged at one side, secured by captive bolts on the other, and provided with stops to retain them securely in the lifted position when opened.
- 11.4.5 The carbody roof walls for accommodating the overhead air-conditioning units shall be a compartment in the car roof structure. Each well shall provide a continuous watertight and weatherproof area complete with adequate water drains to prevent rain, condensate or washing water leakage into the car.
- 11.4.6 Fresh and return air shall be filtered before being passed over the evaporator coil. It shall be possible to remove and replace air filters from inside the cars conveniently without the need for removal of any cable connection.
- 11.4.7 Air-conditioned unit shall have noise less compressor & condenser.
- 11.4.8 The design shall ensure the easy cleaning of the drains, evaporator coil, and condenser coil without lifting of HVAC unit from the roof.

11.5 Air Ducts and Diffusers

- 11.5.1 Conditioned air from each unit shall be directly introduced into a duct running the full length of the car and be discharged into the car through ceiling outlets.
- 11.5.2 The duct shall be constructed from stainless steel or anodised aluminum and diagonally split so that each unit feeds one side of the car. The duct shall be fully lagged with non-combustible insulation material to prevent the formation of condensation. The Duct shall be suitably designed to ensure that no short circuit between the two ducts shall be possible. The design shall ensure that in the event of failure of cab end HVAC, the bleed of cool air is always available in the cab. The Contractor shall take into consideration the requirement of maintenance access for duct cleaning as and when required.
- 11.5.3 Two rows of air diffusers shall be mounted on each side of ceiling panel, blending well with the car interior design. It shall be possible to adjust the air quantity from the diffusers during testing and commissioning, to achieve uniform distribution of air, to the extent possible. The details of the diffusers shall be submitted.
- 11.5.4 The design of duct shall take account of the possible need to provide a recess in the roofs of cars, to accommodate the support for the pantograph base arrangement.
- 11.5.5 A model of the proposed duct made of plywood or any other suitable material shall be prepared to evaluate the design parameters, including air velocity from the outlets and air distribution inside the car.
- 11.5.6 Adequate sized duct from adjacent AC to the cab shall be routed to the driving cab, control cabinets and driving console. Air turbulator shall be provided in the driving console, signaling cubicles and electrical cabinets to achieve uniform cooling.

11.6 HVAC Unit Compressor

- 11.6.1 The Contractor shall provide twin hermetic scroll compressors proven for sufficiently long time in Metro service. Scroll compressor shall be suitable for operation at high ambient temperatures upto 50°C. The details of the drive for the compressor shall be provided. Full details of the compressor and its experience in Metro application, particularly in high temperature, dusty and humid environment shall be furnished. Unloading of compressor shall



be linked with HP setting.

11.7 Condenser and Evaporator Coil

- 11.7.1 The condenser and evaporator coils shall be of copper with copper fins. Condenser fins spacing shall be no closer than 3mm to prevent dirt/dust build up. The coil assembly shall be mounted in a stainless steel / copper alloy frame. Cleaning of condenser and evaporator coils should not be required earlier than 1.5 lakhs KM running. The frequency of cleaning of coils in Delhi climate shall be furnished.
- 11.7.2 The condenser and evaporator fan motor shall work at 415V, 3 phase, 50Hz. However, in case of auxiliary supply failure, the evaporator fan motor shall be fed from the inverter. Dual speed condenser fan motor may be used. The fan motors shall have IP 56 protection as per IEC 60529.
- 11.7.3 A condensate drain stainless steel pan shall be provided beneath the evaporator coil. Baffles shall be provided in the pan to prevent spillage. Adequate big size drain pipe shall be provided for drainage of condensate from drip tray to the rain gutters. Suitable means shall be incorporated for cleaning of drainage system.
The design of rain gutter shall ensure smooth passage of drainage and muck.
- 11.7.4 Quality of HVAC copper tubing and joints shall be of a very high order so as to minimize chances of refrigerant leakage. It the experience to the employer that these may have to provided with suitable coating to insulate against environment pollution.

11.8 Piping

- 11.8.1 The refrigerant piping shall be of copper with suitable non-ferrous fittings. All connections between the piping and equipment shall be made using either capillary fittings or brazed joints. There may be relative movement between the terminals of the compressor, condenser and evaporator coils resulting from vibration. The pipe layout shall take this aspect into consideration.

11.9 Electrical control cubicle

- 11.9.1 An electrical switchgear and control equipment for the system shall be located in a sealed cubicle, which shall be an integral part of the package. The electric switches, contactors and relays etc. should be proven in Metro application. The cables shall be halogen free compliant to EN 45545, Latest Editions in respect of flammability, smoke emission and toxicity requirements.

11.10 Control Equipment

- 11.10.1 Each HVAC unit shall be associated with its microprocessor control panel which shall be easily accessible from within the car. The micro-processor based system, proven in railway service shall be provided with loading, scheduling, diagnostic and operational data interfaced with TMS.
- 11.10.2 The microprocessor shall have extendable memory permitting logging of faults and system events in its memory for sufficiently long durations. The microprocessor shall have suitable interface with TMS for data communication and display. Suitable communication shall be provided to permit logged events to be downloaded to a laptop computer.

11.11 Emergency Inverter

- 11.11.1 An Inverter of adequate capacity shall be provided in each to supply 415 Volt power from 110



Volt d.c. battery to power the ventilator fan motors of the car during emergency mode, when cooling is off, for supplying emergency fresh air. Inverter shall be IGBT based and tested in accordance with IEC 61287. The current rating of IGBT shall be such that the junction temperature has a minimum margin of 10°C in the worst loading conditions. The inverter shall be located in evaporator section of the HVAC unit.

11.12 Operator's Cab Air-conditioning

11.12.1 The driving cab shall have a special package HVAC unit capable of maintaining inside conditions at less than 25°C , 60% RH. The fresh air supply shall be not less than $0.04\text{m}^3/\text{s}$ ($144\text{m}^3/\text{h}$). The temperature shall be easily adjusted by the operator.

11.12.2 In case of the failure of cab air-conditioning, it shall be possible for car cooling air to be supplied to the cab.

11.12.3 A suitable diffuser, adjustable in both vertical and horizontal directions shall be provided.

11.12.4 Manual On-off and two-speed controls shall be provided for fan operation.

11.12.5 Deleted.

11.12.6 The HVAC unit of cab supplied with RS15 stocks shall be completely interchangeable with existing HVACs of RS1/RS6/RS13 stocks.



This page is left blank intentionally



EMPLOYER'S REQUIREMENTS

TECHNICAL SPECIFICATION

CHAPTER 12

ELECTRICAL AND CONTROL EQUIPMENTS



CHAPTER 12: ELECTRICAL AND CONTROL EQUIPMENTS

12.1 General

12.1.1 On-train electrical equipment and control circuits, other than those for the propulsion system, shall use one or more of the following power sources:

- (i) 415V ac, 50 Hz, 3 ϕ , 3 wire
- (ii) 230V ac, 50Hz, 1 ϕ
- (iii) 110V d.c.
- (iv) 24 V d.c.

12.1.2 AC single phase levels at the load end shall be within $230 \pm 6\%$ V and $50 \pm 3\%$ Hz.

12.2 Train Control and Operational Principles

12.2.1 A modern ergonomically designed console located between the train operator's seat and the cab front end structure shall be equipped with vital train operation controls mainly master controller, back-up brake control, door controls, gauges, indicators, push buttons etc as approved by the Engineer. In addition to the above direct controls, an indirect access to miniature circuit breakers, fault indicator lights, sealed switches shall also be provided. The console shall also be provided with TIMS, VDU and ATP/ATO displays besides the identified gauges and indications. Suitable ventilation shall be provided by the Contractor for the backside area of the console.

12.2.2 The control and operation shall be based on the optimized combination of the following principles:

- (i) Maximum safety
- (ii) Maximum reliability and availability
- (iii) Operator convenience and ergonomic design
- (iv) Adequate redundancy
- (v) Energy efficiency
- (vi) Maintenance support

12.2.3 The control logic shall ensure that the vital train control functions (such as Couplers, door system, brakes, propulsion power removal, PEA etc.) are executed using conventional relay control and dedicated hardwired train line signals. All vital circuits not totally within the system apparatus enclosure, shall be double wire, double break, with the exception of connections to non-vital circuits. The identified safety critical signals shall be carried using redundant train line pairs.

12.2.4 Warnings and indications that are necessary for safe operation of train shall be indicated by means of LED lamps and shall also use hardwire system.

12.2.5 TIMS link shall be used to execute non-vital commands and controls of the train.

12.2.6 In addition, TIMS link shall be used for the identified non-vital control functions through VDU interface. TIMS link shall also be designed to provide back-up signals of certain identified vital commands.

12.2.7 The Contractor shall develop overall control logic for review of the Engineer. The proposed equipment shall be service proven and reliable.

12.3 Trainline Electrical Connections

12.3.1 Electrical contact blocks, mounted on the semi-permanent or automatic coupler shall be provided. When the automatic couplers are mechanically coupled, automatic pneumatic and electrical coupling shall be effected between the mating couplers. When the automatic couplers are uncoupled, the electrical contact blocks shall be automatically retracted and



protected by covers with adequate weather protections. Electrical connectors for the semi-permanent couplers shall be mechanically secured together.

- 12.3.2 The Contractor shall submit details for inter-car and inter-unit connections to meet the necessary train operation requirement. Adequate number of spare connection pins shall also be provided.
- 12.3.3 The free end of the cabling from the electrical connector shall be terminated in a multi-pin plug (s) with compatible socket(s) at the interface with the car wiring.
- 12.3.4 All exposed cables at the exterior including the inter car jumper cables, if any shall have suitable mechanical protection.

12.4 Control equipment

- 12.4.1 The control equipment relays and switches and such other devices shall be of proven technology established under the most severe operating conditions with particular regard to reliability.
- 12.4.2 Wherever considered necessary by the Contractor, contacts shall be duplicated to provide redundancy. Inter-vehicular control couplers and data transmission pairs shall be duplicated to ensure reliability of operation.
- 12.4.3 Interlocks and auxiliary contacts connected with important protective, operation, control, auxiliary and safety circuits will be housed in enclosures.
- 12.4.4 The voltage range of all relays and contactors will be 77 to 138 V dc (110V d.c. -30%, +25%, in accordance with IEC requirements). These devices will work within this voltage range properly under their rated temperatures and contact pressures. The contact pressure will be adequate to ensure satisfactory operation under most severe working conditions.

12.5 Wires and Cables

- 12.5.1 All wires and cables shall be adequately protected for the maximum design and fault currents, and designed for minimum voltage drop.
- 12.5.2 The insulation of all wires and cables including those used within equipment / subsystem shall be halogen-free flame- retardant and formulated to minimise generation of smoke, noxious emissions and corrosive fumes, in the case of overheating or fire in compliance with EN 45545 latest editions. All Cables shall comply NF F 63-808 (for low voltages), and NF F 63-826 (for high voltages) or other international standards like EN 50264 (Part 1 to 3) and EN 50306 (Part 1 to 4) as approved by the Engineer.
- 12.5.3 Fire resistant cables shall be proposed for circuits, which should survive for long periods during fire, as per applicable international standards. As a minimum, the cables and wires for Public Address System shall be fire resistant cables.
- 12.5.4 The system adopted to rate cable shall be fully specified for review. All de-rating factors shall be applied, together with the maximum permissible conductor temperature for the particular insulation type. In no case shall the conductor continuous temperature exceed 90°C. The maximum short circuit temperature shall not exceed 250°C. The cable insulation shall be capable of withstanding these temperatures.
- 12.5.5 The minimum cross sectional area of control cables for connections between equipment shall preferably be 1.5 mm². Smaller cable sizes may be used inside equipment cases. Any deviation from this requirement, in exceptional cases, will be subject to approval by Engineer in design stage.
- 12.5.6 The proposed cables shall be proven on metro Rolling Stock. The Contractor shall submit the



voltage grade, size and type of cable for different applications alongwith the proposed specification for the cables for review by the Engineer.

12.6 Indication Circuit

12.6.1 All hardware indications shall be with LED type. Failure of a single LED shall not cause incorrect indication. Individual cars shall have local indication of the operating status of the equipment, being remotely indicated in the VDU display, through TIMS.

12.6.2 Indication on DT Car

Backup LED indication for critical function shall also be provided in the DT Car. In addition to VDU display the indications provided shall be for train and car level. All indications shall be provided either on the driver's console or on the panel behind and adjacent to the driving position. The tenderer shall furnish a list of indicators including function, control and display format for review.

12.6.3 Train Lines for Indication Circuit

The tenderer shall submit proposal for train lines utilised for the indication circuits.

12.6.4 Trainline Electrical Connections

- (i) Electrical contact blocks, mounted on the semi-permanent or automatic coupler shall be provided. When the automatic couplers are mechanically coupled, automatic electrical coupling shall be affected between the mating couplers. When the automatic couplers are uncoupled, the electrical contact blocks shall be automatically retracted and protected by covers with adequate weather protections. Electrical connectors for the semi-permanent couplers shall be mechanically secured together.
- (ii) The tenderer shall submit details for inter-car and inter-train connections to meet the necessary train operation requirement. Adequate number of spare connection pins shall also be provided.
- (iii) The free end of the cabling from the electrical connector shall be terminated in a multi-pin plug (s) with compatible socket(s) at the interface with the car wiring.

12.7 Circuit Protection and Earthing System

12.7.1 All electrical circuits shall be protected by fast acting, 10kA fault current rated MCB's. The Contractor shall propose a protection scheme for review. The Contractor shall submit a detailed protection scheme including calculations to demonstrate proper segregation and discrimination between the cables, fuses and the traction substation circuit breakers. Calculations shall be submitted to verify proper discrimination between different levels of the protection system.

12.7.2 All equipments will be adequately earthed, insulated, screened or enclosed and provided with essential interlocks and keys as may be appropriate to ensure the protection of the equipments and safety of those concerned with its operation and maintenance.

12.7.3 All equipments on the vehicles, except the battery boxes shall be safety grounded to the carbody structure. The safety grounding shall be distinct from power return grounding. Safety grounding points shall be of tinned copper, clean, free from paint, and of a sufficient area to ensure proper electrical contact for the grounding cable fasteners. Untinned bronze grounding points and austenitic grade stainless steel grounding points are also considered acceptable.

12.7.4 The area of any weld joining the grounding pad to a surface shall be at least equal to the cross sectional area of the grounding cable. Grounding points will have either a tapped hole or,



preferably, a clearance hole (with access to both sides) suitably sized for the lug attachment fasteners. Minimum grounding cable size will be 6mm².

- 12.7.5 An earth fault detection system shall be proposed by the Contractor for review. Protective devices shall also prevent fires resulting from short circuits, or other electrical defect.
- 12.7.6 The Earth Concept shall such that requirement in audio frequencies used in signaling track circuits is met.
- 12.7.7 All electrical circuits shall be fully insulated from the superstructure on both the positive and negative sides and the super-structure shall not be used as any portion of an earth return circuit.
- 12.7.8 Earth fault protection shall be provided on control, auxiliary and traction power circuits, so that it shall be possible to continue operation for a limited period even where there is one earth fault on the circuit. For this purpose the earthing of the circuits may be provided through the coils of earth fault detection relays and the supply battery.
- 12.7.9 All electrical and electronic equipment shall be protected against surge or transient voltages caused by switching (internal or external to the rolling stock), lightning discharges and line voltage disturbances by the provision of suitable filters or surge suppressors.
- 12.8 Lighting System
- 12.8.1 Exterior Lighting
- (i) Exterior lights lens assemblies shall be sufficiently robust to resist the impacts of flying ballast.
 - (ii) The IP protection shall be IP65, when fitted on the carbody.
 - (iii) Deleted
 - (iv) Individual power LED clusters used as exterior lights shall be able to be replaced easily from track level. Replacement of individual cluster shall be possible in depot without disturbing the functioning of the light. In case, the change of cluster require readjustment of complete light or component, facility for the same shall be provided in each depot.
 - (v) Access for cleaning and the replacement and adjustment shall be possible.
 - (vi) All LEDs shall conform to the minimum requirements as specified in ERTS 12.9 and its sub-clauses.
 - (vii) Complete lighting system(s), their components shall generally conform to relevant ENs/IECs applicable for railway applications and shall be type tested.

12.8.2 Head and Tail Lights

- (i) Power LED based Head- and tail-lights in watertight sealed, vermin-and-insect proof integrated housings placed at approximately 3m centres and 1.5m above top of rail datum, beneath the windscreens. The units shall be "handed", left and right, so that the taillights are outboard of the headlights.

The two power LED based white light, with provision for dipper shall be mounted at the front of the driving end of the DT Car, to provide even illumination of the tunnel bore, track bed and track side signal posts. It shall be possible to read the number plates provided on the OCS masts and other boards like pantograph lower / raised boards. The illumination level of the head light shall be as per the international norms. Replacement of individual cluster shall be possible in depot without disturbing the functioning of the light. In case, the change of cluster require readjustment of complete light or component, facility for the same shall be provided in each depot.

- (ii) Each beam shall be separately adjustable both horizontally and vertically. The On/Off and Beam controls shall be switched from the train operator's console.
- (iii) Two bi- colour power LED based marker lights (tail lights) shall be provided which may be lit in both active and non-active cab. The taillights shall be LED type. Each LED shall be dual colour



of white and red which shall be selectable from cab. Alternatively white & red LEDs may be provided within the same block/fitting and be used accordingly. In active cab the marker lights shall be white and in non-active cab it should be of red colour. During the normal train operation, white front lights shall glow and rear shall be red. However in case of a stationary train in siding or depot, both front and rear lights shall be red.

- (iv) The taillights shall be sufficiently large and bright, to enable the lamp to be seen and acted upon by a train operator within the stopping distance of the consist travelling at maximum speed.
- (v) When a driving cab is activated by a Train Operator, in the occupied cab either the head lights shall be lit and the tail lights shall be switched off or only tail lights (white colour) shall be lit; while in the non-active cab the head lights shall be switched off and tail lights (red colour) shall be lit.
- (vi) The headlights and taillights shall not be switched off when the train is passing through a neutral section.
- (vii) The Contractor shall propose to suitably indicate the front end of the train while parked at depot, or stabling sidings, by illuminating two white lights either by using dimmer position of head light or using dual colour LEDs in the tail light or by other appropriate means.

12.8.3 Flasher Light

In order to attract the attention of the train operator of the following train or a train approaching from the opposite direction, in emergency, a 'powerful flashing amber light in addition to the tail lamps shall be provided in the front panel of each driving car. This light shall be switched ON by the train operator in case of emergency and shall not be switched OFF even while negotiating neutral sections.

Flasher light when lit and flashing shall be able to attract attention at a distance of 300 meters under clear sunny day light.

12.8.4 Door Indicator Lights

An amber indication lamp (power LED based) shall be located at an appropriate location both outside and inside near each door.

The lamp shall remain extinguished when respective door is fully closed and locked.

The lamp shall be illuminated when the door is in fully open condition, or when the locking mechanism has failed to register, preventing traction circuits from picking up or when the door is closed, locked and isolated.

The lamp shall flash whenever door is opening or closing; for example when close announcement button from the active cab is pressed. It shall continue to flash till such time the door is closed.

12.8.5 Call-On Light Switch

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

12.9 Interior Illumination System

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



The guaranteed life of the LEDs with their control system and optics/luminaire shall not be less than 60000 burning hours.

The specified illumination level shall be met till at the end of the life of 60,000 hours when the illumination is not less than 70% of their original illumination level.

The colour of LED shall be similar to the existing light. It shall be ensured that all LEDs are selected from the same bin to avoid any difference in colour and performance. Approval of Engineer will be required before installation.

The design of the heat dissipation arrangement shall be submitted in details with simulated results. Colour rendering index shall not be less than 70.

Complete light and energy simulation calculations shall be provided during design to prove validity of the proposed solution.

The system shall be designed to limit glare and ensure no glare by night time reflections in windows. Luminaires shall be designed to conform relevant international standards.

The change of chromaticity over the lifetime of the product shall be within 0.007 on CIE 1976 (u',v') diagram or equivalent.

Luminaire efficiency inclusive of LEDs/control gears & optics etc. shall not be less than 100 lm/W at the working junction temperature; higher values shall be preferred.

Design layout of LEDs & their strings/blocks should be such that the failure of one LED should not cause isolation of complete string/block. Similarly failure of one controller on one string/block should not adversely affect other strings/blocks. Details shall be finalized during design stage.

Coaches may remain unpowered in open sun and internal temperature may go upto 70°C (ERTS 3.10). Suitable protection measures shall be taken to ensure that this does not adversely affect the performance, reliability or efficiency of the lighting system and its components. Verification/validation to the above shall be proposed by the contractor during design.

Illumination within saloon with LED luminaires shall be designed so as to ensure that the desired maximum illumination level is achieved with LEDs operating at approximately 50% of its rated capacity. However, driver/control unit/optics etc. shall be designed for full rating of the LEDs.

All luminaires shall be of LED type and fitting shall be protected and diffused. No exposed light sources will be accepted.

LED luminaires and control gears shall be sealed to IP 52 and IP 54, BS EN 60529:1992, respectively to prevent the ingress of dirt and foreign objects.

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

LED luminaires shall be designed to withstand switch cycles of 1,00,000 and tests shall be conducted to prove the compliance.

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

The total cumulative failure rate of the LED luminaires and controlgears within DLP exceeds 5% with 20% of LEDs failed in a LED luminaire is constituted as a failure of the LED luminaire; or

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

Since LED technology is fast evolving and the rolling stock supply is a long drawn process ,



sub-supplier shall commit to supply new generation of improved LEDs progressively and which should be compatible with the luminaries already supplied and installed. The contractor shall regularly update the engineer on this aspect during the manufacture.

Noise generated by the energised LED lighting, fixtures and ballast/control gear installed in a car shall not exceed 50 dbA when measured 1m from the equipment.

LEDs manufactured by reputed manufacturers shall only be used after taking the prior approval of the Engineer during Design Review.

LED(s) shall have lumen rating as 100 lumen/LED or above.

Maximum number of LEDs which a driver/power supply can feed shall not exceed 60 LEDs.

During commissioning and subsequently, it may be desirable to adjust the lux level to 250/200 in the saloon. Provision shall be made for adjustment of the lux level within saloon. At least three levels of adjustments i.e. 200 lux/250 lux/300 lux shall be provided in the saloon illumination design as a minimum. Details shall be discussed during design review.

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

12.9.1 Saloon Illumination

Energy efficient, power LED based lights, in luminaries meeting flame, smoke and toxicity requirements shall be recessed into the ceiling panelling. The light fittings shall be simple, and arranged not to trap dirt, moisture and insects. Suitable sealing protection shall be incorporated to prevent ingress of dust etc from AC ducts. The luminaries shall ensure to minimise the glare.

All the saloon lights shall work on 110V d.c.

The size and number of light fittings with diffuser shall be sufficient to provide a sensibly constant level of illumination of 300lux at a height of 1.0 m above floor level, along the entire length of saloon.

Separately protected lighting circuits shall be used, such that in the event of one tripping, the others provide evenly distributed lighting throughout the saloon.

100% of lamps, evenly distributed over the saloon area, shall remain illuminated, energized even when the train/car passes through neutral section.

The control logic shall ensure automatic selection, with manual over-ride, of the saloon light circuit(s) to maximize utilization of the natural light and maintain the desired illumination level. During day time, the interior lights shall be controlled automatically through dimmer(s) so as to maintain illumination level within acceptable level and reduce the energy consumption. The Contractor shall submit details for review by the Engineer.

The contractor shall submit service life of LED lamp during the design stage which shall be as per the best international practices

The contractor shall submit layout of fittings and control circuit for review by the Employer.

It shall be possible to replace defective LEDs/ block of LEDs with ease and minimum need for readjustments or otherwise. Any special toll required for the purpose shall be supplied as two sets to each depot.

12.9.2 Cab Illumination

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

Separate lighting of the train operator's console shall meet the requirements of UIC 651 OR which stipulates a minimum of 60 lumens/m² measured at the driving control desk. Driving console light shall be operated manually from within the cab.

12.9.3 Cubicle Lighting

All cubicles shall have sufficient lighting arrangement for facilitating their maintenance related works.



12.10 Cab Equipments**12.10.1 Master Controller**

A Master Controller shall be provided on the driver's console. The Master Controller shall be a fore and aft longitudinal shift type. A deadman's device shall be provided on the Master Controller Handle. Driving mode will be achieved by moving handle away from the operator. The tenderer shall propose number of notches in powering and braking mode for review.

12.10.2 Mode Selector

A Mode Selector Switch shall be provided on the driver's console and selection of mode shall be by longitudinal, fore and aft movement. The Mode Selector shall be mechanically and electrically interlocked with the Master Controller.

12.11 Auxiliary Machines and Drives

With the exception of the auxiliary (pantograph, etc.) compressor, which shall be suitable for a supply at 110V d.c., all other drive machines shall be suitable for a (non-sinusoidal) supply from an auxiliary convertor, which will have harmonics.

All auxiliary motors, including that of the auxiliary compressor, shall conform to the requirements of IEC 60349-2.

The temperature rise limits of all auxiliary motors shall be to the maximum temperature index, minus 70°C. The temperature rise test of the auxiliary converter shall be carried out with auxiliary convertor supplying all auxiliary motors simultaneously

12.12 Safety Devices**12.12.1 Fuse Protection**

- (i) Adequate fuse protection for all electrical circuits shall be provided. The Contractor shall propose a protection scheme for review. The Contractor shall submit a detailed protection scheme including calculations to demonstrate proper segregation and discrimination between the cables, fuses and the traction substation circuit breakers. Calculations shall be submitted to verify proper discrimination between different levels of the protection system.

12.12.2 Earthing System

- (i) All equipments will be adequately earthed, insulated, screened or enclosed and provided with essential interlocks and keys as may be appropriate to ensure the protection of the equipments and safety of those concerned with its operation and maintenance
- (ii) An earth fault detection system shall be proposed by the Contractor for review. Protective devices shall also prevent fires resulting from short circuits, or other electrical defect.
- (iii) All electrical circuits shall be fully insulated from the superstructure on both the positive and negative sides and the super-structure shall not be used as any portion of an earth return circuit.
- (iv) DT/T cars shall be provided with a manually operated two position earthing switch. The operation of the switch shall enable earthing of the power circuit of the motor cars. The HT equipment shall be safeguarded by a system of interlocked keys in a receptacle associated with the earthing switch. (Annett's or Castell Key or similar).
- (v) Earth fault protection shall be provided on control, auxiliary and traction power circuits, so that it shall be possible to continue operation for a limited period even where there is one earth fault



on the circuit. For this purpose the earthing of the circuits may be provided through the coils of earth fault detection relays and the supply battery.

- 12.12.3 All electrical and electronic equipment shall be protected against surge or transient voltages caused by switching (internal or external to the rolling stock), lightning discharges and line voltage disturbances by the provision of suitable filters or surge suppressors.

12.13 Speedometer

A speed indicating and recording equipment shall be provided in each DT car which shall also record the distance travelled by the train.

12.14 Automatic Train Control

- 12.14.1 The Automatic Train Control system, is supplied by Signalling and Train Control Contractor.

- 12.14.2 Full details of the interface issues, and the responsibilities of the RS15, and Signalling and Train Control Contractors are set out in Appendix TD to this Specification, entitled: Interfaces between Rolling Stock, and Signalling and Telecommunications Contractors.



This page is left blank intentionally



EMPLOYER'S REQUIREMENTS

TECHNICAL SPECIFICATION

CHAPTER 13

COMMUNICATION SYSTEM



CHAPTER13: COMMUNICATION SYSTEM**13.1 Train Communication Equipment**

13.1.1 The following on-train communications requirements shall be provided :

- (i) Two-way Communication between the Operations Control Centre (OCC) or Back-up Control Centre (BCC), and driver, via train radio equipment (Supplied by Signalling and Train Control and Telecommunications Contractors).
- (ii) Emergency passenger announcements on the train by OCC or BCC via train radio system
- (iii) Means for the driver to address passengers throughout the train from the driving cab.
- (iv) Facilities to permit simplex conversation between a passenger who has operated a passenger alarm device, and the driver.
- (v) Deleted.
- (vi) An automatic voice announcement system
- (vii) A passenger information system
- (viii) Passenger saloon surveillance system using CCTV

13.2 OCC to Driver and Passenger Address Communication Link

13.2.1 A Train-to-OCC (and Train-to-BCC) radio communications link (Supplied by Signalling and Train Control and Telecommunications Contractors). shall be provided to enable :

- (i) Voice communication between the OCC/BCC and passengers, and between the OCC/BCC and the driver.
- (ii) Vehicle health data communication from TIMS to OCC at designated times and locations. The data required to be transferred from the train to the OCC shall be finalised by the Contractor at the detailed design stage and submitted for review by the Engineer.
- (iii) The interface between the radio link and TIMS shall be provided by RS15 Contractor.
- (iv) Voice shall have priority over data communication.
- (v) When the OCC or BCC to passenger communication occurs, any other system set at that time shall be overridden.
- (vi) A radio control head, which shall be integrated with the driving console, shall be supplied by Telecommunications Contractors.

13.2.2 A suitable interface shall be provided by the RS15 Contractor to enable the OCC/BCC-to-Passengers communication link to be transmitted over the train public address system.

13.3 Passenger Alarm

13.3.1 When a passenger alarm device is operated, a warning sonic device shall sound in the cab, an indication shall be given to the driver of the location of the operated device, and a visual indication on the exterior of the car shall advise station staff which is the affected car.



The driver shall acknowledge the alarm by operation of an override device, which shall terminate the cab sonic alarm, and simultaneously cause an indicator to illuminate at the emergency device location.

Passenger communication shall be driver initiated. This will render the local microphone and loudspeaker adjacent to the activated emergency device active, thereby enabling bi-directional inter-communication between the train driver and the passenger.

If more than one emergency device has been operated, each demand shall be independently acknowledged, and alarms shall be stored, displayed and answered sequentially.

Full details shall be submitted for review by the Engineer

- 13.3.2 Whilst the communications system is in the passenger alarm mode it shall be possible for the driver to move between passenger alarm, OCC, PA and cab-to-cab communication.

In the event that the driver fails to acknowledge a passenger alarm call, within a specified time, the call shall be logged by TMS.

Once the doors have been opened, it shall not be possible to restart the train until all the passenger alarms have been reset. Once this has occurred the system shall revert to its normal form of operation.

- 13.3.3 Under no circumstances shall cab-to-cab conversation or driver to OCC conversation be relayed to any passenger.

13.4 On-train Public Address

- 13.4.1 An integrated communications panel shall be supplied by RS15 Contractor, and shall control the public address functions, cab-to-cab communications, and passenger alarm communications.
- 13.4.2 On-train public address shall be capable of being initiated from the OCC, the driving cab or the automatic voice announcement system. The Automatic Voice System shall be the default public address mode (default mode).
- 13.4.3 The Public Address System together with its main components shall comply with internationally accepted standards.
- 13.4.4 Power amplifiers are required for the p.a. system and shall cater for the requirements of an eight car train.
- 13.4.5 Each power amplifier shall ensure that messages are broadcast evenly throughout the train in the event of a single power amplifier failure.
- 13.4.6 The PA system shall have automatic continuous variable volume control, based on saloon background noise level. A sound level adjustable between 6dB(A) and 10dB(A) above background noise level is required throughout the train. The Contractor may however, propose alternative suitable settings.
- 13.4.7 The PA system shall exhibit no oscillation, acoustical feedback or other instabilities at any combination of input level, gain or speaker volume control settings under all test and operational conditions.
- 13.4.8 The public address amplifiers shall be protected against short circuit at the outputs of the amplifier.
- 13.4.9 The through line cable inside the car shall be suitably insulated, screened, armoured and



overall outer sheathed. The cable shall be of the fire survival type.

13.5 Cab to Cab Mode

- 13.5.1 In the cab-to-cab mode, the train driver shall be able to communicate with a person at the other end of the train.
- 13.5.2 The cab-to-cab communication system shall be able to operate independently of, and simultaneously with, automatic announcements and with the passenger alarm system operative.
- 13.5.3 Simplex mode operation between two trains while in proximity, shall be possible, via OCC on the radio communication system.

13.6 Automatic Voice Announcement System

- 13.6.1 An automatic pre-recorded message announcing system shall be provided in each cab by the RS15 Contractor. Functions and features of this system shall be as follows:
 - (i) The device shall be operable from the driver's cab.
 - (ii) To be fully integrated with the train PA system.
 - (iii) To be triggered by ATP/ATO to make an announcement of pre-determined messages. Close liaison is required between the RS15 and Signalling and Train Control and Telecommunications Contractors in this regard.
 - (iv) A monitor repeater in each cab.
 - (v) All interfaces between the automatic voice announcement system and the ATP/ATO system shall be provided by the RS15 Contractor.
 - (vi) Messages shall be digitally stored, and announcements shall be in the Hindi and English languages.
 - (vii) The comprehensive details of message and special messages (their format, frequency, use etc.) shall be subject to review by the Engineer.

13.7 Passenger Information System

13.7.1 General

- (i) The Passenger Information System shall include a high resolution multicolour graphic display, suitable for the remote displaying of moving messages, in Hindi and English, on board the train.
- (ii) The location and number of the display units shall be proposed by the Contractor taking into consideration the need for all-round good visibility by passengers within the saloon. The Contractor shall submit his proposal, including diagrammatic representation of the angle of visibility of the display units.
- (iii) There shall be a Destination Indicator on each side of every car, at an appropriate location close to mid point of the vehicle but beyond the sweep of the passenger saloon doors. The Destination Indicator shall display the destination name to the passengers standing on the platform. It shall be capable of displaying the requisite information in single line alternating



between in Hindi and English language. The device shall be flush mounted with the exterior of the car body. The display shall automatically change as per short loop operation as the case may be. The Contractor shall submit proposal for Engineers's review.

(iv) Programmable Digital Route Maps (DRM):

Four programmable coloured LCD based route maps for the designated lines shall be provided above alternate saloon doors and shall have following provisions as minimum (details shall be decided during design stage):

- (1) Display of real time destination station, present station, approaching station, Train position indicated by a progressive bar, clock and door indications etc. Necessary interface shall be ensured by the Contractor.
- (2) Route-map of respective interchange lines in specified colours, point of inter-change.
- (3) The size of the letter on LCD with LED backlit displays panel and resolution shall be programmable and have adequate clarity and visibility for a seating passenger. Further details shall be decided during design.
- (4) Direction of movement of displays, positioning of destination station on DRM shall match with the geographical direction of destination station/train direction.
- (5) The station names shall be displayed in multi-languages (regional language(s) and English and/or Hindi) alternatively.
- (6) DRM display size has to be much longer to give comfortable view of the complete line(s) and additional information as already described above. DRM display shall fully use the available space in the door coving where the same shall be mounted.
- (7) Detail specification shall be drawn and screens shall be got approved during design. Additional changes if required during design shall be incorporated during upto defect liability period.
- (8) Door indication on DRM shall be finalised during the design stage. Details shall be submitted for review by the engineer.
- (9) Routes map, arrows, lines etc. shall be dynamically updated based on the train location.

(v) The Train Number, Destination Indicator, Train Identification Indicator and Dynamic Route Maps shall be able to be set via the route setting control. The route setting control shall be either through the manual control on the TIMS or be automatically set by the Automatic Train Control (ATP /ATO) system as given in Appendix TD.

(vi) Train Number, Destination Indicator and Train Identification Indicator shall have a view angle of not less than 120 degrees in the horizontal plane and shall be legible under direct sunlight, artificial light and darkness. Light sensors shall be equipped to vary the intensity of the LEDs based on the level of ambient light

13.7.2 Automatic Operation of Passenger Information System

- (i) The system shall be capable of automatic operation throughout. At train set up, the train running number shall automatically initialise the passenger information system by selecting the appropriate information from the train equipment and transmitting it to speakers and displays.
- (ii) The system shall update the journey information by accessing the train location information from the ATO/ATP equipment.
- (iii) The system shall be capable of receiving real time information from the control centre (via the train radio) relating to delays and other relevant information. The system shall be capable of automatically updating the information being presented at the time to include the real time information received.



13.7.3 Manual System

- (i) In addition to automatic operation, visual and audio information shall be capable of being originated from the driver's cab.
- (ii) The system shall be capable at being operated in a manually updated or non-updated mode, in the event that the ATO/ATP positional information is not available.

13.8 Passenger Saloon Surveillance System

13.8.1 The Passenger Saloon Surveillance System (PSSS) shall comprise of a close circuit television (CCTV) network using surveillance cameras, recorder, routers and cables and other accessories for each individual cars. The fully expended system shall be designed for minimum 25 fps or more. The picture quality will be level E as minimum at 100% Rotakin measured according to EN50132-7. The design shall be finalized during design stage.

13.8.2. Each car shall be provided with at least four surveillance camera devices (one additional in cab in case of DT cars) at appropriate location to cover the maximum passenger saloon area for surveillance. It shall be possible to increase number of cameras by atleast 2 per car by simple plug in to the system.

Any hardware/software tool required for expanding the system shall be provided to enable the Employer to plug in additional cameras if so required in future. Employer's Engineers shall be trained for interfacing and commission the same with no extra cost.

The camera shall be suitably selected in respect of best HD resolution, clarity of images, illumination conditions, Wide Dynamic Range (WDR) etc. for on-train applications and shall be of proven design. The design of camera shall be finalized during design stage. Mounting of camera shall be unobtrusive, flushed with, or recessed into the interior panel. Screen shall have facility to enable multiple views of the platform simultaneously. The system shall be based on open environment/protocol like Ethernet for ensuring interchangeability of cameras. The system shall have self-diagnostics and communicate the same suitably to the maintainer.

13.8.3 The visual images from each camera shall be recorded in non-volatile solid state drive memory in a video recorder without any limitation of repetitive writing of the data. The capacity of the recorder shall be of at least 15 days and shall have the provision of First in First out (FIFO). The memory shall be expandable by simple plug in of commercially available memory media. The records shall be easily downloadable. The Contractor shall provide equipment and means for the same.

13.9 Details of storage module used for PA/PIS & PSSS and its capacity, limitation (if any) shall be submitted for review and approval by the Engineer. Storage module used shall be of latest version & latest art of technology.

13.10 Interface

13.10 See Appendix TD for full details of the division of responsibility between the RS15 and Signalling and Train Control and Telecommunications Contractors.



This page is left blank intentionally



EMPLOYER'S REQUIREMENTS
TECHNICAL SPECIFICATIONS

CHAPTER 14

MATERIAL AND WORKMANSHIP



Chapter 14: Material and Workmanship**14.1 General**

- 14.1.1 All equipment shall be constructed in a sufficiently robust manner, and arranged so as not to suffer deterioration, wear, or damage due to vibration or shock loads encountered in traction service.
- 14.1.2 Equipment shall be arranged into groups, where practicable. The items of any one group shall be mounted on a common frame or equivalent, complete with wiring, piping, etc.
- 14.1.3 All such equipment shall be protected against damage caused by dirt, dust, moisture, etc.

14.2 Materials

- 14.2.1 Metals shall be supplied in compliance with the following material standards or equivalent, unless otherwise specified:

- (i) Steel Castings - BS 3100 (592) latest version.
- (ii) Stainless Steel - chromium content not less than 17%, carbon content not more than 0.03 % - JIS 4305 latest version.
- (iii) Steel used in welded structures – BS 4360 (WR-50 or WP-50B) latest version.

- 14.2.2 Glass fibre reinforced plastics may be used for non-structural parts, and applications as accepted by the Engineer. They shall be manufactured to an approved process and satisfy the flammability, toxicity and smoke generation limitations of EN 45545, Latest Editions, or the latest equivalent internationally accepted standard. See also Clause 2.5.8.

- 14.2.3 Natural rubber shall not be used for any components exposed to sunlight or lubricants during operation or maintenance.

- 14.2.4 Soft metals subject to creep (aluminium, zinc, etc.), shall not be used in applications requiring them to carry current, stress or operate in high temperatures. In exceptional cases, such applications shall be submitted to the Engineer for review.

- 4.2.5 Where copper components require to be annealed or brazed during manufacture, special precautions shall be taken to obviate hydrogen embrittlement.

14.3 Welding

- 14.3.1 All welding procedures shall be documented by the Contractor. Approval of the welding procedure shall be as required by BS EN 288-3 : Specification of Approval Testing of Welding Procedures, or equivalent.

- 14.3.2 Approval of the welder shall be as required by BS EN 287-1 : Specification for Approval Testing of Welders Working to Approved Welding Procedures, or equivalent.

- 14.3.3 Arc welding shall be performed by the MIG process and in all cases complete and adequate fusion with the base material shall be ensured.

- 14.3.4 The Contractor shall provide details of all preparatory and post-welding procedures to be undertaken during the process of spot welding. Spot welding of components which carry structural loads shall be performed using equipment fitted with time, current and pressure control.

- 14.3.5 The Engineer or Inspector reserves the right to verify the quality of welds, particularly in critically stressed areas, by appropriate non-destructive testing methods (NDT).



14.4 Corrosion

- 14.4.1 Protection of materials against all types of corrosion shall be appropriate for the environment of Delhi and the operating conditions of the cars.
- 14.4.2 Corrosion protection methods for metallic components and equipment cases shall be submitted. Where feasible, such corrosion protection measures shall not require to be repeated throughout the life of the vehicle.

14.5 Fasteners

- 14.5.1 Screw threads shall be of ISO metric sizes.
- 14.5.2 ISO Metric fine threads shall be used in applications where the fastener is subjected to alternating transverse loads. In other cases, the coarse series of threads shall generally be used, except where precluded by size. The use of studs shall be avoided wherever possible.
- 14.5.3 Normally, screw threads smaller than M5 size shall not be used. Screw and bolt heads shall be of hexagonal form on all M5 and larger screws. Screws smaller than M10 shall be of high tensile material.
- 14.5.4 Fixings shall be locked adequately to prevent loosening in service. Fixings shall withstand any shock loads the equipment is likely to encounter.
- 14.5.5 In critical areas the locking of all nuts, bolts and fixings shall be of a positive form, which prevents mechanical rotation of the nut relative to the bolt, irrespective of source vibration.
- 14.5.6 Stainless steel parts shall be attached by stainless steel screws or fasteners except in locations where high tensile strength is needed.
- 14.5.7 Whenever possible tapped holes shall be drilled and tapped to the full thickness of the material. Blind holes shall be used only where this is unavoidable. All such blind holes shall provide at least 3mm clearance between the end of the screws and the bottom of the tapped hole.
- 14.5.8 Tapped holes shall be provided with suitable thread inserts where necessary, and shall always be used in aluminium or copper.
- 14.5.9 The use of loose nuts and bolts will only be accepted where it is possible for staff to easily reach both parts of the fixing simultaneously.
- 14.5.10 Fixings for covers which may have to be removed for maintenance, shall be captive.
- 14.5.11 Items of electrical equipment shall be fitted to panels so that all fixings can be made from the front only, except where specified otherwise.
- 14.5.12 All steel fasteners used in electrical equipment and/or exterior applications shall be of stainless steel duly coated with double layer of Geomat or superior.

14.6 Enclosures

- 14.6.1 Wherever required equipment shall be mounted in sealed enclosures. Where this is not possible, and cooling is essential, the enclosure shall be pressure ventilated using filtered, clean air. Such enclosures may be treated as mounted in clean conditions, as specified in IEC 60077: Specification for Electric Traction Equipment, or equivalent.
- 14.6.2 Filters shall be of the dry type and shall preferably not require cleaning more frequently than at three monthly intervals. Cleaning shall preferably be by suction cleaning, knocking or blowing



off dirt from the filter. If washing of the filters is required this shall be no more frequently than six monthly.

An exception to the above requirement applies only to the vehicle air conditioning unit filters, which will be unit replaced for cleaning at 5000 kilometers intervals.

- 14.6.3 Air inlets, outlets and vents shall be designed so that ingress of rain, dust or rubbish is prevented, irrespective of whether the car is moving or stationary, and independent of the direction of the wind or the car movement.
- 14.6.4 Enclosure doors and covers shall be securely attached, and wherever possible with quick release latches. These shall include safety devices and keyed access to prevent accidental unlatching.
- 14.6.5 Enclosure interiors shall have smooth easily cleaned self coloured surfaces to assist in maintenance.
- 14.6.6 Apparatus using two stages of insulation shall also be enclosed completely, either in an earthed metal case or in a case made from insulating material.
- 14.6.7 Enclosures in which heat or arcs may be generated shall be lined with barriers of insulating material.
- 14.6.8 All enclosure covers shall be designed to be handled by one person in an ergonomic manner.
- 14.6.9 Signage shall be provided at appropriate positions for clear indication and warning of the potential hazards relating to the equipment or component inside enclosures.

14.7 Wires and Cables

- 14.7.1 All wires and cables shall be adequately protected for the maximum design and fault currents, and designed for minimum voltage drop.
- 14.7.2 The insulation of all wires and cables including those used within equipment / subsystem shall be halogen-free flame- retardant and formulated to minimise generation of smoke, noxious emissions and corrosive fumes, in the case of overheating or fire in compliance with EN 45545 latest edition. All Cables shall comply NF F 63-808 (for low voltages), and NF F 63-826 (for high voltages) or other international standards like EN 50264 (Part 1 to 3) and EN 50306 (Part 1 to 4) as approved by the Engineer.
- 14.7.3 The system adopted to rate cable shall be fully specified for review. All de-rating factors shall be applied, together with the maximum permissible conductor temperature for the particular insulation type. In no case shall the conductor continuous temperature exceed 90°C. The maximum short circuit temperature shall not exceed 250°C. The cable insulation shall be capable of withstanding these temperatures.
- 14.7.4 All cables and pipes shall be cleated at frequent intervals to avoid vibration leading to abrasion or fracture. All holes through which cables pass shall be fluted, or bushed, to prevent chafing and damage to insulation.
- 14.7.5 High and low voltage cables shall, wherever possible be kept separate. Where cables carrying voltages of greater than 200V between conductors are carried in the same jumper as other cables, they shall be run together only as far as the nearest junction box. Any such arrangement shall be submitted to the Engineer for review.
- 14.7.6 All cable runs in exposed locations, such as on the bogies or underframe, and therefore potentially vulnerable to damage shall be in conduits of stainless steel. Where such exposure is not a problem, cables shall be run in enclosed waterproof and dust-proof ducting.
- 14.7.7 All cables of voltage less than 50V shall be kept separated from high and low voltage cables.



- 14.7.8 Wherever cables carrying heavy current, e.g. in traction circuits, pass close to metal structures, adequate clearances shall be provided to obviate inductive heating of the structural members. Temperature rises in the adjacent steel structure shall not exceed 5°C in the steady state condition, with all cables in the vicinity carrying normal working current. Such temperature rise shall be taken into account in selecting the cable ratings.
- 14.7.9 It shall not be necessary to remove cables from their cleats to gain access to equipment for inspection or maintenance. Any deviation from this requirement in exceptional cases will be subject to review by Engineer in design stage.
- 14.7.10 The minimum bend radius in cables shall not be less than twice that required in breakdown tests used in the applicable cable standards. Any deviation from this requirement in exceptional cases will be subject to review by Engineer in design stage.
- 14.7.11 The minimum cross sectional area of control and auxiliary power cables for connections between equipment shall be 3mm². Smaller cable sizes may be used inside equipment cases. External sockets to such cables shall be suitable for 3mm² cables. Any deviation from this requirement in exceptional cases will be subject to review by Engineer in design stage.

14.8 Terminals and Cable Termination

- 14.8.1 Except for electronic equipment, all cable terminations shall be of the crimped type in accordance with BS 4579 : Part 1 : 1988, Compression Joints in Copper Conductors, or other service proven type. Soldered connections will not be accepted.
- 14.8.2 Crimping standards shall conform with current international practice. The Engineer may require that crimped lugs be subjected to random testing before acceptance.
- 14.8.3 Bolted terminations for all high voltage d.c. and return cables shall be torque loaded to a defined torque value.
- 14.8.4 Low voltage cables up to 6.0 mm² conductor cross sectional area shall preferably be fitted with terminals conforming to BS 4579 Pt.1 or equivalent. Alternatives shall be submitted for review.
- 14.8.5 High voltage cables, of conductor sizes up to 6.0 mm² shall be crimped using a lug which grips both the insulation and the conductor. An alternative suitable arrangement intended to prevent excessive flexing of the core where it emerges from the lug may be offered.
- 14.8.6 Terminals shall be of the steel screwed post type, securely moulded into an insulation base. All power terminations on one stud shall be assembled together without the use of intervening nuts, washers etc. Studs or bolts shall not be used to carry current. Alternative types of terminal may be offered but their acceptance will be subject to review by the Engineer in design stage.
- 14.8.7 Control cable terminations assembled on one stud in pre-wired removable enclosures shall be separated such that all outgoing connections may be removed without disturbing internal connections.
- 14.8.8 Terminals and terminal boxes shall be so arranged that if water collects in ducts and conduits this cannot reach live components or parts. Measures shall be taken to avoid the accumulation of water in such enclosures.
- 14.8.9 Terminals for circuits of different voltage shall be arranged in separate groups. Negative and neutral terminals shall also be grouped separately. Any deviation from this requirement in exceptional cases will be subject to review by Engineer in design stage.
- 14.8.10 All equipment enclosures and shock mounted equipment shall be grounded using flexible 'strap' type, grounding leads bolted to a designated carbody grounding pad. Any deviation from this requirement in exceptional cases will be subject to review by Engineer in design stage.



14.8.11 Alternative terminations may be offered for review by the Engineer.

14.8.12 All cable sockets and busbar contact faces shall be tinned. In printed circuit boards contact faces of connectors shall be gold plated. Any deviation from this requirement in exceptional cases will be subject to review by Engineer in design stage.

14.9 Electrical Creepage and Clearance

14.9.1 Surface creepage and clearance distances between voltage potentials and carbody earth shall be as defined in IEC 60077 Specification for Electric Traction Equipment, for all electrical circuits, equipment and associated cabling. Voltages less than 250V shall be treated as 250V.

14.9.2 Creepage or clearance where arcs are present, or along the outside or clearance where arcs are present, or along the outside of a cable sheath, shall be 200% of that defined in IEC 60077 : Specification for Electric Traction Equipment. Any deviation from this requirement in exceptional cases will be subject to review by Engineer in design stage.

14.9.3 Terminal boards and panel surfaces between terminals and live posts shall as far as possible be vertical to minimise the build up of tracking paths.

14.10 Protection & Earthing

14.10.1 Except as specifically required otherwise, d.c. and single-phase a.c. circuits shall be such that one pole of each device shall be connected directly to the negative or neutral line, i.e. without switches, fuses or contacts on the negative or earthy side.

14.10.2 High voltage traction circuits shall be protected in accordance with the requirements of IEC 60077 : Rules for Electric Traction Equipment, by an approved fault interrupting device.

14.10.3 In all cases, the fault discriminating characteristics of the system shall be submitted for review.

14.10.4 Low voltage fuses and associated fuse carriers shall comply with IEC 60269-1 : Low Voltage Fuses. Protection and isolation of low voltage circuits shall be in accordance with IEC 60947-2 : Low Voltage Switch Gear and Control Gear : Pt.2 Circuit Breakers or approved equivalent.

14.10.5 Grounding connections shall be made through copper or bronze pads of adequate area, to the carbody. Any deviation from this requirement in exceptional cases will be subject to review by Engineer in design stage.

14.10.6 High voltage circuits and low voltage circuits should not be earthed together and separate earthing shall be arranged. All earthing pads shall be readily visible and accessible for inspection and trouble-shooting.

14.10.7 The Contractor shall produce a complete earthing scheme, which shall prevent traction return current passing through motor and axle bearings, gearboxes, bogie centre bearings, couplers, or any path other than the designed path. The earthing scheme shall be submitted to the Engineer for review.

14.10.8 Miniature circuit breakers (MCB's) shall be used only for the protection and isolation of the d.c. control voltage and a.c. auxiliary circuits. MCB's shall be of a robust design suitable for use in the railway environment as detailed in IEC 61133.

14.10.9 All grounding and bonding jumpers and straps shall be sized to handle fault currents and lightning discharge currents, for which the voltage drop shall not exceed 25V.

The bonding method employed shall not produce a d.c. resistance in excess of 0.0025Ω; or more than 0.025Ω at 150kHz for any applied a.c. voltage.



14.10.10 Electrical equipments like capacitors and transformers which can develop internal faults shall be provided with effective devices to isolate at once the defective equipment from the source of power such that there is no fire or explosion at any time.

14.10.11 Liquid di-electric materials used in capacitors, transformers and similar equipment shall be of the non-inflammable type.

14.11 Circuit Design

14.11.1 Circuit diagrams shall be clear and easy to interpret, and shall comply with IEC 60617-1 to 13 as applicable.

14.11.2 Apparatus coding, and cable and wire designations shall be submitted to the Engineer.

14.12 Electronic Equipment

14.12.1 As a minimum, all electronic equipment shall comply with IEC 60571 : Electronic Equipment used on Rail Vehicles, for design, manufacture and testing, and shall use components purchased against an internationally recognised quality assurance and reliability certification procedure. However, the dry heat test temperature shall be 80°C as against 70°C specified in IEC.

14.12.2 Variable resistors shall be avoided wherever possible.

14.12.3 Circuit boards in safety control systems shall be connected through a safety circuit to disable the train if a circuit board is removed, unless the control system is proven safe and tolerant of such circumstances.

14.12.4 Electronic components shall only be purchased from suppliers having as a minimum, ISO 9001/2 certification.

14.12.5 Electronic equipment shall not be damaged, nor shall malfunction when subjected to direct spikes and surges on the supply and indirect burst transients as defined in IEC 60571: Electronic Equipment used on Rail Vehicles.

14.12.6 Deleted

14.13 Microprocessors and Software-based Equipment

14.13.1 Where microprocessor systems incorporate technology such as surface mounted components, multi-layer circuit boards, or flexible PCBs, the Contractor shall demonstrate that he has operational experience of the successful use of these technologies in a similar railway environment.

14.13.2 All microprocessor based systems shall have watchdog circuits to ensure correct software operation. When the watchdog circuit detects a fault it shall trigger hardware forcing all system outputs into a safe state before resetting the system and entering a self-test mode. Normal operation shall only be resumed if all self-test checks are satisfactory.

14.13.3 Microprocessor systems shall incorporate self-test and diagnostic facilities to locate and indicate faults within the system. The system shall have sufficient built-in diagnostic capabilities to automatically identify all system faults.

14.13.4 Where microprocessor electronics systems require additional test equipment this shall be portable for use on the car. It shall derive its power supply from that of the system under test.

14.13.5 LED's shall be used to indicate faulty modules, to allow rapid fault diagnosis and maintenance.

14.13.6 Faults occurring during system operation shall be logged, the information being stored in a non-volatile memory.



14.13.7 Deleted

14.14 Software

14.14.1 Software shall be written in a structured manner and fully documented during all stages of its design and development, with at least two levels of documentation above the source code level.

14.14.2 This shall meet the requirements of EN 50126-2: Dependability for Guided Transport Systems - Part 2 : Safety, EN 50128 : Railway Applications : Software for Railway Control and Protection Systems, and EN 50129 : Safety-related Electronic Railway Control and Protection Systems. Any deviation from this requirement will be subject to review by Engineer in design stage.

14.14.3 The Contractor shall submit his Software Quality Plan for review by the Engineer before work commences on software design. The software quality plan shall clearly state the controls and practices used in the software life cycle from specification through to in-service operation.

14.14.4 Independent review, verification and testing, using real and synthetic data, shall be performed at the software module and system level. The Engineer may audit the Contractor against the Software Quality Plan at any stage in the Contract. The Contractor shall ensure that all software is fully de-bugged prior to final review by the Engineer.

14.14.5 Sufficient software documentation shall be provided to give the Engineer a full understanding of the software function and operation. Documentation shall be complete, yet clear and concise, and include all modifications up to final acceptance. Documentation shall include software block diagrams showing signal flow, logic, and hardware interfaces. A top level flow diagram and description of detailed operation shall be provided.

14.15 Printed Circuit Board and Connectors

14.15.1 PCB's shall be of glass epoxy with components mounted on one side only.

14.15.2 The minimum thickness of PCB's shall be not less than 1.6mm. PCB's shall generally comply with IEC 60326-3 : 1991 Printed Boards – Part 3 : Design and Use of Printed Boards.

14.15.3 Soldering of electronic components shall comply with the latest internationally accepted practice. Tenderers shall indicate the standard with which they are compliant.

14.15.4 PCBs shall be connected to the case or rack wiring using multi-pin connectors, which shall have a successful service history in rail applications. Details shall be provided.

14.15.5 In any electronic rack system, the failure of any one module or individual circuit board shall neither cause loss of the electronics power supply within the rack, nor cause subsequent failure of circuits on other PCB's or modules.

14.15.6 Printed circuit board extenders shall be provided for test purposes. The Contractor shall provide detailed maintenance and troubleshooting procedures, including wave-forms at critical locations of the circuitry.

14.15.7 PCB's shall have mechanical polarisation to prevent insertion into a wrong socket. The use of PCB edge connectors is not permitted unless reviewed by the Engineer, on a case by case basis. PCB's and modules shall be positively retained in the rack or case by a fastener or spring loaded locking pin.

14.15.8 All PCB contact faces of connectors shall be gold plated.



14.15.9 PCB's shall be held in place by screwed fasteners to prevent vibration causing wear on terminal contacts. Circuit boards shall be mounted vertically to minimise the accumulation of dust on the boards. Any deviation from this requirement in exceptional cases will be subject to review by Engineer in design stage.

14.16 Integrated Circuits

14.16.1 All integrated circuits and semiconductor devices shall be standard devices available from at least two manufacturers. Proprietary devices shall be submitted to the Engineer for review.

14.16.2 All integrated circuits shall be burned in and screened for defects to a level equivalent to relevant international standards.

14.17 Labels

14.17.1 All items shall be labelled with the maker's name and the type and form of the piece or item, discrete serial number and rating data, and the date of manufacture of the particular piece of equipment.

14.17.2 Rotating machines shall carry a rating plate indicating current and voltage ratings and speed at rated current, and maximum speed. In addition a connection diagram shall be provided inside or adjacent to the terminal box wherever provided.

14.17.3 Unidirectional rotating machines shall carry an arrow showing the correct direction of rotation, and in the case of axial fans, of the airflow.

14.17.4 The labels shall be clearly stamped, cast or engraved and securely attached to the equipment. Where appropriate, equipment shall be labelled with warnings of high temperature and electric shock risk. Warning labels shall be written in both Hindi and English.

14.17.5 All cables and busbars shall be provided with durable and legible cable identification markers at each end, corresponding exactly with those on circuit diagrams. The cable identification numbers should remain intact for the entire service life of cable.

14.18 Lubricants

14.18.1 The Contractor is expected to utilise, as far as possible, lubricants manufactured in India. With this in mind, he shall furnish a list of grades of lubricants and greases manufactured or available in India, which are considered equivalent to those used by him. The technical particulars of the RS1 Contractor's lubricants (from the manufacturer's country of origin) shall be furnished to the Engineer.

14.19 Painting

14.19.1 All painting processes shall be proven in a railway application.

14.19.2 All painting processes shall be proven in railway applications, and suitable for the climate of this project, and shall be subject to review. Such processes shall include surface preparation suitable for the material, corrosion preventative priming and high durability finish. Exterior stainless steel, aluminium or their alloys shall not be painted. Bogies shall be treated with primer and an internationally accepted finishing paint. All steel which will be hidden, except stainless steel, shall be treated with primer and an accepted rust preventative before being concealed. The treatment of copper bearing structural steel shall be subject to acceptance by the Engineer.

14.20 Rubber Items

14.20.1 All rubber hoses, connecting pipes etc used in pneumatic circuit shall not be required to be replaced before 5 years or major overhaul whichever ever later. The rubber/ rubber- metal



components used in suspensions shall not be replaced before major overhaul of the equipment.



This page is left blank intentionally



EMPLOYER'S REQUIREMENTS

TECHNICAL SPECIFICATION

CHAPTER 15

INSPECTIONS, TESTS AND TRIALS



CHAPTER 15: INSPECTIONS, TESTS AND TRIALS

15.1 General

- 15.1.1 Individual cars and complete trains, shall be type and routine tested in accordance with IEC 61133, and as specified below. Such tests may be performed either at the Contractor's works, or on site, as appropriate, and as agreed with the Engineer.
- 15.1.2 The individual equipments, systems and sub-systems, shall be type- and routine-tested in accordance with the IEC Publications or other appropriate international standards listed in Appendix TA, special tests specified in this Chapter, and the test programme drawn up by the Contractor, and agreed by the Engineer. Type test specifications shall be got approved from the Engineer.
- In addition to 'mandatory tests' as prescribed in IECs, the Engineer may also require any of the prescribed 'optional tests' to be carried out.
- 15.1.3 All such tests shall be carried out at the Contractor's cost, wherever performed, in the presence of and to the satisfaction of the Engineer, who reserves the right to witness any or all of the tests.
- 15.1.4 Wherever any equipment, system or sub-system is not specifically covered by an internationally recognised specification or test procedure, or where the type and routine tests prescribed by IEC or other international standard do not adequately cover the requirement, tests which are acceptable both to the Contractor and to the Engineer, shall be devised.
- 15.1.5 Type tests for certain equipment may be waived if these were carried out earlier on equipments of identical design, witnessed by a reputed organisation, and the service performance of such equipments was found to be reliable. The Contractor shall submit a proposal in this regard to the Engineer for review. The waiver of Type Test is entirely at the discretion of the Engineer.
- 15.1.6 Without prejudice to any other provisions of the Contract, the Employer reserves the right to witness any or all of the tests, and to require submission of any or all test specifications and reports. The Employer reserves the right to reasonably call for additional tests as are considered necessary, including the quality of welds particularly in highly stressed areas, by non destructive testing methods. Prototype tests may be required to verify the suitability of the process or the materials proposed. Engineer may if considered necessary may call for conducting optional tests as per relevant standards without any additional cost to the Employer. In case of repetition of tests, as decided by engineer, entire cost including that of engineer's representative(s) shall be borne by the contractor.
- 15.1.7 The results of all tests shall be submitted to the Employer's Representative, who will record his conclusions as to whether or not the equipment being tested has passed satisfactorily.
- 15.1.8 Instrumentation Test

Engineer at his sole discretion (if required) at an appropriate time can initiate testing of one complete four-car train/unit integrated with 4/6 car train (as the case may be) as specified in Clause 1.2.3, mainly to verify and establish operational performance, capacity and safety. The Contractor shall provide full instrumentation to conduct these tests and carry out modifications as required, to ensure that the cars will meet the safety requirements. These tests shall be conducted both at full load, and tare conditions, under both new and fully worn wheel profiles and with both fully inflated and fully deflated secondary suspension air springs. The performance of each type of car will be separately evaluated.



The Contractor shall prepare a report after completion of these tests, which shall be submitted to the competent authority, through the Commissioner of Railway Safety, for statutory approval of the Rolling Stock for revenue operations.

Brief details of the tests to be evaluated during the Oscillation Tests will include, but need not be limited to:

Table 15.1.8

Terms	Definition	Condition	Acceptable Value
Derailment Coefficient	The ratio of the instantaneous lateral force at the axle-box level, to the instantaneous vertical load of the wheel.	Average value over a 2 meter length of track	≤ 1 (unity)
Maximum Vertical Acceleration		Measured at the Centre Pivot. Measured for a time period of 1/20s	$\leq 0.3g$
Maximum Transversal Acceleration		Measured at the Centre Pivot. Measured for a time period of 1/20s	$\leq 0.3g$

The Sperling Ride Index shall however not exceed 2.5, as specified in Clause 3.29

15.1.9 Integrated Testing and Commissioning

On completion of testing and commissioning of the Contractor's own system to the satisfaction of the Engineer, the Contractor shall carry out all tests necessary to verify the functioning of his system with those of other Designated Contractors. Tests and test procedures shall be submitted by the Contractor for acceptance by the Engineer or as required by him. All defects and shortfalls in the Contractor's system, discovered in the course of Integrated Testing and Commissioning, shall be made good and re-tested to the satisfaction of the Engineer before the commencement of service trials.

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

15.1.10 Service Trials

The prototype and other trains shall be subjected to pre-revenue service trials. Service trials are intended to prove not only the satisfactory running performance of the cars, but also to enable practical evaluation of their reliability in service, ease of maintenance and operation, in parallel with the work of other Designated Contractors, and adequacy of the cars and equipment for all performance requirements envisaged in the specification. The Contractor shall make all necessary arrangements including temporary provisions in his system to ensure safety during service trial period. The Contractor and designated contractors will run trains subject to constraint of the newly established railway system.



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

15.2 Test Planning and Procedures

15.2.1 The Contractor shall submit within 120 days after date of Notice to Proceed, a Test Plan for review and acceptance by the Engineer.

15.2.2 The plan shall include the following information :

- (i) Relevant specification applicable to each of the tests.
- (ii) Type, routine and special tests to be carried out.
- (iii) Description of the tests, scheduled dates, and locations of the tests.
- (iv) Test parameters to be measured.
- (v) Constraints to be applied during the test.
- (vi) Defined pass/fail criteria
- (vii) Facilities, equipment, and test and measurement tools.

15.2.3 The Employer reserves the right to reasonably call for additional tests if considered necessary.

15.2.4 The Contractor shall produce a test report, in three copies, and in an approved format, within an agreed period following the test, for acceptance by the Engineer.

15.3 Special Tests

15.3.1 The following clauses specify tests which are either not covered by standard specifications, or require the provisions of the standard specification to be modified to some extent.

15.4 Vehicle Body Shell

15.4.1 A static compressive end-load test, and a lifting test shall be performed in accordance with UIC 566, under a simulated load as specified in Chapter 4, as a type test.

15.4.2 Crashworthiness shall be proved by submission of detailed calculations and demonstration by means of finite element analysis.

15.4.3 The strength of the saloon side wall windows and of those in the doors shall be performed in accordance with UIC 566, as a type test.

15.4.4 The strength of the cab windscreen shall be tested in accordance with the requirements of both UIC 651 and UIC 566, also as a type test.

15.4.5 The strength of couplers and draught gear shall be carried out in accordance with international practice, also as a type test.

15.4.6 The carbody shall also be subjected to a vertical deflection test. All side doors, including the cab side doors, on one side of the car shall be installed, complete with drive mechanisms, and all sealing and weather-stripping. At each increment of test load the doors shall be opened and closed by means of the door controls. Any failure to operate at the prescribed speed profile, or any indication of binding, shall require corrective action to be taken by the Contractor, to the car structure, to the door arrangement, or both.

