

IEC 60349-2.

12.11.5 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 simultaneously carried out with auxiliary converter and all auxiliary motors.

12.12 Deleted.

12.13 Deliverables

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

S.No.	Clause No.	Tools/Equipment/Software	Quantity
1.	12.4.9 (ii)	Relay Testing Kit as per clause 12.4.9 (ii).	Two nos. in each depot.
2.	12.4.9 (iii)	Tools for extension of relay base as per clause 12.4.9 (iii).	Two nos. for each type of relay in each depot.
3.	12.4.9 (iv)	Dummy relay (test switch).	One no. for each type of relay in each depot.
4.	12.8.1 (iv)	Facility for replacement of power LED clusters used as exterior lights.	In each depot.
5.	12.8.2 (i)	Facility for replacement of power LED clusters used as head and tail lights	In each depot.
6.	12.9.1 (x)	Special tool for replacement of defective LEDs/ block of LEDs	Two sets to each depot.

Note:

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



13. 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) and train operator, via train radio equipment (Supplied by Communication Contractor).
- (ii) Means for pre-recorded (manual/automatic), live (other than pre-recorded) Passenger Announcements on the train by OCC via train radio system (Supplied by Communication Contractor).
- (iii) Means for the train operator to address passengers including announcements etc. throughout the train from the driving and non-driving cab.
- (iv) Means for the train operator & OCC to address passenger including announcements etc. in two coupled trains.
- (v) Facilities to permit duplex conversation between a passenger who has operated a Passenger Alarm Device (PAD), and the train operator/OCC.
- (vi) Facilities for duplex conversation between Train Operator(s) in two coupled trains.
- (vii) An automatic voice announcement system.
- (viii) A Public Address and Passenger Information System (PA & PIS).
- (ix) Passenger saloon surveillance system (PSSS).
- (x) Door opening / closing chime and announcement.
- (xi) Complete tools including Software, Hardware, equipment etc. for configuring, editing and creating route /station data, announcements, messages & fonts, audio speech and interface of the system with other sub systems etc. shall be supplied. It shall be possible for the Engineer to configure the PA, PIS & PSSS software for implementing operational & maintenance related modifications. Software tools for recording and analysing interface signals shall also be provided.

Full access to the software for the purpose above shall be provided. Any hardware/software tool required for this purpose shall also be provided. The documentation including but not restricted to flow charts (for complete software), signal flows, and interpretation of signal etc. shall be provided. Engineer shall be fully trained and made fully conversant by the Contractor for this purpose.

- (xii) PA & PIS system shall have full flexibility and dynamic compatibility with any number of short loops/route changes which may be enforced during operation. Necessary interface with signalling system shall be ensured.
- (xiii) All the interface signals relevant for PA & PIS system shall be recorded with time stamp.
- (xiv) PA, PIS & PSSS System shall be designed to cater any single point of failure. Functionality at car/train level (as applicable) shall not be affected due to any type of single point of failure. Adequate redundancy shall be built in the proposed system architecture. Full details shall be submitted for review and approval by Engineer at the time of design approval.
- (xv) PA, PIS & PSSS shall have latest state of the art communication protocol. Provenness of the system shall be ensured by the Contractor. Full details shall be submitted for review by the Engineer.
- (xvi) Single point upload and download of data, software etc. for all PA, PIS & PSSS system shall be provided by the Contractor, along with the provision of remote upload/download. Full details shall be submitted for review by the Engineer during detailed design stage.
- (xvii) PA/PIS & PSSS equipment/cubicles shall be of at least IP53 or better class. Complete details of available IP protection of all PA/PIS & PSSS system's equipment shall be submitted and get approved by the Engineer. Exterior equipment shall be of at least IP65. Any degradation based on technical difficulty or recommendation by OEM shall be reviewed by the Engineer during the design.
- (xviii) Suitable interface of PA, PIS & PSSS for synchronizing time with TCMS shall be ensured by RS Contractor.
- (xix) Any other equipment required onboard for interfacing with the other designated Contractors viz. Signaling, Telecom and others for operation of trains, under UTO mode shall be provided by the Contractor.
- (xx) Provision of self-checking & its result for all PA, PIS & PSSS equipment shall be ensured. Facility

for checking live health status of equipment on VDU shall also be made available. Full details shall be submitted for review and approval by the Engineer.

- (xxi) PA, PIS and PSSS equipment shall have the provision of multilingual system wherever required.
- (xxii) Cables for PA, PIS and PSSS shall be suitably insulated, screened, armoured and overall outer sheathed. These cables shall also be of fire survival, fire retardant/resistant type. Full details of standard along with relevant catalogue etc. shall be submitted for review and approval.
- (xxiii) Fire & Smoke compliance in line with EN45545 part 1 to 7 for complete PA, PIS & PSSS shall be submitted for review by the Engineer.

13.2 OCC to Train operator and On-train Public Address Communication Link

13.2.1 A Train-to-OCC radio communications link (supplied by the Communication Contractor) shall be provided to enable:

- (i) Voice communication between the OCC and passengers, and between the OCC and the train operator.
- (ii) Vehicle health data communication from TCMS 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. Provision for sending train data at end of every trip shall also be ensured by the Contractor.
- (iii) The interface between the radio link and TCMS/PA/PIS/PSSS shall be provided by the Contractor. Interface Control Document (ICD) shall be submitted for review.
- (iv) Voice shall have priority over data communication.
- (v) When the OCC to passenger communication occurs, any other system set at that time shall be overridden.
- (vi) A radio control head, which shall be integrated with the driving console, shall be supplied by Communication Contractor. The mounting location shall be carefully planned as the equipment is frequently used by the Train Operators. Details of the equipment & its mounting location shall be submitted to the Engineer for review before finalization & implementation.

13.2.2 A suitable interface shall be provided by the Contractor to enable the OCC-to-Passengers announcements to be transmitted over the train public address system.

13.2.3 Adequate space and reliable battery backed power supply shall be provided to communication Contractor for the on-board radio system.

13.2.4 Facilities to permit announcements in the train along with the provision for communication with OCC by Roving Attendant through train radio shall be provided. Suitable interface in line with Appendix TD clause 3.10.4.1 shall be ensured along with submission of full details for review by the Engineer.

13.3 Passenger & OCC Alarm

13.3.1 There shall be four passenger alarm devices (PAD)/Passenger Emergency Alarm (PEA) in each car.

13.3.2 When a passenger alarm device is operated, a warning sonic device shall sound in the driving console/OCC, an indication shall be given to the train operator/OCC of the location of the operated device, automatic views from surveillance cameras provided near the location of activated PEA shall be displayed in the monitors inside cab / OCC. Rolling Stock Contractor shall also ensure the following provisions:

- (i) A visual indication on the exterior of the car shall advise station staff which is the affected car.
- (ii) The train operator/OCC shall acknowledge the alarm by operation of an override device in non UTO/UTO operation respectively, which shall terminate the cab sonic alarm, and simultaneously cause an indicator to illuminate at the emergency device location.

It shall be feasible for train operator/OCC to acknowledge and isolate/reset the specific PEA from the driving console/OCC after verifying the conditions in the saloon to his satisfaction through CCTV images which shall be recorded with date, time, train ID/No., rake ID, Camera Name/Camera ID, geographical location, PAD location, event stamping etc.



Recording of image upon certain critical events shall be as per ERTS 13.9.11.

- (iii) Passenger communication shall be train operator/OCC initiated. This will render the local microphone and loudspeaker adjacent to the activated emergency device/OCC active, thereby enabling bi-directional inter-communication between the train operator/OCC and the passenger. Once pressed/operated, it shall be possible for the commuter to communicate with the Train Operator/OCC unless inhibited by the Train Operator/OCC.
- (iv) A fall back system shall be provided to enable the communication between Train Operator/OCC & passengers with PEA in case of failure of normal communication channel. If more than one emergency device has been operated, each demand shall be independently acknowledged, and alarms shall be stored, displayed and answered sequentially.

Full details shall be submitted for review by the Engineer.

- 13.3.3 Whilst the communication system is in the passenger alarm mode it shall be possible for the train operator/OCC to move between passenger alarm, train operator/OCC, PA and cab-to-cab communication.

In the event that the train operator/OCC fails to acknowledge a passenger alarm call, within a specified time, the call shall be logged by TCMS. TCMS shall be provided with following data relating to the passenger emergency alarm:

Current status of each passenger alarm button.

Alarm event for each passenger alarm button, clearing when acknowledged by the train operator/OCC.

- 13.3.3.1 Once the doors have been opened, it shall not be possible to restart the train until all the passenger alarms have been reset from OCC/driver's cab. Once this has occurred the system shall revert to its normal form of operation.

Provision of bypass for enabling traction if required or as decided by the Engineer shall also be provided. Full details shall be submitted for review and shall be discussed during design stage.

Screened cable pairs of fire survival type shall be provided for the passenger alarm system.

- 13.3.4 Under no circumstances shall cab-to-cab conversation or train operator to OCC conversation be relayed to any passenger.

- 13.3.5 The PEA push button once pressed should be resettable from remote i.e. from the operating console or OCC. When train is operating in UTO mode, two way communication shall be established with OCC.

- 13.3.6 The activation of any PEA shall interface with the saloon CCTV such that images of concerned area are automatically displayed on train-borne display unit inside the cab and transmitted to OCC. It shall be possible to OCC to identify which PEA has been activated so that the communication with the passengers can be initiated.

Automatic transmission of CCTV images for live streaming at OCC and creation of historic data (5 min before and 15 min after the event or as discussed with the Engineer during design stage) shall be as per ERTS 13.9.11. Historic data period shall be customizable. Full details shall be submitted for review and approval by the Engineer.

- 13.3.7 Multilingual (regional language(s) and English and/or Hindi) indication of indicators shall be provided on PEA speaker panel (like wait, call, Talk etc.). The indication shall be separate from Labels & Signage provided for the operation & function of PEA. Necessary indication to commuters shall also be made available in case of faulty PAD/PEA.

- 13.3.8 PEA communication system shall be SIL2 compliant except for voice signals.

- 13.3.9 Speaker/mic panel provided for PEA shall be flushed with carbody wall to have good aesthetic. Details shall be submitted for review by the engineer.

13.4 On-train Public Address

- 13.4.1 An integrated main communications panel shall be provided at the driving side of the cab by the Contractor to control the public address functions, cab-to-cab communications, and passenger alarm communications. This panel shall have a backlit LED display with facilities for the touch screen input, capable of handling multilingual (regional language(s) and English and/or Hindi)

characters. Full details shall be submitted for review by the Engineer.

- 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 (AVAS). The Automatic Voice System shall be the default public address mode (default mode).
- 13.4.3 The microphone to be used for public address / announcements from Cab and OCC should have high dynamic noise canceling feature. The contractor shall submit the details of the microphone for review by the Engineer.
- 13.4.4 The Public Address System together with its main components shall comply with internationally accepted standards.
- 13.4.5 Power amplifiers are required for the PA system and shall cater for the requirements of complete train.
- 13.4.6 Power amplifiers are required for the PA system and shall be provided in each car. Each power amplifier shall feed 50% of the speakers in the same car and 50% in the adjoining car, to ensure that in the event of a single power amplifier failure, at least half of the speakers are still operative in the car. Full details shall be submitted for review by the Engineer.
- 13.4.7 The number, positioning and output of each loudspeaker and power amplifier shall be designed such that an even sound coverage in all areas of the passenger saloon is achieved. The sound pressure level when measured at a height of 1.5m above the floor shall not vary by more than 3dB along the entire length of the consist. At least 12 number of saloon speakers shall be provided in each car. Loudspeakers shall be positioned to give uniform distribution of sound pressure level. Full details along with simulation shall be submitted for review and approval by the Engineer.
- 13.4.8 Adequate number of exterior speakers in order to warn/aware the passengers/commuters while boarding/de-boarding shall also be provided.
- 13.4.9 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. The Contractor shall supply software / hardware configurator for enabling the Employer's personnel carry out the adjustment as per the proposed system. Full details shall be submitted for review by the Engineer.
- 13.4.10 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.
- 13.4.11 The public address amplifiers shall be protected against short circuit at the outputs of the amplifier.
- 13.4.12 Any enclosure, if required for exterior speakers' material, shall be of at least SUS-304 or better SS grade in order to avoid any corrosion. Equipment shall be at least IP 65 or better. Full details shall also be submitted for review by the Engineer.
- 13.4.13 Deleted.
- 13.4.14 Deleted.
- 13.4.15 Suitable provision to adjust the volume independently for the announcements, external chimes internal chimes, interior speaker, driving console speaker, exterior speaker shall be provided for the Train Operator. Further adjustment (if required), easy access to potentiometers or equipment provided for the adjustment of volume for speakers shall be ensured for maintenance personnel. Full details shall be submitted for review and approval by the Engineer.

13.5 Cab to Cab Mode

- 13.5.1 In the cab-to-cab mode, the train operator shall be able to communicate with a person at the other end of the train or with the train operator(s) of a train coupled to this train (e.g. to undertake a push-out). Two way communication shall be established in this mode.
- 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 Duplex mode operation between two trains while in proximity shall be possible, via OCC on the radio communication system (supplied by Communications Contractor).
- 13.5.4 The Contractor shall submit procedure for review of the Engineer.



13.5.5 It shall be possible for Train operator to adjust the volume in the cab.

13.5.6 In case of train coupled, train operator(s) shall be able to communicate with a person available in other cab(s). Communication with the passenger from any of the Cab(s)/OCC shall also be made available. Full details shall also be submitted for review by the Engineer.

13.6 Automatic Voice Announcement System (AVAS)

13.6.1 An automatic pre-recorded message announcing system shall be provided in front and rear car of the train by the Contractor. Functions and features of this system shall be as follows:

- (i) One device shall be provided in front and rear car of the train which shall be on hot standby. In case of failure of the identified master, the device at the other end shall automatically become master. The device shall be operable from the train operator's cab (for UTO, equipment shall be properly concealed in the driving desk).
- (ii) The Automatic Voice Announcement System shall be fully integrated with the On-train PA system. Any failure of component which can adversely affect functionality shall be logged by the system itself and also be communicated to TCMS for reporting to the train operator and data logging. Full details shall be submitted for review by the Engineer.
- (iii) The pre-determined messages (voice announcements and text messages) shall be automatically triggered by train events and / or the ATP/ATO system to make an announcement. Close liaisoning is required between the Contractor and the Signalling Contractors in this regard. Full details shall be submitted for review by the Engineer.
- (iv) All the hardware requirements to achieve interfaces between the Automatic Voice Announcement System and the ATP/ATO system shall be provided by the Contractor.
- (v) Voice announcements and text messages for the displays shall be pre-recorded and configured into the system using the "off line" speech and route database editor. Messages, audio or visual or both shall be multilingual (regional language(s) and English and/or Hindi). Messages shall be recorded in the voice of professionals Announcers to be approved by the Employer.

The hardware and dedicated software etc. for editing, creating and modifying the speech and route database shall be handed over to Employer at an appropriate time, during the Contract period, and shall be decided during the design stage. The Employer's staff shall be associated during the editing activity. Messages shall be digitally stored. Provision for adding /expunging / editing any type of message shall also be ensured. Necessary tools shall also be handed over at an appropriate time.

- (vi) The Automatic Voice Announcement System shall also be equipped with display and announcement of computer generated messages. The Contractor shall provide equipment and means to achieve this by Employer's maintenance personnel.
- (vii) The comprehensive details (their format, frequency, use etc.) of message and special messages (to be triggered manually) shall be subject to review by the Engineer.
- (viii) A door open and door close announcement followed by a chime shall be triggered automatically and shall be synchronised with the door operation. Close liaisoning is required between the Rolling Stock Contractor & Signalling Contractor. Also, a "Door Close Announcement" button shall be provided to trigger door close announcement followed by a chime.

Suitable arrangement for door close announcement in case of slave to master or vice versa of hot stand by equipment shall also be ensured by the Rolling Stock Contractor.

The door close chime shall continue to play till the Doors achieve locked position. Similarly, a chime shall be played during the door opening. During this time, any existing auto announcement shall be aborted. The chime shall warn the passengers inside the train as well as those on the platform about the door operation. The adjustment of volume of the chime shall be independent of the volume of the announcements.

In case of obstruction in particular door(s), the chime on the corresponding car/door(s) shall only be broadcasted.

Independent volume adjustment of external chime, internal chime, announcement volume, exterior speaker volume, saloon speaker volume shall also be provided. Full details shall be submitted for review by the Engineer.

- (ix) The system shall be capable of storing 120 minutes of pre-recorded messages preferably in digital MP3 format or a latest format. The memory shall be able to store Route Database for at least 200 stations. However, it shall be possible to enhance the memory by expansion using commercially



available memory devices. Full details shall be submitted for review by the Engineer.

- (x) It is proposed to provide commercial / general audio and/or visual messages/video in between the announcements. The system shall be capable of playing / displaying of such advertisements (including videos). Details shall be submitted for review by the Engineer.
- (xi) In case of train parting, both cab's automatic voice announcement system shall become active and it shall be possible to make an announcement from either of the Cab and from OCC.
- (xii) In case of non-closure of any door, the chime shall continue for the effected car only.

13.7 Passenger Information System

13.7.1 General

- (i) The Passenger Information System shall include a high resolution multi colour graphic display, suitable for the remote displaying of moving messages, in multilingual (regional language(s) and English and/or Hindi), on board the train, in the passenger area. The colour of multilingual (regional language(s) and English and/or Hindi) character shall be approved by the Engineer. Emergency announcements may be displayed in red.

6 no. of LCD with LED backlit programmable displays (approximate length of 37 inches and the width shall be in line with the side coving panel width) with adequate protection from vandalism shall be provided in each saloon (location shall be decided during mock-up review). Details of available size of displays and mounting locations shall be discussed during design stage. These displays shall be used for messages/ advertisements (incl. video) etc which shall be downloadable from one end of the car/unit and/or from the cab. Provision shall be made for remote downloading as well. Provision shall be made to install equal number of LCD panel with LED backlit displays in future by the Employer by simply connecting it to the system. Size and location of provisional displays shall be decided during design stage. Any wiring etc. if need to be provided, shall be ensured. The Employer shall be able to interface and commission such screens at these locations. The location & size shall be decided during design. The displays shall be commercially available and work on open/commercial protocols. The colour combination of the display content should be such that these may be distinguished by colour blind person.

- (ii) The location and number of the display units shall be proposed by the Contractor taking into consideration the need for all-round good visibility by passengers within the saloon/platform. The Contractor shall submit proposal, including diagrammatic representation of the angle of visibility of the display units.
- (iii) There shall be a Destination Indicator behind operator cab's wind screen. The destination indicator shall be capable of displaying two lines of multilingual messages. The top line shall display characters in regional language(s) of at least 90 mm height while the second line shall display Hindi and/or English characters of at least 45 mm height with yellow LEDs. The Contractor shall submit proposal for Engineer's review.
- (iv) There shall be a Train Number Indicator similar to the 'Destination Indicator' behind operator cab's wind screen. The Train Number Indicator shall be capable of displaying up to 6 digit alpha-numeric train ID. The Contractor shall submit proposal for Engineer's review. Suitable interface to ensure alpha-numeric Train ID shall be ensured with designated Contractors.
- (v) There shall be an External Side Destination Indicator on each side [capable of displaying multilingual (regional language(s) and English and/or Hindi) displays, to be decided during design stage] 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 regional and Hindi and/or English language(s). 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.

Interface with designated PSD Contractor shall be ensured to finalize the location of external displays in order to get clear view of displays by Passengers on platform.

- (vi) The Destination Indicators and Train Identification Indicator shall be able to be set via the route setting control. The route setting control shall be either through the manual control on the TCMS or be automatically set by the Automatic Train Control (ATP /ATO) system as given in Appendix TD.
- (vii) The 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.

- (viii) The Destination Indicator, External Side Destination Indicator and Train Number Indicator shall have pixel diameter of 3 mm and pixel per pitch shall not be greater than from 4 mm. Alternative displays panel configurations may also be considered for better resolution. The Contractor shall submit the proposal for review of the Engineer.

- (ix) Size and location of Destination Indicator, External side Destination indicator and Train number indicator shall be optimized as much as possible with reference to mounting location. Details shall be submitted for review by the Engineer.

Location & size of all the displays shall be reviewed during mock-up review.

- (x) Programmable Digital Route Maps (DRM):

Four programmable coloured LCD with LED backlit based route maps for the respective lines shall be provided above saloon door, gangway ends etc. and shall have following provisions as minimum. Details shall be decided during design:

- a. Display of destination station, present station, approaching station, distance for reaching next stations, real time clock and door indications etc. Necessary interface shall be ensured by the Contractor.

Route-map of respective lines in different colours, point of inter-change or any other important information, flashing of emergency messages, important train messages, scrolling of routes, adding/ expunging of stations, selectable display of route.

- b. The size of the letter on LCD with LED backlit displays panel and resolution shall be programmable and have adequate clarity and visibility for a seating passenger. Further details shall be decided during design.
- c. Direction of movement of displays, positioning of destination station on DRM shall match with the geographical direction of destination station/train direction.
- d. The station names shall be displayed in multi-languages (regional language(s) and English and/or Hindi) alternatively.
- e. DRM display size has to be much longer to give comfortable view of the complete line(s) and additional information as already described above. DRM display shall fully use the available space in the door coving where the same shall be mounted.

Provision shall also be made to install equal number of LCD with LED backlit display in future by the Employer by simply connecting it to the system. Size and location of the provisional displays shall be decided during design.

Detail specification shall be drawn and screens shall be got approved during design. Additional changes if required during design shall be incorporated during design.

- f. Door indication on DRM shall be discussed during the design stage and is likely to be different on each DRM due to its mounting location. Details shall be submitted for review by the engineer.
- g. Routes map, arrows, lines etc. shall be dynamically updated based on the train location.

- (xi) Provision for setting up of a PA/PIS Lab in each Depot for programming of all displays including DRM shall be ensured by the Contractor. Full facilities including any hardware/software tools for programming the displays and system shall be supplied to each Depot. Employer's engineers shall be fully trained to programme, edit and interface the display panels with the system.

- (xii) The external displays shall have adequate brightness which shall have auto adjustment with the outside ambient light.

13.7.2 Programmable split screens of all Displays (LCD with LED backlit) capable of displaying different messages, advertisements (including videos) etc. in each split shall be provided. Full details shall be submitted for review by the Engineer.

- 13.7.3 Size & location of all the displays shall be optimized as much as possible with reference to the mounting location. Details shall be submitted for review and approval by the Engineer.
- 13.7.4 Layout of fully programmable displays shall be discussed during the design. Any requirement for the decision on layout shall be suitable taken care by the RS contractor.
- 13.7.5 Displays & system shall be capable for displaying live videos like news, sports etc. full details shall be discussed during the design.
- 13.7.6 There shall be no limitations on assigning different files (including video, gif etc.) on the programmable displays split screens.

13.8 Operation of Passenger Information and Automatic Announcement System

13.8.1 Automatic Operation of Passenger Information System

- (i) The system shall be capable of automatic operation throughout. At train set up, the train number provided by ATO/ATP shall automatically select the route to initialise the passenger information system by selecting the appropriate information from the train equipment and transmitting it to speakers and displays. The train operator shall be able to over-ride the automatically supplied train number and when no automatic route selection is given shall be able to enter the train route.
- (ii) The system shall update the journey information by accessing the train location information from the ATO/ATP equipment. The Automatic Announcement and the Passenger Information System shall at all times provide the same route, destination and next stop information to the passengers. The Automatic Announcement and the Passenger Information System shall indicate which side of the car that the doors will open at the next station stop
- (iii) The system shall be capable of receiving real time information from the control centre relating to delays and other relevant information. The system shall be capable of automatically updating the information being presented at the time to include the real time information received without the train operator's intervention.
- (iv) Planned and Unplanned skip station operation & announcements at appropriate location & station shall also be available. Necessary interface shall be ensured by the Contractor. Full details shall be submitted for review by Engineer.

13.8.2 Manual System

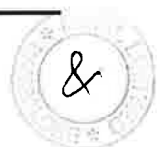
- (i) In addition to automatic operation, visual and audio information shall be capable of being originated from the train operator's cab. The system shall be capable of making pre-recorded announcements (both audio and visual) by manual triggering from main communications panel in the event that the ATO/ATP positional information is not available. Under such circumstances, messages shall operate automatically for the route from the TCMS information. Messages and announcements shall be triggered based on distance travelled and door operations. Manual override shall be provided to allow for station skipping. The train operator shall be able to override the automatic system and select message to be broadcasted randomly. All activation criteria shall be submitted for review by the Engineer.
- (ii) In case of system degradation, train operator shall be able to make manual announcements through microphone from the cab.

13.8.3 Audio Recorder

An automatic recorder shall be provided to record all automatic announcements made by PA system in saloon, manual announcements through MOP/AOP in saloon, announcements made by OCC in saloon (train), announcement made by roving attendant, conversation between cab to cab and conversation between passenger (recorded PEA wise with time stamp) & train operator when Passenger emergency alarm is activated in MP3 format or any other superior format. It shall be possible to download the recorded data without using any special tool/equipment directly from the recorder. The recorder shall have expandable memory to store the data for at least three days in revenue service."

13.9 Passenger Saloon Surveillance System

- 13.9.1 The Passenger Saloon Surveillance System (PSSS) shall comprise of a close circuit television (CCTV) network using surveillance cameras, routers and cables, monitors and other accessories. The fully expended system shall be designed for minimum 25fps 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.



- 13.9.2. Each car shall be provided with at least four surveillance camera devices at appropriate location to cover the maximum passenger saloon area for surveillance. It shall be possible to increase number of cameras by at least 2 per train by simple plug in to the system. The wiring and end connector to mount camera in cab(s) and mounting arrangement complete in all respect, but masked, shall be provided. Any additional tool hardware/software required for expending the system shall be provided to enable the Employer to plug in the cameras if so required in future. Employer's Engineers shall be trained for interfacing and commission the same.

The camera shall be suitably selected in respect of best HD resolution, clarity of images, illumination conditions, iris control, 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 Train Operator/maintainer.

- 13.9.3 Additional camera(s) shall be placed on outer sides per two cars as minimum for gathering rear view of the platform. Selection of type and number of cameras shall be finalized during design and shall ensure clear view of passengers on platform to Train Operator, before start at each station till train leaves the platform completely. The system shall automatically switch to rear view when the train stops and will go back to default mode after the train leaves the platform. Train operator shall have full flexibility in selection of camera(s) as per his need. Suitable icons on the monitor shall be provided to monitor all the cameras as required by train operator. The HMI screen shall be large enough to accommodate with acceptable clarity simultaneous view up to four(selectable) rear view/saloon cameras.
- 13.9.4 Interface with designated contractor for PSD shall be ensured to finalize the location of outside camera in order to get clear view of passenger on platform to train operator.
- 13.9.5 TCMS HMI screen can be used as CCTV screen on demand or event actuated. The TCMS screen shall have provision to have to show simultaneous multiple views of CCTV/TCMS/PA/PIS. The final screen shall be decided during design.
- 13.9.6 Under normal operation, the views gathered from each of the camera located in the train shall be sequentially played in the monitor screens of both the cabs. Adequate controls shall be provided for necessary surveillance requirements and priorities.
- 13.9.7 In case of activation of PEA in any of the cars, the views from camera provided near the location of activated PEA shall be automatically displayed in the monitors. However, the train operator shall be able to select any other camera, as required. The cameras shall have inbuilt digital zoom function. It shall be possible to filter, zoom and select images in off line mode for investigation purpose. The images shall be with time stamping and it shall be possible to link them with respective location of train.
- 13.9.8 Similarly, in case of certain critical events like opening of Emergency door, Fire & Smoke, opening of driver console desk, Obstacle detected by saloon door or by obstruction deflection device, ADD (Auto-Dropping Device) track/catenary/infrastructure related events etc. the camera(s) shall focus and alert the train operator/OCC by automatically flashing the image(Refer Clause TD 3.1.20 of Appendix TD). Full details shall be submitted for Engineer's review.
- 13.9.9 Full details for automatic pop-up of images at OCC shall be submitted for review by the Engineer.
- 13.9.10 Each camera shall have recording capacity of at least 24 hrs.
- 13.9.11 The visual images from each camera shall be recorded in non volatile SSD memory in a video recorder without any limitation of repetitive writing of the data. The capacity of the recorder shall be of at least 7 days and shall have the provision of First in First out (FIFO). The memory shall be expandable by simple plug in of commercially available memory media. The records shall be easily downloadable. The Contractor shall provide equipment and means for the same. At least one set of such equipment shall be provided to each depot.
- 13.9.12 Provision shall be made and tested to store relayed CCTV images to dedicated server at OCC and depot in case of emergency or on demand. Storage device shall be of SSD type. Separate server for this purpose shall be provided by the contractor. The radio communication used for CBTC/CCTV may be used for relaying the images as above. As a minimum, the images should be selectable for

a time or time interval as required. Final scheme shall be worked out during design. The contractor shall provide the on-board equipment and commission the system based on the communication link provided by the Employer.

Full details shall be submitted for Engineer's review.

- 13.9.13 Facility to transfer historic data (5 min pre and 15 min post recorded CCTV feeds or as discussed with the Engineer during design stage) on demand from train to OCC shall also be possible from OCC. Necessary provision in terms of playing the historic data in OCC along with sufficient storage capacity of 2 TB shall be ensured in CCTV server. Provision shall also be made to retrieve all historic data of last 7 days in one go from CCTV Server at OCC. Full details shall be discussed during the design.

The CCTV recordings 5 minutes prior and up to 15 minutes after the event shall be so stored that these are retrievable as a single data file for each event.

- 13.9.14 Two way, duplex, communication between saloon CCTV/Cab front CCTV and OCC shall be provided. CCTV images shall be transmitted to the driving console through IP network and to OCC, on demand through communication link on real time basis.

- 13.9.15 The events which shall automatic trigger OCC viewing and considered essential for UTO operation shall be discussed and decided by the Engineer during detail design stage.

- 13.9.16 During such event(s) as mentioned above, the recording speed & view of the associated cameras will change from low to high speed. Full details shall be submitted for Engineer's review.

- 13.9.17 Additional camera(s) for gathering front end view, track, ODD (Obstruction Deflection Device)) conditions and detrainment process view camera shall be provided by the Contractor. Suitable high sensitive camera(s) capable to record at low light shall be ensured. Full details shall be submitted for review by the Engineer. Selection and type/number of the camera shall be finalized during design stage.

- 13.9.18 Outside camera enclosure material shall be better grade to avoid any corrosion effect. Suitable dust & water/moisture protection shall also be ensured by the Contractor.

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

- 13.9.20 Suitable provision for monitoring of track, pantograph, OHE shall be in line with ERTS Clause 12.2.1(B)(k). Full details shall be discussed during the design stage.

13.10 PA/PIS & PSSS Test

- 13.10.1 All electronic equipment used shall be tested in line with ERTS 14.12 and shall also confirm to climate and environmental condition as stipulated in ERTS 3.10.

- 13.10.2 Details in line with ERTS chapter 14 shall also be submitted for review by the Engineer.

13.11 Interface

- 13.11.1 Appropriate interfacing with TCMS shall be developed to carry out the abovementioned functionality. The interface shall include provision of single point downloading the data logs stored in the memory of all train based Communication Equipment using TCMS interface.

- 13.11.2 See Appendix TD for full details of the division of responsibility between the Rolling Stock Contractor and Signalling Contractors.

- 13.11.3 Contractor shall provide adequate tools (two sets) and also impart training to Employer's Engineers for modifying/adding etc. the station names as well as audio visual announcements without changing the complete software.

- 13.11.4 Wi-Fi internet facility in train shall be installed by Designated Contractor. Rolling Stock Contractor shall install CAT 7 standard communication cable or latest standard cable. Complete cabling to access points, router, and internet antennae etc. shall be carried out by Rolling Stock Contractor. Full details shall be submitted for review by the Engineer.



- 13.11.5 Provision of dynamic bandwidth and its optimization for different uses shall be ensured suitable. Details shall be submitted for review by the Engineer.
- 13.11.6 Provision of displaying live news, sports etc. shall be ensured suitably. Details shall be submitted for review by the engineer.
- 13.11.7 Provision of remote update of display content shall be ensured suitably. Details shall be submitted for review by the Engineer.
- 13.11.8 Mounting location of train radio equipment shall be suitably chosen.

13.12 Set-up facilities for PA, PIS & PSSS:

Rolling Stock Contractor shall facilitate the necessary set-up in Depots for following:

- Complete integrated tools, hardware, software, equipment etc. for checking each functionality (as decided by the Engineer) of all the equipment.
- Fault diagnostic, repair centre etc. for the for each equipment with necessary training to Employer's Engineers.
- Necessary set-up including Software, Hardware, Equipment etc. to realise the change/modification shall also be ensured by the contractor.
- Provision for setting up of a PA/PIS Lab in each Depot for programming of all displays including DRM shall be ensured by the Contractor. Full facilities including any hardware/software tools for programming the displays and system shall be supplied to each Depot. Employer's engineers shall be fully trained to programme, edit and interface the display panels with the system.

Full Details for above mentioned facilities shall be submitted for review by the Engineer. Any other requirement shall be discussed during design stage.

13.13 Deliverables

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

S.No.	Clause No.	Tools/Equipment/Software	Quantity
1.	13.1.1 (xi)	Complete tools including software, hardware, equipment etc. as per clause 13.1.1 (xi)	One Complete set at each depot.
2.	Deleted.		
3.	13.6.1(v)	The hardware and dedicated software etc. for editing, creating and modifying the speech and route database in line with clause 13.6.1(v).	One Complete set at each depot.
4.	Deleted.		
5.	13.9.2	Any additional tool hardware/software required as per clause 13.9.2	One Complete set at each depot, if required.
6.	13.9.11	Equipment and means for downloading of visual images recorded in non-volatile SSD memory of PSSS.	At least one set of such equipment in each depot.
7.	13.11.3	Adequate tools for modifying/adding etc. the station names as well as audio visual announcements without changing the complete software.	Two sets (as advised by Engineer).
8.	13.12	Set-up facilities for PA, PIS & PSSS in depots as per clause 13.12.	One Complete set at each depot.

Note:

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



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. including during transport.
- 14.1.4 Welding, painting and crimping are considered as special processes. Contractor shall ensure process qualification and validation for these processes and records of the same shall be maintained for scrutiny and review by the Engineer.
- 14.1.5 All relays/MCBs/equipment etc. shall be suitably de-rated for specified temperatures including the proximity effect.

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 (grade 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 fiber reinforced plastics may be used for non-structural parts, and applications as accepted by the Engineers. They shall be manufactured to an approved process and satisfy the flammability, toxicity and smoke generation limitations of EN 45545 Part 1 to 7 latest editions, or the better equivalent internationally accepted standard. See also Clause 2.5.8.
- 14.2.3 Synthetic rubber, conforming to International Standards, shall be used for components exposed to sunlight or lubricants during Operation & Maintenance. Complete purchase technical specifications with drawings of all rubber components shall be submitted.
- 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 Engineers for review.
- 14.2.5 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 for each sub and major assemblies. Approval of the welding procedure shall be as required by BS EN 288-3: Specification of Approval Testing of Welding Procedures, or equivalent. All welding procedure shall be proven to avoid /control distortion of sub and major assemblies.
- 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/TIG process and in all cases complete and adequate fusion with the base material shall be ensured. All consumables for welding like gas, electrode shall conform to International Standards. The welding symbols shall be as per ISO 4553 or any other relevant International Standards.
- 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 Engineers or Inspector reserves the right to verify the quality of the technique/technology employed for joining the modular element of shell.
- 14.3.6 Deleted.



14.4 Corrosion

- 14.4.1 Protection of materials against all types of corrosion shall be appropriate for the environment of Mumbai 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.
- 14.4.3 The Contractor shall take adequate precautions at each stage of processing of stainless steel materials to avoid contamination from harmful materials which can affect corrosion and/or rust resistance properties. Precautions shall also be taken to avoid deep rolling marks, which can potentially affect corrosion resistance properties or enhance stress.
- 14.4.4 The Contractor shall provide suitable protection to eliminate galvanic corrosion, between dissimilar metals.
- 14.4.5 It has been experienced that the un-protected silver contacts/connections get corroded leading to premature failures. Contractor shall take adequate protection during design, selection of equipment & manufacture.
- 14.4.6 Solutions to all corrosion problems, if any, shall be without increasing maintenance activities. Contractor to provide inbuilt corrosion resistant measures over the entire committed life span 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, hot dip galvanised or cadmium plated.
- 14.5.13 Nord lock or equivalent arrangement shall be provided on the fasteners which are subject to heavy vibrations or can cause operational issues.

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 months.
- 14.6.3 An exception to the above requirement applies only to the vehicle HVAC unit filters, which will be unit replaced for cleaning at two weekly intervals.
- 14.6.4 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.
- 14.6.5 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.
- 14.6.6 Enclosure interiors shall have smooth easily cleaned self coloured surfaces to assist in maintenance.
- 14.6.7 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.
- 14.6.8 Enclosures in which heat or arcs may be generated shall be lined with barriers of insulating material.
- 14.6.9 All enclosure covers shall be designed to be handled by one person in an ergonomic manner.
- 14.6.10 Signage shall be provided at appropriate positions for clear indication and warning of the potential hazards relating to the equipment or component inside enclosures.
- 14.6.11 The enclosures containing control equipment including relays etc. shall be fully protected against dust ingress and shall be tested for the same.
- 14.6.12 Enclosures/cubicles shall be provided with Linear Heat Detectors (LHD) or heat detectors (refer ERTS clause 2.20) to protect against any abnormal increase of temperature within the enclosed cubicles which may lead to risk of fire.

14.7 Wiring and Cabling

- 14.7.1 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.
- 14.7.2 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.
- 14.7.3 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.
- 14.7.4 All cables of voltage less than 50V shall be kept separated from high and low voltage cables.
- 14.7.5 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.
- 14.7.6 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.
- 14.7.7 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.
- 14.7.8 The minimum cross sectional area of auxiliary power cables for connections between equipment shall be 1.5mm² copper. External sockets to such cables shall be suitable for 1.5mm² copper cables. Any deviation from this requirement in exceptional cases will be subject to review by Engineer in design stage.



- 14.7.9 All cables used in the train shall be e-beam cables conforming to international standards (EN/IEC) suitable for being used in underground metros.

14.8 Terminals and Cable Termination

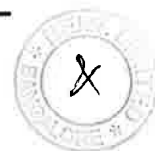
- 14.8.1 Except for electronic equipment, all cable terminations shall be of the crimped type in accordance with BS 4579: Part 1: 1988, Compression Joints in Copper Conductors, or other service proven type. Soldered connections will not be accepted.
- 14.8.2 Crimping standards shall conform to current international practice. The Contractor shall employ only approved and certified staff for crimping process. The Engineer may require that crimped lugs be subjected to random testing before acceptance.
- 14.8.3 Bolted terminations for all high voltage 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 BS4579 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.
- 14.8.13 All Cable glands used in cable layout shall be got approved from Engineer and shall be state of art, easily adjustable and fit for long life. The gland shall be flexible and shall have provision to adjust with the cable dia and space available. Use of putty etc. shall not be permissible.

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 buildup of tracking paths.

14.10 Protection & Earthing

- 14.10.1 Except as specifically required otherwise, DC and single-phase AC 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 DC control voltage and AC 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 either be with copper cables or copper braids of adequate size to handle fault currents and lightning discharge currents, for which the voltage drop shall not exceed 25V. All earthing connections shall be color coded as per relevant International Standards.
- The bonding method employed shall not produce a DC resistance in excess of 0.0025Ω; or more than 0.025Ω at 150kHz for any applied AC voltage.
- 14.10.10 Electrical equipment 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.
- 14.11.3 The soft version of all Circuit diagrams & TCMS sheets shall be inter-linked for smooth and seamless tracing of signals and wiring.

14.12 Electronic Equipment

- 14.12.1 Following type test shall be carried out on electronics equipment used in the train. As a minimum, all electronic equipment shall comply with IEC 60571/EN 50155: Electronic Equipment used on Rail Vehicles, for design, manufacture and testing, and shall use components purchased against an internationally recognised quality assurance and reliability certification procedure.
- (i) Dry heat test: The dry heat test shall be conducted for class T3 and temperature shall be considered 80°C against 70°C specified in IEC/EN. An extra performance check at 95°C shall also be carried out for 10 minutes over temperature value. LCD/LED display units may be tested into 70°C and an extra performance check at 85°C shall also be carried out for 10 minutes over temperature value.
- (ii) Salt Mist test (ST3 category)
- (a) Cyclic Humidity tests (IEC 60571).
- (b) Dust and sand test & Mould growth tests: The tests shall be done as per IEC 60068 & IEC 60721. The dust settlement rate shall be taken as 6gm/m²/day and dust particle size shall not be larger than 100 microns.
- 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 The Contractor shall furnish the following information in respect of printed circuit boards as a part of contract:
- (i) Voltage and/or waveform expected at each critical test point.
 - (ii) Instructions for carrying out testing and troubleshooting and the function of each circuit block.
 - (iii) Component layout of the printed circuit boards and assemblies.
 - (iv) Connection or interfacing diagrams for the printed circuit boards and assemblies.

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 Metro 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.
- 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 Microprocessor system hardware block diagrams shall be provided.

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.
- 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 of standard design for Rolling Stock applications with components mounted on one/both sides will be acceptable.
- 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. Tenderer's shall indicate the standard with which they are compliant.
- 14.15.4 PCB's shall be connected to the case or rack wiring using multi-pin connectors, which shall have a successful service history in rail applications. Details shall be provided.
- 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 vital and important PCB contact faces of connectors shall be gold plated. The details shall be furnished during detailed design stage.
- 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.
- 14.15.10 All PCBs shall be adequately lacquered to isolate from environment pollution.

14.16 Integrated Circuits

- 14.16.1 All integrated circuits and semiconductor devices shall be standard devices.
- 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 in English 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. It is desirable that the labels used for different equipment/ sub-systems / systems on the train are of a standard pattern.
- 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 multilingual (regional language(s) and English and/or Hindi).
- 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.
- 14.17.6 Labelling scheme shall be got approved from the Engineer.
- 14.17.7 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 utilize, 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



Rolling Stock 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 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 painting system. 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.
- 14.19.2 Employer expects painting of the equipment/ sub-assemblies as per best International practices. Contractor shall submit the guaranteed life cycles for the paint application for different equipment and sub-assemblies for Engineer's review during design stage.

14.20 Rubber Items

All rubber hoses, connecting pipes etc. used in pneumatic circuit shall not be required to be replaced before 5 years or major overhaul whichever is later. The rubber/ rubber- metal components used in suspensions shall not be replaced before 12 years or during major overhaul of the equipment, whichever is later. All rubber hoses shall be steel reinforced for better life and reliability.

14.21 Cables and Pipes Entries Seal

To prevent entry and ensure fool proof protection against water, dust, humidity, insulation damage/ failure, fire, vibrations, temperature variations, pull tension noise as well as rodents etc. and increasing life of cable/ equipment, all the cables and pipe transits in all cars including rooftop shall be sealed with a suitable EPDM (Ethylene Propylene Diene Monomer) based cable and pipe sealing system. Sealing and Protection application area shall be identified and got approved from Engineer during design stage.

Suitable cable transit system with EPDM should be used for holding/ retention of running power cables and control cables, HT cables at underframe.

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 equipment, systems and sub-systems, shall be type- and routine-tested in accordance with detailed respective test procedures to be drawn up by Contractor and agreed by the Employer which shall take into account the requirements of respective IEC Publications or other appropriate international standards listed in Appendix 'TA', special tests specified in this Chapter, and tests programme drawn up by the Contractor to demonstrate that the individual equipment, sub-systems and systems meet the other specified requirements 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 equipment of identical design, witnessed by a reputed organisation, and the service performance of such equipment 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. Change of manufacturing place may require re-type test.
- 15.1.6 Without prejudice to any other provisions of the Contract, the Engineer reserves the right to witness any or all of the tests, and to require submission of any or all test specifications and reports. The Engineer reserves the right to reasonably call for additional tests as are considered necessary, including the quality of welds particularly in highly stressed areas, by nondestructive 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 Engineer, who will record his conclusions as to whether or not the equipment being tested has passed satisfactorily.
- 15.1.8 Certain vital type tests as listed at 15.29 may be witnessed by the Engineer/employer or his representatives. However, the Engineer at his discretion may witness any other tests/FAIs. The contractor shall advise the engineer complete type test plan and seek approval of type test specifications.

15.2 Inspections

- 15.2.1 All the materials, fittings, equipment, manufacturing processes, and assembly workmanship shall be inspected by the Contractor, without exception and record for the same shall be maintained and made available for review/check by Engineer.
- 15.2.2 The Employer and the Engineer shall have free access to the Contractor's and sub-contractors' premises, and to any other places where tests are proposed to be carried out, throughout the contract, for the purpose of reviewing and inspecting the designs and manufacturing processes, and mock-ups. The Contractor shall provide the Engineer full opportunity to inspect, examine, measure, and test any of the Works on site, or wherever carried out.
- 15.2.3 The Employer and the Engineer shall be at liberty to inspect the manufacturing process at any stage. Without prejudice to any other provision of the Contract, the Engineer reserves the right to reject all materials and workmanship, which do not fully conform to the specification.
- 15.2.4 Repeated rejections, at either the Contractor's or sub-contractors' facilities, shall be cause for the Engineer to suspend inspection. In such case, the work in question shall also be suspended until satisfactory corrective action is taken by the Contractor.



- 15.2.5 The Contractor shall not be released from any liability or obligation under the Contract by reason of any such inspection, testing or witnessing, nor by submission of reports of inspection or testing to the Engineer.

15.3 Inspection Hold Points

- 15.3.1 The Contractor shall, propose a set of inspection hold points in the Inspection, Testing and Commissioning Plan. The hold points shall be structured so that a formal hold point is allowed for each significant element of the car's manufacturing process. At each hold point the Inspecting Officer appointed by the Employer shall hold a formal inspection, or advise that the inspection has been waived.
- 15.3.2 The manufacture of each car or part thereof shall not proceed until the inspection by the Inspecting Officer has been completed or waived.
- 15.3.3 The Employer and the Engineer shall be afforded the opportunity of inspecting all cars, trains and mock-up to be delivered under the Contract before they leave the Contractor's premises. No car shall be considered ready for delivery without Engineer endorsement in writing.
- 15.3.4 The Contractor shall advise the Engineer no fewer than 30 days in advance of a car or train being available for inspection, and shall notify him of the tests proposed to be carried out. In case inspection is not carried out at the time agreed upon as a result of the Engineer not being available, the Contractor shall notify the Engineer immediately and he will deploy an Inspecting Officer within one week. In case the Inspecting Officer fails to turn up within this period, the Contractor may proceed with the work and the Inspection Certificate issued by the Manufacturer will be accepted by the Engineer.
- 15.3.5 Once the inspection and any required remedial actions are completed to the satisfaction of the Engineer, he shall give consent for the cars' or trains' shipment and/or dispatch.

15.4 Test Planning & Procedure

- 15.4.1 The Contractor shall submit detailed test procedures for each of the equipment/sub system/system for the review of the Employer as part of design submissions. The plan test procedures shall include the following information:
- (i) Relevant specification applicable to each of the tests.
 - (ii) Type, routine and special tests to be carried out.
 - (iii) Description of the tests, scheduled dates, and locations of the tests.
 - (iv) Test parameters to be measured.
 - (v) Constraints to be applied during the test.
 - (vi) Defined pass/fail criteria
 - (vii) Facilities, equipment, and test and measurement tools.

Test procedures shall be amended, as required by the Contractor throughout the duration of the Contract, to reflect changes in system design or the identification of additional testing requirements.

- 15.4.2 The Engineer shall have the facility to monitor all tests and have access to all test records. Ample time shall be allowed within the testing programme for necessary alterations to equipment, systems and designs to be undertaken, together with re-testing prior to final Commissioning.
- 15.4.3 Unless agreed in writing by the Engineer, personnel engaged on testing shall be independent of those directly engaged in the design or installation of that equipment.
- 15.4.4 All test equipment shall carry an appropriate and valid calibration label and / or certificate.
- 15.4.5 For each of the identified tests, 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. The Contractor shall sign all reports of Tests. The Employer reserves the right to reasonably call for additional tests if considered necessary.

15.5 Obligatory Tests on Prototype

- 15.5.1 For introduction of a Rolling stock in revenue service, tests are required to confirm that the design meets all the specified safety and statutory requirements and the train is fit for revenue service. Present statutory requirements make it mandatory to follow the Research Design & Standards

Organization (RDSO) "Procedure for Safety Certification and Technical clearance of Metro systems" for introducing new rolling stock for passenger services and "The Metro Railways General Rules". A copy of the same is attached in Part-II: Section 6G. The methodology & acceptance criterion for conducting oscillation trials as mentioned in the above RDSO procedure Annexure- F-1 & F-2 (latest updated) shall be applicable.

- 15.5.2 As per statutory requirements in India the passenger cars have to fulfill the following requirements "under all conditions of track upto maintenance limits" (table 15.1 'A') at all speeds.

Table 15.1 'A' Obligatory requirements on prototype

S. N.	Term	Conditions	Acceptable Value
1.	Maximum vertical Acceleration on coach body	Measured on car floor of car body as near to bogie center as possible	≤ 0.27 g
2.	Maximum lateral Acceleration on coach body	Measured on car floor of car body as near to bogie center as possible	≤ 0.27 g
3.	Maximum Dynamic wheel unloading $\Delta Q/Q$	-----	≤ 0.5
4.	Maximum value of RI	Calculated on the basis of acceleration values recorded in items (1 and 2) above	3.0 for both vertical & Lateral directions
5.	A general indication of stable running characteristics of the vehicle as evidenced by the movement of the bogie on a straight and curved track and by the acceleration readings and instantaneous wheel load variation.		

The oscillation trial are to be conducted with tare and fully loaded vehicles, in both inflated and deflated conditions upto maximum designed speed starting from 40 kmph in the incremental order of 10 kmph; upto 90 kmph .

As far as operation with deflated springs are concerned, trials will be conducted upto the speed where the above maximum level of parameters are experienced and based upon the results, the maximum speed of operation with deflated springs will be decided.

The test will preferably be conducted on track blocks of approximately 200 m each for tangent track and 100m minimum for curve track. The minimum total numbers of blocks will be 25. However the actual test scheme shall be decided based on the section available for testing. The results will be calculated for each block separately. The maximum value of each index on the results of evaluation of all blocks independently will be the accepting criteria. The oscillation trials may have to conducted in stages to facilitate opening of section. Contractor shall plan accordingly.

The contractor shall also make arrangements to measure the forces / impact on the check rails on main line / turn outs with new and wornout wheels. Suitable interface shall be ensured with the track contractor. The forces, if any, shall bewell within limits .

The performance of each type of car will be separately evaluated.

- 15.5.3 Besides the above statutory test, other tests as specified in EN14363 including following investigation test to confirm the safe behaviour of the coach will also be carried out

- (i) Measurement of natural frequency in Bouncing, pitching and
- (ii) Rolling modes using a wedge of 18mm (Investigation test)
- (iii) Bogie Rotational resistance (x-factor)
- (iv) Damping Factors.



- (v) Braking Distance Test.
- (vi) Carbody movements with reference to the KE

Table 15.1 B – The Limiting Values

S.No.	Term	Conditions	Acceptable Value
1.	Damping factor (under tare condition)		
	(i) Lateral	By quick release side pull test	0.30 to 0.40
	(ii) Vertical	Using wedge of 18 mm thickness	0.20 to 0.25
2.	Bogie Rotational Resistance	Under tare with inflated & deflated spring conditions	< 0.08 at 0.8 degrees per second rotational speed
3.	Emergency Braking Distance of 6 car train set with all bogie brakes working under fully loaded conditions.	Pick up speed of 80 kmph on level tangent track & apply emergency brakes	245m (Maximum)

15.5.4

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

15.5.5 Software package required for analysis of the raw data acquired during oscillation trials shall be supplied by the Contractor at designated Depot as advised by the Engineer. The cost of this software package is deemed to be included in the quoted price of contract. Necessary training to use this software package shall also be given to the Engineer's Representatives.

15.6 Integrated Testing and Commissioning

15.6.1 Complete propulsion system shall be tested on Combined Test Bed as per IEC61377. On completion of testing and commissioning of the Contractor's own system to the satisfaction of the Engineer, the Contractor shall carry out all tests necessary to verify the functioning of his system with those of other Designated Contractors. These tests shall be carried out in various phases and for different sections, as the work progresses. Following procedure shall be adopted:

- (i) Complete propulsion system incl. Transformer, converter-inverter, traction motor with loading arrangement shall be placed on test bed. Preferably arrangement shall be made to heat the ambient air to 47°C during the tests. It will be preferred to use the same gear case & transmission arrangement as proposed during design.
- (ii) List of points where temperature shall be measured shall be finalized with the Engineer. Decision of engineer shall be final and binding.
- (iii) All specified operational scenarios shall be tested. These include emergency cases also.
- (iv) Worst case conditions with permissible wheel dia difference of 8mm
- (v) 6 car train (with 1MC isolation) pushing 6 car train on 4% gradient shall also be included as one of the investigative case.
- (vi) Performance test shall be done at half worn wheel. Suitable correction shall be made for traction motor temperature under full wheel dia.
- (vii) The parameters recorded during combined test bed shall be revalidated during line tests as per IEC

1133. The recorded values during line test shall be normalized by adding the difference of temperature rise due to wheel dia difference as above, difference due to measurement procedure adopted in field and specified in IEC 60349 (Winding resistance method) and difference in ambient temperature from the specified. Similar normalization shall be done for other equipment as well.

- (viii) Train Performance test (IEC 1133): Complete train shall be subjected to the tests specified in IEC 1133 or any other tests required to be incorporated by the engineer. Detail test protocol shall be drawn and got approved from the engineer. The train performance specified in ERTS3.22 shall also be got validated along with the final simulated performance parameters after design. The run time performance shall meet the following parameter.

Train Load (1)	Achieved Speed (KMPH) (2)	Minimum Distance Moved (m) in time at Column (4) (3)	Maximum Time taken to achieve the speed (sec) (4)
Crush load @ 8 passengers/m ² and All out run	0 to 40	62	12
	0 to 60	232	23
	0 to 80	811	53
Crush load @ 6 passengers/m ² and All out run	0 to 35	40	9
	0 to 60	213	21
	0 to 80	715	47

The measurements shall include jerk consideration and shall start from the moment the Master controller is brought to traction. The measurements shall also be done during ATO and shall be optimized. Similar procedure shall be used for testing of regenerative braking.

- 15.6.2 Tests and test procedures shall be submitted by the Contractor for acceptance by the Engineer or as required by him.

- 15.6.3 The Integrated test procedures shall include, but not limited to, the necessary tests to verify the functioning with the Designated Contractors responsible for the following systems:

- (i) Signalling and Train Control
- (ii) Telecommunication
- (iii) Overhead Equipment
- (iv) Civil Constructions for underground sections
- (v) Track works
- (vi) Station Construction
- (vii) Depot Equipment Supply
- (viii) Platform Screen Door (PSD)
- (ix) Any other Designated Contractor as communicated by the Engineer.

- 15.6.4 All defects and shortfalls in the Contractor's system, discovered in the course of Integrated Testing and Commissioning, shall be made good and re-tested to the satisfaction of the Engineer before the commencement of service trials.

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



15.7 Service Trials

- 15.7.1 The prototype and other trains shall be subjected to pre-revenue Service Trials. Service trials are intended to prove not only the satisfactory running performance of the cars, but also to enable practical evaluation of their reliability in service, ease of maintenance and operation, in parallel with the work of other Designated Contractors, and adequacy of the cars and equipment for all performance requirements envisaged in the specification.
- 15.7.2 Service Trials for the prototype train shall be carried out for a minimum of 2,000 km and for other trains 500 km which may be further subjected to Engineer's review during design stage.
- 15.7.3 The Contractor shall submit the Service Trial Procedure for review by the Employer, enlisting the various operability and maintainability aspects to be performed during the service trials.
- 15.7.4 During the Service Trial period, the Contractor shall make the train set completely fit for introduction in revenue service.
- 15.7.5 The Contractor shall make all necessary arrangements including temporary provisions in his system to ensure safety during service trial period. The Contractor shall provide full support by way of driving Instructors, staff and material during the Service Trials of the prototype and first few (maximum 10 no) trains. By that time the contractor shall complete on-shore training of train operators and provide competency certificates to such trained TO's, who are found suitable for driving such trains.
- 15.7.6 During the pre-revenue operations, the Contractor and designated contractors, will run trains subject to constraints of the ongoing construction activities.
- 15.7.7 Trains shall be inducted into Revenue Service only after Service Trials to ensure that functions and operations of various systems are satisfactorily integrated and permit all the technical systems to stabilise.
- 15.7.8 Upon completion of Service trials the Contractor shall submit a statement confirming that the rolling stock is safe and ready for commencement of revenue service.

15.8 Special Tests

- 15.8.1 The Contractor shall carry out the requisite tests to demonstrate the performance of equipment, sub-system and system as per procedure mentioned in clause 15.4. 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.

15.9 Vehicle Body Shell

- 15.9.1 Car body strength test (see clause 4.6) shall be carried out and a lifting test shall also be performed in accordance with UIC 566/EN 12663 (clause 1.2.2.3) under simulated loads as specified, as type test.
- 15.9.2 Crashworthiness shall be proved by submission of detailed calculations and demonstration by means of finite element analysis.
- 15.9.3 The strength of the saloon car side wall windows and of those in the doors shall be performed in accordance with UIC 566/EN 12663, as a type test.
- 15.9.4 The strength of the cab windscreen shall be tested in accordance with the requirements of both UIC 651 and UIC 566/EN 12663, for a maximum train speed of 85 kmph also as a type test.
- 15.9.5 The strength of couplers and draught gear shall be carried out in accordance with international practice, also as a type test.
- 15.9.6 The carbody shall also be subjected to a vertical deflection test. All side doors on one side of the car shall be installed, complete with drive mechanisms, and all sealing and weather-stripping.
- 15.9.7 At each increment of test load the doors shall be opened and closed by means of the door controls. Any failure to operate at the prescribed speed profile, or any indication of binding, shall require corrective action to be taken by the Contractor, to the car structure, to the door arrangement, or both.
- 15.9.8 One shell out of every 4 bare shells, to be randomly selected by the Engineer, shall be subjected to water tightness test as per an agreed procedure based on IEC 61133.

15.10 Bogie Tests

- 15.10.1 The bogie frame(s) shall be subject to static as well as fatigue tests in accordance with UIC 515-4

for T car bogie and UIC 615-4 and EN-13749 for DM and M car bogie, with the payload as specified in Chapter 5. This shall be a type test. However, in case of only one type of bogie frame is proposed to be tested, the maximum of all loads shall be considered.

15.10.2 Tests for clearances in the bogie, and between bogie and body shall be carried out on straight track as a routine test.

15.10.3 Tests for clearances in the bogie, and between bogie and body shall also be carried out by rotating the bogie to simulate a 100m radius curve. This shall be a type test.

15.10.4 The Contractor shall perform a wheel-unloading test to verify the calculations submitted. The test shall be conducted in the most disadvantageous combination of unloading and suspension conditions.

15.10.5 A load deflection test and accelerated ageing tests shall be performed to demonstrate that the spring rate of the primary suspension system and the creep rate for the materials used are within the design limits.

15.10.6 These tests shall prove that the primary suspension system behaves as predicted and will not result in excessive deflection or a decrease in bogie clearance above top of rail to less than the minimum specified herein.

15.11 Passenger Saloon Door, Type Tests

15.11.1 The body side doors shall be tested for strength as required in Chapter 7, for relevant parameters which are required to be met.

15.11.2 The following type test shall be carried out on a complete double leaf door and operating assembly equipment with its control gear.

(i) Endurance

Two million operations shall be performed. A record of the velocity profile shall be taken at the beginning and the end of the test. It should also be demonstrated that no undue wear or compression of seals has occurred. This test shall be performed under representative dry and wet conditions. Endurance test shall be done on actual replica of the door portion of the car and door shall be as assembled in the coach. Approval of engineer shall be sought on the complete arrangement.

(ii) Vibration Tests

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

15.11.3 Detrainment door Endurance test—The door/detrainment arrangement shall not deform after loading and unloading cycles with equivalent load of passengers in 6 car train/8 car train.

15.12 Passenger Saloon Door, Routine Tests

15.12.1 These will comprise functional test to verify that performance is consistent with accepted type test results, and shall include tests to IEC 60077 for the electrical portion.

15.13 Saloon to Cab Door Type tests

15.13.1 The Prototype Saloon to Cab door shall be subjected to an endurance test of one hundred thousand (100,000) operations, during which it shall be demonstrated that no component fails.

15.14 Compressor and Motor Test

15.14.1 Type Test

(i) Starting Test

The motor shall undergo type- and routine-tests in accordance with IEC 60349-2, Electric Traction. Rotating Electrical Machines for Rail and Road Vehicles, Part 2-Electronic Converter Fed Alternating Current Motors.

The compressor shall undergo type- and routine-tests in accordance with ISO 1217: 1996 and BS 1571: Pt.2: 1984 Methods for Simplified Acceptance Testing of Air Compressors and Exhausters.

In addition to the above, starting tests shall be performed, five times at the maximum permissible rated voltage, and five times at the minimum rated voltage, the ten tests being performed in succession, at two minute intervals, at the specified reservoir pressure. The machine shall not exhibit a temperature rise higher than the specified maximum permissible.



(ii) Voltage Interruption Test

The supply shall be interrupted and restored, at intervals of one second, five times in succession, allowing the normal load conditions to be re-established between successive interruptions, the motor operating at its maximum voltage and rated load. The motor shall withstand the test without mechanical deterioration.

(iii) Heat Run

The set shall be tested at its rated voltage against the specified pressure for six hours, to show that the motor temperature rise does not exceed the specified limit, based on the class of insulation, and that the permissible temperature rise of the compressor is not exceeded.

(iv) Air Quality check of complete unit as ISO procedure.

15.15 Brake Equipment Type Tests

15.15.1 Brake system and its components shall be subjected to type tests as per relevant UIC. Following Tests shall be carried out on TBUs based brake system:

- (i) Functional checks such as working stroke, slack adjuster operation and parking brake action.
- (ii) Recording of the relationship of brake pad force to cylinder pressure over the full working range.
- (iii) Plotting of brake force against pressure curves in all conditions of operation of brake cylinder and parking brake.
- (iv) Vibration test as defined in IEC 61373.
- (v) Air leakage test.

15.15.2 Brake Lining:

The Contractor shall carry out testing of brake pads in respect of coefficient of friction with respect to the wheel tread under dry and wet conditions, maximum temperature attained during braking, rate of wear etc.

15.15.3 Brake Control Equipment

Individual items of electro-pneumatic equipment shall be type tested as follows:

- (i) Mechanical Operation and Endurance as defined in IEC 60077
- (ii) Vibration and Shock as defined in IEC 61373.
- (iii) Air Tightness generally as in IEC 60077.
- (iv) Electrical Test, generally as in IEC 60077.
- (v) Characteristic Tests
- (vi) Each item of equipment having a pilot or transducing function, shall be tested to confirm compliance with the Contractor's design data. Oscillograms shall be produced in support.
- (vii) Type Tests on Electronic Equipment

The electronic equipment used in brake system shall be tested as laid down in IEC 60571 and EN 50121-3-2.

15.15.4 WSP test

Complete train (AW0 & AW3) shall be subjected to Wheel slip-slide type test as per UIC 541-05. The detail type test specification shall be got agreed from the Engineer. Followings shall be included in the type test

- (i) Braking Modes as EB (Emergency Brake), FSB (Full Service Brake with ED Dynamic Brake), FSB (Full Service Brake without ED Dynamic Brake) and EB (Emergency Brake) with 1 M car isolated for Evaluation with at least 4 valid runs each.
- (ii) Braking Modes as FSB (Full Service Brake with ED Dynamic Brake) followed by Failure of ED Dynamic Brake, FSB (Full Service Brake with ED Dynamic Brake) followed by EB (Emergency Brake) for Reference with at least 3 valid runs each.

- (iii) Low Speed and Low Adhesion WSP Tests will be done for reference at speeds of 25kmph and initial adhesion < 5%
- (iv) WSP Tests will be done on Randomly selected 3 trains in Tare Load in speed range 60-30kmph for Braking Modes as EB (Emergency Brake), FSB (Full Service Brake with ED Dynamic Brake), FSB (Full Service Brake without ED Dynamic Brake) for evaluation as and when directed by Engineer.
- (v) Initial Adhesion will be evaluated as per UIC i.e. when First axle starts sliding irrespective of location on train. In case of Full Service Brake with Dynamic Brake First axle to slide is expected from Motor car due to Dynamic Brake applied on Motor Car.
- (vi) An Axle will be considered Sliding if its speed is at least 10% lesser than Reference Speed.
- (vii) Minimum Slide Criteria will be fulfilled on the basis of Braked Axles of complete Train Set i.e. At least 50% of braked axles, of train. Axle will be considered Sliding if it is sliding for more than 35% of the time (Actual time taken from 85-45 or 60-30).
- (viii) Extension of Stopping Distance in Wet Condition over Dry Condition, for Adhesion Level of 6-8% will be 15% and 25% for adhesion level of 5% up to 6%.
Braking Distance under Dry and WSP condition shall be within the distances specified in the Table 15.2.

WSP software shall be fine tuned to ensure minimum reduction of brake distance due to low adhesion and shall be state of art being used in metros worldwide by the contractor.

Table 15.2: Braking Distance under Dry and WSP condition

Braking Mode	Speed (kmph)	Maximum Braking Distances for AW0 and AW3 (meters)		
		DRY	WET (Adhesion)	
			6%-8%	5%-6%
EB	85	245	282	306
	60	123	142	153
EB (1 car Isolated)	85	308	354	385
	60	158	182	198
FSB with ED	85	307	354	384
FSB w/o ED	60	155	179	199

15.16 Complete Brake System, Type Tests

15.16.1 A complete set of brake equipment comprising all items of equipment forming the Brake System shall be assembled and shall be subjected to brake system bed test. These shall include the Brake Controller and interface with ATO equipment and a transceiver to measure force at the push rod of Brake unit. A complete series of tests shall be carried out on this rig under all service conditions to demonstrate the function of the brake system as a whole, both in manual and auto modes.

The Contractor may submit a proposal to combine the test of individual items with the system test if agreed by for review and acceptance of the Engineer.

15.16.2 Instrumented tests shall be carried out at train level both in tare and loaded condition, to establish designed performance of pneumatic/ regenerative braking. Similarly, emergency braking distance tests shall be carried out in tare and loaded condition under dry and wet rail conditions. Wheel Slide Protection system shall be tested under dry and wet rail conditions. The Contractor shall submit detailed Test Procedure for review by the Engineer.

15.16.3 The prototype train shall be used for carrying out emergency braking distance trials under tare and loaded conditions of the train.

15.17 Complete Brake System, Routine Tests



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

15.18 Propulsion System Type Tests

- 15.18.1 The Contractor shall, in addition to type tests carried out individually on all electrical equipment, in accordance with internationally accepted specifications, shall undertake combined propulsion, braking and TCMS test, using simulated loads on the traction motors. The testing shall reflect, as far as practicable, the layout of equipment on the car. Combined propulsion system testing shall be in accordance with IEC 61287-1 and IEC 61377.
- 15.18.2 Testing shall include simulated service operation, fault handling, including wheel slip/wheel slide control, braking and load weigh interfaces and abnormal operation and failure condition operation.

15.19 Auxiliary System Type Test

- 15.19.1 Testing shall be carried out to demonstrate the ability of the auxiliary power system to provide the required level of standby power under the normal and emergency conditions specified in Clause 9.4.

15.20 TCMS Type Test

- 15.20.1 The Contractor shall perform tests on the TCMS system to verify designed capacity of the systems, proper functioning, robustness, efficiency, ease of use and maintenance for the TCMS software, with reference to the design specification, correct interfaces as described in Chapter 10. The real interface hardware and software should be used where possible. All software parameters, as well as the functionality and reliability of its associated hardware shall be validated on-board a completed train. The test procedure shall be submitted for acceptance by the Engineer, prior to the commencement of the test.

15.21 Roof Mounted HVAC Package Unit Type Tests

- 15.21.1 The following tests shall be carried out at the manufacture's works or at a reputed testing laboratory on the prototype unit in the presence of the Engineer.
- (i) Refrigerant circuit leakage test (with nitrogen gas under pressure, before filling refrigerant), vacuum test, refrigerant gas charge quantity test and refrigerant gas (right quantity of refrigerant in HVAC unit) and refrigerant leakage tests (less than 3 gm/year leakage). Any leaks shall be corrected and the leakage tests repeated.
 - (ii) Dimensional and visual inspection, including weight test.
 - (iii) Measurements in Psychrometric Test Rooms

(a) Blower fan performance tests

- Fresh air, return air and supply air flow rates shall be measured for different fresh air damper openings. Static pressure developed by the blower fan at the outlet shall be recorded for different supply air flow rates. All supply air flow rate versus pressure graphs shall be plotted to demonstrate blower fan performance. Emergency air flow rate shall also be measured. These measurements may be made with only blower fan(s) working. The test room temperatures need not be controlled.
- Parameters to be measured
 - Fresh air, return air and supply air flow rates;
 - Condenser fans air flow rate;
 - Static pressure at blower outlet.
- Acceptance criteria
 - Supply airflow rate at blower fan outlet static pressure of 25 mm WG should be equal to or more than design supply airflow rate;
 - Design air flow rates should be achieved at different fresh air damper openings.

(b) Cooling and heating capacity tests



- These tests shall be conducted by adjusting static head at 25 mm WG at blower fan outlet. The tests shall be conducted as per ASHRAE 37 or IS 8148 or any other acceptable standard in the following conditions of hot and cold rooms when all compressors are working or in case of variable frequency control all compressors should be working at highest frequency:

Table 15.3: HVAC unit test Conditions

Test Condition	Ambient Condition	Car (Inside)
Dry summer condition	36°C 65% R.H.	25°C 60% R.H.
Monsoon Condition	32°C 85% R.H.	25°C 60% R.H.
High ambient	50°C	25°C 60% R.H.
Extreme ambient	58°C	25°C 60% R.H.
Low load	19°C, 60% R.H	25°C 60% R.H.
High humidity	27°C, 90% R.H	25°C 60% R.H.

All the above cooling tests shall be conducted for 3 hours in steady state conditions, except for extreme ambient test at 58°C, which will be conducted for 1 hour in steady state and low load test to be conducted for 4 hours in steady state. More tests can be added by Engineer.

Cooling capacity tests under summer & monsoon ambient conditions will have to be conducted to check COP as per ERTS clause 11.2.14 under all combinations of compressor's operation (i.e. different no. of compressors working & different operating frequency steps in case of variable frequency control pertaining to different loading conditions from AW0 to AW3.

- Parameters to be measured

- Temperatures and humidity at various locations of the HVAC, hot room and cold room;
- Fresh air, return air and supply air flow rates;
- Condenser fans air flow rate;
- Static pressure at blower outlet;
- Condensate water drainage rate;
- Refrigerant temperatures and pressures at different locations;
- Voltage, current and power factor of compressors, blower fan(s), condenser fans and heaters.

- Calculated values

- Cooling capacity from evaporator and condenser side;
- Power consumption in compressors, blower fan(s) and condenser fans;
- EER or COP;
- Heating capacity and power consumption in heaters.

- Acceptance criteria

- Design and ERTS specified cooling capacities and COP to be achieved;
- There should not be much difference in cooling capacities measured from evaporator side and condenser side;
- Air flow rates should not change during the tests;
- The HVAC unit should not trip/stop during the tests;
- HP and LP switches should not trip during the tests;
- Ice should not form over evaporator coils;
- Condensate drainage should be smooth, with no water accumulation in the drain pan;



- Condensed water should not be carried in the air stream to the heater coils, blower fan and supply air discharge plenum/duct/diffusers.
- (iv) Insulation Resistance Test
Insulation resistance tests under all weather conditions shall be undertaken on all equipment, using a IR tester suitable for the equipment as specified in the EN/IEC. The resistance reading shall in no case be less than 100MΩ.
- (v) Dielectric Test
The equipment shall withstand a high potential difference as specified in the EN/IEC .
- (vi) Voltage change test and frequency change test;
- (vii) Starting sequence test;
- (viii) External and internal smoke tests;
- (ix) HP and LP cut-out tripping test;
- (x) Thermal expansion valve superheat test;
- (xi) Fresh air damper and return air damper tests;
- (xii) Temperature probes test;
- (xiii) Rain/water tightness test;
- (xiv) PLC functional test and software testing;
- (xv) Acoustic test as per ISO 9614-2 and ISO 7626-5, or any other relevant standard;
- (xvi) Vibration and Shock Tests
These tests shall be done as per IEC 61373;
- (xvii) EMC Test
EMC test shall be carried out in accordance with EN 50121-3-2 on one unit;
- (xviii) Testing of Emergency Inverter
The Emergency Inverter unit shall be tested in accordance with IEC 61287, EN 55101 and IEC 61373;
- (xix) All rotating electrical machines shall be tested in accordance with IEC 60349-2: Electric Traction - Rotating Electrical Machines for Rail and Road Vehicles Part 2-Electronic Converter Fed Alternating Current Motors.

15.22 Complete Car HVAC System Type Tests

15.22.1 One car body equipped with all interior finish and all underframe mounted equipment, shall be tested to demonstrate the effectiveness of the equipment in meeting the specified temperature and humidity conditions inside the car. Complete car shall be tested in climate conditions as specified in the ERTS, EN 14750 or other relevant standards.

15.22.2 The extent of such tests shall be decided by the Engineer and shall include, as a minimum, the following:

- (i) **Air Distribution Tests**
 - (a) Air velocities and air flow rates shall be measured at all saloon supply air diffusers to ensure even distribution of air along the length of the car for each duct partition. Air velocities should not exceed ERTS and standards limits.
 - (b) Air velocities in side supply air ducts, at different saloon passenger areas, at return air and exhaust air grilles/ openings shall be measured to check that they do not exceed the ERTS

and standards limits.

(ii) **Air Flow Tests**

- (a) Air velocities and air flow rates will be measured at the fresh air inlets to the HVAC unit, exhaust air openings, inlets to cubicles and return air inlets for different fresh air damper openings for clean and clogged filters and evaporator coils. Emergency ventilation and any other special air flow requirement shall also be measured for verification. Interior static pressure shall be recorded for all conditions. Measured values should satisfy ERTS, relevant standards and design values.
- (b) Condenser fan inlet and outlet airflows shall be measured.

(iii) **Cooling performance test**

- (a) These tests shall be conducted inside a Climate Chamber for judging the cooling and heating performances of the HVAC system for Summer, Monsoon (for under tunnel ventilation), high ambient, low ambient, high humidity and any other ambient conditions as per EN 14750 or any other equivalent standard and Engineer's requirements. Heating and humidifying equipment shall be provided in the car for test purposes. Testing shall be done for different passenger loads for:
 - Pre-cooling (with full passenger occupancy heat load) - Set temperature should be achieved in 30 minutes.
 - Regulation (doors closed) - Cooling capacity of HVACs shall be sufficiently high to demonstrate 3 complete regulation cycles during the regulation test.
 - Doors open-close - It should be done for 10 cycles as per EN 14750, and/or for door open-close cycles for complete to-and-fro route run, as decided by the Engineer.

Any other test as required by the Engineer shall also be conducted.

- (b) Measurements of thermal conductivity (K factor) and cooling capacities shall also be done as per EN 14750-2.

(c) **Parameters to be Measured and Criteria**

- Recorded Parameters

Temperature, humidity, pressure, current, voltage, power etc. at various locations of the HVACs, test car, climate chamber and equipment used for creating the ambient and interior heat load conditions. Each parameter shall be recorded on a digital data logger.

- Acceptance Criteria

- (i) ERTS, relevant standards and design values should be achieved.
- (ii) In regulation tests, there should not be large variations in interior conditions.
- (iii) Pre-cooling timings should be less than 30 minutes.
- (iv) HVAC system should be able to quickly recover average interior temperature and humidity within the average doors closed interval and shall maintain this performance indefinitely, without degradation of interior conditions on long runs.

15.22.3 Fresh air flow rate shall also be verified by using dummy passengers as per full passenger load and measuring interior CO₂ levels with doors closed and doors open-close situation in all different types of cars.



15.22.4 TCMS-HVAC interface testing shall be done.

15.22.5 Any other vehicle level tests as deemed necessary by Engineer shall be conducted.

15.23 HVAC System Routine Tests

15.23.1 HVAC Unit Routine Tests (to be done on all units)

15.23.1.1 Dimensional & Visual inspection.

15.23.1.2 Refrigerant charging and leakage tests

- (i) Refrigerant circuit leakage test (with nitrogen under pressure),
- (ii) Vacuum test,
- (iii) Refrigerant gas charge,
- (iv) Refrigerant gas leaking tests (less than 3 gm/year leakage).

15.23.1.3 Electrical tests

- (i) Insulation resistance test
- (ii) High voltage test (Dielectric test)
- (iii) Presetting of thermal overload relay.

15.23.1.4 Functional and running tests (to check functioning of working parts and to measure some important performance parameters). These tests shall also include measurement of conditioned air-delivery, fresh air quantity and power consumption.

15.23.1.5 Rain/water tightness tests.

15.23.2 Complete Car HVAC System Routine Tests (to be done on all cars).

15.23.2.1 Preliminary checks and checks before ACU operation.

15.23.2.2 Checks under ACU operation conditions

- (i) System operation start,
- (ii) Airflow checks,
- (iii) Temperature checks,
- (iv) Failure checks using TCMS,
- (v) Emergency ventilation,
- (vi) Functioning of smoke detection units.

15.24 Emergency Operation

15.24.1 After delivery of two trains, the ability of one healthy train to rescue a disabled train in section as specified in Clause 3.23 shall be tested.

15.25 Noise and Vibration Verification

15.25.1 The Contractor shall perform noise and vibration type tests on complete 6-car trains to demonstrate compliance with Clause 2.18. All test procedures; data and results shall be submitted to the Engineer for acceptance.

15.26 Fire Performance Verification

15.26.1 Types tests according to the EN 45545 (part 1 to 7) shall be undertaken to establish fire ratings for all materials proposed. However, test certificates from any Testing Agency of international repute may be accepted in lieu by the Engineer at his sole discretion.

15.26.2 Fire Detection System Functional Tests

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The aim of these tests is to prove functionality and positioning of smoke and heat detectors in passenger areas and heat detectors/LHD in electric cabinets (enclosures/cubicles). The tests shall conform to the requirements of the ARGE Guideline (Part-1 for "Fire detection in Rolling Stock" and Part-3 for "System functionality fire detection & fire fighting in Rolling Stock") or any other applicable international standard.

Type tests shall be conducted for the following:

- (i) Dual Smoke and Heat detectors (multi-sensors),
- (ii) Heat Detectors,
- (iii) Linear Heat Detectors (LHD).

15.27 EMC Testing

15.27.1 The Contractor shall perform measurements to demonstrate EMC requirements specified in Clause 2.15 ERTS have been achieved. Demonstration of EMC compliance shall be considered a type test requirement.

15.28 Integrated Testing with Signalling and Train Control, and Telecommunications Contractors

15.28.1 Integrated testing of each car shall comply with the accepted international standards agreed between the Contractors as agreed with the Engineer. Integration testing shall be done at the rolling stock factory and main line to ensure satisfactory performance of all train control and telecommunications interfaces. The test certificate subsequently shall be issued jointly by the Rolling Stock, Signalling and Train Control and Telecommunications contractors.

15.28.2 In case of ATO, the Integration test between the Rolling Stock, and Signalling and Train Control contractors shall include tests on mainline to confirm the realisation of demanded acceleration and deceleration rate by the ATO under various conditions.

15.28.3 See Appendix TD for details.

15.29 Type Test Witness

No.	System /Subsystem Type tests
1.	Combined system tests
2.	Compression load test of carbody
3	Bogie incl. X factor
4	HVAC system test incl. FAI
5	Traction motor & gear case
6	Converter /inverter
7	Auxiliary converter
8	Brake system
9	Transformer
10	Doors incl. FAI
11	TCMS
12	Power Electronics



13	PIS & CCTV
14	Prototype train Inspection Hold Points (2) Final Prototype Inspection

15.30 Deliverables

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

S.No.	Clause No.	Tools/Equipment/Software	Quantity
1.	15.5.5	Software package required for analysis of the raw data acquired during oscillation trials.	One set at nominated depot.

Note:

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



APPENDIX TA. INTERNATIONAL STANDARDS**TA1 General**

TA1.1 Standards are set out in alphabetical order of the Standards Organization (in English) in tables TA1.1 to TA1.19. Many of the standards included in the listing are suggested as guidance only.

Table TA1.1: American Society for Testing and Materials Standards

Standard Organization	Standard Reference Number	Title or Description of the Standard
ASTM	A 480	Standard specification for general requirements for flat rolled stainless and heat resisting steel plates.
ASTM	B 280	Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
ASTM	B743	Standard Specification for Seamless Copper Tube in Coils.
ASTM	D 2563	Standard Practice for Classifying Visual Defects in Glass-Reinforced Plastic Laminate Parts1.

Table TA1.2: British Standards Institution

Standard Organization	Standard Reference Number	Title or Description of the Standard
BS	88	Cartridge Fuses for Voltages up to and including 1000V AC and 1500V DC.
BS	476-7	Flame Spread Requirements for Paint
BS	476-15 : 1993 ISO 5660-1 : 1993	Fire Test on Building Materials and Structures : Method of Measuring the Rate of Heat Release of Products.
BS	857:1990	Specification for Safety Glass for Land Transport.
BS	1571 : Pt. 2 1984	Methods for Simplified Acceptance Testing of Air Compressors and Exhausters : Part 2 : Simplified testing of reciprocating and rotating types, including permissible deviations pressure and temperature measurements and arrangement of tests, form of test report and gives adjustment of test result to guarantee conditions.
BS	1725 Pt. 1	Domestic furniture - Beds and mattresses - Safety requirements and test methods.
BS	3100:1991	Specification for Steel Castings for General Engineering Purposes. Chemical Composition Heat treatment and Mechanical Properties of Cast Steels.
BS	3682 Pt.1: 1994	Specification for Compressed Air Brake Hose.
BS	3900:1980	Methods of Test for Paint.
BS	4066	Cable Tests in Fire Conditions.
BS	4360 :	Steel Used in Welded Structures.
BS	4579: Pt.1 1988	Compression Joints in Copper Conductors. Covers requirements for the performance of general application compression joints for use with copper and copper alloy conductors up to 1000mm ² cross sectional area operating below 85°C.
BS	4743	Specification for Safety Requirements for Electronic Measurement Apparatus.



BS	4870	Specification for Approval Testing of Welding Procedures.
BS	4870 : Pt.3 1985	Arc Welding of Tube to Tube-Plate Joints in Metallic Materials. Welding procedure tests, approval & its extent, test joints, examination and testing, results.
BS	4870 : Pt.4 1988	Specification for Automatic Fusion Welding of Metallic Materials including Welding Operator Approval. Approval testing of procedures, programmes, systems, and operators for automatic or robotic welding. Items in welding procedure test, changes affecting approval, extent of approval, examination and testing.
BS	5135:1984	Specification of Arc Welding of Carbon and Carbon Manganese Steels. Parent metals, welding consumables, butt and fillet weld details, preparation and assembly, procedures to avoid cracking, welding procedure details, approval of welders, inspection and testing. Appendices on design, typical weld details, avoidance of hydrogen cracking, solidification cracking, lamellar tearing and guidance on acceptance levels.
BS	6656	Prevention of inadvertent ignition of flammable atmospheres by radio frequency radiation
BS	7371 Pt. 10 : 1994	Specification for Organic Coatings (The Deltaseal Process)

Table TA1.3: British Standards Institution/Euro Normes

Standard Organisation	Standard Reference Number	Title or Description of the Standard
BS-EN	3	Portable Fire Extinguishers.
BS-EN	286-3:1995	Simple Pressure Vessels designed for Air Braking and Auxiliary Pneumatic Equip-ment for Railway Rolling Stock.
BS-EN	286-4:1995	Simple Unfired Pressure Vessels Designed to Contain Air or Nitrogen. Aluminium Alloy Pressure Vessels for Air Braking Equipment and Auxiliary Equipment for Rolling Stock.
BS-EN	287-1 : 1992	Specification of Approval Testing of Welders Working to Approved Welding Procedures : Pt. 1 Fusion Welding of Steel.
BS-EN	288-3 : 1993	Fusion Welding of Steel
BS-EN	10025	Hot Rolled Products of Non-Alloy Structural Steels. Technical delivery conditions. Requirements for long and flat products.
BS-EN	10210	Hot Finished Structural Hollow Sections of Non-Alloy and Finer Grain Structural Steels.
BS-EN	24014 : 1992	Hexagon Head Bolts. Product grades A, B.
BS-EN	24017 : 1992	Hexagon Head Machine Screws. Product grades A and B.
BS-EN	30042 : 1994	Arc Welded Joints in Aluminium and its Weldable Alloys. Guidance on quality levels for imperfections.
BS-EN	50081	Electromagnetic Compatibility. Generic emission standard.
BS-EN	60529 :1992	Specification for Degrees of Protection Provided by Enclosures (IP Code). Gives

		uniformity in methods of describing protection provided by enclosures and in tests to prove protection. Provides an optional extension of the IP code by an additional letter A – D, if the actual protection of persons against access to hazardous parts is higher than that indicated by the first characteristic numeral.
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Table TA1.4: CISPR

Standard Organisation	Standard Number	Reference	Title or Description of the Standard
CISPR	16 am1 (1997-08)		Specification for Radio Disturbance and Immunity Measuring Apparatus and Methods : 1 Radio Disturbance and Immunity Measuring Apparatus

Table TA1.5: Defence Standards

Standard Organisation	Standard Number	Reference	Title or Description of the Standard
DEF-STD-	00-56		Hazard Analysis

Table TA1.6: German Standards / Deutsches Institut für Normung

Standard Organisation	Standard Number	Reference	Title or Description of the Standard
DIN	2353	1998	Compression fittings and couplings

Table TA1.7: Euro Normes

Standard Organisation	Standard Number	Reference	Title or Description of the Standard
EN	438-2		High-pressure decorative laminates (HPL) - Sheets based on thermosetting resins (Usually called Laminates) - Part 2: Determination of properties
EN	779		Particulate air filters for general ventilation - Determination of the filtration performance
ECE	Regulations-43		Uniform provisions concerning the Approval of safety glazing and glazing materials
EN	10089		Hot rolled steels for quenched and tempered springs - Technical delivery conditions
EN	10155		Structural Steels with improved atmospheric Corrosion
EN	12663		Railway applications Structural requirements of railway vehicle bodies
EN	13103		Railway applications – Wheelsets and bogies Non-powered axles – Design method
EN	13104		Railway applications – Wheelsets and bogies Powered axles – Design method
EN	13261		Railway applications –Wheelsets and bogies Axles – Product requirements
EN	13262		Railway applications - Wheelsets and bogies - Wheels - Product requirements
EN	13272		Electrical Lighting in Rolling Stock
EN	13452		Railway applications - Braking - Mass transit brake systems
EN	13452-1		Railway applications - Braking - Mass transit brake systems : Performance Requirements.



EN	13749	Railway applications - Wheelsets and bogies method of specifying the structural requirements of bogie frames
EN	14363	Railway applications. Testing and Simulation for the acceptance of running characteristics of railway vehicles. Running Behaviour and stationary tests
EN	14750-1	Railway applications - Air conditioning for urban and suburban rolling stock Part 1: Comfort parameters
EN	14750-2	Railway applications - Air conditioning for urban and suburban rolling stock Part 2: Type tests
EN	14750:2005	Railway applications - Bodyside entrance systems
EN	14752:2015	Railway applications - Bodyside entrance systems for Rolling Stock.
EN	15152	Railway applications- Front windscreens for train cabs.
EN	15227	Railway applications - Crashworthiness requirements for railway vehicle bodies.
EN	45545 Part 1 to 7 (Category 4-A, Hazard level HL3) latest edition	Railway applications – Fire protection on railway vehicles – Part 1-7.
EN	50082	EMC
ENV	50121	Railway Application – Electro-Magnetic Compatibility – Rolling Stock
EN	50121-1 : 1996	Railway Application – Electro-Magnetic Compatibility Part 1. General
ENV (DD)	50121-2 : 1996	Railway Application – Electro-Magnetic Compatibility Part 2. Emission of the Whole Railway System to the Outside World.
EN	50121-3	Railway Application – Electro-Magnetic Compatibility – Rolling Stock
EN	50122-1	Railway Applications - fixed installations - part 1_protective provisions relatingto electrical safety and earthing
EN	50264	Railway Application- Railway Rolling Stock cables having special fire performance
EN	50126	Railway Application – Specification and Demonstration of RAMS
EN V	50121-3-1	Railway Application – Electro-Magnetic Compatibility – Rolling Stock Pt. 3-1 : Train and Complete Vehicle. traction stock, train sets and independent hauled stock. Covers the frequency range DC to 400GHz.
EN	50121-3-2	Railway Application – Electro-Magnetic Compatibility – Pt. 3-2 : Rolling Stock Apparatus. Specifies emission and immunity requirements for electrical and electronic apparatus for use on rolling stock. Covers the frequency range DC to 400GHz.
EN	50124-1	Electrical Enclosures
EN	50124-2	Railway applications- Insulation Coordination- Part 2: Overvoltages and related protection
EN	50126-2	Railway Applications – Dependability for Guided Transport System - Pt. 2 : Safety
EN	50128	Railway Applications : Software for Railway Control and Protection Systems



EN	50129	Safety Related Electronic Railway Control and Protection Systems
EN	50132-7	Alarm systems - CCTV surveillance systems for use in security applications - Part 7: Application guidelines.
EN	50155	Railway Application - Electronic equipment used on Rolling stock.
EN	50163	Lightning Arrestors.
EN	50200-PH-15	Fire Resistant Cables
EN	50200-PH-90	Fire resistant LSZH cables
EN	50207	Power Converters for Rolling Stock
EN	50264 1 to 3	Railway Applications - Railway Rolling Stock Power and Control Cables having special fire performance.
EN	50306 Part 1 to 4	Railway Rolling Stock cables having special fire performance.
EN	50388	Railway Applications. Power supply and rolling stock. Technical criteria for the coordination between power supply (substation) and rolling stock to achieve interoperability.
EN	50405	Railway applications - Current collection systems - Pantographs, testing methods for carbon contact strips.
EN	50533	Railway applications - Three-phase train line voltage characteristics.
EN	50547	Railway applications. Batteries for auxiliary power supply systems.
EN	55011	Industrial, scientific and medical equipment radio-frequency equipment – disturbance characteristics – limits and methods of measurement.
EN	55101	Immunity of information Technology Equipment.
EN ISO	2813	Determination of specular gloss of non-metallic paint films.

Table TA1.8: International Electro-technical Commission

IEC	815	Guide for the selection of insulators in respect of polluted conditions.
IEC	1133	Electric traction-Rolling stock-Test methods for electric and thermal/electric rolling stock on completion of construction and before entry into service.
IEC	300-3-3	Dependability management – Part 3: Application guide Section 3: Life Cycle costing.
IEC	60034-1 : (1996-12) 60034-1 : am1 (1997-06)	Rotating Auxiliary Machines : Pt. 1 Rating and Performance Amendment No.1
IEC	60034-7	Rotating Auxiliary Machines : Pt. 7 Rating and Performance.
IEC	60044	Instrument transformers.
IEC	60044-1	Instrument transformers - Part 1 Current transformers.
IEC	60044-2	Instrument transformers- Part 2- Inductive voltage transformers.
IEC	60056 (1987-03) 60056 am3 (1996-10)	High Voltage Alternating Current Circuit Breakers Amendment No.3



IEC	60068-2	Environmental Testing.
IEC	60076	Power Transformers.
IEC	60077 (1968-01)	Specification for Electric Traction Equipment. Motive power units of 600-3000V DC or high-voltage AC or independent power source, also for control trailers or multiple unit trains. Can be applied to DC rolling stock at voltages below 600V.
IEC	60077-1	Railway applications-Electric equipment for rolling stock- Part1 – General service conditions and general rules.
IEC	60077-2	Railway applications-Electric equipment for rolling stock-Part 2 - Electrotechnical components-General rules.
IEC	60077-4	Railway applications- Electric equipment for Rolling Stock Part 4: Electrotechnical components Rules for AC circuit breakers
IEC	60099-4 (1991-11)	Surge Arrestors – Pt.4 Metal Oxide, without Gaps for AC Systems.
IEC	60115-1	Smaller Resistors.
IEC	60228	Cables.
IEC	60268-1 (1985-01) 60268-1 60268-1 (1988-01)	Sound System Equipment : Pt. 1 General. Amendment 1 Amendment 1
IEC	60268-16 Part 16	The Objective Rating of Speech Intelligibility in Auditoria by the "RASTI" Method
IEC	60269-1 1998-12	Low Voltage Fuses Pt. 1 : General Requirements.
IEC	60269-2 am1 (1995-11)	Low Voltage Fuses Pt. 2 : Supplementary Requirements for Fuses for Use by Authorised Persons (Fuses mainly for Industrial Applications).
IEC	60300-1 (1993-04)	Dependability Management – Pt. 1 Dependability Programme Management.
IEC	60300-2 (1995-12)	Dependability Management – Pt. 2 Dependability Programme Elements and Tasks.
IEC	60300-3-1 (1991-11)	Dependability Management – Pt. 3 Application Guide Sct. 1 Analysis Techniques for Dependability. Guide on Methodology
IEC	60300-3-2 (1993-10)	Dependability Management – Pt. 3 Application Guide Sct. 2 Collection of Dependability Data from the Field.
IEC	60300-3-3 (1996-09)	Dependability Management – Pt. 3 Application Guide Sct. 3 Life Cycle Costing.
IEC	60300-3-5	Dependability management – Part 3-5: Application guide – Reliability test conditions and statistical test principles.
IEC	60310 1991-11)	Traction Transformers and Inductors.
IEC	60319 1978-01	Presentation of Reliability Data on Electronic Components (or Parts).
IEC	60322	Railway applications -Electric equipment for rolling stock - Rules for power resistors of open construction.
IEC	60326-3 : 1991 BS 6221 : Pt.3 : 1991	Guide for the design and use of printed wiring boards. Design and application of printed boards, irrespective of their method of manufacture.



		Recommends design, specification, and application.
IEC	60332-1 1993-04	Tests on Electric Cables under Fire Conditions – Pt.1 : Test on a Single Vertical Insulated Wire or Cable
IEC	60332-3 1992-03	Tests on Electric Cables under Fire Conditions – Pt.3 : Tests on Bunched Wires or Cables.
IEC	60349 1991-12	Electric Traction. Rotating Electrical Machines for Rail and Road Vehicles.
IEC	60349-1	Electric Traction – Rotating Electrical Machines for Rail and Road Cars.
IEC	60349-2 1993-04	Electric Traction – Rotating Electrical Machines for Rail and Road Vehicles Pt. 2 Electronic Converter-fed AC Motors.
IEC/TR2	60349-3 1995-08	Electric Traction – Rotating Electrical Machines for Rail and Road Vehicles Pt. 3 Determination of the Total Losses of Converter-fed Alternating Current Motors by Summation of the Component Losses.
IEC	60384-1	Electrolytic Capacitors.
IEC	60384-4	Electrolytic Capacitors.
IEC/TR	60411-2 (1978-01)	Power Convertors for Electric Traction Pt. 2 Additional Technical Information.
IEC	60494 1974-01	Rules for Pantographs of Electric Rolling Stock.
IEC	60494-2	Railway applications - Rolling stock - Pantographs Characteristic and tests -Part 2: Pantographs for metros and light rail vehicles.
IEC	60502	High Voltage Cables.
IEC/TR	60505 1975-01	Guide for the Evaluation and Identification of Insulation Systems of Electrical Equipment.
IEC	60529	IP Codes, etc.
IEC	60563	Permissible Limiting Temperatures in Service for Components of Electrical Equipment of Traction Vehicles.
IEC	60571 Latest version	Electronic Equipment Used on Rail Vehicles.
IEC	60571-1	Electronic Equipment Used on Rail Vehicles.
IEC	60571-2	Electronic Equipment Used on Rail Vehicles.
IEC	60571-3	Electronic Equipment Used on Rail Vehicles.
IEC	60605	Reliability and maintainability Requirements in Equipment.
IEC	60617	Graphical Symbols For Diagrams.
IEC	60617-1 (1985-01)	Graphical Symbols For Diagrams : Pt. 1 General Information, General Index. Cross Reference Tables.
IEC	60617-2 (1996-05)	Graphical Symbols For Diagrams : Pt. 2 Symbol Elements, Qualifying Symbols and Other Symbols Having General Application.
IEC	60617-3 (1996-05)	Graphical Symbols For Diagrams : Pt. 3 Conductors and Connecting Devices.
IEC	60617-4 (1996-06)	Graphical Symbols For Diagrams : Pt. 4 Passive Components.
IEC	60617-5 (1996-06)	Graphical Symbols For Diagrams : Pt. 5 Semiconductors and Electron Tubes.
IEC	60617-6 (1996-05)	Graphical Symbols For Diagrams : Pt. 6 Production & Conversion of Electrical Energy.
IEC	60617-7 (1996-05)	Graphical Symbols For Diagrams : Pt. 7 Switch gear, Control gear, and Protective Devices.



IEC	60617-8 (1996-05)	Graphical Symbols For Diagrams : Pt. 8 Measuring Instruments, Lamps and Signalling Devices.
IEC	60617-9 (1996-05)	Graphical Symbols For Diagrams : Pt. 9 Telecommunications Switching & Peripheral Equipment.
IEC	60617-10 (1996-05)	Graphical Symbols For Diagrams : Pt. 10 Telecommunications Transmission.
IEC	60617-11	Graphical symbols for diagrams - Part 11: Architectural and topographical installation plans and diagrams.
IEC	60617-12	Graphical symbols for diagrams - Part 12: Binary logic elements.
IEC	60617-13	Graphical symbols for diagrams - Part 13: Analogue elements.
IEC	60623 1990-03 60623 am1 1992-04	Vented Nickel Cadmium Prismatic Rechargeable Single Cells. Amendment No. 1
	60623 am2 1992-07	Amendment No. 2
IEC	60631	Electro-dynamic Braking.
IEC	60664	Surface Creepage and Electrical Clearance.
IEC	60721	Classification of environmental Conditions - Part 1 : Environmental parameters and their severities.
IEC	60747-6	Electrical Type Test.
IEC	60749	Mechanical and Climatic Test Methods.
IEC	60754-1 1994-01	Tests on Gases Evolved During Combustion of Materials from Cables Pt. 1 : Determination of Amount of Halogen Acid Gas.
IEC	60754-2 1991-08	Tests on Gases Evolved During Combustion of Materials from Cables Pt. 2 : Determination of Amount of Halogen Acid Gas.
	60754-2 1997-04	Amendment No. 1
IEC	60850 (1988-03)	Supply Voltages for Traction Systems.
IEC	60871-1 (1997-10)	Shunt Capacitor for AC Power Systems having a Rated Voltage above 1000V – Pt. 1 General Performance, Testing and Rating – Safety Requirements – Guide for Installation and Operation.
IEC	60913 (1988-12)	Electric Traction Overhead Lines.
IEC	60947-1 (1998-11)	Low Voltage Switch Gear and Control Gear Pt.1 General Rules.
IEC	60947-2 (1998-03)	Low Voltage Switch Gear and Control Gear Pt.2 Circuit Breakers.
IEC	60947-3	Circuit Breakers
IEC	60947-4	Circuit Breakers
IEC	60993 (1989-08)	Electrolyte for Vented Nickel-Cadmium Cells.
IEC/TR3	61000-1-1 (1992-05)	Electro-magnetic Compatibility EMC Pt. 1 : General
IEC	61000-3-6	Electromagnetic Compatibility (EMC) - Part 3-6: Limits - Assessment of emission limits for the connection of distorting installations to MV, HV and EHV power systems.
IEC	61000-4-2 (1995-01)	Testing and Measurement Techniques Pt. 4, Sct. 2 : Electrostatic Discharge Immunity Test.



	61000-4-2 am1(1998-01)	Amendment No. 1
IEC	61000-4-3 (1995-03) 61000-4-3 am1(98-06)	Testing and Measurement Techniques Pt.4 Sct 3 : Radiated Radio Frequency Electromagnetic Field Immunity Tests. Amendment No. 1
IEC	61000-4-4 (1995-01)	Testing and Measurement Techniques Pt.4 Sct. 4 : Electrical Fast Transient/Burst Immunity Test.
IEC	61000-4-5 (1995-03)	Testing and Measurement Techniques Pt.4 Sct. 5 : Surge Immunity Test.
IEC	61000-4-6 (1996-04)	Testing and Measurement Techniques Pt.4 Sct. 6 : Immunity to Conducted Disturbances Induced by Radio Frequency Fields.
IEC	61000-4-8 (1993-06)	Testing and Measurement Techniques Pt.4 Sct.8 : Power Frequency Magnetic Field Immunity Test.
IEC	61000-4-9 (1993-06)	Testing and Measurement Techniques Pt.4 Sct. 9 : Pulse Magnetic Field Immunity Test.
IEC	61000-4-10 (1993-06)	Testing and Measurement Techniques Pt.4 Sct. 10 : Damping Oscillatory Magnetic Field Immunity Test.
IEC	61000-4-11 (1993-06)	Testing and Measurement Techniques Pt.4 Sct. 11: Voltage Dips, Short Interruptions and Voltage Variations Immunity Test.
IEC	61000-4-12 (1993-06)	Testing and Measurement Techniques Pt.4 Sct. 12 : Oscillatory Waves Immunity Test.
IEC	61000-5-1 (1996-12)	EMC Pt. 5 :Installation and Mitigation Guidelines Sct. 1 General Considerations.
IEC	61000-5-2 (1996-12)	EMC Pt. 5 :Installation and Mitigation Guidelines Sct. 2 Earthing and Cabling.
IEC	61034	Cables.
IEC	61071-1	Power Electronic Capacitors.
IEC	61131	Programmable controllers.
IEC	61133 (1992-11)	Electric Traction – Rolling Stock – Test Methods for Electric and Thermal/ Electric Rolling Stock on Completion of Construction and Before Entry into Service.
IEC	61287-1 (1995-07)	Power Converters Installed on Board Rolling Stock – Part 1 Characteristics and Test Methods.
IEC	61287-2 Latest version	Power convertors installed on board railway rolling stock – Part 2: Additional technical information.
IEC	61371	Shocks and vibrations standards.
IEC	61373	Requirements for Vibration and Shock Testing of Equipment for Railway Cars.
IEC	61375-1	Electronic railway equipment - Train Communication Network - Part 1: TCN Communication Network General Architecture.
IEC	61375-2-5	Electronic railway equipment - Train Communication Network - Part 2 - 5: ETB - Ethernet Train Backbone.
IEC	61375-3-4:2014	Electrical equipment and systems for railways.
IEC	61377 (1996-05)	Electric Traction – Rolling Stock –Combined Testing of Inverter Fed Alternating Current Motors and their Control.
IEC	61508-1 1998-12	Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems : Part 1. General Requirements.
IEC	61508-3 1998-12	Functional Safety of Electrical/Electronic/Programmable Electronic



		Safety-Related Systems : Part 3. Software Requirements.
IEC	61881	Power Electronic Capacitors used on Rolling Stock.
IEC	62313	Railway applications - Power supply and rolling stock - Technical criteria for the coordination between power supply (substation) and rolling stock.
IEC	62290-1 (2006)	Railway applications –Urban guided transport management and command/control systems – Part 1: System principles and fundamental concepts.

Table TA1.9: Institution of Electrical and Electronics Engineers

Standard Organisation	Standard Reference Number	Title or Description of the Standard
IEEE	16	Standard for Electrical and Electronic Control Apparatus on Rail Vehicles.
IEEE	1474.1	Communications-Based Train Control (CBTC) Performance and Functional Requirements.
IEEE	304	Thermal Endurance of Insulation.
IEEE	429	Sealing Against Moisture.
IEEE	519 – 1992, 2014	IEEE Recommended Practice and Requirements for Harmonic Control in Electrical Power Systems.

Table TA1.10: Indian Railways Standards

Standard Organisation	Standard Reference Number	Title or Description of the Standard
IRS	R16	Unpowered Axles for Broad Gauge Vehicles.
IRS	R19	Wheels for Broad Gauge Vehicles.
IRS	R43	Powered Axles for Broad Gauge Vehicles.

Table TA1.11: Indian Standard

Standard Organisation	Standard Reference Number	Title or Description of the Standard
IS	2553 (Part 1 & 2)	Safety Glass - Specification Part 1: General Purpose Part 2 : For Road Transport
IS	8148	Packaged air conditioners - specification.

Table TA1.12: International Standards Organisation

Standard Organisation	Standard Reference Number	Title or Description of the Standard
ISO	281/1	Steel for Railway Wheels.
ISO	1553	Methods of the Determination of Copper, Lead, Iron, Aluminium and Nickel in Copper Alloys.
ISO	1554	
ISO	1810	
ISO	1217:1996	Displacement compressors - Acceptance Tests.
ISO	2439	Flexible cellular polymeric materials – Determination of hardness(indentation technique).
ISO	2553	Welding & allied processes- Symbolic representation on drawings- Welded joints

ISO	2631 -1(1997)	Mechanical Vibration and Shock – Evaluation of Human Exposure to Whole Body Vibration
ISO	2631-4(2001)	Mechanical vibration and shock- Evaluation of human exposure to whole- body vibration- Part 4: Guidelines for the evaluation of the effects of vibration and rotational motion on passenger and crew comfort in fixed- guideway transport systems.
ISO	3095	Acoustics – Measurement of Noise Emitted by Railbound Vehicles 1 st . Edition.
ISO	3381	Acoustics – Measurement of Noise Inside Railbound Vehicles 1 st Edition.
ISO	4649	Rubber, vulcanized or thermoplastic- Determination of Abrasion resistance using a rotating cylindrical drum device
ISO	7626-5	Vibration and shock - Experimental determination of mechanical mobility.
ISO	8573	Compressed air quality standard.

Table TA1.13: International Standards Organisation

Standard Organisation	Standard Reference Number	Title or Description of the Standard
ISO	9000	Design Management and Control. Quality Systems : Model for Quality Assurance in Design, Development, Production, Installation and Servicing .
ISO	9001	
ISO	9002	
ISO	9614-2	Acoustics - determination of sound power levels of noise sources using sound intensity - part 3_ precision method for measurement by scanning.
ISO	9662	Information Processing – Volume and File Structure of CD-ROM for Information Exchange.

Table TA1.14: Japan Industrial Standards

Standard Organisation	Standard Reference Number	Title or Description of the Standard
JIS	G 3114	Hot rolled atmospheric corrosion resisting steels for welded structure.
JIS	G 3459	Stainless steel pipes.
JIS	G 4305	Cold rolled stainless steel plates, sheets and strip 50126.

Table TA1.15: Military Standards

Standard Organisation	Standard Reference Number	Title or Description of the Standard
MIL-HDBK-	454 (1)	General Guidelines for Electronic Equipment.
MIL-I-	46058	Insulating Compound (for Coating Printed Circuit Assemblies).
MIL-STD-	882 C	Hazard Analysis.
MIL-STD-	883 E (1)	Test Methods Standard Microcircuits.
MIL-STD-	889 B (3)	Dissimilar Metals.

Table TA1.16: French Standards (Normes Françaises)

Standard Organisation	Standard Reference Number	Title or Description of the Standard
NF-F	31-112	Railway Rolling Stock – Protection in Relation to Graffiti – Tests Procedures and Methods of Valuation, Behaviour of Materials and Products of Expulsion



NF-F	31-119	Behavior of seats at static, fatigue, vibrations and impact stresses
NF-F	01-281	Fibre reinforced thermosetting plastics
NF-F	63-808	Halogen Free Cables for Low Voltage Applications
NF-F	63-826	Halogen Free Cables for High Voltage Applications
NF	T51-113	Plastic Materials Determination of Resistance to Scratching

Table TA1.17: Research and Study Organisation (ORE)

Standard Organisation	Standard Reference Number	Title or Description of the Standard
ORE	C116/RP8	DB WZ Ride Index : Frequency Weighting Curves

Table TA1.18: International Railway Union

Standard Organisation	Standard Reference Number	Title or Description of the Standard
UIC	410 O	Composition and Calculation of the Weight and Braking of Passenger Trains
UIC	510-2 OR	Trailing stock: wheels and wheelsets. Conditions concerning the use of wheels of various diameters
UIC	515 OR	Passenger rolling stock trailer bogies - running gear
UIC	515-3 OR	Rolling Stock – Bogies – Running gear – Axle design calculation method
UIC	515-4 O	Passenger Rolling Stock – Trailer bogies – Running gear – Axle design calculation method
UIC	518 OR	Testing and Approval of railway Vehicles from the Point of View of their Dynamic Behaviour, Safety, Track fatigue and Ride Quality.
UIC	534 OR	Signal lamps and signal lamp brackets for locomotives, railcars and all tractive and self propelled stock.
UIC	541	Brakes – All UIC 541 Standards
UIC	541-5 OR	Brakes – Electropneumatic brakes for passenger trains and freight trains.
UIC	541-6 OR	Brakes – Electropneumatic brakes test programmes for passenger trains and freight trains.
UIC	555 OR	Electric lighting in passenger rolling stock.
UIC	555-1 OR	Transistorised inverters for supplying fluorescent lamps (1).
UIC	560 OR	Doors of coaches and luggage vans.
UIC	564-2 OR	Regulations Relating to Fire Protection and Fire Fighting Measures in Passenger Carrying Railway Vehicles.
UIC	566 OR	Loadings of coach bodies and their components.
UIC	615 OR	Tractive units-Bogies and running gear.
UIC	615-1 OR	Tractive units – Bogies and running gear – General conditions applicable to component parts.
UIC	615-4 OR	Motive power units - Bogies and running gear – Bogie frame structure strength test



UIC	651	Layout of driver's cabs in locomotives, railcars, multiple unit trains and driving trailers.
UIC	811-1 OR	Technical Specification for the Supply of Axles for Tractive and Trailing Stock
UIC	812-2 OR	Solid Wheels for Tractive and Trailing Stock Tolerances (1).
UIC	812-3	Technical Specification for the Supply of Solid Wheels for Trailing Stock.
UIC	813 O	Technical Specification for the Supply of Wheelsets for Tractive and Trailing Stock : Tolerances and Assembly.
UIC	861-3	Standard 60 kg/m rail profiles.
UIC	S1002	Standardization of wheel profile.

Table TA1.19: Miscellaneous

Standard Organisation	Standard Reference Number	Title or Description of the Standard
ASHRAE	37	Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment.
ASHRAE	55	Thermal environmental conditions for human occupancy.
ASHRAE	62	Ventilation for Acceptable Indoor Air Quality.
ASHRAE Hndbook Fundamentals		
ARGE Guidelines		Fire detection in rolling stock.
ANSI/AMCA	204	Balance Quality and Vibration Levels for Fans.
ANSI	B 31.5	Refrigeration Piping and Heat Transfer Components.
Railway Group Standard	GM/RT 2130	Vehicle Fire, Safety and Evacuation.
Railway Group Standard	GM/RT 2472:2002	Requirements for Data Recorders on Trains.

1. All sub-systems including major equipment, assemblies and complete car/train must comply with the latest international standards.
2. The above list is for guidance only. Wherever update standard is released, the same shall be applicable.
3. The Contractor shall provide the relevant Standard in soft copy to DMRC for reference.

