

INTEGRAL COACH FACTORY, CHENNAI- 600 038					
SPECIFICATIONS AND STANDARDS FOR DEVELOPMENT OF NEW GENERATION ENERGY EFFICIENT TRAIN WITH DISTRIBUTED POWER SYSTEM (LIGHT WEIGHT STAINLESS STEEL BODIES CARS)				ICF/MD/SPEC- 447	
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1.**Abbreviations**

The following abbreviations are used in these Specifications and Standards:

Abbreviation	Full Name
AAR	Association of American Railroad
AC	Alternating Current
AF	Audio Frequency
ASHRAE	American Society of Heating, Refrigeration and Air-conditioning Engineers
ADD	Automatic Dropping Device
ATP	Automatic Train Protection
BP	Brake Pipe
BPAC	Block proving by Axle Counter
BS	British Standards
CBC	Centre Buffer Coupler
DC	Direct Current
EER	Energy Efficiency Ratio
EMC	Electro-magnetic Compatibility
EMI	Electro-magnetic Interference
ATP	Automatic Train Protection
EN	Euro Norm (European Standard)
EMU	Electrical Multiple Unit
EP	Electro Pneumatic
ETCS	European Train Control System
FEM	Finite Element Method
GPS	Global Positioning System
GSM	Global System for Mobile
GSM-R	Global System for Mobile – Railways
HT	High Tension (Voltage) (according to Indian Electricity Rules)
HMI	Human Machine Interface
IC	Integrated Circuit
IEC	International Electro technical Commission
IER	Indian Electricity Rules
IEEE	Institution of Electrical and Electronic Engineers
IGBT	Insulated Gate Bipolar Transistor
IR	Indian Railways

Abbreviation	Full Name
IRS	Indian Railway Standards
IS	Indian Standard
ISO	International Standards Organization
Kmph	Kilometers per hour
LED	Light Emitting Diode
LTE	Long Term Evolution
MAHSR	Mumbai-Ahmedabad High Speed Rail
MCB	Miniature Circuit Breaker
MMD	Maximum Moving Dimension
MR	Main Reservoir
NF	Norme Française (French Standard)
OCC	Operations Control Center
OEM	Original Equipment Manufacturer
OHE	Over Head Equipment
ORD	Over Reach Detection
ORE	Office for Research and Experiments
PA	Public Address
PCB	Printed Circuit Board
PIS	Public Information System
PWD	Persons with Disabilities
RAMS	Reliability, Availability, Maintainability and Safety
RDSO	Research Designs & Standards Organization, Manak Nagar Lucknow -226011
SG	Standard Gauge
SI	Système Internationale
SIL	Safety Integrity level
TCMS	Train Control and Management System
UHF	Ultra High Frequency
UIC	Union Internationale des Chemins de Fer (International Union of Railways)
UL	Underwriters Laboratories
VHF	Very High Frequency
VCU	Vehicle Control Unit
VVVF	Variable Voltage Variable Frequency
VCD	Vigilance Control Device

Abbreviation	Full Name
WC	Water Closet (i.e. a flush toilet)

2. Definitions and Interpretation

This Specifications and Standards for light weight stainless steel bodied coaches with distributed power system (the “Schedule”), the following words and expressions shall, unless repugnant to the context or meaning thereof, have the meaning hereinafter respectively assigned to them:

Term	Definition
Accounting Year	Shall mean a year from commencement of the service trial and subsequent years thereof, counted from the end of the previous Accounting Year, except in case when the Reliability or Availability target for an Accounting Year is not met. In such case, the Accounting Year shall be considered by incrementing a rolling window of 3 months till the targets are achieved
Available Hours	With respect to any period shall mean the duration in hours during such period minus Non-Available Hours during such period
Availability	Shall have meaning as defined in Clause 3.3.2
Nominated Agency	Agency Nominated by Purchaser for the purpose of carrying out Design approvals, Tests, Trials etc. required as per the agreement. Such agency will act on behalf of purchaser and guide purchaser.
Basic Unit	Shall mean a composite unit of two or more Cars comprising of Motor and Trailer Car
Car	Shall mean a passenger carrying rail vehicle, either powered or non-powered, built in conformity with the provisions of these Specifications and Standards
Driving Cab	Shall mean a cabin, segregated from the passenger area, and situated at both the ends of a Train, and includes the equipment and Sub-systems to operate the Train.
Driving Car	Shall mean a Car having Driving Cab and positioned at either end of the Train
Failure	shall mean any detention in the service of the Train causing more than or equal to 10 minutes' delay; or withdrawal of the Train from the service due to break down of the Train.
Fleet	Shall mean all the Trains collectively available for service in an Accounting Year.
Fleet-hour	Fleet-hour in any period shall mean sum total of Train-hours for each Trains in the Fleet during such period
Human Machine Interface (HMI)	Shall mean the interface between the system or equipment and the human interfacing with that equipment
IP or Ingress Protection	Shall mean the degree of protection provided by enclosures in accordance with IEC 60529
Kavach	Indian Railways Train Collision and Avoidance System to RDSO Specification No. RDSO/SPN/196/2012 Version 3.2 date effective from 17.05.2017 with latest amendments.
Maintenance Depot	Shall mean the depots of MAHSR railway network at Surat depot and Sabarmati depot.
Nominated Agency	Shall mean NHSRCL and its representatives including an ISA (if any) deployed by NHSRCL.
Non-Available Hours	Shall mean the following: (a) duration of schedule maintenance including depot cleaning i.e., the period between entry of the Train at depot or workshop and the time when it is declared as available for the service; and (b) in the case of unscheduled maintenance arising out of Failures in the Train, i.e., the period between the time of occurrence of an event that renders the Train unfit or unavailable for the service and the time when it is declared available for the service.
Purchaser	Shall mean Integral Coach Factory (ICF), Chennai, Indian Railways.

Term	Definition
Rail Level	Shall mean the plane which passes through the top of the cross-sectional center line of both running rails
Reliability	Shall have meaning as defined in Clause 3.3.1.
Rolling Stock	Shall refer to the fleet of rail borne cars with flanged wheels designed to operate on guiding rails, for carrying passengers. The words “Rolling Stock” and “Trains” as used in this Specifications and Standards are interchangeable;
SG	Shall mean 1435 mm standard gauge.
Sub-system	shall mean and include all equipment forming part of such sub-system
TCMS	Train Control and Management System (TCMS) is a modular, scalable, secure, standard control and communication platform, which manages and controls the flow of information among various Sub-systems like Driver’s control, converters, doors, brakes, PIS, lighting, heating, ventilation and air-conditioning etc. TCMS allows for efficient & reliable Train operation with in-built redundancy. It generates diagnostic messages useful in Train operation, troubleshooting, maintenance and communicates with the wayside control centers
Test	Shall mean all types of testing i.e., Type, Routine, Optional and Investigative as referred in these Specifications and Standards.
Test Speed	Shall mean the speed adopted for conducting the tests as defined in EN 14363.
Train	shall mean a series of Cars hauled as a single unit by integral motors for transporting Users on the Trial Section.
Train Crew	shall mean collectively Train Driver and Train Manager.
Train Driver	shall mean the person in the Driving Cab who is in control of the operation of the Train
Train Manager	shall mean the person in the Train who is monitoring the passenger facilities, interact and guide the passengers in the Train.
Trial Section	shall mean the railway section between Surat and Bilimora stations of MAHSR railway network or any other section so defined subsequently by NHSRCL on which the Trains are going to be tested and operated.
Others	any capitalized term used herein not specifically defined shall have the meaning ascribed to such term in the Agreement
VDE	Verband der Elektrotechnik, Elektronik und Informationstechnik. The VDE is the Association for Electrical, Electronic and Information Technologies and their related sciences, technologies and applications.
Vehicle	Shall mean and include powered and non powered cars The words “Vehicle” and “Car” as used in this Specifications and Standards are interchangeable;

3. General Technical Requirements

3.1. General

- 3.1.1. The Trains shall conform to the technical requirements of design, development, manufacture, testing, commissioning and maintenance as per these Specifications and Standards for operating on MAHSR Section.
- 3.1.2. The Train shall be distributed power type which shall have Driving Cab(s) on both ends and shall be capable of running in either direction without the requirement for any change in its composition. The Train shall be of 8 car consist with at least (minimum) 50% of the axles powered, so as to meet all the performance requirements of this Specification and Standards.
- 3.1.3. The environmental and service conditions, performance & technical requirements are specified in these Specifications and Standards.
- 3.1.4. The design and manufacture of the Train and the various Sub-systems thereof shall be based on the requirements set out in these Specifications and Standards and in accordance with Good Industry Practice.
- 3.1.5. The Supplier shall demonstrate, to the satisfaction of the Purchaser, that the Sub-systems proposed to be used in the Train are based on proven technology and design. Development of any sub-system based on proven technology may be verified and validated by third party experts.
- 3.1.6. Due consideration shall be given at design stage to ambient conditions of dust, moisture, high temperature and vibrations prevalent in India, as specified in Clause 3.6 of this Schedule.
- 3.1.7. The Supplier shall comply with the requirements specified in Chapter 6 of this Schedule with regard to Design and Drawings. The Testing and Acceptance of the Trains shall be carried out by Nominated Agency in terms of the provisions of Chapter 7 of this Schedule.
- 3.1.8. The Trains shall conform to the design requirements set out in this Schedule, which are the minimum prescribed. The Supplier shall be solely responsible for undertaking all the surveys, investigations and detailed designs in accordance with Good Industry Practice and shall have no claim against the Purchaser for any loss, damage, risks, costs, liabilities or obligations arising out of or in relation to such surveys, investigations and designs
- 3.1.9. Where practical and unless otherwise stated, all requirements in this Schedule shall apply together simultaneously.
- 3.1.10. The Bidder shall furnish clause-by-clause compliance on this Specification and Standards. Clause by clause compliance to the specification shall only be considered for evaluation of offers. It shall be the responsibility of the Supplier to meet the specification as per the clause-by-clause compliance.

3.2. References to various Standards

- 3.2.1. The standards applicable and relevant to the complete Train and to the various Sub-systems and systems shall be:
- (i) IEC publications;
 - (ii) EN ;
 - (iii) UIC;
 - (iv) AAR;
 - (v) IEEE;
 - (vi) BS;
 - (vii) RDSO specifications;
 - (viii) ICF/RCF specifications;
 - (ix) NF-F;
 - (x) ORE;
 - (xi) VDE;
 - (xii) UL;
 - (xiii) JIS

- (xiv) IS;
- (xv) TSI; and
- (xvi) Any other standards referred to in this Schedule.

In the event of any contradiction in the aforesaid standards, the following standards shall have priority in the order listed:

- (i) Standards mentioned in these Specifications and Standards set forth herein;
 - (ii) EN /IEC/UIC/AAR/TSI and
 - (iii) IS.
- 3.2.2. For avoidance of any doubt, in case of any conflict between the requirements of these standards, the stipulations of Specifications and Standards in this Schedule shall have precedence.
- 3.2.3. The design of the Train and the Sub-systems and systems thereof shall comply with the standards specified at Annexure-I. The temperature rise shall be measured according to the procedure stipulated by IEC and shall comply with the limits specified and the ambient conditions defined in this Specification and Standards. Specified temperature rise of equipment shall be calculated after taking into account at least 25% choking of air filters and radiator fins etc.
- 3.2.4. The latest version of the aforesaid standards, which have been published at least 60 (sixty) days prior to Bid Due Date shall be considered applicable.
- 3.2.5. **Alternative Standards**
The requirements listed in these Specifications and Standards are the minimum. The Supplier may adopt alternative internationally recognized codes, standards and specifications, if it can demonstrate to Purchaser that such alternative is superior or more pertinent to the Train than the standards specified in these Specifications and Standards. The Supplier shall seek the prior approval of Purchaser for any alternative standards proposed to be used.

3.3. Reliability, Availability, Maintainability and Safety (RAMS)

3.3.1. Reliability

- (i) The Reliability of the Fleet in any period shall be measured in terms of the Mean Distance Between Failures (MDBF), i.e. the Reliability of the Fleet shall be calculated by dividing the cumulative distance travelled by the Fleet during the relevant period by the aggregate number of Failures of the Fleet during the relevant period.

$$MDBF = \left(\frac{\text{Cumulative distance travelled by the Fleet in the relevant period}}{\text{Aggregate number of Failures in the relevant period}} \right)$$

- (ii) Supplier shall submit a guaranteed Reliability target for an Accounting Year during detailed design to the Nominated Agency for consideration.

3.3.2. Availability

- (i) The Availability of the Fleet during any period shall be calculated as (the “Availability”):

$$\text{Availability} = \left(1 - \frac{\text{Total Non Available Hours of the Fleet during the relevant period}}{\text{Total Fleet – hours during the relevant period}} \right) * 100$$

- (ii) The Supplier shall submit guaranteed Availability target for an Accounting Year during detailed design to the Purchaser for consideration. The design of the Train shall give due consideration to simplicity of maintenance, operation and emergency procedures and ease of restoration or repair of damaged cars and equipment.

- 3.3.3. The Supplier shall design the Train to ensure Reliability, Availability, maintainability and high degree of safety in order to provide a dependable service. The optimization of the system with respect to reliability, availability, maintainability and safety shall form an integral element of these Specifications and Standards. The plan for reliability, availability, maintainability and safety shall conform to EN 50126/ IEC 61709/ IEC 62278. Reliability of electronic components shall conform to IEC 61709.

- 3.3.4. Supplier shall ensure to identify the components critical for safety that shall fall into safe operating mode in case of malfunctioning. The system safety plan shall identify and list safety critical components and this list shall be updated periodically.

- 3.3.5. Safety Assessment shall be carried out and shall include the following principles:

- (i) Degraded modes and emergency operations shall be considered as well as normal operations;
- (ii) Safety risk assessment shall utilize more than one methodology to assess risks; and
- (iii) Safety risk assessment shall include the consideration of dependent failures, in particular the traction power, braking and control systems.

3.4. Power supply system

The power supply system for operation of the Trains is 25 kV, 50 Hz single phase AC with following features:

Nominal supply voltage	25 kV (RMS), 50 Hz, single phase, AC
Normal variation in supply voltage	22.5 kV to 30 kV (RMS)
Voltage range for Train to operate in full compliance with these Specifications and Standards	22.5 kV to 30 kV
Occasional maximum voltage	30 kV (RMS)
Occasional minimum voltage	20 kV (RMS) for less than 2 minutes
Normal variation in frequency	± 3% (48.5 Hz to 51.5 Hz)
Type of OHE	Mainline: Heavy Compound Catenary System Depot area, Approach line, Loop line, Cross-over line and All lines of Mumbai station: Heavy Simple Catenary System
Feeding System	Mainline: 2x25 KV AT feeding system Depot and Workshop: 25 KV feeding system Note: Under normal condition each traction substation feeds adjacent sectioning post.
Maximum Speed to be considered for design	Main Line: Test Speed Other Lines: 140 km/h
Stagger of the contact wire	± 150 mm on straight track Up to ±200mm on curves
Normal contact wire height in mid span	5 m from Rail Level
Max. contact wire height	5.1 m from Rail Level
Min. contact wire height	4.9 m from Rail Level
Neutral sections	After around every 25 kms <u>Note:</u> Automatic Switching Neutral Section of length 1.4 kms is being used on MAHSR corridor. Refer clause 5.4.1.3.
Max. continuous OHE current rating	1020 Amps.
Features of Contact Wire	<ul style="list-style-type: none"> Material: Grooved hard-drawn copper with Tin alloy (SN alloy) Cross-section: 170 sq.mm. Tension: 19.6 KN Note: Details will be discussed during design stage.
Automatic Tensioning Device (ATD)	Pulley Type ATDs Max. tension: 21.96 KN Tension Load Capacity: 53.9 KN

3.5. Track parameters

The track parameters shall be the following:

Gauge	Standard Gauge 1435 mm
Minimum curve radius of the track	1) Horizontal

	a) Main line, excluding the curves incidental to turnout and the curves along the platform: 6,000 m b) Loop line: 1,000 m c) Under unavoidable circumstances due to geographies on main line and loop line: 400 m d) Approach line: 400 m e) Depot and workshop: 200 m Permissible speed on curves is specified at Annexure-II (para A2.5) 2) Vertical a) Train Speed > 110 km/h: 25,000 m (Unavoidable 15,000 m) b) Train Speed \leq 110 km/h: 5,000 m
Minimum radius of curve incidental to the turnout	a) Loop line: 500 m (Recommended 1,000 m) b) Other line: 200 m (Recommended 500 m)
Minimum radius of curve along the platform	Recommended 1,000 m
Maximum permissible cant	180 mm
Maximum permissible cant deficiency	90 mm
Maximum gradient	a) Main line <ul style="list-style-type: none"> Recommended 15‰ (1 in 66.6.) Unavoidable 25‰ (1 in 40) b) Approach line <ul style="list-style-type: none"> Recommended 25‰ (1 in 40) Unavoidable 30‰ (1 in 33.3.) c) Station yard, depot and workshop: 3‰ (1 in 333.3.) d) Turnout area: 3‰ (1 in 333.3.)

The above parameters are considered from Schedule of Dimensions for Mumbai-Ahmedabad High Speed Railway (MAHSR) Corridor standard gauge (1435 mm). The specification of rail will be as per JIS E 1101: 2012 and 60 kg rail will be installed on main line.

3.6. Climatic and Environmental Conditions

3.6.1. The climatic and environmental conditions prevailing in India are the following:

Atmospheric Temperature [Note-1]	Minimum temperature: - 10°C Maximum temperature: 50°C Maximum touch temperature of metallic surface under the sunlit and shade shall be considered and calculated as per ASHRAE 2021.
Humidity	100% saturation during rainy season
Solar radiation	Value and calculation method shall be based on ASHRAE 2021.
Altitude	1000 meter above mean sea level
Rain fall	Very heavy and continuous rainfall in certain areas (heavy continuous rainfall up to 2500mm, rainy season is as long as 5 months in some stretches)
Atmospheric conditions	Extremely dusty and desert terrain in certain areas. The dust concentration in air may reach a high value of 0.4 mg/m ³ .
Coastal area	Humid, salt laden and corrosive atmosphere as prevailing in coastal region.
Wind speed	High wind speed in certain areas, with wind pressure reaching 216 kg/m ² . [Note-2]

Flood level	<p>The Train shall function in accordance with these Specifications and Standards in the event of flooding up to 50 mm above Rail Level as follows:</p> <ul style="list-style-type: none"> • In the event of flooding at any level below Rail Level, the Train shall operate in full compliance with these Specifications and Standards. • In the event of flooding at a height between Rail Level and 50 mm above Rail Level, the Train shall operate in full compliance with these Specifications and Standards with the exception that it is permissible to restrict the operation of the Train to a maximum of 10 km/h. <p>Allowance is to be made in addition for increase in the height of water level due to the “bow wave” effect of the Train passing through the water.</p>
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[Note-1] Ambient temperature for HVAC calculations shall be based on the highest temperature of the Indian region specified in ASHRAE-2021.

[Note-2] Depending on the operational rule, special speed limits shall be imposed on the Train Sets in conditions where wind speed is 20 m/s or greater. Train Set operation shall cease at wind speeds of 30 m/s or greater.

- 3.6.2. In developing the detailed design, the supplier shall acquaint himself and take note of the environmental operating conditions prevailing on the Trial Section during heavy monsoon, track flooding conditions, saline, humid and dusty atmosphere etc.

3.7. Signal and Telecommunications

3.7.1. Signalling Systems shall be as follows:

Item	Description
Train control system	Signalling system shall be ETCS level 2, with ETCS level-1 as fall back as defined in UNISIG specification ATO (GOA2) functionalities shall be as per IEC 62290 . Further details are given in Annexure-V.

3.7.2. The Supplier shall make provision for full interface of control system with ATP system like Kavach/TPWS/AWS/ETCS in the offered section. Supplier shall provide necessary space and mounting arrangements required for installation of ATP system in the rolling stock. The Driver Machine Interface (DMI) shall be fitted towards Train Driver side. Details to be decided during design stage.

3.8. Passenger Capacity and Payload

3.8.1. The 8 car Train shall have minimum number of seats as follows

Type of Car	No. of Cars per Train	Minimum Seats per Car (reference only)	Remarks
Standard Car (2x3)	5	78	The number of seats shall be limited by considering the maximum axle load and shall include two seats for passengers with restricted mobility (one (01) in Standard Car and one (01) in Executive Car.
Executive Car (2x2)	1	52	
Driving Car - Standard Car (2x3)	2	44	
Total	8		

3.8.2. One (01) tip-up seat shall be provided per car (except driving cars). In Driving Cars three (03) tip-up seats (per Driving Car) shall be provided.

3.8.3. In Driving cab, space shall be provided for carrying diagnostic tools required for online attention of the Train.

3.8.4. The number of seats mentioned in the clause 3.8.1 above is for reference purpose only, however, the Supplier shall endeavour to optimize the space available in each Car to maximize the number of seats within the maximum axle load.

3.8.5. Supplier shall design all types of cars for payloads as per UIC 566/EN 12663 such that the axle load of each Car is within the maximum axle load limitation specified in this Specifications and Standards.

3.8.6. Weight of 80 kg (including 10 kg for luggage) has been considered per passenger for arriving at gross weight of Train.

3.9. Station Platforms

3.9.1. Stations will have platforms of standard height 1,250 mm +0, -10 mm from Rail Level. The standard floor height of the Train shall be 1,300 mm from Rail Level and minimum floor height of the Train Set under any condition shall not be less than 1,230 mm from Rail Level.

The Cars shall have suitable safe and comfortable arrangement to allow users to board and alight from the Train at stations having platform heights mentioned above.

3.9.2. The Cars shall have the provision for ground-level maintenance access for critical & safety items, passenger emergency evacuation and fire / rescue access to the Car interior.

3.10. Superstructure and Tunnels

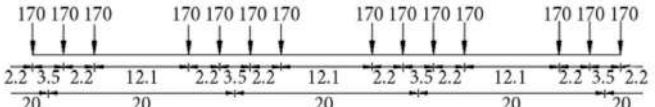
3.10.1. The superstructure will include viaducts with rigid frame structures at stations, FSLM (RCC, PSC girders of box and I section) of various lengths: 20m, 25m, 30m, 35m, and 45m, all designed for a

load capacity of 17 tons. The static loading condition shall be as per clause 4.9. The Trial Section passes through both seabed and mountains terrain. A twin-track tunnel with a minimum 80 sq.m free tunnel area is designed in this area to allow the trains operating at maximum operating speed.

4. Performance Requirements

4.1. Parameters of Train

The performance requirements of the Train shall be governed according to the following leading parameters:

SN	Description	Values/parameters
1.	Limiting profile of Car	Car length over Couplers: 25000 mm (maximum) Car Width: 3350 mm (Maximum) Car Height: 3650 mm (preferable) - 3850 mm (maximum) Height of couplers from Rail Level under tare load condition: 1000mm (standard) Drop in coupler height under full load: 70 mm (maximum) Maximum moving dimensions (MMD): refer Annexure-II.
2.	Maximum axle load	Should not exceed 17 tonnes. The specification of rail will be as per JIS E 1101: 2012 and 60 kg rail will be installed on main line.
3.	Track Loading	Refer to Clause 4.9 of these Specifications and Standards. The static load spacing on structure shall be higher than the values mentioned below:  The above image shall be read with these values: Car length:20m, Wheelbase:2.2m, Bogie base:14.3m and vertical loading of 170 KN.

Notes:

- For any infringement with MMD (Annexure II), Supplier shall establish by technical analysis that such infringement shall not have any effect on safety of Train & fixed infrastructure.
- No part of the Train, except the wheels, shall be within the limits specified in Annexure-1 when the wheels are at their minimum permissible diameter and the Cars are loaded.

4.2. Maximum Speed

4.2.1. The Train shall be designed to operate at 249 kmph, however, the Test Speed for the same shall be considered as 280 kmph.

4.3. Test and Trials

4.3.1. Tests and Trials of the Trains shall be conducted in terms of the provisions of chapter 7 of this document.

4.4. Kinematic Envelopes

4.4.1. The Kinematic envelope represents the maximum dynamic displacement of a Vehicle outline from track center line and from rail level. This is an envelope comprising:

- Rolling Stock profile.
- Track and Vehicle tolerance.
- Allowances for curvature and super elevation.
- Dynamic effects.

4.4.2. The Kinematic envelope of the Train shall be calculated in accordance with UIC505 series for MAHSR infrastructure . These shall define the behavior of the Cars on the MAHSR track. The kinematic envelopes shall not infringe the Maximum Moving Dimension specified in Annexure-II. Track effects to be considered for working out the kinematic profile are:

- Rail wear (Vertical and Lateral),

- (b) Lateral track movement - (separately for straight track and for curved track),
 - (c) Cant on curves,
 - (d) Track tolerances,
 - (e) Horizontal curvature effects:
 - (i) End throw; and
 - (ii) Middle throw,
 - (f) Any other effect of track influencing kinematic profile such as maximum cant deficiency, maximum cant excess etc.
- 4.4.3. These values depend on track curve, Car length and Bogie centers which needs to be developed as part of the design by the Supplier. Vehicle effects to be considered for working out the kinematic profile are:
- (a) Tolerance of Vehicle dimensions,
 - (b) Surging and lurch (including the effect of wheel and undergear wear),
 - (c) Tilting due to cant,
 - (d) Vehicle roll,
 - (e) Vehicle bounce,
 - (f) Pantograph profile, dynamic effect like oscillation & sway of pantograph, electrical clearance, and
 - (g) Any other change having implication of additional movement of Rolling Stock.
- 4.4.4. Other dynamic effects are:
- (a) Deviation due to wind loading,
 - (b) Unequal loading of Vehicles.
- 4.4.5. Track tolerances to be considered for kinematic Envelopes are as follows:

Gauge	+6 mm, -4 mm
Lateral	6 mm
Cross level	7 mm
Vertical	6 mm

4.5. Traction Performance

- 4.5.1. All the requirements specified shall be achieved when the Train is loaded as per EN12663/ EN 15663 for the whole service range of wheel diameter.
- 4.5.2. All the requirements specified shall be achieved when the overhead line voltage is as per Clause 3.4 of these Specifications and Standards.
- 4.5.3. Train shall be capable of accelerating to a speed of 249 kmph from 0 kmph in a maximum of 300 seconds on level track. For the purpose of this clause, minimum Train length of 8 Car shall be considered. However, there shall be a power boost mode which can accelerate the Train to 249 kmph in less than 280 seconds which can be used in case of schedule delays. The ratings of the propulsion system shall be such that the power boost mode can be utilized at least 3 times consecutively in an hour.
- 4.5.4. Train shall be capable of achieving a minimum average acceleration of 0.54 m/s^2 for speed not less than 75 kmph, subject to the requirements with respect to jerk rate specified in Clause 4.7 of these Specification and Standards.
- 4.5.5. Train shall be capable of achieving a minimum residual acceleration of 0.08 m/s^2 at 249 kmph.
- 4.5.6. Train Resistance: Supplier shall furnish the formulae along with justification and reference, which have been used to determine Train resistance and guaranteed performance as per these Specifications and Standards.
- 4.5.7. Supplier shall submit the RMS current values of traction motor and temperature rise of propulsion equipment for a 8 Car rake operation for repeated all-out cycles of 30 km with a dwell time of 30 seconds up to stabilization of temperatures of all propulsion equipment. The R.M.S. (root mean square) loading of the traction motor with regenerative braking in use for all out running as mentioned herein shall not exceed the continuous rating of the traction motor.
- 4.5.8. The continuous rating of the traction converter, traction motor & the traction transformer shall be

based on the criteria specified in Clause no. 4.5.7. The rating of equipment shall be demonstrated by thermal simulation and measurement during combined system testing as well as Vehicle testing in the field. The procedure adopted for calculation of propulsion equipment ratings including the boundary conditions shall be submitted.

4.6. Brake System Performance

- 4.6.1. All the requirements specified in this Clause shall be achieved when the Train load is as specified in these Specifications and Standards.
- 4.6.2. Train shall achieve a minimum deceleration of 0.8 m/s^2 during full-service braking following the jerk limit as specified.
- 4.6.3. Train shall achieve a uniform full-service braking across the whole speed range from 0 to 249 kmph. The full-service brake shall not achieve deceleration of greater than 1.2 m/s^2 at any speed.
- 4.6.4. Train shall be fitted with an emergency brake which can bring the Train to standstill in less than 2430 m when the Train is travelling at 249 kmph.
- 4.6.5. Specified brake performance shall also be achieved in case of failure of regenerative braking.

4.7. Jerk Limit

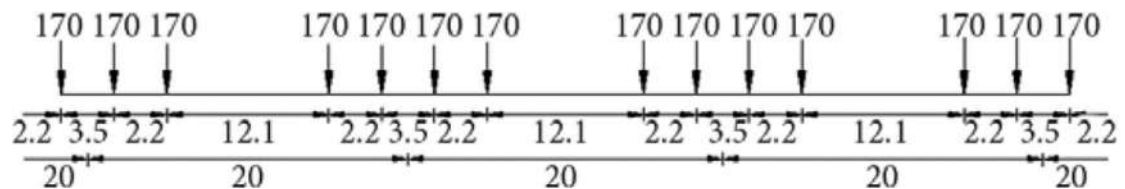
Under all normal operating conditions, the rate of change of the Train acceleration or deceleration shall be less than 0.7 m/s^3 . Failure of the jerk limiting system shall not limit braking effort. Emergency brake applications and any associated ramp down of tractive effort shall not be jerk limited. Reduction of tractive effort due to a power interruption (including passing through neutral sections) need not be jerk limited.

4.8. Ride Index

Rolling stock shall also be evaluated for Mean Ride Comfort (N_{mv}) by Standard method as per EN 12299 for rolling stocks. Acceptable Mean Comfort Index shall be less than or equal to 2 (comfortable).

4.9. Track loading limit & track interaction

- 4.9.1. The static load spacing on structure shall be higher than the values mentioned below Please refer Fig.4 of "ISSN 1822-427X / eISSN 1822-4288 2016 Volume 11(4): 274–282" (Link: <https://bjrbe-journals.rtu.lv/bjrbe/article/view/bjrbe.2016.32/368>)



The above image shall be read with these values: Car length:20m, Wheelbase:2.2m, Bogie base:14.3m and vertical load: 170 kN.

- 4.9.2. During the design phase, the Dynamic augmentation (Dynamic impact factor) caused by rolling stock on superstructure will be calculated in collaboration with the Nominated Agency to ensure the compatibility.
- 4.9.3. Provision shall be made to minimize the impact of the Train on the track.

4.10. Preferred Wheel profile.

- 4.10.1. Supplier shall propose wheel diameter (new/worn) as per the design requirement. The shinkansen wheel profile with standard wheel diameter of 860 mm can be referred at Fig.4 of the "Journal of the Chinese Society of Mechanical Engineers, Vol.38, No.4, pp331~346 (2017)" for reference. (Link:https://www.researchgate.net/publication/321677256_Simplified_Methodology_for_Ride_Comfort_Assessment_Based_on_WheelRail_Contact_Geometry_Synthesis)

However, suitable wheel profile shall be proposed to match rail profile by conducting wheel-rail interaction study during design phase for the approval.

- 4.10.2. Rail profile with inclination.
The specification of rail will be as per JIS E 1101: 2012 and 60 kg rail will be installed on main line. Inclination of rail profile will be 1 in 40.

4.11. Specific Energy Consumption (SEC)

- 4.11.1. SEC is the maximum energy consumption of the Train per seat per kilometre distance travelled (kWhr/Seat-km) meeting the requirements as mentioned in this Clause. Supplier shall endeavour to design the Rolling Stock such that the SEC achieved is comparable to the existing international semi-high-speed Trains. As a reference, the target value for SEC may be considered as 0.034 kWhr/Seat-km.
- 4.11.2. Supplier shall submit the detailed simulations of energy consumption, indicating the SEC during design stage considering the following operating conditions:
- (i) Trains will stop at each station.
 - (ii) Dwell time shall be 60 seconds at each intermediate station stoppages (including door opening and closing time) and 6 minutes at terminal stations i.e., three (03) minutes at each terminal station (including two cycles of door opening and closing at each terminal).
 - (iii) Train will be required to run 500 meters at each turnaround.
 - (iv) Passenger loading with all seats occupied i.e., Design Mass under Normal Payload as defined in Table-3 of EN15663.
 - (v) Maximum acceleration/braking rate and jerk rate shall remain within limits as per applicable standards and best industry practices.
 - (vi) Loading of traction system shall be kept within the boundary limits of the design. Regenerative braking shall be maximized subject to meeting the requirements of travel time and safety in braking.
 - (vii) Auxiliary loads will be considered at full design load and with duty cycle of 100% wherever applicable.
 - (viii) Energy consumption of HVAC shall be considered at the design capacity.
- 4.11.3. Supplier shall submit the detailed methodology of validating the SEC in the Trial Section during design stage.

4.12. Train Weight

- 4.12.1. The Cars shall comply with all applicable strength and testing requirements and shall minimize weight to the extent possible. In the selection of the type and thickness of material to be used, the Supplier shall be guided by the desire to obtain the maximum strength and reliability with the minimum weight which is obtainable at reasonable cost. The Supplier shall base its structural design on the specific loads, deflections and properties of structural sections called for in these Specifications and Standards. For structures not specifically covered, the Supplier shall base its design on its experience, subject to successful stress analysis and structural testing. The structure and equipment supplied shall resist these loads, including fatigue loads, with sufficient factors of safety. The equipment shall be so designed such that the total overall axle load of each Car, fitted with necessary equipment & other accessories and laden as specified in Clause 3.8 of these Specifications and Standards, does not exceed 17.0 tonnes.
- 4.12.2. Axle load limitation shall be taken into account while finalizing and designing the equipment layout giving due consideration to weight unbalancing during tare and payload as specified in Clause 3.8 of these Specification and Standards.
- 4.12.3. The tare weight of the Cars shall be optimized such that under the exceptional payloads, defined in EN 15663 'as fully seated and 2-4 standing passengers/m²', Train shall be met with all required performances and safety requirements (including maximum axle load requirements).
- 4.12.4. Wheel load balance shall comply with TSI Loco & PAS. As a minimum, weight distribution shall be as defined in IEC 1133-1992.

4.13. Power Factor

- 4.13.1. Train shall at all times achieve a minimum power factor of 0.98 as measured at the pantograph.

The measurement of power factor shall be governed by EN 50388.

4.14. Efficiency

- 4.14.1. The peak efficiency of traction system consisting of traction transformer, traction converter (line side converter and drive side inverter) and traction motor shall not be less than 87% at one operating point in the maximum power zone of the driving operation characteristics under loading conditions specified in clause 3.8 with a line voltage as per clause 3.4. The efficiency of the traction system shall be calculated duly taking into account the energy consumed by the associated cooling equipment viz. blowers, pumps etc. of transformer, traction converter, traction motor etc. Efficiencies by running at constant speeds of 45, 110, 130, 160, 200, 220 and 249 kmph shall also be measured and recorded. Efficiency at 280 kmph shall be recorded for reference purpose. The measurement of the efficiency shall be performed on the combined test bed with full complement of equipment and shall be governed by IEC 61377.
- 4.14.2. The efficiency of the complete auxiliary converter system including sine filter shall not be less than 94% at full load. Complete system shall also include input inductors and output transformers (if any). The measurement of the efficiency shall be governed by IEC 61287. Further the efficiency shall also be validated during Vehicle type test.

4.15. Coupling within Train

- 4.15.1. Couplers having mechanical, pneumatic and electrical coupling shall be provided between all the Cars. The couplers shall have sufficient mechanical strength for loads from car body and shall be capable of absorbing the impacts. Each Basic Unit shall have automatic coupler with electrical head at end to facilitate automatic coupling and uncoupling of the Basic Unit.
- 4.15.2. Coupling among two Trains shall be realized through an automatic coupler which shall have mechanical, pneumatic, and electrical coupling to enable multiple Train operation i.e., 8-Car Train coupled with another 8-car Train in all service conditions.
- 4.15.3. The coupler of the Train shall be designed to facilitate easy coupling and de-coupling of Cars.

4.16. Environmental Noise Standards

- 4.16.1. General
The noise levels emitted from the Train shall be as low as possible and the Train shall be designed to prevent drumming, rattles or vibrations throughout the design life of the Vehicles. All noise levels specified below are in decibels referred to 20 micro-Pascal as measured with “A” weighting network of standard type 1 sound level meter with time weighting F.
- 4.16.2. Limits of Interior Noise
The noise level inside the Car (passenger areas) shall not exceed 65 dB(A) when stationary and shall not exceed 72 dB(A) at maximum service speed with all auxiliary equipment operating at its greatest noise output. The measurement shall be done as per ISO 3381.
NOTE: The noise level in areas other than passenger area (Driving Cab, vestibules, toilets etc.) shall confirm to internationally acceptable norms / standards.
- 4.16.3. Limits of Stationary Noise
The limiting value for noise emission of the Cars shall be 68 dB (A) at a distance of 7.5 m from the centreline of the track, 1.2m and 3.5m above the upper surface of the rails. The measurement shall be done in accordance with the standard EN ISO3095.
- 4.16.4. Limits of Starting Noise
The limiting value for noise emission of the Cars shall be $L_{pAFmax} \leq 82$ dBA at a distance of 7.5m from the center line of the track, 1.2m and 3.5m above the upper surface of the rails. The measurement shall be done in accordance with the standard EN ISO 3095.
- 4.16.5. Limits of Passing - by Noise
The limiting value for noise emission of the Cars shall be $L_{pAeq,Tp} \leq 93$ dBA at a distance of 7.5 m from the center line of the track, 1.2 m and 3.5 m above the upper surface of the rails at maximum service/operational speed. The measurement shall be carried out in accordance with the standard EN ISO 3095.

4.17. Electro-magnetic Compatibility Requirements

All components on the Cars shall be designed and constructed to fulfil the requirements of EN 50121-3-2. The complete Train shall meet the requirements of standard EN 50121-3-1.

4.18. Fire Protection

4.18.1. The fire protection on Train shall be designed and constructed in accordance with EN45545 Part 1 to 7 (latest editions).The applicable Hazard level will be HL 2.

4.18.2. The Train shall be designed to prevent fire propagation through the use of fire barriers in the floor, and in walls at the sides and ends and fire-resistant equipment housings. The Vehicle floor shall provide a fire barrier of 15 (fifteen) minutes duration tested in accordance with EN45545 Part 1 to 7 (latest editions).

4.18.3. Supplier shall furnish the relevant data, fire load calculations, certifications etc. of the items considered in fire load calculations separately for above & below the floor level.

4.18.4. The calculations and validation shall conform to the standard adopted by the contractor for fire strategy.

4.18.5. At least two fire extinguishers of the dry powder type of minimum 9 kg capacity or better system shall be installed in each car, readily accessible and flush mounted on panel diagonally.

4.19. General safety requirements

4.19.1. The Train shall present a safe, hazard-free environment to users, crew members and the general public. Passage through the Car shall be easy and safe. Adequate handholds shall be provided throughout the Car. Users and crew shall not be exposed to tripping hazards, exposed electrical voltage, toxic materials or similar hazards. Normal and emergency equipment and controls which the users or crew may operate, shall be clearly identified, and operating procedures shall be presented in both text and graphic formats. Passenger emergency signs shall also be embossed in Braille raised typeface.

4.20. Adhesion Limit

The equipment shall be so designed that the coefficient of adhesion requirement does not exceed 20% during powering and braking under all performance requirements as specified in these Specifications and Standards. The coefficient of adhesion requirement shall not exceed 16% in case of only pneumatic brake application.

4.21. Design Life

The Train shall be designed for a life of 30 years. The Train shall be designed so as to minimize the risks posed by obsolescence.

4.22. Maintenance schedule

Supplier shall submit the basic maintenance schedules of the proposed Train. Minimum interval between two maintenance schedules in the depot for the Train should be based on international standards/norms. Average running distance of a rake may be considered 2000 kilometer per day.

The maintenance program prepared by Supplier shall have the following objectives:

- Enhancement of availability
- Minimization of maintenance costs
- Minimization of Car downtime/MTTS (meantime to restore serviceability)

5. Technical Requirements of System/Sub-systems

5.1. General

- 5.1.1. The Train shall be designed to ensure satisfactory and safe operation under the running conditions specified herein and especially under sudden variations of load and electric supply as may arise under working conditions due to faulty operation and short circuits.
- 5.1.2. Deleted.
- 5.1.3. Deleted.
- 5.1.4. Deleted.
- 5.1.5. The design and arrangement of the Sub-systems and systems shall ensure that the performance requirements of the Train are achieved under the climatic and environmental conditions prevalent in India as specified in Clause 3.6 of these Specifications and Standards. The equipment, Sub-system and their mounting arrangement shall be designed to withstand satisfactorily the vibrations and shocks encountered in service and as specified in IEC 61373 except where specifically defined in these Specifications and Standards.
- 5.1.6. Deleted.
- 5.1.7. Redundancy shall be built in with the design of the Sub-systems and systems in order to ensure reliability and availability. In the vital units of the power control circuit, where any defect/failure of a component would cause complete failure of Train's electrical system, suitable redundancy shall be provided preferably with automatic substitution features to avoid Train failure due to such defects.
- 5.1.8. There shall be provision of receiving shore supply of 415 volts, 50 Hz, 3 phase supply, on Train, for testing during maintenance in the depot.
- 5.1.9. The Train, including all Sub-systems and equipment shall be of proven design i.e. the design of equipment, components etc. shall be based on sound, proven and reliable engineering practices. For the avoidance of doubt, the Purchaser may require the Supplier to conduct such tests and trials as may be necessary to establish the reliability and efficiency of such technology and designs in accordance with the Good Industry Practice.
- 5.1.10. Ingress Protection
All equipment shall be suitably protected from dust and water. As a minimum, equipment shall be sealed to the standards stated below.
- (i) Under frame & externally mounted equipment: IP65 (other than traction / auxiliary converter, Traction Motor) and IP20 can be adopted for Battery Box and Brake Chopper
 - (ii) Equipment mounted inside the Car body: IP54
 - (iii) It may be necessary to protect some equipment to IP67 in order to meet the requirements of Clause 3.6 of these Specifications and Standards.

5.2. Environmental Protection

The materials likely to cause environmental damage during the manufacture, maintenance, operation and disposal of Train shall be avoided. The material listed in this Clause are a minimum list of restricted material and the Supplier shall provide adequate evidence to the Purchaser that all materials used shall not cause environmental damage. The material viz. asbestos; chlorofluorocarbons; polychlorinated biphenyls; Exposed lead and paints containing lead; chromates; cadmium, except in nickel cadmium batteries; and cyanide shall not be used. Use & disposal of all material should be governed by norms set by Government of India (Central Pollution Control Board).

5.3. Pantograph

- 5.3.1. The 8 Car Train shall be equipped with two (02) Pantographs and Trains shall work with one Pantograph during the service operations. Minimum distance between two pantographs should be as per EN 50367.
- 5.3.2. Supplier shall provide the profile of the pantograph compatible with the OHE type of Heavy Compound Catenary System for MAHSR corridor as mentioned in Clause 3.4 of these Specifications and Standards. Special consideration shall be given to the lifting forces of the pantograph acting on OHE.

- 5.3.3. It shall be possible for each of these pantographs to be electrically disconnected from the roof equipment and earthed in case of damage.
- 5.3.4. The pantograph selector switch shall be provided in the Driver's Cab for raising and lowering of any of the pantographs. The raising or lowering of the pantograph, with the Train in motion, shall not cause any unwanted disturbance to OHE. Pantograph control shall be configured such that any one pantograph or all pantographs can be raised or lowered. When all pantographs are raised there shall be a time delay function such that the instantaneous line current demand peak and inrush current characteristics are reduced to less than the operating limit of the traction power and OHE system. In the event of failure/damage of pantographs, it shall still be possible to work with other healthy pantographs of the Train.
- 5.3.5. The design of pantograph shall incorporate the following desired features:
- (i) Efficient current collection at all speed with least sparking while traversing the OHE shall be ensured. As a design criterion, the maximum limit of contact loss should be of the order of 0.1% and the same shall be tested in accordance with EN 50367. Simulated test results shall be submitted during the design stage.
 - (ii) Supplier shall conduct on-line current collection test with GPS supported location recording system. The output report in soft copy shall be supplied for continuous / selective viewing of location having abnormal behaviour and in hard copy with exception report of spark image, location wise report in excel/ word format for complete section selected for trial.
 - (iii) It shall be able to work with the contract force requirements as per Annexure-D of IEC 60494-1 (Japanese Shinkansen) and the dynamic interaction with the OHE shall be validated in compliance to IEC 62486. The pantograph shall have auto drop function to drop the pantograph automatically when excessive height is detected (ORD). The pantograph shall also have auto drop function in case of worn current strip or damaged pan head (ADD).

5.4. Electric Propulsion System

5.4.1. Main Circuit Breakers

5.4.1.1. Each pantograph Car shall be provided with a minimum of one main circuit breaker. Other Cars having traction transformers shall also be provided with main circuit breaker.

5.4.1.2. Vacuum Circuit breaker (VCB) of proven and approved type shall be provided on 25 kV AC system. Independent VCBs (Both with earthing switch - One for Traction Circuit protection and one for HT cable protection). A suitable scheme for protection of 25 kV AC voltage system including roof bus bar and HV cable to be adopted.

5.4.1.3. MAHSR corridor is provided with an Automatic Switching Neutral Section (ASNS). Supplier shall discuss the details of the switching of VCBs in accordance with ASNS during design stage.

5.4.2. Lightning Arrestor

Two metal oxide gapless lightning arrestors shall be provided in each Car fitted with a pantograph and/or traction transformer for protection against the line voltage transients caused by lightning and system switching. One lightning arrestor shall be connected to the high voltage circuit between the pantograph & the main circuit breaker and the other shall be connected to the high voltage circuit between the main circuit breaker and the transformer. These gapless lightning arrestors shall have discharge class-4 for primary and class-3 for secondary.

5.4.3. Main Transformer

5.4.3.1. The kVA rating of the transformer shall be specified at a line voltage of 22.5kV and shall be designed to deliver the power at a total current corresponding to the continuous rated traction motor currents after accounting for the efficiency & power factor of traction motor, traction converter, auxiliary converter for meeting the auxiliary load as specified in the specification.

5.4.3.2. The transformer shall be designed to conform to IEC: 60310 and the temperature rise limits on the windings and the oil shall correspond to IEC: 60310 limits minus 20K under all conditions of operation.

5.4.3.3. The cooling agent for the transformer shall be K-class, biodegradable, arc resistant and shall have high flash point (> 250 °C) & high fire point (>300 °C)

- 5.4.4. High voltage cable assembly
- 5.4.4.1. A suitably rated high voltage cable conforming to the external application for running on the roof under the ambient conditions as per the specification shall connect the VCB to the main transformer. The Supplier shall submit the cable layout schemes (preferably avoiding the passenger areas) during the design evaluation stage. All the safety measures must be listed along with the references of materials used by the Supplier.
- 5.4.4.2. In normal condition, 8-car Train shall work on one (01) Pantograph. For this purpose, HT cable shall be laid with suitable flexible inter-Vehicle connections between adjacent Cars. This cable shall be suitably protected against insulation failure/ earth leakage and isolation through VCB shall be provided to avoid repeated tripping of feeding traction substation.
- 5.4.5. Power Traction Converter
- 5.4.5.1. The four-quadrant power converter shall be IGBT or SiC based with PWM control to ensure regeneration and the power factor to near unity. The voltage rating of IGBT/SiC shall be so chosen that at least 25% margin is available after taking into consideration the DC link voltage and voltage jump on account of inductances and capacitances in the circuit. The wheel slip detection and correction system shall be an integral part of the control system of the power traction converter which shall capture any excessive acceleration, differential speeds between axles, over speed and any other parameter considered necessary to maximize adhesion and minimize wheel slipping / skidding.
- 5.4.5.2. The traction converter shall meet the requirements of IEC-61287 & the control electronics and PCBs shall conform to IEC-60571 including compliance to the optional tests. However, due to higher ambient temperature in India, the temperature for dry heat test shall be 80°C as against 70°C specified in IEC/EN. LCD display units may be tested at 70°C. The vibration and shock tests and endurance tests shall be done as per IEC 61373 as per the requirements of design.
- 5.4.6. Traction Motor and Drive
- 5.4.6.1. Three phase high efficiency traction motor (encapsulated design of traction motor will also be acceptable) shall be provided. The general design and manufacture of the motor shall be done to the standard IEC 60349-2 in accordance with the modern practices.
- 5.4.6.2. Insulation system
- (i) The evaluation of the insulation system for thermal endurance shall be with fabricated test models by way of accelerated ageing tests based on the test programme drawn up in accordance with the norms specified in IEC: 60034-18. Evaluation of the insulation system shall be done according to IEC 60034-18.
- (ii) The temperature at which an extrapolated life of 20,000 hours is obtained shall be treated as the thermal endurance limit (Temperature Index) of the insulation system.
- 5.4.6.3. The designed L10 life of traction motor bearing should be at least 2.5 million km.
- 5.4.6.4. Maximum temperature rise of traction motor winding shall be IEC: 60349-2 limits minus 20K under all conditions of operation including 25% choking of filters. Thermal simulation of temperature rise in stator and rotor (if wound) with given duty cycle of the Train operation shall be carried out to establish maximum temperature rise. In case of cage rotor, temperature rise of cage rotor should not endanger any winding or any other parts like bearings etc. and the acceptable limit of temperature rise of cage rotor to be declared by propulsion supplier. Further to monitor the temperature status of the traction motor either a temperature sensor or a thermal cut-out switch shall be installed in the traction motor, details to be discussed during design stage.
- 5.4.6.5. Deleted.
- 5.4.6.6. Traction Gear
- All traction gears will be case hardened alloy steel of approved quality or any other proven material which shall have sufficient mechanical strength. Supplier shall submit proof of stability for gear tooth forming and total design, description of the gear tooth forming, provided materials, manufacturing and hardening procedures with corresponding specifications, oil types and lubrication intervals.
- 5.4.6.7. Gear Case
- Gear case shall be made of proven material and shall have sufficient mechanical strength so as not to

get damaged due to being hit by ballast or any other foreign objects. The design of gear case shall ensure minimum loss of lubricant during run. The oil circulation in gear case should be independent to the lubrication of bearings for the traction motor. The use of helicals for fastening purpose shall not be permissible.

5.4.6.8. Traction Motor Tests

The traction motor shall be subjected to all the prototype & routine tests in line with IEC 60349-2. Prototype tests shall include continuous temperature rise test, short time rating tests, characteristics tests, over speed, power factor, efficiency, dielectric & torque measurement tests.

5.4.7. Auxiliary System

5.4.7.1. The auxiliary system shall consist of auxiliary converters, auxiliary machines, blower-motors, compressor motors, oil / water pumps, battery charger, DC loads and associated protection system. The AC auxiliary system shall be galvanically isolated from the traction power system and the DC battery system.

5.4.7.2. The power supply for the auxiliaries may be through IGBT/SIC based auxiliary converter. The system shall be protected and devices shall be selected suitably to ensure that there is no damage on account of surges. The standard low tension supply voltage for Train shall be 415 V, 3-phase, 50Hz AC.

5.4.7.3. The sub-pantry equipment shall be operated on $230 \pm 10\%$ V.

5.4.7.4. The auxiliary system shall be designed in such a way that in the event of failure of one auxiliary converter, all the loads (including air conditioning) shall work normally. In case of failure of two or more auxiliary converters, switching-off the non-essential loads so that the service operation can be continued without any impact on passenger comfort and safety. During design stage the detailed auxiliary design concept shall be submitted for approval. The changeover/load sharing shall be affected automatically and without any time delay through control electronics. Auxiliary converter shall be capable to cater the full auxiliary (100%) load at input voltage range between 20 kV to 30 kV AC.

5.4.7.5. In addition to above, galvanically isolated 230 V AC, single phase supply of 1 kVA shall also be made available in the Driving Cabs to enable powering any small equipment when the Train is standing in the Maintenance Depot.

5.4.7.6. The Auxiliary supply system shall be designed with a 10% additional capacity to cater the future needs.

5.4.7.7. Auxiliary converters of Train (optional for HVAC) shall be operated in synchronization for load sharing through three phase 415V, 50 Hz bus line.

5.4.7.8. The temperature rise limits for auxiliary machines shall be reduced compared to IEC limits to take care of the higher ambient temperature specified. Only Insulation system of class 180°C or higher shall be adopted. The permitted maximum temperature rise for different classes will be

- Class 180: 80K
- Class 200: 100K

5.4.7.9. The protection scheme of the auxiliary system shall ensure that:

- (i) A single earth fault does not have any adverse impact on the performance of the auxiliary system and auxiliary converters shall continue to feed the load.
- (ii) In the case of multiple earth faults or phase to phase faults, the affected equipment shall be immediately shut down and no damage to the equipment shall occur.

5.4.8. Auxiliary Compressor Set

A 110 volts DC battery operated auxiliary compressor set having sufficient capacity shall be provided for feeding the auxiliary air reservoir for operation of the pantograph and main circuit breaker, during the preparation of the Train for service. A suitable pressure governor device shall also be included.

5.4.9. Battery and Battery Charger system along with Battery Box

5.4.9.1. Low maintenance explosion proof batteries of adequate capacity shall be provided on each Basic Unit to feed the emergency loads for at least 3 hours in the event OHE supply is not available. Nominal voltage of the battery shall be 110 V.

5.4.9.2. The design and control of the battery shall ensure that the battery gets disconnected from non-essential loads when the battery gets discharged, however there shall be sufficient capacity left under all

- conditions to raise pantograph and to power voice recorder and flasher light. When auxiliary load is reconnected, the initial battery load shall not cause the battery output to oscillate.
- 5.4.9.3. The batteries shall be maintained at an adequate level of charge to satisfy the requirements of the following emergency loads for a duration of 3 hours after the loss of OHE power as given below:
- (i) Emergency ventilation in all Cars including Driving Cabs
 - (ii) Communication system (PIS and PA system) including CCTV (PRSS and Cab recording equipment) and passenger alarm signal apparatus
 - (iii) Head light, Flasher lights and car Interior Lighting at 50%
 - (iv) Diagonally opposite doors on either side
 - (v) Train controls (full load)
 - (vi) Fire detection system
 - (vii) For the purpose of capacity calculations, a total of 15 Close-Open operations of door per hour shall be considered.
 - (viii) Power requirements for maintaining vacuum/ power for Vacuum Toilets.
 - (ix) Water raising pump.
- 5.4.9.4. There shall be provision for using the external power supply of 415 volts, 50 Hz, 3- phase on Basic Unit level for testing of auxiliary machines, HVAC during maintenance in the depot and charging of battery. Movement of the Train is not required with this power supply.
- 5.4.9.5. The emergency lighting system or luminaries shall be supplied from power supply from Overhead power supply as well as from Vehicle battery. Lights shall perform normally when Train is passing through the neutral section.
- 5.4.10. Control Equipment
- 5.4.10.1. All control equipment, relays and contactors shall be mounted on suitable panels placed in enclosures with IP54 protection and shall remain in the scope of supply of the Supplier including harnessing thereof. All cabinets/housings shall be made of corrosion free material and those mounted in underframe shall not require any painting. Electrical equipment installed in the underframe shall be protected by a housing made of stainless steel SS304 or anodized sea waterproof aluminum or alternate material based on suitability for application. However, proper isolation is ensured between two different materials come into contact to avoid electrolytic corrosion.
- 5.4.10.2. All vital contacts for operation of the Train shall be duplicated to provide redundancy.
- 5.4.10.3. Endurance tests, both mechanical and electrical, shall be in accordance with IEC60337.
- 5.4.11. Wiring and Cabling
- 5.4.11.1. The cables for wiring in the Train and equipment shall use high grade electrolytic copper stranded conductors tinned in accordance with Good Industry practices.
- 5.4.11.2. Electron beam, irradiated, thin walled, halogen free, low smoke and less toxic cables according to relevant international standards and the Good Industry Practice for rolling stock application, shall be used. The insulation/sheathing material shall be EPDM/EVA. At locations in the Train, where high temperatures are likely to be encountered, special cables shall be used. Supplier shall submit details of cables conforming to EN 50264 for fire retardant, fire survival characteristics.
- 5.4.11.3. Cable layout shall be according to EN50343.
- 5.4.11.4. All incoming and outgoing cable outlets shall be provided with cable fire barriers of intumescent material (at cable cleat) to prevent fire propagation through cable insulation.
- 5.4.11.5. No cable having a conductor size of less than 1.5 sq. mm shall be used except for multi core cables where 1.0 sq. mm cable is permitted. Smaller size cables for internal wiring of panels, control cubicles, consistent with the mechanical and electrical requirements, may be adopted.
- 5.4.11.6. A systematic cable transit management & sealing system shall be provided for protection of cables against cutting, damage, fire, vibration, pull tension, temperature variation, dust, water, humidity & rodents as well. Cable management transit system must be fire resistant, smoke and gas tight, and the pressure/vibration shall not damage it or compromise its seal or security.
- 5.4.11.7. Sufficient spare Train line cables and contacts (at least 15 % and minimum 10 nos.) shall be provided for catering to future needs.
- 5.4.11.8. Fire survival cables according to EN 50200 shall be used for PA/PIS, ETB circuit, Passenger Alarm,

supply and other essential circuits of Fire detection system, Brake system and Door system for their continued functioning to the extent possible in the event of fire. Survivable duration classification of PH30 (30 minutes) or higher shall be provided.

5.4.12. Interior Lighting

5.4.12.1. Lights shall be fed by the auxiliary power supply system. All lighting equipment shall generally be provided with LED technology, unless the lighting equipment does not have proven service record. The guaranteed life of the LEDs with their control system and optics/luminary shall not be less than 50,000 burning hours. The specified illumination level shall be met till at the end of the life of 50,000 hours when the illumination is not less than 70% of their original illumination level. The colour of the LEDs shall be cool day white (temperature 4000K-7000K). LED shall be certified for LM80. Separately protected lighting circuits shall be used, such that in the event of tripping of one circuit, the others should provide evenly distributed lighting throughout the Car.

5.4.12.2. With all lights switched on in a Car (except emergency and seat light), the illumination shall be not less than 200 lux at height of 1.5 m above floor level along the entire length of the Car. With the exception of the illumination level, lighting shall be of similar or equivalent performance to EN 13272 – “Railway Application – Electrical Lighting for Rolling Stock in Public Transport Systems” as applicable to urban rail transport systems. Uniformity level as per EN 13272 shall be achieved.

5.4.12.3. At least 50% of lights, evenly distributed over the Car area, shall remain energized and provide sufficient light for safety of passengers, in the event of an OHE failure.

5.4.12.4. For lighting the interior of the Car, suitable lamps with colour rendering index R_a as per EN 13272 shall be used. R_a shall be calculated as specified in the paper by Nickerson and Jerome in 1965, republished by the CIE in 1995.

5.4.12.5. The Electricity act 2003: Relevant provisions stipulated in The Electricity act 2003 shall strictly be followed in the interest of safety of passengers/staff as well as for equipment / instruments provided in the Cars.

5.4.12.6. Reading Light: All Cars shall be equipped with an easy-to-use LED reading lights.

5.4.13. Circuit Protection: Supplier shall ensure that electric circuits shall be protected in accordance with the requirements of IEC 60077 - ‘Railway Applications-Electric Equipment for Rolling Stock’.

5.4.14. Master Controller

5.4.14.1. A combined traction cum brake controller, integrated into a single unit shall be provided in each Driving Cab. The master controller shall be designed so that the electrical/dynamic/regenerative brake is applied by pulling the handle towards the Train Driver and traction is given by pulling the handle away from the Train Driver. The master controller shall be of step less type.

5.4.14.2. Master controller to be operational only after operation of Driving Cab activation switch. Only authorized persons having necessary keys / handles shall be able to operate the master controller. A separate reverser switch to be provided to select the direction of operation i.e., forward, reverse and neutral. All three i.e., Driving Cab activation key switch, reverser switch and traction/braking lever shall be interlocked. Only one Driving Cab shall be activated in the Train at a time.

5.4.14.3. The Master Controller, shall be ergonomically placed on the driver's desk to be accessible from both sitting and standing positions of the Train Driver.

5.5. Instruments and Gauges

5.5.1. The following information shall be made available to the Train Driver:

- (i) Pressure in the main reservoir pipe;
- (ii) Pressure in the brake cylinder;
- (iii) Pressure in the brake pipe;
- (iv) Indication of air flow in the brake pipe;
- (v) OHE line voltage;
- (vi) Battery voltage;
- (vii) Tractive/braking efforts; and
- (viii) Train speed with Analog & digital display

Items marked above shall be continually displayed to the Train Driver via gauges with good visibility in daylight / night conditions.

- 5.5.2. Status indication shall be provided on HMI for lights, ventilation, brake system, PA & PIS, auxiliary supply system, speed, VCB open & closed, pantograph raised/down, compressors, MR/BP pressure of both Driving Cabs, condition of suspension systems, condition of axle bearings and brake cylinder pressures of all Cars etc. Graphical representation for status of different Sub-system viz. brake system, auxiliary supply, PA & PIS, TCMS and propulsion & control system shall be provided on HMI.

5.6. Deleted

5.7. Head Light, Flasher and Tail Lights

5.7.1. Headlights:

- (i) Each Driving Car shall be provided with twin beam LED headlights.
- (ii) The headlight units shall be pre-focused, capable of giving minimum 3.2 lux at a distance of 305 meters. The beam spread shall be symmetrical and angle of beam shall not be less than seven (07) degrees.
- (iii) Arrangements shall be provided for dimming the headlight output when required. The headlight shall be provided in suitable waterproof enclosures conforming to IP 65 or better.

5.7.2. Flasher Lights

- (i) Two flasher lights, one at each end of the Train, shall be provided. It shall be designed to provide forty \pm five (40 ± 5) flashes per minute. It shall emit sufficiently bright amber-yellow light with dominant wavelength of 590-595 nanometers to be visible at a distance of two (02) km in clear daylight and not be affected by sunlight glare. The lux measured in axial direction shall not be less than 500 lux at one (01) meter and fifty-five (55) lux at three (03) meters. The flasher lights shall be provided in suitable waterproof enclosures conforming to IP 65 or better. These shall work on battery supply. The flasher light shall work in neutral section also.
- (ii) Facility for monitoring and positive confirmation whether flasher light is lit or not shall be provided in the form of audio-visual indication in Driving Cabs.
- (iii) The working of the flasher lights shall be so integrated with the Train brake system that in the event of Train parting, flasher light shall get automatically turned on and any tractive effort on the Train shall be disabled until acknowledged by the Train Driver.

5.7.3. Tail Lights

- (i) The tail light shall be red in colour flashing at a rate of fifty-five to sixty-five (55-65) flashes per minute in operation
- (ii) The clear visibility of tail light in clear daylight shall not be less than one and six tenths (1.6) km along the longitudinal axis and 100 meters at six (06) degree angular displacement from longitudinal axis.
- (iii) The tail light shall be provided in suitable waterproof enclosures conforming to IP 65 or better.

5.7.4. Marker Lights

- (i) Two twin marker lights with suitable waterproof enclosures conforming to IP 65 or better and window toughened front glass.
- (ii) Each twin marker light shall provide one white and one red array.
- (iii) If the marker lights are mounted with the twin lenses side by side, the red lens or array shall be towards the outside of the Car. If the marker lights are mounted with the twin lenses one on top of the other, the red lens or array shall be on the top.
- (iv) The marker lamp shall have a nominal light output of forty (40) lux at one (01) meter.
- (v) The functionality of Tail light may be realized through Marker lights in rear of the Train.

5.8. Train Control and Management System (TCMS)

- 5.8.1. TCMS shall integrate the task of fault diagnostics and display the same in addition to its control tasks. It shall be capable of real time monitoring of the status of all the vital equipment continuously

and occurrence of faults. It shall also take appropriate protective action and shut down the equipment whenever necessary.

5.8.2. TCMS shall interface with all microprocessor/micro-controller based systems/subsystems on Train. The system shall include, as a minimum:

- (i) HAVC system;
- (ii) auxiliary power supply system;
- (iii) brake system;
- (iv) Passenger announcement/PIS;
- (v) doors;
- (vi) propulsion system;
- (vii) CCTV;
- (viii) fire detection unit;
- (ix) train protection system;
- (x) train radio; and
- (xi) others

5.8.3. The leading cab will be controlling the coaches in the rake formation. Necessary provision shall be made for acquisition and transmission of data required for leading cabs and control equipment on other cars. Necessary measures shall also be taken to ensure that the control signals are not distorted by any type of interferences.

5.8.4. It shall be possible to execute equipment control commands in the Train through TCMS. Unless otherwise indicated specifically in these specifications, hardwire back up shall be provided for each safety related control functions. Control features available for the Train Driver's control via TCMS visual display unit shall include, but not be limited to, the following:

- (i) Train start up;
- (ii) control of various saloon and cab air conditioner;
- (iii) resetting of minor faults in sub-systems;
- (iv) selective operation of circuit breaker and pantograph;
- (v) sequential operation of circuit breaker as desired; and
- (vi) any other item as desired by the Nominated Agency.

Supplier shall submit during detailed design stage details of TCMS controls/commands clearly discriminating vital and non-vital controls/commands as well as manually triggered/operator based & automatically executed controls

5.8.5. TCMS shall have diagnostics facility, with non-volatile memory, to store all the relevant diagnostic data. On occurrence of each fault, fault information on equipment parameters, GPS location of Train, background data with time stamp shall be captured and stored with a view to enable proper fault analysis. There shall be a facility to capture post trigger and pre-trigger background information. The fault display to Train Driver shall also accompany the standard trouble shooting instructions in simple language. The diagnostic system shall be able to identify and log the faults of the Train and such data shall be stored for a period of not less than 100 days. The diagnostic system shall be able to identify the faults occurring due to defects in the Train and incorrect operation by the Crew.

5.8.6. The electronics used on the Train shall conform to IEC 60571/EN50155, IEC 60068, EN 50121, IEC 60721-2-5 and IEC 61373. All electronic equipment shall be designed to function correctly when the Train has been standing stationary in full sunlight at the maximum ambient air temperature (refer to Clause 3.6 of these Specifications and Standards). As a minimum, electronic equipment shall be designed to operate at internal cubicle air temperatures of 70°C under these conditions. Features of self-check and calibration shall be incorporated in the design.

5.8.7. The TCMS shall be interfaced with the brake system. The Automatic flasher operation (in case of Train parting) and vigilance control functionality shall also be implemented.

5.8.8. The TCMS shall provide on-line, context sensitive trouble shooting assistance to the Train Driver in case of any fault, through the HMI display. The fault display to Train Driver shall also accompany the standard trouble shooting instructions in simple English language. Based on the operational requirement it shall be possible to update trouble shooting directory during contract period.

- 5.8.9. There should be a Rescue Drive Mode (RDM) with restricted speed in case of failure of Train wide communication. Speed limit shall be decided during detailed design in accordance with best international practices.
- 5.8.10. The entire functions essential for the Train operation shall have redundancy to avoid any single point of failure. Adequate redundancy in the system design of TCMS, as permissible vide the standard adopted, shall be ensured. A complete schematic of the scheme with the redundancies shall be submitted by the Supplier. Critical signals for Train operation on hard wires shall be redundant. Details shall be finalized at design approval stage. As a minimum, following shall be included:
- (i) All Driver desk interfaces to TCMS including signal bells shall be fully redundant;
 - (ii) There shall be no single point of failure in safety loops like emergency stop, Emergency Brake, cab occupation, door related safety loops and door operation etc., which can cause immobility of the Train;
 - (iii) There shall be two physically independent bus systems on Train as well as Basic Unit level OR following Ethernet topologies supported by EN61375-3-4 on Train as well as Basic Unit;
For Ethernet Topologies, Ethernet Consist Network with linear type (parallel network) with dual homing topology / ladder-type with dual homing topology/ ring-type with dual homing topology (compliant with IEC 61375-3-4) shall be provided.
All the End Devices shall support dual-homing connections to the network via physically independent ports or shall have redundancy in end devices, if having single port connection, to increase system reliability and availability. A single point failure of any individual equipment/ component/ board/ communication link etc. shall not affect data acquisition or cause any adverse performance impact on Train performance or loss of data. For critical Sub-system where performance can't be managed at Train level redundancy, there shall be provision of receiving input through redundant means i.e. either by redundant physical inputs or by communication and physical input.
 - (iv) Suitable arrangement shall be provided to enable coupled multiple Train operation by coupling two 8-Car Trains for all performance requirements.
 - (v) The control of passenger amenities and safety functions shall be redundant;
 - (vi) Availability of the Basic Unit even in case Auxiliary Converter(s) of that Basic Unit is (are) not available.
- 5.8.11. For control functions integrated in the TCMS, the requirements of EN 50126 and EN 50128 shall be applied. In particular, the risks associated with the integration of any control function shall be assessed and the design of the TCMS (SIL level according to EN 50128) shall reflect the level of risk identified.
- 5.8.12. The functionalities indicated as under (but not limited to) shall be minimum SIL2 Compliant for below defined vital and safety related control & monitoring functions:
- (i) Emergency brake
 - (ii) Standstill detection
 - (iii) Vigilance control
 - (iv) Speed control
 - (v) Roll back detection
 - (vi) Speed indication
 - (vii) Traction release
 - (viii) Smoke and Fire detection.
 - (ix) Door closed and locked status
- 5.8.13. Independent safety audit or safety assessment by an accredited agency shall be done for above functionalities for validation and certification of SIL-2 levels according to prevailing EN standards and international practices.
- 5.8.14. Acceleration and speed shall be clamped to a selectable value while opting for 'shunting' operation. The shunting operation shall be selectable and shall be recorded. For clamping the speed, provision of separate push button shall also be made on the Driver desk to limit the speed to fifteen (15) kmph (configurable parameter).

- 5.8.15. It shall be possible to read and record the energy consumption and regeneration figures for a particular time period for the individual Basic Unit and for the complete rake, along with Train no., the name of the driver, date, time, distance, journey details etc. as fed through suitable electronic device in the driver's cab, details to be worked out during design stage. These figures shall be available readily on the driver's display panel as and when required and shall be retrieved through laptop.
- 5.8.16. The Supplier shall submit the values of parameters, list of fault messages, their environmental data, hierarchy of fault display, fault categorization, trouble shooting of each fault by way of graphical representation on HMI etc.
- 5.8.17. In the event of removal of any Basic Unit from the Train or addition of a Basic Unit to the Train, it shall be possible to automatically configure the modified Train formation in TCMS.
- 5.8.18. It shall be possible to selectively operate the circuit breakers or pantographs, if so, required by the driver. Sequential operation of VCB as desired shall be ensured.
- 5.8.19. TCMS shall synchronise its clock with the system master clock through GPS or signalling and telecommunication interface. All the microprocessor/micro-controller based on-train systems shall synchronize respective clocks with TCMS clock. Synchronized time stamping of TCMS and PIS and interface of PIS with TCMS shall be adopted.
- 5.8.20. TCMS shall incorporate built-in self-check functions for its own components. The result of these self-checks shall be accessible on HMI.
All on-board microprocessor / microcontroller based system which are considered vital for Train operation shall also perform self-diagnostic tests and report the health status to TCMS both automatically at the time of start-up and on specific request (using VDU) by maintenance personnel. Supplier shall submit details of self-diagnostic tests during detailed design stage for Employer's review and approval.
- 5.8.21. Faults/events with alarm, without alarm, events just being recorded in memory only etc. shall be defined. In addition, faults shall be suitably prioritised and filtered so that Driver and maintenance staff receives information appropriate to their roles. On occurrence of each fault, besides the fault information on equipment parameters, GPS location of Train, background data with time stamp, shall also be captured and stored with a view to enable proper fault analysis.
- 5.8.22. It shall be possible to read and record the energy consumption and regeneration figures for a particular time period for the Basic Unit and for complete Train along with Train ID, the name of the Train Driver, date, time, distance, etc.
The accuracy and integrity of these measurements shall be specifically ensured.
These measurements shall be available on the Train Driver's display panel as when required and shall be retrieved through laptop. Details to be decided during detailed design
- 5.8.23. It shall be possible to upload software, download fault diagnostic details for microprocessor / microcontroller-based Train equipment through any cars in the rake.
It shall be possible to modify some of the permissible parameters e.g. line current & voltage sensor settings, temperature sensor settings, pressure sensor settings, maximum speed of Train etc., for adjusting the characteristic within range, changing preset values, limits, etc. of Train in general and add/alter the protection feature, if so, required in future to improve operation of Train.
The hardware tool with necessary software required for the above shall be provided by the Supplier. The Supplier shall also provide the detail procedure for software uploading, modifying parameters and data downloading during detailed design stage.
- 5.8.24. The Train shall be provided with remote diagnostic and tracking equipment. This equipment shall perform the function of tracking of the Train and also communicate with the Train diagnostic system and pass on this information to the central server. It shall be possible to remotely send and obtain the information stored in the diagnostic memory of the computer system, depending on availability of communication channel, for troubleshooting/ diagnosis with the aim of facilitating and speeding up the maintenance process of the Train. Exception reports shall be generated by the TCMS and downloaded remotely in the Maintenance Depot for planning the corrective action. Supplier shall supply the necessary hardware and software of the central server for data download and analysis in

accordance with interface of S&T contractor as per Annexure-V.

5.8.25. Cyber Security

5.8.25.1. The Supplier shall adopt and develop an information security framework, security plan and a thorough SDLC process that integrates risk management for protection against malicious and inadvertent manipulation of data transmitted over ISM bands to maintain the confidentiality, availability and/or integrity of S&TC and wireless data transmission. This plan must be regularly reviewed, updated and accepted through a process of security certification, access control, gateway security, communications security, physical security, accreditations and certifications. The manipulation may be caused by malicious activity like intrusion, hacking, phishing, wireless signal jamming, physical tampering, damaging critical communication cable or nodes, accident or natural disaster. The supplier must demonstrate practically, the ability of the system to proactively detect, contain, eradicate and recover from a security breach. The supplier shall define procedures for assured operations and continuous monitoring of the security controls.

Relevant Standards for compliance: -

- a. ISO 27005
- b. IEC 62443
- c. TS 50701

Cyber Security measures such as, Backup and Disaster recovery, Antivirus, perimeter security devices (firewall, IPS/IDS, Proxy), Active Directory and Domain server, Encryption for data transmission and SAN storage server on a Centralised network. Also, shall cover Identity and Access Management, Application Security, threat and vulnerability management. For this purpose, supplier shall engage a Cyber Security Consultant, who will recommend Cyber Security Guidelines complying the requirements of above standards.

5.8.25.2. The Supplier shall be required to engage with designated Cyber Security Consultant at the early stage of design development. The Supplier shall consider the inputs of Cyber Security Consultant into their design and develop their System Safety & Cyber Security Assurance Plan and submit to Nominated Agency for approval. Cyber Security Consultant shall verify the implementation of the cyber security requirement as per international standards IEC62443, TS50701, ISO 27005 etc.

5.8.25.3. The Supplier shall be fully responsible for compliance with Cyber security standards and implementation of their System Safety & Cyber Security Assurance

5.8.25.4. Cyber Security Assurance

Notwithstanding, the cyber security requirement defined elsewhere, the design of RS system should comply with ISO 27005, IEC62443 and TS50701, while designing and implementing the cybersecurity solution for the RS system.

The Supplier has to ensure non-interference of security functionalities from safety. The Supplier shall define procedures for assured operations and continuous monitoring of the security controls. The Supplier must ensure a non-intrusive, passive, real time continuous monitoring of the Rolling Stock network (TCMS, PA/PIS and passenger wi-fi networks) has no negative impact on the operation of the system. The system should be capable of understanding the railway protocols, asset types in real time in rolling stock network.

The Supplier has to ensure next-generation threat detection to safeguard the operational network and from emerging cyber threats and ensure regulatory compliance.

Major security objectives should include the following:

- (i) Restricting logical access to the network and network activity;
- (ii) Restricting physical access to the network and devices;
- (iii) Restricting unauthorized modification of data;
- (iv) Detecting security events and incident;
- (v) Maintaining functionality during adverse conditions and restoring the system after an incident; and
- (vi) Restricting hacking, phishing, malware, Denial-of-Service (DoS) attack etc.

The Supplier shall be fully responsible for compliance with Cybersecurity standards and implementation of their System Safety & Cyber Security Assurance Plan. Any cost associated with

implementation of Cybersecurity guidelines shall be deemed to be included in the bid proposal.

5.9. Speed Indicating and Recording Equipment

The Train shall be provided with speed indicating-cum-recording equipment in each cab. The equipment shall also incorporate the feature of indicating and recording kilometers travelled by the Train. The capacity of the memory shall be such that it retains most recent data of at least forty-five (45) days' service period.

5.10. Driving Cab and Driver's Display

- 5.10.1. Driver's Cab shall be designed in accordance with EN 16186-1, EN 16186-2 and EN 16186-3. The interface with the Train Driver shall be simple considering average level of proficiency of drivers in handling electronic devices. Window openings to allow Train Driver to look back shall be provided on each side of the Driving Cab. The front windscreen shall be laminated and shall comply with EN15152.
- 5.10.2. Aerodynamically designed Driving Cab with suitable nose cone with provision for adequate forward visibility shall be provided in the Driving Car. Driving Cab shall be adequately reinforced and connected with the main under frame at the cab ends. The Nosecone should give streamlined look to the Train. The nosecone cladding/structure shall be modular, so that in case of minor damages, the damage portion can be easily replaced.
- 5.10.3. The Driving Cab shall be adequately insulated against noise, vibration, heat, ingress of water and dust.
- 5.10.4. The maximum peak-to-peak pressure changes i.e. head pressure pulse outside the Train, during the passage of the head shall be in accordance with TSI LOC&PAS and EN14067-4.
- 5.10.5. The maximum air speed outside the Train, due to slipstream effects on passenger and worker standing on platform and on trackside respectively during the Train passage shall be in accordance with TSI LOC& PAS and EN14067-4.
- 5.10.6. The display shall be designed to provide full guidance and assistance to the Train Driver about the action to be taken in case of a fault. Selection of display medium shall take into account high ambient temperature and lighting conditions.
- 5.10.7. System shall provide foolproof safety against unauthorized person driving the Train.
- 5.10.8. The Driving Cab shall be ergonomically designed for convenience and to minimize fatigue of the Train Driver. Ergonomic and human engineering aspects of the cab design shall be compatible with Indian Anthropometric Dimensions for Ergonomic Design Practice 1997. The visibility diagram shall be in accordance with UIC 651.
- 5.10.9. The driving position shall be on the left side of the Driving Cab and the brake handles shall be located on the left-hand side of the Train Driver in the running direction.
- 5.10.10. A separate emergency brake valve should be placed in an ergonomic position on the left side of the Driving Cab. It must be installed in a fail-safe position so that it can only be operated by the driver when intend to open the air brake pipe directly in case of an emergency.
- 5.10.11. Vigilance Control Device (VCD): VCD shall be provided in Driving Cab for monitoring alertness of the Train Driver through multi-resetting system which resets by specified normal operational activities of the Train Driver and also by acknowledgement of the vigilance check by pressing a pedal switch provided for this purpose. Absence of the normal driving functions and acknowledgement at specified interval of one (01) minute shall cause audiovisual warning. If audiovisual warning is not acknowledged for sixteen \pm four (16 \pm 4) seconds, it shall result into emergency brake application. VCD may be integrated into the Master Controller.

5.11. Safety Measures

- 5.11.1. General
 - 5.11.1.1. Standard protective systems shall be provided, in accordance with the Good Industry Practice, for protection of the electrical equipment against abnormal currents, excessive voltages etc., with indicating facilities, so as to ensure safe and correct operations.
 - 5.11.1.2. All exterior components including under-slung equipment shall be attached with use of secondary

restraints, redundant fixings or secondary latches as appropriate to ensure that no single point failure shall cause equipment to either physically detach or protrude out of gauge.

- 5.11.1.3. Provision for protective earthing against electrical hazard shall be in line with EN 50153: Railway applications - Rolling stock - Protective provisions relating to electrical hazards. All electrical equipment shall be provided with essential interlocks & keys as may be adequate to ensure the protection of the equipment and the safety of those concerned with its operation and maintenance.

5.12. Electrical Fire safety

- 5.12.1. The design of equipment shall incorporate all measures to prevent fire and will be such that should any fire take place, the effects shall be minimized and no spread of fire should take place. Materials that are not fire retardant shall not be used. Cables which are fire retardant, low smoke, halogen free, less toxic according to relevant international and industrial applications for rolling stock shall be used.
- 5.12.2. All electrical circuits including 110 V DC shall be fully insulated from the super structure on both the positive and negative sides and the super-structure shall not be used as a part of any earth return circuit.
- 5.12.3. Relevant provisions stipulated in Central Electricity Authority (Measures related to Safety and Electric Supply) Regulations, 2010, shall be followed in the interest of safety of passenger/staff as well as for equipment / instruments provided in the Cars.
- 5.12.4. A manually operated two-position earthing switch shall be provided. Operation of the switch shall enable earthing of the power circuit of the Train and allow attention to the high voltage equipment by releasing interlocked keys from a box fitted to the earthing switch.
- 5.12.5. A discharging and an isolation switch shall be provided by the Supplier to facilitate the maintenance personnel with a simple means of isolating the traction equipment, discharging all high voltage capacitors to a safe voltage of 50 volt and earthing all high voltage equipment.
- 5.12.6. The inter-vehicular couplers for high-tension connections between equipment, if used, shall be proven. Such couplers shall be designed to cater for abnormal conditions such as vandalism activities. Details of the coupling arrangement shall be furnished during design stage. To ensure safety of personnel, it shall be ensured that coupling/ uncoupling of HT & power couplers (not applicable to roof HT coupling which is otherwise protected by VCB) shall be possible only in de-energized conditions.
- 5.12.7. Suitable danger/warning sign to warn the maintenance staff and commuters for the presence of hazardous electrical equipment shall be provided.

5.13. Automatic Fire Detection with Alarm System

- 5.13.1. Train shall have automatic fire/smoke detection system complying to ARGE Guideline – Part 1. In the event of detection of a fire, the system shall have different levels of response and minimize the spread of fire as per standardized global practice.
- 5.13.2. Automatic fire detection with alarm system covering all the onboard cabinets housing electrical switchgear / equipment. Necessary interface of automatic fire detection system with TCMS shall be provided.

5.14. Power Sockets

- 5.14.1. Light circuits and associated control circuits shall be on 110 V DC in the Cars. However, 110 V sinusoidal AC electrical sockets with international standard safety features shall be provided inside the Cars for charging batteries of portable electronic devices, mobiles or for powering a laptop computer.
- 5.14.2. A shore supply power socket to supply to HVAC for cooling, and battery charging of Train from external supply source also needs to be provided.

5.15. Disaster Management Light

Separate self-contained disaster management LED type Emergency light units, four (04) nos. in each Car having inbuilt primary/rechargeable battery (to provide backup of twelve (12) hours) shall be

provided. These lights shall be automatically switched ON in the event of non-availability of battery supply due to parting of Cars or derailment of Train.

5.16. Fire Loading

All the electrical material to be provided in Car shall have fire retardant properties and shall meet the requirement of EN 45545 (part-1 to 7) standard.

5.17. Train Data Recorder

5.17.1. Train Data Recorder (TDR) equipment and its installation shall conform to EN 60529 and shall meet the crash protection requirements of RGS GM/RT/2472. EN 62625-1-2013 shall be followed for minimum recording of parameters.

5.17.2. One TDR shall be fitted per Train to record at least the following parameters: Speed of Train; OHE voltage; OHE current; tractive/braking effort; battery voltage; brake pipe pressure; brake cylinder pressure; cab1/cab2 activated cab; pantograph up/down position; status of main circuit breaker i.e. open/close; mode of operation i.e. traction mode/braking mode; Direction of travel; Traction controller position; Brake controller position and brake equipment response; Condition of suspension systems; Condition of axle bearings; Status of head lights, trail lights, marker lights, flasher light, horn status on/off; status of penalty brake (ATC) application; status of emergency brake; GPS location; wiper on/off; status of smoke detector units i.e., healthy/smoke detected etc.; and any other parameter considered necessary.

5.17.3. Interface signals of S&T system required to be stored in TDR shall be interfaced as per Annexure-V. The data recorded should be capable of indefinite retention. All data should be date and time stamped. The memory shall be allocated to store short-term data at 1 second interval for the last seventy-two (72) hrs. in crash protected memory and long-term data for ninety (90) days with resolution of twenty (20) seconds in data logging memory.

5.18. Heating, Ventilation and Air Conditioning (HVAC)

5.18.1. All the Cars including Driving Cabs shall be air-conditioned. The complete system shall have EER better than seven (7.0). The Vehicles shall be provided with refrigeration system using R407C refrigerant or any other eco-friendly HFC refrigerant having zero ozone depletion potential and A1 safety category as per ASHRAE standards. One of the compressors in each HVAC shall have automatic capacity control through hot gas bypass system or through VVVF control to optimize the efficiency of HVAC. It shall also be able to provide heating during winter through reverse cycle heating concept or alternate method based on suitability, proven technology, and better energy efficiency.

5.18.2. The Air-conditioning package unit shall have adequate capacity to air condition the coach under the following conditions:

Condition	Outside	Inside
Summer (dry)	Ambient temperature and RH for HVAC calculations shall be based on the highest temperature of the Indian region specified in ASHRAE-2021.	25°C at 45°C outside temperature 27°C at 50°C outside temperature RH – 40% to 60%
Summer (wet)	40°C (Dry Bulb) and 28°C (Wet Bulb)	
Winter	-10°C	19°C to 21°C

5.18.3. The air flow parameters shall be as per ASHRAE/ EN 13129.

5.18.4. In the event of the failure of air conditioning unit in a Car, an emergency ventilation shall operate automatically to admit fresh air directly into Car to maintain the required oxygen level in fully loaded Car, in accordance with ASHRAE.

5.18.5. The minimum fresh air quantities shall not be less than 0.25 m³ / minute / person for all types of Cars. The air-flow parameters shall be as per ASHRAE / EN13129:2016.

5.18.6. In the event of failure of 50% of HVAC system in a car, the remaining HVAC shall cater 60% of the total air- conditioning load of the Car.

- 5.18.7. The single HVAC shall be able to work even with one condenser fan and the cooling capacity so obtained shall not be less than 75% of the rated capacity of the said HVAC.
- 5.18.8. The design of HVAC shall facilitate easy maintenance even when rakes are placed for inspection/maintenance in washing lines.
- 5.18.9. Automatic control of fresh air and return air dampers of HVAC shall be provided.
- 5.18.10. Air conditioning of each coach and Fresh air and return air ducts should be controllable as per fire system requirement.

5.19. Voice Communication System

- 5.19.1. General
 - 5.19.1.1. The voice communication system shall consist of Public Address (PA) system, an automatic announcement system, emergency call equipment and an intercom system.
 - 5.19.1.2. Priority shall be allocated to various voice modes. Option of overriding facility shall also be made available to crew, detail functionality of which shall be finalised during detailed design.
 - 5.19.1.3. The voice communication system shall have automatic continuous variable volume control, based on car background noise level.
 - 5.19.1.4. In case of failure of one unit of PA system or a passenger communication unit in one car, there shall not be failure of the whole system.
 - 5.19.1.5. All the communication and control cables shall be conforming to international standards of Train services so that full functionality for passenger communication is maintained.
 - 5.19.1.6. 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 car is achieved. The loudspeaker should be separated into two groups and each audio line should be supplied by its own amplifier.
 - 5.19.1.7. The power amplifiers shall be protected against short circuit at the outputs of the amplifier. The through line cable inside the car shall be suitably insulated, screened, armoured and overall outer sheathed.
 - 5.19.1.8. 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.
- 5.19.2. Public Address System
 - 5.19.2.1. PA system shall be provided to broadcast voice messages to the passengers from driving/non driving cars.
 - 5.19.2.2. It shall provide announcement to all cars simultaneously or in selected cars.
 - 5.19.2.3. Train crew shall have the facility of adjusting the volume level of the announcement from a minimum to maximum level from TCMS display unit or separate arrangement shall be provided for the same. Details to be discussed and finalised during detailed design.
 - 5.19.2.4. The public address system shall be acoustically designed and provided with active noise control to reduce the unwanted sound. The microphone to be used for public address/announcement shall have high dynamic noise cancellation feature. Supplier shall submit the details of the system during detailed design stage.
- 5.19.3. Automatic Announcement System
 - 5.19.3.1. The automatic announcement system shall be provided in the Train to broadcast pre-recorded voice messages and pre-recorded emergency voice messages to the passengers.
 - 5.19.3.2. Pre-recorded voice messages shall be broadcasted automatically by Train events. Pre-recorded emergency voice messages shall be broadcasted manually by the crew through display unit of TCMS.
 - 5.19.3.3. The system shall be capable of storing 120 minutes of pre-recorded messages preferably in digital MP3 format or latest format. The memory shall be able to store route data base for at least 50 stations. However, it shall be possible to enhance the memory by expansion using commercially available devices.
 - 5.19.3.4. Voice announcements shall be pre-recorded and configured into the system using the “offline” speech and route data base editor. Messages, audio or visual or both shall be in the Hindi, English and regional language. The hardware and dedicated software etc. for editing and modifying the speech and route database shall be supplied.

- 5.19.4. Emergency Call Equipment
- 5.19.4.1. The emergency call equipment shall consist of Emergency button and Talk Back (ETB) device. The emergency call equipment shall be in accordance with UIC 541-6. Provision of UIC 541-6 (Clause 1.3) to shall be complied with. Number and location of the devices shall be agreed during detailed design stage.
- 5.19.4.2. Once emergency button is pressed/operated, notification along with alarm on TCMS display shall be displayed and inter-communication between crew and passenger shall be established.
- 5.19.4.3. A fall-back system shall be provided to enable the communication between Driver / Train Manager & passengers in case of failure of normal communication channel.
- 5.19.4.4. If more than one emergency device has been operated, each demand shall be independently acknowledged, and alarms shall be stored, displayed and answered sequentially.
- 5.19.4.5. The activation of any ETB device shall interface with the saloon CCTV such that images of concerned area are automatically displayed on train-borne display unit inside the cab it shall be possible to Driver to identify which PEA has been activated so that the communication with the passengers can be initiated. The CCTV camera of the car shall focus on the ETB area during the conversation. Small LCD display at the passenger end shall communicate the status of his request in case of multiple operation of ETBs.
- 5.19.4.6. Provision shall be there for voice recording of the conversations with GPS stamping.
- 5.19.4.7. The effect on the Train due to activated emergency call equipment may vary, depending on the location of the Train and the lines on which it is travelling. Generally, the effects on the Train of an activated emergency call equipment are:
- (i) Event (Activated emergency call equipment) occurring within station area (for example due to a person being pinned between the doors or between the platform and the Train): immediate halt of the Train at platform.
 - (ii) Event occurring outside the station area (for example, fire or passenger becoming unwell): transmission of the activated alarm signal to the Train Driver in order to inform him that an incident has occurred in the Train and to ensure that the Train is brought to a halt by the Train Driver in a place which is suitable for assistant to be rendered (away from tunnel, gallery or bridge).
 - (iii) The passenger shall receive confirmation that the activation of emergency call equipment has been noted within the Train.
- 5.19.5. Intercom System
- 5.19.5.1. There shall public address intercom system for voice communication system between the crews and between crew and passenger, if desired.
- 5.19.5.2. The communication between train crew shall be in full duplex mode and multiplexed with suitable measures to prevent acoustic feedback.

5.20. Passenger information system (PIS)

- 5.20.1. A Passenger information system (PIS) shall be provided to give audio visual guidance to the passengers. It shall be designed to provide information on displays in Hindi, English and regional languages throughout the journey. The colour of multilingual character shall be reviewed and approved by the Nominated Agency.
- Full facilities including any hardware/software tools for programming the displays and system shall be supplied. Supplier shall arrange training to program, edit and interface the display panels with the system.
- 5.20.2. PIS shall use a GPS / S&T based system to determine the location of Train to provide automatic announcement and the display of destination information on displays throughout the Train in Hindi, English and regional languages.
- It shall also be capable of making pre-recorded announcements (both audio and visual) by manual triggering from main communication panel if 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 operation. The

- audio announcements shall be done through the same speakers as that of voice communication system.
- 5.20.3. All elements of the PIS installation shall be designed so as to resist damage and vandalism. Information displays shall be protected by transparent covers so as to protect against damage. Suitable IP shall be proposed for both external and internal displays during detailed design.
- 5.20.4. The equipment/ system shall be suitably interfaced with TCMS to ensure detection of equipment failure. The diagnostic and failure data shall be downloadable in the same manner of the TCMS data.
- 5.20.5. Displays
- 5.20.5.1. External Displays
- 5.20.5.1.1. Each Driving Car shall be provided with a front indicator board of good visibility in day and night of suitable size for showing Train / service identification code. The display shall be of LED type
- 5.20.5.1.2. Each Car shall be provided with two (02) digital destination indicator boards (minimum LED matrix size 16x128) of good visibility in day / night on the outside (one on each side) displaying the originating, destination station, Vehicle number, Train number etc.
- 5.20.5.1.3. The external displays shall have adequate brightness, which shall have auto adjustment with the outside ambient light. It shall be possible for someone of normal vision to read the display from a distance of at least twenty (20) meters under all lighting conditions.
- 5.20.5.2. Internal Displays
- 5.20.5.2.1. At least two (02) high resolution multi-colour graphic LCD display with backlit LED, suitable for the remote displaying of moving messages shall be provided on board the train, in the passenger area. The internal displays shall show, but not limited to, following information::
- Name of approaching station;
 - Current and next Halting Station;
 - Time to next stations;
 - Running speed;
 - Platform side;
 - Safety / Emergency Messages;
 - Late running status; and
 - Approximate distance to next station.
- 5.20.5.2.2. Besides above, there shall be at least four (04) LCD displays with backlit LED of suitable size for displaying any other information such as pictures/video messages for advertisement or other purposes. Infotainment shall be part of the scope of the Supplier.
- 5.20.5.2.3. The size of the letter and the resolution shall be programmable and have adequate clarity and visibility for all the passengers of the Car. Detail specification, screen size, mounting arrangement and screen content shall be finalized during detailed design.

5.21. Passenger Car Surveillance System (PRSS)

- 5.21.1. The passenger Car surveillance system shall comprise of an IP based close circuit television (CCTV) network, surveillance cameras and other accessories as required.
- 5.21.2. Each Car of Train shall be provided with adequate surveillance cameras to cover the passenger area. For a sleeper car, coverage of the entire corridor is required. In addition, coverage in Gangway/vestibule area as deemed necessary shall also be provided.
- 5.21.3. Additionally, at least one camera shall be placed in Driving Cab for gathering front-end view, track and OHE conditions etc. Camera(s) shall be placed on outer side of the each Basic Unit for gathering rear view of the platform. One/two camera(s) shall be installed on the roof towards pantograph to monitor the roof equipment.
- 5.21.4. An integrated monitor screen shall be provided for the passenger Car surveillance system in each Driving Cab. It shall be so placed in the cab that normally it does not cause distraction to the Train Driver but it shall be easily viewable by the Train Driver/Train Manager, when needed.
- 5.21.5. The visual images from each camera shall be recorded in First in First Out (FIFO) non-volatile memory. The on-board system should have capacity of recording such that it can be downloaded in the Maintenance Depot during the scheduled maintenance. The capacity of the memory shall be expandable. The capacity of the memory shall be sufficient enough to record videos up to 25 frames

per second, for a minimum period of 30 days @ 24 hours per day. The CCTV cameras shall conform to IEC 62676. The CCTV cameras have to meet the following minimum parameters:

- Image sensor: 1/2.8" or larger, CMOS sensor
- Minimum Illumination: 0.3 lux (colour)
- Lens: Focal length 2.8 mm or larger
- Resolution: 2 MP and above

The field of view-object size shall be up to (identify the target) as per IEC 62676-4 from 1.5 m distance.

5.22. Cab Recording Equipment

- 5.22.1. Separate and independent recording equipment apart from CCTV system shall be provided in each cab for Audio cum video recording. Further, as this equipment are expected to be used for post-accident/incident analysis and defining the mitigation actions, compliance to UK rail standard GM/RT 2472 or equivalent shall be ensured. The duration of the storage for the memory shall be for the last 30 minutes in the above-mentioned memory complying to GM/RT 2472 and for last 24 hrs. in flash memory. Resolution and placement of the cab recording equipment shall be appropriate to clearly make out various actions of crew from the recorded data. The equipment should be rugged so as to ensure trouble-free performance in the harsh environment of the Driving Cabs. Measures must be taken to prevent pilferage and damage of the equipment by vandalism and shall be such designed that the retrieval of the data is simple.
- 5.22.2. The equipment shall be designed to permit rapid extraction and analysis of data; assist retrieval of data after an incident or accident; and mitigate the effects on recorded data of foreseeable impact or derailment.

5.23. Deleted

5.24. Centralized Coach Monitoring System (CCMS)

- 5.24.1. Each Driving Car shall have provision for Centralized Coach Monitoring System (CCMS) for monitoring, recording and control of the air-conditioning and faults of bearing, running gear etc. as mentioned in this Clause. CCMS shall also run diagnostic routines on the HVAC and generate alerts like low gas pressure in compressors, faulty sensors etc. Other functionalities viz. CCTV, PIS etc. and automatic voice announcement system shall also be available in CCMS. Details shall be finalized at design stage.
- 5.24.2. The CCMS shall have touch screen display (minimum 18-inch size) and have hardwired suitable communication to microcontroller of HVACs of each Car. The CCMS can use the same communication backbone as of TCMS.
- 5.24.3. The CCMS shall also have GSM/GPRS/LTE based wireless modem through which information/alert to operation control centre / maintenance staff shall be communicated. Information should also be available to the maintenance staff on a mobile application, which shall be developed by the Supplier.
- 5.24.4. CCMS shall have instrumentation to monitor the following, but not limited to:
- Auto/bypassed mode working of HVAC
 - Temperature (return air, supply air temperature and ambient temperature)
 - Pressure (Low pressure, High Pressure and Oil pressure in HVAC)
 - LP & HP tripping
 - Compressor tripping
 - HVAC-AC motors tripping
 - Health of the axle bearings
 - Running Gear Hunting Detection
 - Running Gear Derailment Detection
 - Deflated / broken Suspension Monitoring
 - Fire Detection system status

- Other inputs and output to be decided during design approval stage

These data shall be transmitted to the control centre through GPRS/GSM/LTE regularly at suitable intervals. In case of failure, on board systems shall take action to mitigate the damages to the rolling stock and passengers by Traction cut-off, Brake application etc.

- 5.24.5. It is preferable that the functionalities specified for CCMS is implemented through TCMS. However, Supplier may also propose separate arrangement for the implementation of CCMS. Detail to be discussed and finalised during detailed design.

5.25. Wi-Fi based infotainment system

Suitable Wi-Fi based infotainment system as per good industry practices shall be provided. The system shall be suitable for rolling stock application. It should be possible for uploading pre-loaded content for the complete Train from a centralized location. Wi-Fi based system shall have provision of internet support, which can be enabled whenever the system is connected to external internet service. Passengers should be able to access the content from handheld devices.

5.26. Wheel, Axles Roller Bearings

- 5.26.1. Axles shall be designed in accordance with BS EN 13103-1:2017 or latest.
- 5.26.2. Wheels shall be in accordance with EN 13262 and EN13979-1+A2.
- 5.26.3. Wheel sets shall be in accordance with EN 13260 or other equivalent internationally recognized standard.
- 5.26.4. Axles shall be in accordance with EN13261.
- 5.26.5. Components including wheels, secured to the axle by interference fit shall be designed to remain secure over appropriate temperature ranges in accordance with the Good Industry Practice.
- 5.26.6. Design validation of wheels and axles shall be required to be carried out to validate the design. Latest versions of EN standards as mentioned in Annexure-I should be used.
- 5.26.7. Any type of roller bearing shall be used to cater for the axle load prescribed in this specification. Roller bearing shall be grease lubricated & sealed and also supplied by any established supplier. Roller bearings shall be conforming to EN 12080:2017.
- 5.26.8. Axle Box guide device as per Annexure-III for prevention of running away of Train in case of derailment shall be provided shall be installed on each axle box. Supplier can refer the technical paper titled "Development of an L-Shaped Guide to Prevent Deviation from Rails for material and design related information of Axle Box guide device.
(Link: https://www.jreast.co.jp/e/development/tech/pdf_15/Tec-15-53-56eng.pdf).
- 5.26.9. Thermal switch for the temperature monitoring of all the Axle box bearings, gear box bearings and traction motor shall be provided. Details to be finalized during design stage.

5.27. Bogie Design

- 5.27.1. The bogie frames shall be of fabricated, robust construction, using high tensile carbon steel to EN10025/ JIS G3114 or an approved international standard, capable of withstanding heavy duty, the design incorporating adequate safety margins. The bogie frame construction shall be consistent with good mechanical design, be as light as possible. Use of cast steel inserts of acceptable grade in fabrication with specific prior approval of the Purchaser/Nominated Agency in the bogie may be permitted.
- 5.27.2. The structural design of the bogie frame shall conform to EN 13749:2011, category B-1 or equivalent standard, but with payload as specified in Clause 3.8 of these Specifications and Standards
- 5.27.3. Testing of the bogie frame shall be in accordance with Annexes F and G of BS EN 13749:2011.
- 5.27.4. The bogies shall provide the required riding comfort. Bogie design & validation shall generally conform to EN15827.
- 5.27.5. The bogies shall be of the two axle, bolster less type, incorporating a primary suspension system of proven helical coil steel-springs. Vertical dampers shall be provided with primary suspension. Anti-yaw dampers shall be provided between Car body and bogie, if the bogie design warrants it.
- 5.27.6. Design of suspension elements will comply to following standards:
- (i) Air spring as per EN 13597.

- (ii) Rubber suspension/guiding elements including rubber metal bonded items as per EN 13913.
 - (iii) Coil springs as per EN 13298.
 - (iv) Any other suspension element as per relevant standards.
- 5.27.7. No component of bogie shall infringe with the minimum clearance as specified in Annexure-II with fully worn wheels and with maximum permissible load (stops under contact in primary & secondary suspension and suspension in failed mode).
- 5.27.8. Rolling Stock shall be designed with its curve negotiating design capability with minimum cant deficiency for operation as specified in these Specifications and Standards. Designer shall technically establish maximum possible cant deficiency potential in rolling stock design by way of calculations / dynamic simulations.

5.28. Draw and Buffing Gear

- 5.28.1. The Driving Cab shall be equipped with the necessary means to achieve the coupling / uncoupling functionalities. Design shall be finalized during design stage.
- 5.28.2. The end couplers, inner couplers provided for the Train shall meet the requirements as per TSI LOC&PAS.
- 5.28.3. In case of Train rescue, the couplers shall meet the requirements as per TSI LOC & PAS.
- 5.28.4. The Supplier shall submit allowable coupler force in tensile and compressive mode of operation.
- 5.28.5. Supplier shall supply five (05) nos. adapters compatible for coupling of Trains with inspection/maintenance vehicles of Maintenance Depots of the Trial Section. Details to be discussed with the Nominated Agency during detailed design.

5.29. Brake System

- 5.29.1. The brake system shall be of proven design, which has worked successfully in long-distance high-speed passenger Trains.
- 5.29.2. The brake system shall comprise the following types of brakes:
- (i) Electro-Pneumatic (EP/ EP assist) friction service brake or more advanced version
 - (ii) Electric regenerative service brakes
 - (iii) Provision of smooth and continuous blending of EP and regenerative braking
 - (iv) Fail safe, electro pneumatic friction emergency brakes
 - (v) Fail safe, fully pneumatic (BP controlled) friction emergency brakes (if required)
 - (vi) Spring applied air-release parking brakes
- 5.29.3. The braking system shall have provision for interface with ETCS / ATP system depending on its availability.
- 5.29.4. Air brake system comprising MR & BP shall run from end to end of the Train with two isolating cocks at either end of cars terminating outside. It shall have pressure settings of $5 \pm 0.1 \text{ kg/cm}^2$ for BP $8.5 \pm 0.1 \text{ kg/cm}^2$ to $10 \pm 0.1 \text{ kg/cm}^2$ for MR.
- 5.29.5. In the event of critical failure of brake equipment of the Train having adverse impact on safety of the Train, brakes shall be automatically applied.
- 5.29.6. **Electro-Pneumatic (EP) Friction Braking**
The electrically operated pneumatic friction brake system shall be of proven design and capable of achieving all performance requirements mentioned in Clause 4.6 of these Specifications and Standards without the aid of electric regenerative braking.
- (i) The friction braking system shall function as the ultimate braking system on the Train, acting as a backup during normal service braking and as the primary braking system during emergency stops and while stationary.
 - (ii) The friction brake shall be achieved by means of a pneumatic brake and shall be fully rated to meet, on its own, the full braking performance and shall be capable of sustaining the continuous full emergency braking requirement.
 - (iii) In the event of a failure of the regenerative brake, the friction brake shall be capable of carrying out two consecutive emergency brake applications from maximum speed to standstill of a rake in loaded condition. The rake shall be deemed to then accelerate at its maximum rate up to

maximum speed after each stop.

- (iv) The Cars shall be provided with disc brakes in accordance with EN 14535-1 or EN 14535-2 as applicable.
- (v) Brake pad shall conform to the requirements of UIC 541-3. Brake pad material shall not contaminate the track or rails leading to interfering with signalling system.
- (vi) Adequate safety straps shall be provided below the moving components of brake rigging to prevent falling on the track in the event of failure of any component.
- (vii) The braking system shall provide adequate safety against rolling back of the Train in case the Train is to be started on a rising gradient of 1 in 33.3.
- (viii) Specific provision shall be made in the software to ensure that the Train while starting on the gradient, the roll back, if any, is nominal.

5.29.7. Electric regenerative Braking

5.29.7.1. The electrical regenerative braking system shall be the primary braking system of the Train. The braking system of the Train shall also ensure that when the electric brake is insufficient to provide the required braking effort, the necessary proportion of the air brake of the Train, superimposed on the electric brake, is applied (system also known as “brake blending”).

5.29.7.2. The Train shall be designed so that the regenerative brake system is used to the maximum extent possible. Full utilization of the regenerative braking is envisaged in the 3-phase drive system such that regenerative braking is available over full range of speed to be blended / interfaced with the EP brakes.

- If the re-generative braking becomes ineffective, the friction brakes shall immediately be applied to maintain the braking rate demanded by the Train Driver.
- A smooth changeover between the re-generative brake and the friction brake shall be achieved. This smooth changeover shall be achieved even in the event of failure of the overhead line or when passing through neutral sections.
- Electric regenerative brake fadeout shall not occur above five (05) kmph.

5.29.8. Emergency Braking

Emergency braking shall be applied as a consequence of break in emergency brake loop wire. The break can be caused by the Train operator intentionally or by opening of contacts of safety devices in the brake loop, provided in the design, to avoid unsafe conditions. Emergency Brake loops shall be redundant.

- (i) Emergency brake is applied by friction brake system. Emergency braking distance as specified in Clause 4.6.4 of these Specifications and Standards shall be achieved from 249 kmph to 0 kmph for all loading condition on level tangent track.
- (ii) Two emergency brake push-buttons shall be installed in each Driving Cab in the Train. Activation of the buttons, including that of non-active Driving Cabs, shall apply the emergency brakes.
- (iii) Any device provided to allow the Train Driver to apply the brake in an emergency shall cause an emergency brake application. in the Train.
- (iv) Unintended parting of the Train shall result in an emergency brake application on both portions of the Train. An indication or message as required for the same should be provided.
- (v) Wheel slide protection shall be available during emergency braking. Any failure in the wheel slide protection in emergency braking shall result in the application of full brake force and deactivation of the slide system.
- (vi) Activation of the emergency brake by any means shall result in the propulsion system being disabled in a safe manner. The propulsion system shall not be re-enabled until the Train is at zero speed and the emergency condition has been reset.
- (vii) The friction brake system shall be rated to and have sufficient thermal capacity to safely complete two successive accelerations and emergency brake cycles, with no interval between each cycle on loaded Train. Each cycle shall comprise a full acceleration from standstill to maximum operating speed followed by the application of emergency brake to standstill. On completion of the two cycles, the brake system shall show no abnormalities. The requirement

shall be demonstrated during testing. Thereafter, the Train friction brake shall have sufficient thermal capacity to be able to complete its journey without regenerative brakes.

- (viii) The Trial Section is equipped with an earthquake detection system. Emergency brake shall be applied on power failure due to earthquake or any other triggers which causes OHE power disruption. Implementation and functionality shall be discussed during design.
- (ix) A separate emergency brake valve should be placed in an ergonomic position on the left side of the Driving Cab. It must be installed in a fail-safe position so that it can only be operated by the driver when intend to open the air brake pipe directly in case of an emergency. During service and emergency brake application through push button and emergency brake valve automatic Train power cut off shall take place

5.29.9. Brake Control System

All circuits and controls essential for braking equipment shall be a fail-safe with redundancy. A microprocessor based brake control system shall be offered.

Adequate redundancy shall be provided to ensure that the brakes in the cars do not become non-functional in case of failure of power supplies, isolation of traction equipment or failure of control electronics and pressure transducers etc. In case of isolation due to any defect, the brake system shall take adequate corrective action with least system isolation.

5.29.10. Brake Operating Timing

The following maximum brake operating timing shall be achieved as per EN13452-1. The maximum time for a brake application from full application to 90% of full Brake Cylinder Pressure (BCP) and for brake release from full BCP to 10% shall not exceed the following:

- (i) Service Brake Application : 2.0seconds
- (ii) Emergency Brake Application : 1.5seconds (max.)
- (iii) Service and Emergency Brake Release : 3.5 seconds

A malfunction of the EP friction brake affecting the braking rate or safety shall result in an emergency brake application. In case of single point failure, brake compensation shall take place to account for failure of brake on one bogie. This shall be achieved with minimal intervention of the Train Driver.

5.29.11. Brake Pipe (BP) controlled back-up system (if required)

- (i) A brake pipe controlled back-up brake system shall be provided in cars, allowing the brakes on each Car to be controlled by the pressure in the brake pipe, irrespective of the presence of electrical power on any Car.
- (ii) The brake pipe pressure shall be controlled by means of a separate control unit ergonomically placed on the Train Driver's console and having three positions for application, charging and lap modes.
- (iii) This system shall also be used to control brake system of dead Train during rescue by a healthy Train, transit of Cars and shunting operation.
- (iv) During the operation of this mode, dynamic brakes shall be isolated and the pneumatic brake application shall be resorted.
- (v) During the rescue operation of the faulty Train by the healthy Train, the operation of driver brake valve shall be able to drop the BP pressure of both the trains to apply backup brake.

5.29.12. Parking Brake

- (i) The parking brake shall apply automatically in all circumstances where the service brake is no longer capable of holding the Train stationary and shall be designed to hold an Train with payload as specified in clause 3.8 of these Specifications and Standards, on the gradient of 1 in 37 in the wind condition for an unlimited time.
- (ii) Parking brakes shall be applied in the event of loss of the main compressed air supply. The parking brakes shall be capable of release from within the Driving Cab when the compressed air supply is present. With no compressed air supply available, it shall be possible to release individual parking brake actuators manually from track level. Application of parking brakes shall also be controllable from the Driving Cab. Unintended parking brake application due to air leakage from parking brake line will be detected and displayed on Train Control &

Management System (TCMS) as fault indication.

- (iii) The design shall be such that the parking brakes will take effect prior to fade off holding brake and shall ensure that the combined brake effect of the pneumatic brake and parking brake is never less than the full brake effort of the parking brake alone.
- (iv) Status of Train parking brake shall be displayed on the Huma-Machin Interface (HMI).
- (v) Parking brake control – The parking brake shall be applied and released using an illuminated pushbutton(s). The parking brake shall be interlocked with the traction equipment to prevent the Train Driver taking traction with the parking brake applied. The system shall not permit application of parking brake when the Train speed is greater than 5 kmph.

5.29.13. Wheel Slip-Slide Protection

- (i) Traction and brake control system shall be designed to eliminate, by means of a reduction of short duration in the traction or braking power, the excessive slipping or sliding of axles occurring during acceleration or deceleration, and to prevent locking of axles. In addition, the system shall make optimum use of the available adhesion between rail and wheel.
- (ii) In the event of wheel slip, corrective action shall be taken by the wheel-slip protection subsystem to adjust the effort to the available wheel-rail adhesion. The slip shall be detected by evaluation of each axle speed and acceleration and compared with a calculated speed reference for the Train.
- (iii) In the event of wheel slip/slide, adequate brake system effectiveness should be maintained.
- (iv) Digital wheel slide protection with gradual slide correction shall be provided in all braking modes. The slide detection shall be performed per axle and the correction per car / bogie (in case of electro-dynamic braking) and bogie / axle level (in case of friction braking). The correction of slide shall operate independently on each Vehicle. Automatic wheel wear compensation shall be incorporated in the wheel slip/slide protection Sub-system.
- (v) The sliding effect shall be maintained during a relevant period of time, in order to increase the available adhesion at the wheel-rail contact with permanent control, in minimizing the air consumption and optimizing the stopping distance.
- (vi) The correction process for wheel slip/slide shall not cause infringements of the signalling compatibility requirements.
- (vii) The performance of the wheel slide protection equipment shall satisfy the relevant requirements of UIC 541-05.
- (viii) The wheel slide system shall detect the onset of slip/slide by either an axle deceleration exceeding a pre-set parameter, or detection of a difference between the relative speeds of the axles of any one axle of the bogie.

5.29.14. Load Weighing System

- (i) Load weighing system shall be used for measurement of air spring pressure to limit the adhesion utilization, meet the requirements of acceleration, braking and detection of deflated air spring. The pneumatic signal for the load weighing system is to be provided by the Supplier. The load weighing compensation signals to the propulsion and braking systems shall be a continuous function available for all Car weights up to full load. Adequate redundancy shall be provided in the load weighing system and failure shall be recorded in the diagnostic. If there is a failure of this system, the coach shall respond as if it was fully loaded. Air spring deflation indication shall be provided in the driver's cab including the information regarding Car, air spring position in Bogie, status messages etc. In order to ensure reliability of the scheme, adequate redundancy shall be considered to take care of the failure conditions. Separate weight sensor for each air spring in one bogie shall be provided to achieve redundancy at bogie level.
- (ii) Air spring deflation indication system shall monitor the air spring pressure for each air spring, and in case of air spring deflation permitted speed restriction shall get applied automatically. Air spring failure indication alert should be provided in driver's cab with location details. Failure events of air springs should be logged.
- (iii) If one secondary suspension bursts in a bogie, the other suspension of the same bogie shall

release air and maintain the required pressure for safe operation.

5.29.15. Pipe System

- (i) A main reservoir pipe shall run continuously throughout the Train. Foreign matter shall be removed from all pipes prior to installation.
- (ii) All piping shall be of stainless-steel conforming to the requirements of duplex steel or SUS316L with flare less bite type double compression fittings generally conforming to the requirements of DIN 2353.
- (iii) Sharp bends shall be avoided and standard connections shall be used as far as possible. All pipelines shall be suitably colour coded. The proposed colour coding shall be reviewed during the design phase.
- (iv) All branches from the main reservoir pipe or control system shall be fed via self-locking cocks (coloured according to the corresponding pipe colour) with or without vent and electrical switches as appropriate. Magnet valves, reducing valves, check valves, silencer and drain plugs etc. shall be incorporated as required. Quick release coupling test points made of stainless steel, with blanking plugs shall be provided. They shall be located in easily accessible positions.
- (v) Flexible hoses shall be kept to a minimum and be proven in semi-high-speed trains. Burst hose protection shall be provided to increase the integrity of the air supply system against rupturing of inter-car flexible hoses. Armoured hoses shall be provided in the flexible connections in the parking brake piping.
- (vi) All pipes shall be installed by means of clamps with integral, moulded vibration damping inserts to prevent any rattling in service. Clamps shall not be welded to the pipe. Where piping pass through holes in the floor, structure member etc. it shall be rigidly clamped immediately adjacent to the hole to prevent contact to the edge of the hole.
- (vii) In the event of leakage from the pneumatic circuit/system, it shall be possible to isolate the effected part of the circuit and reach up to destination station. Isolation arrangement shall be simple and shall not require more than special key normally carried by Train Driver. Supplier shall submit detail plan during design for engineer's approval. The isolation arrangement shall preferably be in the saloon and shall be secured.

5.30. Compressed Air System

5.30.1. The compressed air system shall ensure delivery of the compressed air complying with the air quality class specified in ISO-8573.

5.30.2. Compressor

- (i) The motor compressor unit shall be under slung, resiliently mounted with the under frame to minimize the levels of vibrations transmitted to the car body.
- (ii) The motor shall be 3-phase AC motor suitable for working from the 3-phase output of the Auxiliary converter or independent inverter as the case may be.
- (iii) System design shall be such that average duty cycle of any compressor without electrical braking is not below 30% and does not exceed 80%. The run time and duty cycle of each compressor shall be recorded through TCMS for maintenance schedule point of view.

5.30.3. Air Dryer

The air delivered to the pneumatic system shall be clean and dry, free from water vapor, oil and particles.

5.30.4. Air Reservoirs

Main reservoirs of adequate capacity, made of corrosion resistant material, shall be provided with provision of adequate safety arrangements.

5.31. Horns

Dual tone pneumatic horns shall be provided facing outwards at each end of the Train. The horns shall be of sufficient size and power to be distinctly audible at a distance of one (01) kilometer from the Train. The two horns shall have different tones but shall be in harmony with each other when blown together.

5.32. Deleted

5.33. Car Body Structure

- 5.33.1. Airtight Car body structure with maximum width of 3350 mm shall be adopted for all types of cars. The car body shall be manufactured using Austenitic stainless steel as per JIS G4305 or equivalent international standards and it shall be from the latest and best practiced Rolling Stock application. The Car body shall be lightweight and corrosion resistant and rugged to withstand the tractive and braking effort as well as impact and accidental damage. The mechanical strength of car body shall conform to EN 12663 (Category P1) and the design of coach body shall meet EN 15227 (Category C1) standard collision scenarios using complete Train method or reference Train method.
- 5.33.2. The pressure experienced by a passenger on board a Train should not exceed a change of following as per TSI_Loc & PAS regulations and EN 14067-5: Sealed Trains:
- 1000 Pa within a period of 1 sec
 - 1600 Pa within a period of 4 sec
 - 2000 Pa within a period of 10 sec
- 5.33.3. The Car body shall be of an integral design, where under frame, sidewalls, end walls and roof shall be integrated so that the body structure contributes to strength of under frame and the unit as a whole behaves as a rigid tube in its ability to withstand loads. The longitudinal end of the car body shall incorporate an anti-telescopic feature.
- 5.33.4. The exterior colour schemes including Logo of the Car shall be developed by the Supplier in consultation with the Supplier.
- 5.33.5. Throughout the design life of thirty (30) years (including the fatigue life due to aerodynamic effect), the Car body material shall not degrade or be etched by the environmental conditions that exist in India, to the extent that the original appearance of the Car does not deteriorate to the extent that it cannot be restored by normal washing / painting to acceptable levels of appearance for similar class of Trains globally. Supplier shall decide painting/finishing schedule accordingly.
- 5.33.6. Underframe equipment shall have side-covers and bottom-covers to reduce the aerodynamic drag resistance.

5.34. Crashworthiness

- 5.34.1. The design and crash worthiness of the Car body shall meet EN 15227 (Category C1) standard collision scenarios using complete Train method or reference Train method.
- 5.34.2. The Car structure and its supplemental energy absorption devices shall be designed to minimize accelerations transmitted to passengers, by absorbing collision energy, whilst not permitting one Vehicle to over-ride another, nor to telescope one into another. A suitable proven energy absorption feature with associated collapse and anti-climbing features shall be incorporated into the coupler/buffers or other structural members.

5.35. Appearance

- 5.35.1. Exterior Painting/finishing
- (i) Exterior finishing shall be carried out with a proven paint or self-adhesive bonding decals system used on Train globally. The paint / decal system shall be compliant to EN 45545 HL2 with respect to Fire standards.
 - (ii) The exterior colour scheme of different variants of the Cars listed in these Specifications and Standards shall be submitted to Nominated Agency for approval.
 - (iii) The paint coating/decals shall be tested in accordance with relevant latest international standards. In case of decals, tests shall also include peel adhesion and tensile lap-shear strength tests as per applicable ISO standards.
 - (iv) Anti-graffiti clear coating shall be provided on exterior finished surface of passenger Cars.
- 5.35.2. Finish
- The surface finish of the Carbody, Exterior Doors and other external surfaces visible to passengers shall present a high-quality finish that delivers:

- a smooth and continuous surface free from protuberances, sharp edges, weld spatter or manufacturing marks;
- a ripple-free appearance when painted or covered in high gloss materials; panel joints on the exterior that are not visually misaligned to an observer with normal eyesight standing one (01)m from the joint; and
- no undulations on any exterior surfaces exceed two (02) mm over 1m length, excluding Vehicle roof and under frame.

5.35.3. The Vehicle number shall be applied on both sides of each Vehicle, at both ends, both externally & internally.

5.36. Obstacle deflector

5.36.1. The Driving Cab end of the Train shall be provided with an obstacle deflector that can withstand collisions at the maximum service speed with obstacle weighing up to 100 kg or less, with a height of 250 mm or lower. It shall not cause any effect on the safe operation of the Train. Clearance between the obstacle deflector and rail level shall be 150 ± 5 mm.

5.36.2. Auxiliary lifeguard: When the Train is running at speed of 249 kmph, an obstacle with a height of 50 mm to 250 mm and a weight of two (02) kg or less shall not cause any effect on the safe operation of the Train. Clearance between the auxiliary lifeguard and rail level shall be twenty (20) mm.

5.37. Deleted.

5.38. Car Interior Furnishing

5.38.1. The Car interior shall have resistance to fire and shall be designed in accordance with the directives of EN 45545 (part 1 to 7). The Car interior furnishing material should have fire retardant properties confirming to European Standards EN 45545.

5.38.2. Interfaces between passengers and the Train shall have a modern, uncluttered appearance. Passengers shall be presented with a consistent design theme throughout their interactions with the Train, including consistent controls and visual themes.

5.38.3. Materials and finishes on the interior shall give passengers the impression of a high-quality service, while also meeting requirements for robustness, cleanability, graffiti-resistance, etc.

5.38.4. All interior surfaces, including walls, partitions, body side panels and ceiling panels shall be hard wearing, resistant to physical damage by vandalism, fading, scouring, acid etching or graffiti, and shall be easy to clean and maintain.

5.38.5. Cars shall have Overhead luggage racks for keeping bags.

5.38.6. Passenger amenities shall be comparable to that of best-in-class trains globally in terms of comfort, functionality and aesthetics. Following passenger interface items shall be sourced preferably from the firms who have adequate experience and proven credentials of manufacturing and supplying similar items:

- Doors and Windows
- Interior Panelling and Flooring
- Seats

Supporting documents for the same shall be submitted at detailed design stage.

5.39. Toilet System

5.39.1. The Car(s) shall include zero discharge toilet systems. Number of toilets shall be limited and shall be decided during design Phase considering max axle load.

5.39.2. The Car(s) shall include environment friendly toilet (bio digester / bio toilet with vacuum evacuation) systems of a modular design, spacious, environment & user friendly and easily maintainable. The environment friendly toilet (bio digester / bio toilet) shall treat the human waste by biological degradation (aerobic/anaerobic) and shall confirm the effluent discharge quality to the existing norms applicable by Central Pollution Control Board (CPCB) or any other authority applicable in India..

5.39.3. Following additional preferable features for toilets shall also be included:

- Automated toilet flushing when not flushed by the user.
 - Toilet ready indications etc.
- 5.39.4. It shall be possible to display availability of all Toilets (free, occupied or out-of-service) in the PIS displays.
- 5.39.5. Each toilet shall include the following equipment:
- Mirrors;
 - Wash basin with water tap;
 - Health faucet for personal cleaning;
 - Toilet paper dispenser;
 - Liquid soap dispenser
 - Waste container (Waste Bin)
 - Coat hooks (Two);
 - Lighting;
 - Circulation of fresh air;
 - Provision of toilet freshener liquid /tablets;
 - Flush push button;
 - Grab handle;
 - Water taps and 01 bowl/ stainless steel mug for water with stand should be provided with anti-pilferage provision;
 - Lavatory engaged / free indication light shall be provided at both ends inside the Car at a convenient location, this light shall be generally visible throughout the Car; and
 - Suitable devices for extraction of foul air from toilet compartment shall be provided.
- 5.39.6. Lavatory doors
The strength of the lavatory doors shall be as per UIC566. In addition toilet doors shall have a structure that can be locked from the inside and unlocked with a common key from the vestibule side.
- 5.39.7. Each toilet shall have an odour control measures so that there is no foul smell at any time from the toilets. One of the odour control measures for reference is installation of flapper at the bottom of the toilet and installing a ventilator to exhaust air when the flapper is operated duly ensuring that the flapper does not jam.
- 5.39.8. The toilet shall have proper slope and drainage and all joints shall be sealed so that there is no accumulation of water or other matter, liquid or otherwise, at any time.
- 5.39.9. The size of the toilet and toilet seat inside toilets shall be adequate for the anthropometric dimensions of the Indian Passengers.

5.40. Sub-Pantry

The Cars shall have the following sub-pantry equipment:

- Bottle cooler cum deep freezer
- Water boiler of minimum 20-liter capacity.
- Hot case (Veg & non-veg compartment
- Trolley size with suitable dimensions for serving the passengers
- Adequate waste disposal arrangement
- The sub-pantry equipment shall work on the 230 V AC, single phase, sinusoidal
- 50HZ auxiliary converter supply.
- The sub-pantry load shall be suitably distributed on the three phases.

However, further details, numbers and layout of Sub-pantry and its equipment shall be finalized at design stage.

5.41. Water Tanks and Water Circulation

- 5.41.1. Water tanks of defined capacity shall be provided under slung and interconnected, Cars shall be provided with suitable water pumps for supply of water to lavatories in Cars. Each lavatory shall also be provided with one overhead water tank of minimum 30-liter capacity. Material selection for

water tanks, piping and pipe fittings shall be protected against corrosion and shall be suitable for intended service life of the Cars.

5.41.2. Water capacity requirement per Car has been mentioned below for reference:

SN	Type of Car	Water requirements (in litres)
1.	Executive Car	1000
2.	Standard Car	1000

5.41.3. Mechanical strength of the water tanks and their suspension shall meet the requirement as per para 2.1.4 of UIC566 or equivalent specification.

5.41.4. All coaches shall be provided with potable hot water, cold water and normal water provision.

5.41.5. The water tank shall have level indicators and an indication or an alarm or both shall be generated for the Train Crew in the event water tank level is low. The details shall be submitted during the detailed design.

5.41.6. Water sealing device with sufficient air tightness shall be provided in drainage facility.

5.41.7. Supplier shall supply coupling connectors equivalent to six (06) Trains for the connection of hoses to water tank at stations as well as at depot. Supplier shall submit design details of coupling connector to the Nominated Agency during detailed design

5.42. Seats

5.42.1. The design of seats shall meet the strength requirements /loading conditions in accordance with UIC 566 or equivalent standard. Seats shall be ergonomically designed to accommodate range users covering 95th percentile of Indian adult male/female population. The seating arrangement inside the Car shall ensure the following:

5.42.2. As a minimum the basic amenities as mentioned below shall be provided.

Car Type	Minimum amenities
All variants	<ul style="list-style-type: none"> • Infotainment system • Panels without blind holes and visible fasteners • Seats shall be rotatable • Sub-Pantry (nos. to be decided during detailed design stage) • Two-digit seat numbers shall be displayed on each Passenger Seat such that they can be clearly read by the full User Population from the aisle in any position within 1m of the seat. The seat number shall remain visible when the seat is occupied.
Standard Car	<ul style="list-style-type: none"> • Individual cushioned reclining seats • Sufficient leg room for free movement of passengers • Laptop cum mobile charging socket and USB for each seat • Reading light for each seat • 570 mm aisle space • Snack table for each seat • Magazine pouch and bottle holder for each seat
Executive Car	<ul style="list-style-type: none"> • Individual cushioned reclining seats • Leg room more than that of Standard Car • Laptop cum mobile charging socket and USB for each seat • Reading light for each seat • 600 mm aisle space or more • Snack table for each seat • Magazine pouch and bottle holder for each seat

5.42.3. Indian Anthropometric Dimensions shall be referred to in this regard.

5.43. Mock-up (if required)

- 5.43.1. The supplier shall make available for review by the purchaser, the mock-ups for all passenger and crew interface related items for each of the variants -
- Interior Panelling along with HVAC ducting
 - Interior lights
 - Partitions
 - Luggage racks
 - Seats
 - Hand holds
 - Modular toilets
 - Flooring
 - Doors
 - Driving Cab
 - Driver's desk
 - Hot water and cold water dispenser
 - Sub-Pantry with equipment etc.
 - One module of each Car variant shall be submitted with all original fittings planned intact as a mock-up. Digital model alone shall not be acceptable except for the roof layout. The mock-ups shall demonstrate, together with all the aesthetic design sessions supported by samples, design book, 3D virtual views etc. The mock-ups shall be constructed at the Supplier's facilities and shall be placed at location (within India) required by Purchaser. The mock-up will be reviewed by Purchaser/Nominated Agency and based on the review; the supplier shall carry out necessary modifications.

5.44. Deleted

5.45. Doors, Windows and Gangway

- 5.45.1. All Cars shall be provided with automatic internal doors duly segregating saloon (passenger) area and doorway vestibule areas.
- 5.45.2. Each Car shall have four (04) number of automatic plug type doors capable of retaining airtightness inside the saloon. The pass-through height & width of the opening of the door shall be suitable for comfortable ingress /egress of passengers.
- 5.45.3. Each Car shall have airtight exterior plug type doors conforming to EN 14752 - 'Railway applications- Body side entrance system' with sensitivity of obstacle detection as follows:
- When a rod with a maximum rectangular cross section of 30mm×60mm is trapped with its long edge vertically between the door leading edge and the frame or between two door panels, the door shall not be indicated as closed and locked.
 - An obstacle with maximum dimension of 10mm×50mm trapped with its vertical edge between the leading door edge and the frame or between two door panels, shall be withdrawn slowly in outward direction with a force not higher than 150 N, measured perpendicularly to the door surface. Alternating, the door shall not be indicated closed and locked.
- 5.45.4. The door mechanism shall have safety provision whereby the Train shall not start unless all doors have been closed and electrically locked.
- 5.45.5. The strength of the sliding door shall be as per EN 14752, and the doors shall be able to resist the loads without deformation or damage. Provision shall be made for passengers to open Car doors to permit evacuation from a stopped Train in an emergency. There shall be an internal and external manual release mechanism on one door per side in each Car. It shall be possible to monitor the status of each door on the TCMS.
- 5.45.6. The PIS system provided shall be capable of automatically providing audio announcements that are triggered as part of the Exterior Door obstacle detection sequence. This message shall be audibly broadcast in the affected Vestibule and a suitable visual indicator to be provided for indicating the status adjacent to the Exterior Door.
- 5.45.7. The operational status of each Exterior Door shall be reported to the Train Driver and TCMS.

- 5.45.8. If an Exterior Door is locked out of service or does not operate correctly, the Unit shall provide visual information to Passengers and platform staff via a suitable visual indicator to be provided for indicating the status.
- 5.45.9. Emergency Evacuation:
- (i) Each door shall be capable to open from inside by Train Crew during emergency. In order to prevent activation or handling of the device capable of unlocking doors during running, the lid of the device shall be locked and the Train Crew shall be able to unlock this lid in the event of an emergency.
 - (ii) Devices capable to unlock the side door shall be installed on the side of the Car duly protected. These devices shall be installed at an appropriate height so that it can be manually handled from the platform and the ground. When a device installed at the height of the platform is operated, only the door on the side of the Car in which the operation occurred shall be unlocked.
 - (iii) Necessary equipment required for emergency scenarios such as controlled evacuation shall be stored in the Train. For reference, the following equipment may be considered:
 - Ladder for controlled evacuation (suitable for wheelchair passengers also);
 - Signal flags (red and green);
 - Portable flashlight;
 - First aid boxes;
 - Tool boxes; and
 - Any other necessary equipment / tools required for emergency.
- 5.45.10. All windows shall be provided with double-glazed safety glass conforming to Railway Group Standard GMRT2100 Issue: Six Date: March 2020 (or latest issue) - Rail Vehicle Structures and Passive Safety and UIC 564-1: 'Coaches - Windows made from safety glass'.
- 5.45.11. All windows shall be provided with Roller Blinds (Fire retardant) which when deployed, cover at least 80% of the Window; and when stowed, cover no clear part of the Window.
- 5.45.12. The Car shall have interior and exterior gangway. An interior gangway connecting to the adjoining Cars excluding the Driving Cab conforming to EN 16286 - 'Railway applications- Gangway systems between Vehicles - Main applications'. The gangways shall be completely weatherproof, draught proof and resist vandalism. It shall be possible to lock/ unlock the fully sealed gangway between the cars by operation of suitable lever and quick release mechanism. The lever shall be concealed and should be accessible only from outside / inside the Train by maintenance staff, with suitable anti-tamper provisions. The exterior gangway shall be so designed to reduce the aerodynamic drag
- 5.45.13. The PIS shall have one OLED/LCD colour displays suitable for rolling stock application in each Vestibule area. These displays shall have a minimum size of 18-inch diagonal. Important route and journey information should be provided within the Vestibules to allow Passengers to continue to receive information whilst waiting to disembark or whilst moving through the Train. These displays can also provide detailed door opening information specific to the Exterior Doorway.
- 5.45.14. Indian Anthropometric Dimensions for Ergonomic Design – 1997 shall be referred to for ergonomic design.

5.46. Footstep (if required)

A motorized retractable type foot step shall be provided at all body side doors in all the Cars (if required). The design of the footstep shall be skid free. These shall be designed so that it is possible to board the Train from the platforms. The design of foot step shall be such that the gap between the platforms and the foot step is minimal and ensure smooth movement of passengers between the platforms and the Trains.

5.47. Deleted

5.48. Facilities for Passengers with Restricted Mobility (PRM)

- 5.48.1. The Train shall have the facility for persons with PRM to accommodate a wheelchair, complete with its occupant, duly facilitating entry and exit (relevant standard UIC 565-3) in Cars where

seats for passengers with restricted mobility are envisaged in these Specifications and Standards. There shall be a clear and unobstructed pathway of a width of 900mm or more through which wheelchair passengers can access the identified location of PRM in the Cars. These Cars will have one toilet for PRM and another toilet for other passengers.

6. Designs and Drawings

6.1. Designs and Drawings

- 6.1.1. The Supplier shall provide to the Nominated Agency:
- a) Designs and Drawings of the Train, as specified in this Chapter-6;
 - b) Reports of simulation of the safety, performance, running characteristics & ride index of the Train.
 - c) Design verification report by design consultancy
 - d) Operation and Maintenance Manuals
- 6.1.2. Drawing submitted shall be of full sizes as they are originally prepared. The dimensions, weight, capacity, etc. shall be in SI units unless otherwise agreed.
- 6.1.3. Nominated Agency shall undertake a review of the Designs and Drawings and issue a report to the Supplier within four (04) weeks from the date of receiving the Designs and Drawings. It is agreed that any failure or omission of Nominated Agency to review and/ or comment hereunder shall not be construed or deemed as acceptance of any such Designs and Drawings by Nominated Agency.
- 6.1.4. Pursuant to the report of Nominated Agency or otherwise, the Supplier shall carry out such modifications in the designs as may be necessary for conforming with the Specifications and Standards.
- 6.1.5. Supplier shall submit in an approved format, the originals and two (02) coloured copies along with electronic copy of all Designs and Drawings. The language of these documents shall be English.

6.2. Additional designs and drawings

If the Nominated Agency determines that it requires any designs or drawings other than those listed in this Chapter-6, it may by notice require the Supplier to prepare and furnish such designs and drawings forthwith. However, Nominated Agency / Purchaser shall endeavour to protect the Intellectual Property rights of the Supplier therein.

6.3. Design Verification by Design Consultant

- 6.3.1. The functional requirements and key performances designed for the Rolling Stock under these Specifications and Standards shall be based on proven design practices to ensure the safe and optimal operation of Trains up to 250 kmph on the Trial Section.
- 6.3.2. The Supplier shall engage a design consultant with a proven track record to verify the Rolling Stock design & integration of all Sub-systems/systems conforming to the performance, quality and safety requirements as envisaged in these Specifications and Standards.
- 6.3.3. The design consultant shall at least have experience of 3 projects in the past 10 years of verifying the design of Rolling Stock designed for 250 kmph or above.
- 6.3.4. In order to satisfy this requirement, the Supplier shall submit a design conformation report to this extent and detailed analysis on conformity of Car body Structure, Bogie Design, Brake System, Pantograph and Electric Propulsion systems

6.4. List of Drawings

The Supplier shall provide the Designs and Drawings of the following:

- 6.4.1. Train: The Design shall include (a) Car profile; (b) tractive effort corresponding to continuous rated speed; (c) Design of Car body shell and interiors.
- 6.4.2. Weight: The Design shall include the weight of the complete fully furnished Car of each type along with weight breakup of all the equipment and sub-systems.
- 6.4.3. Traction motor: The Design shall include suspension arrangement & overall General Arrangement Drawing of traction motor along with necessary calculations.
- 6.4.4. Brake system and Parking Brake: The Design shall include (a) functional description of complete system and individual components; (b) regenerative braking calculations including braking effort, brake blending and its speed range; (c) brake effort calculations, EP, Auto and regenerative brakes (d) parking brake calculations; (e) interfacing of service brake and parking brake; (f) braking curves

- for the Train; (g) braking distance calculations under gross load condition at maximum permissible operating speed at level track; (h) control system; (i) redundancy (k) operating times; (l) wheel slip-slide protection; (m) SIL level; (n) brake pipe controlled back-up system; and (o) emergency brake.
- 6.4.5. Bogie including brake rigging and suspension: The Design & drawings shall include (a) traction motor mounting arrangement if any; (b) unsprung mass; (c) primary and secondary suspension; (d) bolster arrangement; (e) axle floating arrangement; (f) Bogie frame and major bogie components under static and dynamic loading conditions & strength calculations; (g) deleted (h) throw over at head stock coupler; (i) movement of bogie parts with clearances; (j) estimation of flange forces on curves and turn outs; (k) kinematic/dynamic profile of Vehicles for any infringement (l) design validation of components of bogie as per specification & applicable standard Structural reports (structural as well as dynamic validation)..
- 6.4.6. Wheel Set: The Design shall include (a) bearing and lubrication; (b) wheels, axles and roller bearings, including maximum stress under fatigue loading conditions and anticipated service life; (c) weight distribution indicating lateral and longitudinal balance; (d) method of adjustment of wheel and axle load; (e) diameter of wheels (in mm) when new and fully worn; (f) wheel profile as per Specification and Standards and (g) Design validation as per Specification and Standards
- 6.4.7. End lighting: The Design shall include the installation details of (a) headlight; (b) marker light; (c) taillight; and (d) flasher light.

6.5. Other Designs

The Supplier shall also provide the following Designs:

- (a) the strength of the under-frame as well as under-frame equipment under static and dynamic loading conditions using FEM;
- (b) The carbody strength, fatigue life estimation under static and aerodynamic dynamic loading conditions using CFD and FEM.
- (c) projected stability and riding performance of the Train using mathematical modelling technique with parameters of suspension system and dimensions adopted for track standards;
- (d) stresses & FEA of under-frame, bogie frame / bolster, suspension springs, wheels, bearing, axles, other components and fatigue life of these components;
- (e) deflection calculations of under-frame under different loading conditions;
- (f) maximum moving dimension calculations;
- (g) calculations of harmonics and EMI/EMC parameters;
- (h) Crashworthiness shall be proved by submission of a detailed report having relevant calculations & crash simulations carried out with standard software;
- (i) hazard identification, safety assessments and mitigations;
- (j) calculations for tractive and braking effort versus speed curves showing balancing speed;
- (k) Air consumption calculation of healthy and partially cutout air supply by compressor and consumption of air by equipment with acceptable air loss;
- (l) centre buffing force calculations;
- (m) calculations for safety against derailment, primary and secondary spring and damper characteristics under tare and loaded conditions, braking distance calculations with and without load on level and gradient section
- (n) Finite Element Modelling of Car shell with standard computer software's shall be carried out for stress/deflection analysis of the car body.
- (o) System design documents and simulation for compliance of various performance parameters of Train.
- (p) Design documents for compliance of electrical fire & Train safety requirements.
- (q) Train configuration including distribution of propulsion equipment.
- (r) Document certifying the compliance of IER-1956 (as amended up to 25th November 2000) and Central Electricity Authority (Measures related to Safety and Electric Supply) Regulations, 2010.
- (s) Document for compliance of Disaster Management Light

- (t) Document for compliance of Train Data Recorder (TDR).
- (u) Document for certifying the compliance of minimum fresh air quantities under different conditions.
- (v) Document for compliance of Passenger Car Surveillance System and Cab Recording Equipment.
- (w) Document for certifying the compliance of Horns.
- (x) Document for certifying the compliance of Vigilance Control Device (VCD).
- (y) Document for compliance of passenger amenities and safety items like PA/PIS, ETB and Infotainment System etc.
- (z) Document for compliance of Car and Cab lighting.
- (aa) Aerodynamically shaped nosed design and simulation document.

6.6. Vehicle Dynamics Simulation

6.6.1. Supplier shall conduct Vehicle dynamic simulations on the bogies and the results thereof shall conform to the performance requirements stipulated in the Specifications and Standards.

- All the parameters and values used in simulations shall be provided to enable Vehicle Modelling on SIMPACK or any similar proven software including CG of coach & bogie frame, mass moment of inertia (x, y, z), balancing of mass of the coach and coefficient of damping both lateral and vertical directions etc.
- Parameters as per EN 14363 on track having parameter decided on the basis of prevailing track tolerances of MAHSR corridor for first stage & second stage (dynamic performance) assessment by simplified as well as normal method & other tests shall be evaluated including Mean Ride Comfort (N_{mv}) by Standard Method as per EN 12299, Bogie rotational resistance, wheel offloading on twisted track, safety & performance on twisted track, Wheel wear index, Bogie rotation, Curving capability and any tendency to hunt, Natural frequency of the suspension etc.

6.6.2. Derailment Safety and Stability

- (i) The design of the bogie, including the wheel profile, shall prevent the generation of high lateral to vertical force ratios on any wheel that could result in derailment under all track conditions defined in its specifications, and at all permitted Car speeds over the alignment, up to 10% above the maximum speed permitted, the Y/Q ratio shall not exceed values as per EN14363. Yard operation and deflated secondary suspension conditions shall also be considered.
- (ii) Calculations to confirm that the derailment quotient Y/Q is not exceeding values defined in Annexure - IV, where Y & Q are the instantaneous lateral force on the wheel flange and the instantaneous vertical load on that wheel tread respectively under the most adverse conditions.

6.6.3. Simulations / calculations for establishing maximum possible cant deficiency potential in rolling stock design.

6.6.4. Drawings:

The Supplier shall also provide the following Drawings:

- (a) General layout of all equipment in the Car body including driving cab layout, driver's desk layout, driver's visibility diagram, Car lifting arrangement, location of jacking pads and bogie retention arrangement;
- (b) Diagram showing alignment of Car on sharpest curve and sharpest turnout. This diagram shall also show that the profile of the Car body is within the moving dimensions including the extra clearance permitted on curves when the Car is negotiating a sharp curve;
- (c) Arrangement of return current and earth brushes;
- (d) Lubrication diagram with lubricant brands and quantities;
- (e) Schematic diagram of power, control and auxiliary circuits;
- (f) Air Supply and Brake system diagram;
- (g) Layout of Train on curves including reverse curves showing coupler, gangway and interconnections between Cars;
- (h) Arrangement of draw and buffing gear, side buffer installation, draw gear, and connections at

Train ends;

- (i) Maximum moving dimension drawing showing extreme cases including curve overthrows;
- (j) Earthing and bonding arrangements of all Cars

6.7. Operation and Maintenance Manual

6.7.1. General

6.7.1.1. The Supplier shall provide operation and maintenance manuals, for use by supervisory, operating and technical staff of the Purchaser, in English, in accordance with good industry practice.

6.7.1.2. Supplier shall deliver within thirty days from the date of delivery of the TS#01, the originals and two (02) coloured copies each of the provisional operation and maintenance manuals along with user friendly electronic copies. These manuals shall have been submitted for proof reading and training purposes two (02) months prior to the delivery of TS#01. It is accepted that further amendments may subsequently be required during testing and commissioning and the operation and maintenance manual shall be finalized before the Take Over of TS#01.

6.7.1.3. Each and every manual shall be divided into indexed sections explaining the subject matter in logical steps. Most manuals shall consist of A4-size printed sheets bound in stiff-cover wear-resistant binders clearly and uniformly marked with the subject matter and reference number. Where alternative sizes are proposed, (e.g. A5/A6 pocketbooks of schematic wiring diagrams) these shall be for review and acceptance. The binding shall allow for all subsequent changes and additions to be readily affected.

6.7.1.4. Information shall be provided in pictorial form wherever whenever possible and shall include step-by-step instructions and views of the particular equipment including exploded views. Information on programmable equipment shall be supplied with sufficient flow charts and fully documented programmes to enable faults to be quickly identified and system modification to be undertaken at any time.

6.7.1.5. The Supplier shall provide clarifications and amendments to the operation and maintenance manuals as necessary during the execution of contract. Updates shall be provided for the originals and all copies.

6.7.2. Operation Manuals

6.7.2.1. The Supplier shall provide operation manuals explaining the purpose and operation of the complete system together with its component subsidiary systems and individual item of equipment. The characteristics, ratings and any necessary operating limits of the equipment and Sub-systems shall be provided.

6.7.2.2. The Operation Manual shall include:

- (i) instructions to Train Driver for operation of the Train;
- (ii) instructions for troubleshooting;
- (iii) dos and don'ts for Train Drivers;
- (iv) safety precautions to be taken by the Train Driver;
- (v) rating and layout of equipment;
- (vi) operating limits of installed systems;
- (vii) control and safety features of the Train;
- (viii) instructions to Train Driver to retrieve the Train in case of axle lock;
- (ix) Travel Worthiness Certificate (TWC) which shall include the items to be checked before issue of that Certificate;
- (x) Safety certification to be undertaken by the safety certification official after each Scheduled Maintenance;
- (xi) instructions for Train Operations with limited or degraded or deteriorated features and special conditions for clearance of failed rolling stock from section; and
- (xii) a chapter on handling of Trains for rescue and restoration during accidents.

6.7.3. Maintenance Manuals

6.7.3.1. The Supplier shall provide comprehensive instructions for conducting preventive maintenance, corrective maintenance, overhauling of the Train including the requisite frequency of maintenance, duration of maintenance, requisite manpower and material (spares, consumables, special tools, jigs, fixtures and diagnostic equipment). It shall have details of all the various systems and Sub-systems from a maintenance

and fault-finding standpoint, with particulars of operating parameters, tools for dismantling and testing, methods of assembly and disassembly, tolerances, repair techniques and all other information necessary to set up a repair and servicing programme.

- 6.7.3.2. Cleaning manuals shall also be part of maintenance manuals inclusive of the data sheets of the cleaning agents and material to be used.
- 6.7.3.3. As and when any change to the configuration design or maintenance plan and practice, the manuals shall be updated and submitted accordingly to the Nominated Agency.
- 6.7.3.4. The Supplier shall provide documentation for all hardware and software for computer systems and other associated electronic equipment to meet the following requirements.
- 6.7.3.5. Supplier shall ensure that any hardware(s)/software(s) required for the purpose as covered in the maintenance manuals are supplied free of cost. Such documents shall include but not be limited to:
- a) manufacturers' documentation supplied as standard with the equipment;
 - b) hardware configuration with details of expansion capabilities and options;
 - c) programme loading instructions, including runtime environment configuration;
- 6.7.3.6. Furthermore, on request, Supplier shall made available the following for inspection and audit:
- a) programme listing including comprehensive 'comment statements' in hard copy and soft format for source code, compilers and development tools necessary to modify and recompile software;
 - b) flow charts, data flow diagrams and state diagrams as appropriate;
 - c) description of software modules including purpose, linkage with other modules, error routines and any special considerations;
 - d) memory maps for both internal and peripheral memory showing description of all programmes, data files, overlay areas, memory available for expansion and the like;
 - e) loading and operating instructions for diagnostic programmes and specifically developed debugging tools; and
 - f) programming manuals relevant to operating systems, languages, development tools, etc.
- 6.7.3.7. The documentation of software shall be provided once the software is finalised. The manual shall also include inspection/overhaul procedure and periodicity of various inspection/overhaul schedules in detail including the tools, special tools/plants, and facilities required. The manual shall be subject to review by the Nominated Agency.
- 6.7.3.8. The maintenance manual shall also include Maintenance Work Instructions (MWIs) of all major systems and Sub-systems of train, depot machinery & plants, special tools, diagnostics equipment, tools, jigs and fixtures etc. in detail for troubleshooting, maintenance, repairing overhauling, testing and acceptance parameters. The MWIs shall include details of the required materials and consumables, general tools, special tools and facilities.

7. Testing of Rolling Stock

7.1. General

- 7.1.1. The Supplier shall establish a testing and commissioning plan consisting, but not limited to, the following aspects:
- (i) Supplier's methodology for inspection, testing and commissioning;
 - (ii) all inspections and quality hold points;
 - (iii) the objectives of each test and criteria for successful tests;
 - (iv) organisation chart of key personnel in the Testing and Commissioning team;
 - (v) submission of inspection and test specifications and procedures.
- 7.1.2. Purchaser / Nominated Agency shall undertake a review of the above received documents and issue a notice of either no-objection (or) no-objection with comments (or) objection with comments to the Supplier within four (04) weeks from the date of receiving, upon which the Supplier shall appropriately respond and conduct the inspections and tests as required in this Chapter-7.
- 7.1.3. In the event on notice of objection with comments, the Supplier shall take such steps or make such changes in the said methods or supply such further documents or information as may be necessary to meet the Purchaser's requirements and to obtain his notice of no-objection. The Supplier shall not change the methods of inspection, testing and commissioning (including Integrated Testing and Commissioning) which have received no-objection from the Purchaser/Nominated Agency without further review and consent in writing of the Purchaser/Nominated Agency.
- 7.1.4. The general sequence of the testing of Rolling Stock shall be followed as mentioned below:
- (i) Equipment/Sub-system level Type and Routine tests;
 - (ii) Complete Car level testing at manufacturer's premises;
 - (iii) Testing and commissioning of Train in Maintenance Depot;
 - (iv) Integrated Testing and Commissioning of Train with Infrastructure;
 - (v) Design Validation by Third Party Testing;
 - (vi) Testing, Commissioning and Service Trials by the Supplier.
- 7.1.5. Tests and test procedures shall be submitted by the Supplier for acceptance by the Purchaser unless specified otherwise elsewhere in these Specifications and Standards.
- 7.1.6. Supplier shall provide the Train Drivers for all the activities envisaged in this Chapter.

7.2. Integrated Testing and Commissioning of Trains with Infrastructure (Overall ITC)

7.2.1. General

- (i) For integrated testing and commissioning of the fixed infrastructure namely civil structure, track, overhead power supply equipment, signaling and telecommunication equipment of complete MAHSR sections along with associated testing and usage of Rolling Stock (referred to as "Overall ITC" hereinafter), the Supplier shall ensure the availability of Rolling Stock during Overall ITC as well as its compatibility with required interfacing systems.
- (ii) The Overall ITC consists of Static Inspection, shall include static inspection of the infrastructure. And Dynamic Inspection, which is conducted by actual Train running.
- (iii) Prior to the implementation of overall ITC, Supplier shall scrutinize the design, installation and test status of the Train for ensuring speed potential up to the maximum operating speed along with safety and stability of the Train.
- (iv) The Overall ITC shall be done in the Trial Section in stages. As a reference the sections shown below may be considered and it can be revised later based on Purchaser's requirements. Supplier shall note that simultaneous testing of two (02) or more stages is not considered.

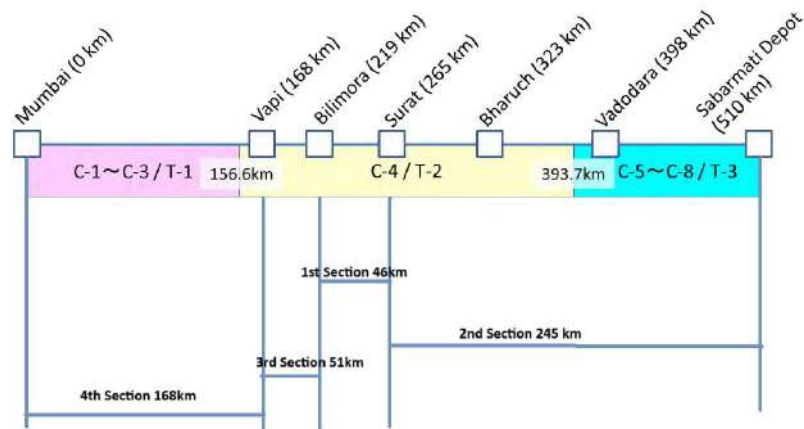


Figure: Estimated Divided Section of Overall ITC Area

- 7.2.2. Supplier shall consider the duration of Overall ITC of each stage as mentioned below:
- Static Inspection is estimated to be one (1) month.
 - Dynamic Inspection is estimated to be 5 (five) months.
- The estimated durations include spare days for testing and repair days for the ground facilities, Train and measurement equipment related to Overall ITC.
- 7.2.3. Tests to validate Civil structure
- During Overall ITC following tests and measurement as a minimum shall be performed for civil infrastructure.
- Clearance and elevation between platform and vehicle (three locations per coach)
 - Girder deflection of the bridges (where specified)
 - Girder deflection of bridges
- 7.2.4. Tests to validate Track infrastructure
- During Overall ITC following tests and measurement as a minimum shall be performed for track infrastructure using measuring devices installed on Train
- Verification of structure gauge by track contractor
 - Measurement of dynamic track irregularities
 - Train Oscillation and Y/Q measurement
- 7.2.5. Tests to validate Power Supply infrastructure
- During Overall ITC following tests and measurement as a minimum shall be performed for Power Supply and OHE equipment using measuring devices installed on Train.
- Noise measurement test for electrical facilities
 - Confirmation of contact loss
 - Confirmation of uplift amount of contact wire
 - Confirmation of contact wire strain
 - Confirmation of condition of contact wire deviation and height of contact wire and pantograph
 - Power characteristic test for TSS and SP
 - Section switching test for TSS and SP
- 7.2.6. Tests to validate Signalling & Telecommunication
- Please refer to Annexure-V for the test items of Signalling & Telecommunication.
- 7.2.7. Testing Methodology
- A dedicated team, referred as ITC Coordination team, will be deployed by the Nominated Agency and be responsible for Overall ITC activities which includes making required adjustments to the activities to ensure effective progress of Overall ITC.
 - Overall ITC will be conducted in the following phases:
 - Phase 0: Preparation work
The ITC Coordination Team will create the overall program and schedule for Static and Dynamic Inspections and issue the ITC Overall Basic Document.

- Phase 1: Static Inspection
Integration of several packages will be checked without actual Train running. The main inspection in this phase will be the verification of structure gauge by running the structure gauge measuring vehicle. Detailed sampling check will be re-conducted, if necessary. Also, signalling pre-test may be conducted as part of this inspection.
- Phase 2: Dynamic Inspection
After receipt of information establishing the readiness to conduct Dynamic Inspection issued by contractors of infrastructure, and after completion of Static Inspection, Dynamic Inspection with actual Train running will be carried out.

7.2.8. Role of the Supplier

Major activities of the Supplier shall be as follows:

- a. Supplier shall deploy a dedicated team of personnel for conducting Overall-ITC whenever Nominated Agency intimated.
- b. Supplier shall work in cooperation with related contractors/parties in the execution of Overall ITC;
- c. Supplier shall place “safety” as the first priority in all activities related to the overall ITC.
- d. All defects and shortfalls in the Supplier’s system, discovered in the course of Overall ITC, shall be made good and re-tested to the satisfaction of the Purchaser.
- e. Supplier shall provide Y/Q wheelset, train oscillation equipment and dynamic track irregularity measuring equipment installed in the Train to track contractor and assist in taking necessary measurements.
- f. Supplier shall cooperate with other contractors identified by Nominated Agency in installing and uninstalling of measuring equipment on/from the rolling stock as and when needed during the period of Overall ITC.
- g. Supplier shall remove temporary fittings, if necessary, for the delivery of his items and shall restore the fittings to the original state and to the satisfaction of the Nominated Agency.

7.3. Testing of Train

7.3.1. General

- 7.3.1.1. Supplier, at its own cost and expense, shall carry out all Tests as detailed in this Chapter-7 and such other Tests that the Supplier may consider necessary to demonstrate that the Trains comply in all respects with these Specifications and Standards. The Supplier shall provide to the Purchaser / Nominated Agency forthwith, a copy of the Supplier’s report on each test containing the results of each test and the action, if any that it proposes to take for compliance with these Specifications and Standards.
- 7.3.1.2. The individual prototype equipment, systems and sub-systems shall be type and routine tested in accordance with the relevant IEC/UIC/EN publications inclusive of the mandatory and optional tests along with the special tests as specified. All type tests shall be conducted either by Supplier or third party agency or person agreed by Nominated Agency at the Supplier’s cost wherever performed in presence of and to the satisfaction of Nominated Agency, who reserves the right to witness any or all of the tests. Nominated Agency on its own cost, may deploy an Independent Safety Assessor (ISA) to witness any or all of the tests.
- 7.3.1.3. All tests and trials on Train level will be carried out on TS#01. Tests & trials already carried out on TS#01 will generally not be repeated on subsequent Trains except the routine tests as mentioned in this Specificationd. Detailed test plan will be finalized during design stage.
- 7.3.1.4. Nominated Agency may waive some of these tests in case of equipment/ sub-assemblies where the manufacturer can establish to the satisfaction of the Nominated Agency that such tests have already been carried out earlier. In such a case, manufacturer shall submit complete test reports along with necessary certification.
- 7.3.1.5. Wherever any equipment, system, sub system is not specifically covered by an international recognized specification or test procedure, the tests which are acceptable to both to Supplier and to the Nominated Agency shall be devised.
- 7.3.1.6. Without prejudice to any provisions of the contract, the Purchaser, on its own costs and expense, reserves

- the right to witness any or all of the type tests and to require submission of any or all test specification and reports.
- 7.3.1.7. The Supplier shall arrange instrumentation and record speed, voltage, current, temperature rise of various equipment, energy consumption, tractive effort and other relevant parameter as necessary for ensuring compliance of these Specifications and Standards.
- 7.3.1.8. The temperature of the various parts of the electrical and control equipment shall be recorded during the Tests as per the standard procedure specified. The Supplier shall supervise and carry out the Tests at its works on combined test bed and also at the site and shall provide all equipment and consumables necessary for such Tests.
- 7.3.1.9. The Supplier shall submit a detailed test plan for specified trials indicating the tests to be conducted, procedure/method to be followed for tests, parameters to be measured and devices/instruments to be used; and Pass/Fail criteria etc. for approval. Submitted test plans shall be as per IEC 61133 and after the approval from Nominated Agency. After successful completion of the tests & trials and acceptance of the results, TS#01 will be cleared by Nominated Agency for commercial services.
- 7.3.2. Mechanical Tests
- 7.3.2.1. Validation of Designs of Bogie and testing of prototype Bogie including static load and fatigue tests as per relevant standards. Characteristic tests of various suspension items including rubber suspension elements will be submitted. Type testing reports for these suspension elements shall also be submitted.
- 7.3.2.2. Vehicle Body Shell:
Car body strength Test shall be carried out and a lifting Test shall also be performed in accordance with UIC 566/ EN 12663 (Category P1) under simulated loads as a type test.
- 7.3.2.2.1. Squeeze Test of shell:
(i) The shells of Cars including the end Driving Cab shell shall be subjected to static vertical and squeeze load Test for the TS#01. Cars having different types of body shell will undergo the squeeze Test separately. The superstructure shall be subjected to vertical loads and combination of vertical and squeeze load as specified in EN 12663/EN 15663. Tests shall be as per UIC 566/EN 12663 & EN 15663.
- 7.3.2.3. Brake equipment – Type Test
Following Tests shall be carried out on the 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.
- 7.3.2.3.1. Brake Lining:
The Supplier shall carry out testing of brake lining in respect of coefficient of friction with respect to the wheel disc/ brake disc under dry and wet conditions, maximum temperature attained during braking, rate of wear etc.
- 7.3.2.3.2. 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 60529.
(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 Supplier's design data. Oscillograms shall be produced in support.
- 7.3.2.4. Bogie Frame
- 7.3.2.4.1. Finite Element Analysis(FEA)

- (i) The load test on bogie frame shall be conducted with the help of solid modelling and FE analysis using latest software package to evaluate the maximum stress at critical locations on the bogie/bogies.
 - (ii) The test load (vertical, lateral and longitudinal load) required to be applied on bogies shall be calculated as per EN 13749 & load cases obtained through simulations.
- 7.3.2.4.2. Bogie Static & Fatigue Test
Static test, Fatigue test, Field test (Track test) on bogie frame & bolster as per EN 13749/UIC 515-4/UIC 615-4 as applicable. General conditions mentioned in EN 13749/UIC 515-4/UIC 615-4 & given examples of programs for static & fatigue tests will be adopted based on load cases obtained through simulations. Necessary changes for differences in bogie suspension or Vehicle body characters shall be made with the detailed explanation.
- 7.3.2.4.3. Bogie Rotational Resistance (X Factor) Test
The bogies rotational resistance (X factor) test under inflated and deflated air spring conditions shall be carried out at the manufacturer's works / suitable location/laboratory under tare and loaded conditions as detailed in EN14363. The rotational resistance shall neither cause excessive flange wear nor cause any possibility of flange climbing but shall be adequate to avoid bogie hunting on straight track. The Supplier shall show by analysis that no flange climbing occurs on any curve and moving at all possible speeds set using the wheel unloading factor $\Delta Q/Q_0$ and the bogie rotational factor X.
- 7.3.2.4.4. Bogie Suspension Elements
- (i) Air spring: The suspension characteristics of air spring provided in the bogie shall be tested for its stiffness, loads v/s deflection, pressure v/s load characteristics, creep test, endurance test and damping characteristics in vertical and lateral mode under the different preload conditions by the Supplier. EN 13597 is to be referred in this regard.
 - (ii) Rubber suspension/guiding elements including rubber metal bonded items: The rubber suspension/ guiding including rubber metal bonded items components shall comply & type tested as per the requirements of EN 13913.
 - (iii) Hydraulic damper: All the hydraulic dampers provided in the suspension shall be tested for load v/s velocity at different frequencies and amplitude of oscillations. Tests shall also be conducted on the hydraulic damper for practical determination of effective stroke length and dynamic durability for maintenance free operation. Endurance testing will also be conducted as part of type test.
 - (iv) Coil springs: Type testing as per EN 13298 along with endurance testing.
- 7.3.2.4.5. Wheel, Axle & Bearings
Type testing as per standards mentioned for wheel, axle & bearing in this specification for Track conditions as specified in these Specifications and Standards.
- 7.3.2.4.6. Test for Air Spring Deflation Detection System:
Air spring deflation detection test shall be carried out through reduction in pressure inside the air spring. For this purpose, necessary instrumentation shall be arranged by Supplier.
- 7.3.2.5. Oscillation trials
- 7.3.2.5.1. Oscillation Trials for determining Vehicle Dynamics, Derailment Safety and Stability: -
- (i) Based on satisfactory simulation results, the Prototype shall be subjected to trials and evaluation. assessment of rolling stock (First Stage Assessment: at suitable location / rig & Second Stage Assessment: dynamic performance assessment by normal method) shall be carried out as per EN 14363:2016 standard, on track having parameter decided on the basis of prevailing track tolerances of MAHSR corridor. The acceptance limits will be as per EN 14363:2016. For conducting First Stage or Second Stage Assessment(s) as per EN 14363-2016, the required instrumented measuring wheel sets and concomitant accessories like compatible data acquisition systems, sensors etc. along with any other specialized equipment / rig / instrumentation / software which shall be provided by the Supplier. First Stage Assessment of rolling stock as per EN 14363:2016 for MAHSR track parameters shall be got done by the supplier through any independent accredited agency and necessary reports submitted to Nominated Agency for

evaluation.

- (ii) Second Stage Assessment (dynamic performance assessment) / Oscillation Trials of rolling stock as per EN14363:2016 shall be conducted. The required instrumented measuring wheelsets along with all compatible sensors, instrumentation, required software and data acquisition system for acquisition of data compliant to EN14363 will be provided by the Supplier. Necessary raw data acquired during trials would be submitted to Nominated Agency after every trial run. Final analysis and test report would be submitted to Nominated Agency for review and approval.
- (iii) Rolling stock shall also be evaluated for Mean Ride Comfort (N_{mv}) by Standard method as per EN 12299 for rolling stock. Acceptable Mean Comfort Index shall be less than 2 (Comfortable). Track condition for the purpose will be MAHSR track maintained to Japanese standards. Passenger comfort analysis as per EN 12299:2009 shall be got done by Supplier through any independent accredited agency and necessary reports along with raw data shall be submitted to Nominated Agency for evaluation.
- (iv) Trials in fault modes like deflated air spring etc. shall also be conducted for safety & stability of the Train.
- (v) Please refer Annexure - IV for acceptance limits for dynamic behaviour of testing Rolling Stock as per the methodology detailed in EN-14363

7.3.2.6. Braking Distance trial After the completion of satisfactory oscillation trial, the braking distance trials shall be conducted by the Supplier.

7.3.2.7. Tests on Parking brakes Parking brakes shall be tested by applying the parking brakes fully and air brake released under the specified conditions as defined in the Specification and Standards.

7.3.2.8. Coupler force trials The measurements shall be recorded in accordance with the test scheme submitted by the Supplier in accordance with Good Industry Practice and approved by the Nominated Agency.

7.3.2.9. Train Resistance:

Supplier shall conduct appropriate test scheme approved by the Nominated Agency to work out the actual Train resistance formula on TS#01.

7.3.2.10. Pressure comfort/airtightness of the Car body, as specified in clause 5.33.2 of these specifications, shall be verified by Tests in accordance with TSI LOC&PAS and EN 14067-5.

7.3.2.11. Driving Cab head pressure pulse and maximum air speed requirements, as specified in clause 5.10.4 and 5.10.5 respectively of these specifications shall be verified by conducting Type tests in accordance with TSI LOC&PAS and EN 14067-4.

7.3.3. Electrical Tests

7.3.3.1. Generally, test procedures shall be followed as per the latest IECs of equipment/systems/Sub-systems testing.

7.3.3.2. Test on Sub-system concerning passenger amenities and safety like, PA/PIS, ETB, CCTV, Infotainment system, Interior Lighting, Head Light, Flasher Light, Tail Light, Cab Recording etc. as per specification and relevant standards.

7.3.3.3. The individual sub-systems of the TS#01 shall be tested in accordance with Good Industry Practice to determine their compliance with Specifications and Standards. Such Tests may include simulation validation, laboratory and field tests for validating the design of each Sub-systems and optional tests in accordance with relevant standard specifications/IECs for various Sub-systems. All equipment should be type and routine tested with relevant standards as detailed in specification &/or Annexure-I of this specification.

7.3.3.4. Type tests on electronic equipment and control electronics

The electronic equipment and control electronics shall be tested as per IEC 60571/EN50155, IEC 60068, EN 50121, IEC 60721-2-5 and IEC 61373 including both compulsory and optional tests. Dry heat test, as specified in IEC 60571, shall be conducted for testing power and control electronic equipment at 80°C. LCD display units shall be tested at 70°C.

7.3.3.5. Test on combined test bed

- i) The propulsion equipment shall be tested on the combined test bed at the manufacturer's works as per the stipulations of IEC 61377.
- ii) The hot spot measurement shall be done during the combined bed test on traction transformer, traction converter and traction motor by an embedded or suitably arranged thermocouples.

7.3.3.6. Efficiency Test

The efficiency of the transformer, power converter line side converter and drive side inverter, auxiliary converter and traction motor shall be measured at full load on combines test bed. Efficiency at full load means efficiency computed from parameters measured at conditions corresponding to full load and governed by IEC 60310 for transformer, IEC 61287-1 for power converter and auxiliary converter and IEC 60349-2 for traction motor.

Along with 'mandatory' tests as described in the IECs, 'optional and investigative' tests shall also be conducted. Any other tests which become imperative due to the specific requirement of this specification and is categorically mentioned in this specification shall also be carried out.

7.3.4. Complete Train:

Complete Train shall be type & routine tested as per IEC 61133 and as per the test program agreed by Nominated Agency. After erection, the complete equipment shall satisfactorily withstand the dielectric voltages as specified in the IEC specification.

7.3.4.1. Sequence Test:

Connection shall be made to the 25 kV AC overhead contact system and all parts of the control and main power circuit shall be tested out to ensure correct sequence of operation, all interlock cut-out switches shall then be tested, and the pantograph shall be tested to prove the speed of raising and lowering.

7.3.4.2. Interference Test:

Tests to determine the levels of interference with traction power supply, signal and telecommunication equipment and facilities to prove that these are within acceptable limits in accordance with the Specifications and Standards. The Supplier shall provide a necessary complete set of calibrated equipment/instrumentation and technical guidance to verify such parameters, which are necessary for evaluation of the Trains.

7.3.4.3. Pacemaker Interference Test:

This shall include test to verify that any emissions from the equipment of Train do not adversely affect the pacemakers/ hearing aids that may be used by the passengers. Test shall be conducted as per EN 45502 and EN 50500.

7.3.4.4. Vibration and Shock Test:

The equipment used in the cars shall conform to IEC 61373 for shocks and vibrations as specified on the basis of the location and mounting of the equipment. The tests shall also cover Endurance tests included herein.

7.3.5. Performance Test

The Train performance with regard to the supplied equipment shall be demonstrated in test runs and shall meet the target figures given in Chapter 5.

7.3.5.1. Test Runs:

- (i) Test runs shall be carried out on the Trial Section or any other sections on which the Train is to be operated with sufficient number of Trains to ensure that the Train equipment meets the operating conditions. The Supplier shall arrange instrumentation and record speed, voltage, current and temperature rise of various equipment, energy consumption, tractive effort and any other relevant parameter.
- (ii) The temperature of the various parts of the electrical equipment shall be recorded during the test as per the standard procedure specified. For further details refer Chapter 5.
- (iii) The Supplier shall supervise and carry out the above tests both at his works on combined test bed and also at the site and shall provide all equipment required for such tests and such special consumable stores as oil, grease etc, for the first filling and for trial runs. Special measuring instruments shall be provided by the Supplier.

- (iv) During the tests, acceleration, deceleration, speed on straight level track and the energy consumption for a round trip shall be measured. In all cases, 8-Car fully loaded Train shall be tested.
- 7.3.5.2. **Energy Consumption**
 - (i) The Supplier shall measure the required values of energy consumption for a 8-car, fully loaded Train in all out run, (full traction up to max. service speed followed by full service braking up to standstill).
 - (ii) The validation of efficiency and energy consumption shall be done on the combined system test bed as per the IEC 61377 and 61133.
 - (iii) The Supplier shall validate the Specific Energy Consumption as per Clause 4.11 in the Trial Section.
- 7.3.5.3. **Acceleration**
The acceleration will be calculated from the time taken to reach a speed of 75 kmph. The time taken shall be from the instant master controller is switched on to the instant speed of 75 kmph is touched. Tests will be conducted to confirm acceleration performance and jerk performance.
- 7.3.5.4. **Deceleration:**
The deceleration test shall be taken after preliminary runs of the rake in order to bed the brake pads. The test shall be taken on dry rail and the average of three tests will be taken as the final figure for deceleration.
- 7.3.6. **Commissioning of Trains at Maintenance Depot:**
- 7.3.6.1. Each Train shall be commissioned at Maintenance Depot of MAHSR by the Supplier's staff before putting into commercial service. The Supplier shall be responsible for commissioning of all the Trains.
- 7.3.6.2. TS#01 & TS#02 after the successful completion of all tests and trials and clearance of Nominated Agency shall undergo trials for six months or one lakh km whichever is earlier (Service Trials).
- 7.3.6.3. Service Trials are intended to prove the satisfactory running performance of the supplied equipment and evaluate their reliability in service, ease of maintenance and operations. Upon successful completion of which the Trains will be accepted by the Nominated Agency/Purchaser (Take Over).
- 7.3.6.4. If considered necessary, instrumentation may also be required during service trials in addition to downloading of subsystem data for analysis. During the TS#01 tests/service trials, if any problem arise or feedback is obtained, which warrants a re-check of the design/ manufacture/ quality of the equipment and components, action will be taken as may be necessary by the Supplier to carry out the required investigations and to incorporate the modification considered most appropriate to reach compliance with the specification without any extra costs to the Purchaser and in a manner approved by the Nominated Agency on equipment/components already supplied as well as those to be supplied later.
- 7.3.7. **Routine Tests:**
- 7.3.7.1. Routine Tests on Trains: All the routine tests specified for a Train in IEC 61133 shall be conducted at the manufacturer's plant.
- 7.3.7.2. **Routine Tests on Sub-systems**
 - (i) The individual sub-systems of the Trains shall be tested in accordance with Good Industry Practice to determine their compliance with Specifications and Standards.
 - (ii) The Nominated Agency may, in its discretion, require the Supplier to furnish copies of the work test certificates (WTC) of any sub-system of the Train.

7.4. Design Validation by Third Party

- 7.4.1. Notwithstanding the provisions of this Chapter-7.3, Supplier shall engage a third-party testing agency to conduct the following tests:
 - (iii) Oscillation trials;
 - (iv) Braking Distance trials;
 - (v) Derailment Co-efficient (Y/Q);
 - (vi) Train resistance;

- (vii) Wayside Driving Cab head pressure pulse and maximum air speed;
- (viii) Stress on Car body due to aerodynamic effect for fatigue life estimation;
- (ix) Air Tightness for complete Car/Train;
- (x) Specific Energy Consumption;

7.4.2. The testing agency shall have proven experience record of conducting such tests in at least 3 projects in the last 10 years for Rolling Stock designed for 250 kmph or above.

8. Measuring Equipment

8.1. General

- 8.1.1. Supplier shall install appropriate measuring equipment onto the Train (preferably TS#02) to monitor the infrastructure of the MAHSR Corridor – Track, Power Supply (OHE) and Signalling & Telecommunication (S&T).
- 8.1.2. Supplier shall be responsible for the following but not limited to:
- (i) design, installation, testing of measuring equipment, validating the measurements done on the infrastructure;
 - (ii) Defects Notification Period (DNP) obligations for a period of two (02) years from the completion of service trials as defined in the Clause 7.3.6 (Commissioning of Trains at Maintenance Depot) including calibration of the measuring equipment as recommended by the OEM.
 - (iii) Supply of operation and maintenance manuals including the corresponding spares, special tools, jigs, fixtures and diagnostic equipment for maintaining the measuring equipment.
 - (iv) As an option, Supplier may propose Annual Maintenance Contract (AMC) for the measuring equipment considering a period of fifteen (15) years for requisite man & material including preventive maintenance, corrective maintenance and overhaul of the measuring equipment.
- 8.1.3. General function of measuring equipment shall include data acquisition, analysis and processing, real time display, data storage, waveform and report printing, system parameter setting, test parameter calibration, basic data input, displaying alarm in case of abnormal result etc. Details of the parameters which are meant to be monitored using this measuring equipment to be discussed during detailed design.
- 8.1.4. For each measuring tool, the measurement thresholds and tolerances shall be specified, and devices shall be adjusted and calibrated. Details to be discussed during detailed design.
- 8.1.5. The measurement of data shall be performed at maximum operational speed of 249 kmph. In case, there is some technical restriction of any device to measure at 249 kmph, Supplier shall propose the maximum measurement speed of that device with justification for Purchaser's review during detailed design.
- 8.1.6. Supplier shall propose appropriate measuring equipment arrangement during design stage. Measurement sensors and transmitters may be installed on the bogie, car-body, roof and underframe, as required.
- 8.1.7. Measuring equipment and wiring both in and between the cars shall take EMC and EMI into consideration.
- 8.1.8. Storage temperature of measuring equipment shall be designed in accordance with the climatic and environmental conditions specified in clause 3.6 of these Specifications and Standards. Operational and performance guaranteed temperature for measuring equipment outside of the Car shall be in accordance with clause 3.6 of these Specifications and Standards. Operational and performance guaranteed temperature for measuring equipment inside the Car shall be in accordance with clause 5.18.2 of these Specifications and Standards.
- 8.1.9. The measuring equipment shall be capable of measurements under all weather conditions. However, if there are any weather conditions, during which measurement is not possible, Supplier shall submit details and justification for Purchaser's review during detailed design.
- 8.1.10. Supplier shall indicate the feasibility of providing the measuring equipment for the parameters mentioned in Clause 8.2 of these Specifications and Standards. In case of difficulties Supplier shall indicate so with detailed justification in its proposal.

8.2. Measuring Items

- 8.2.1. The detailed measuring parameters of each measuring equipment shall be, but not limited to, as per below listed table:

SN	Measuring Equipment	Measuring Parameters/Items
1	Track Measuring Equipment	<ol style="list-style-type: none"> 10m- chord Longitudinal Level versine (left rail); 10 m-chord Longitudinal Level versine (right rail); 10 m-chord Lateral Alignment versine (left rail); 10 m-chord Lateral Alignment versine (right rail); Twist; Gauge; Cross level; Vertical oscillation acceleration; Lateral oscillation acceleration; Acoustic noise level at underframe; Vertical axle box acceleration. <p>In addition to above, 20 m and 40 m-chord Longitudinal level (left and right rail) and lateral Alignment versine (left and right rail) shall be calculated with 10 m-chord Longitudinal Level and Lateral Alignment versine.</p>
2	Power Supply (OHE) Measuring Equipment	<ol style="list-style-type: none"> OHE related measurement parameters <ol style="list-style-type: none"> Wear of the contact wire (residual diameter measurement); Contact wire slide surface recording (Current Collecting state); Contact wire horizontal deviation; Contact wire height; Measurement of separation of overhead wires (overlap location and overhead crossing line devices for crossing type); Mast chainage by detection of mast point. Feeding circuit related measurement parameters; <ol style="list-style-type: none"> Switching no-voltage time; Switching total time; Contact line voltage.
3	Signalling and Telecommunication (S&T)	As required for Signalling & Telecommunication System

8.3. Performance requirement of Measuring Equipment (reference only)

- 8.3.1. Supplier may consider the below mentioned performance requirements of Track Measuring Equipment and Power Supply Measuring equipment for reference purpose only.
- 8.3.2. The specific measurement requirement such as measurement range, accuracy, interval, measurement number, data recording and display format etc. shall be discussed and finalized during detailed design.
- 8.3.3. Track Measuring Equipment
- 8.3.3.1. The track irregularity is measured by use of the Inertial Mid-chord Offset Method (IMOM). Track irregularity is detected by the angle measuring method and the necessary units are configured for this purpose.
- 8.3.3.2. The Train oscillation acceleration detector converts the acceleration of the Train into an electrical signal. The performance requirements of the Train oscillation acceleration detector

shall be as follows:

Measuring range	$\pm 10 \text{ m/s}^2$
Frequency response	0.1 to 250 Hz

- 8.3.3.3. Acoustic noise measurement devices may be equipped on the under-frame of a Car to measure the noise level with microphones. The microphone of back end shall be used in the running direction. The performance requirements of acoustic noise measurement equipment shall be as follows:

Measuring range	From 80 to 140 dB
Frequency range	From 10 Hz to 20 kHz
Frequency filter	Filter: A weight, Dynamic Characteristic: Fast

- 8.3.3.4. Vertical axle box acceleration may be measured using the accelerometers which may be equipped with axle box. The band pass filters connected to the accelerometers shall be capable of extracting the following data:

- The low frequency band; 1 Hz to 30 Hz
- The corrugation band; 50 Hz to 100 Hz
- The high frequency band; 500 Hz to 1 kHz

Log amplifier shall amplify the corrugation data, low frequency data and level data output.

- 8.3.4. Power supply (OHE) Measuring Equipment

- 8.3.4.1. The wear of the contact wire shall be continuously measured during inspection. Measurement of two parallel contact wires shall be possible at any time, during the operation, in overlapping locations. Specific measurement functions shall be as defined in table below.

Function	Performance	Remarks
Measurement range	Sliding surface width as 4 to 16 mm	Convert the sliding surface width to the remaining diameter and output
Static measurement accuracy	Sliding surface width as ± 0.2 mm	When the vehicle is stopped.
Measurement interval	50 mm or less	At 275 km/h
Simultaneous measurement number	Up to 2 contact wires simultaneous measurement	Data to be classified by each contact wire unit.

- 8.3.4.2. Contact wire sliding surface image shall be recorded simultaneously with the measurement of the wear of the contact wire. Recording of images shall be in black and white. The still image shall be capable of cutting out and enlarging. The number of pixels shall be selected so that the recording image can be checked easily for the condition of the sliding surface

- 8.3.4.3. Deviation of the contact wire shall be continuously measured during inspection. Necessary corrections shall be made to exclude the influence of the fluctuation during the operation. Specific measurement functions shall be as per table below.

Function	Performance	Remarks
Measurement range	300 mm from the center of the Car body	
Static measurement accuracy	± 10 mm	When the Train is stopped.
Measurement interval	50 mm or less	Same as wear measurement
Simultaneous measurement number	Simultaneous measurement up to 2 contact wires	Same as wear measurement

- 8.3.4.4. The height of the contact wire shall be continuously measured at high-speed operation during inspection. The specific measurement functions shall be as defined in table below.

Function	Performance	Remarks
Measurement range	4,800 to 5,300 mm above the rail surface	

Function	Performance	Remarks
Static measurement accuracy	± 10 mm	When the Train is stopped.
Measurement interval	50 mm or less	Same as wear measurement

8.3.4.5. The measurement of separation of overhead wires (Overlap location and overhead crossing line devices) shall be as follows:

- For the Overlap section (both insulated and un-insulated types) and overhead crossing line device (at least crossing type), the distance between two contact wires calculated from their height and deviation which are measured simultaneously and continuously shall be recorded.
- Mutual separation shall be obtained from the measurement results of height and deviation of two parallel contact wires.
- The necessary corrections in the horizontal separation shall be made to exclude the influence of the car fluctuation during the operation.
- In the insulated Overlap, insulator of the pulling side contact wire shall be excluded and the vertical separation between the lower end and the running side contact wire shall be measured.

The specific measurement function shall be defined in table below.

Function	Performance	Remarks
Vertical detection range	4,700 to 5,600 mm above the rail surface	Insulator position 5,100 to 5,600 mm
Vertical direction static measurement accuracy	± 10 mm	
Horizontal direction detection range	Within 900 mm from the center of the Car body	Insulator position within 800 mm from the center of the Car body
Horizontal static measurement accuracy	± 20 mm	

8.3.4.6. Current collecting state shooting: The camera shall capture the image and video of the pantograph head and the deviation of the contact wire. It shall also be possible to monitor the live images and videos through the display. The image resolution and quality shall be such that which can be viewed sufficiently and utilized for preparing the report. The current collecting state shooting camera shall be full HD camera (full HD: 1920 × 1080, 120 p) with high quality lens and imaging element. It shall be possible to zoom and crop the captured still image to identify the installation state of the metal fittings such as hangers. The collection of images and videos used for inspection data should be possible up to 250 km/h running.

8.3.4.7. Feeding Circuit related measurement function:

- Device for measuring switching no-voltage time (changeover section) shall measure the time when “changeover section” changes to “no voltage”.
- Device for measuring switching total time shall measure the total time elapsed from entry of the Train into the electrified classification control track circuit to the input of the changeover section.
- Device for measuring contact line voltage shall measure the pantograph point voltage and its position during the operation and record the maximum and minimum voltage and its position between each post.
- Specific functions in various measurement of the feeding circuit shall be as defined in table below:

Measurement items	Measurement range	Measurement accuracy
Switching no voltage time	100 to 500 msec	± 2 msec

Measurement items	Measurement range	Measurement accuracy
Switching total time	0.9 to 3.1 sec	± 0.1 sec
Contact line voltage	15,000 to 35,000 V	± 1 %

9. Defects Notification Period

9.1. Objective

- 9.1.1. The Train shall be able to achieve the targets of Reliability and Availability as declared by the Supplier in compliance to the Clause 3.3 of these Specifications and Standards by the end of DNP.
- 9.1.2. The duration of the Defects Notification Period shall be considered as two (02) years from the date of Take Over as defined in Clause 7.3.6.

9.2. DNP Obligations of the Supplier

- 9.2.1. Supplier shall monitor the progress of Availability and Reliability of the Trains.
- 9.2.2. Supplier shall repair / replace / modify the equipment/Sub-system/system on account of any Failure attributed to the Supplier's scope of work, so as to ensure that the Train meets the Reliability and Availability targets during the DNP. All requisite manpower and material required to meet the Availability and Reliability shall be the responsibility of the Supplier.
- 9.2.3. Supplier shall maintain sufficient spares, consumables and special tools required to monitor the Trains during the DNP.
- 9.2.4. All necessary spares, consumables and any other material for preventive maintenance as per Operation and Maintenance Manual(s) required till the completion of DNP shall be supplied to the Purchaser/Nominated Agency by the Supplier, free of cost.
- 9.2.5. Additionally, Supplier shall develop and supply spares, consumables, special tools, jigs, fixtures and diagnostic equipment ("**Payable Spares**"). Details to be discussed and agreed at least six (06) months before the delivery of TS#01.
- 9.2.6. Supplier shall provide necessary "**Training**" as defined in this Chapter to the operation and maintenance staff of the Nominated Agency to undertake the Train driving/operation, troubleshooting, preventive and corrective maintenance.

9.3. Training

- 9.3.1. The Supplier shall plan and design the training modules including lesson plan for Manpower of Nominated Agency for operation, maintenance, overhauling, testing and repair of Trains, machinery and plants, special tools, equipment. The training shall also focus on maintenance monitoring and asset management system. The training shall include initial, on-the-job as well as refresher training.

9.3.2. Maintenance Training

Training should enable the maintenance staff to achieve the following broad objectives:

- (i) Attain a thorough comprehension of all facets of the system design and the functions of all equipment, encompassing proprietary and third-party equipment, software, and related components.
- (ii) Gain a deep understanding of all aspects concerning the scheduled maintenance and overhaul requirements of train-borne systems and equipment.
- (iii) Master the procedures to be adhered to for fault diagnostics, fault investigation, and the execution of unscheduled or corrective maintenance and repair of systems and equipment.
- (iv) Develop the capability to identify failed or defective components and equipment within various sub-systems utilizing specialized test and diagnostic equipment as necessary.
- (v) Understand the methodology required for software modifications and the alteration of parameters to adapt control and monitoring functions.
- (vi) Cultivate the confidence and competence to execute both scheduled and unscheduled maintenance tasks on trains in accordance with the maintenance instructions delineated in the maintenance manual, ensuring these tasks are completed within the designated timeframe and in a safe and efficient manner.

9.3.3. Train Driver training:

- (i) The objective of training of train operating staff is that the batches of drivers and instructors who will operate the trains should be able to run the trains safely under all operating conditions.
 - (ii) The training program should be designed to ensure that trainee driver acquires the necessary knowledge and skills to safely operate trains at a maximum operational speed of 249 kmph.
 - (iii) The Supplier's instructors shall provide training in classroom and actual driving of trains. Knowledge should be imparted to trainees through comprehensive classroom lectures, practical demonstrations and hand on practice inside the depot & on mainline. Emphasis should be given to rolling stock and its subsystems from operation point of view.
 - (iv) The instructors shall also train the operating staff in trouble shooting of the faults and emergency procedures. The training should enable them to acquire full capability for identification and troubleshooting of the faults within a specific duration.
- 9.3.4. The Supplier is mandated to arrange for experts from the original equipment manufacturers to deliver the training on-site. Supplier shall arrange for experienced instructors for supervised driving of the trainees
- 9.3.5. Regular evaluations will be conducted to monitor the progress and suitability of the training as well as the trainees' development.
- 9.3.6. Training requirements:
- 9.3.6.1. The training requirements mentioned herein, are the minimum requirements, therefore, the Supplier, shall make its own assessment of the training of the manpower and propose such additional training requirements.
- 9.3.6.2. Maintenance Staff (40 nos. trainees)
- a. Theoretical training for 50 trainer man-days.
 - b. Practical training of 180 trainer man-days. (Demonstration and hands on of preventive maintenance activities including overhauling for one (01) train set.)
- 9.3.6.3. Train Driver (16 nos. trainees)
- a. Theoretical training including demonstration and hands-on practise for 60 trainer man-days.
 - b. Practical training for a minimum of 10,000 km supervised driving on the Train on mainline for each trainee. Supplier may explore the opportunity to include the above supervised driving partially during the Testing of Rolling Stock.
- 9.3.6.4. Location of Training: Maintenance Depot of Nominated Agency. Details to be discussed six (06) months prior to the commencement of training.
- 9.3.7. The Supplier shall provide Training Manual for use by the Purchaser/Nominated Agency for conducting in-house training. The Manuals shall cover all requirements specified in this Chapter. The Supplier shall review and modify the Training manual based on the feedback of Purchaser/Nominated Agency. Purchaser/Nominated Agency shall have right to use all the training material including all the manuals for imparting training to other its personnel. The Supplier shall provide 10 coloured hard copies of the training manual along with a digital version for the use of Purchaser/Nominated Agency in facilitating inhouse training sessions.
- 9.3.8. All educational aids, materials, and documentation, including both trainer and trainee manuals employed in the training process, shall become the property of the Purchaser/Nominated Agency.

9.4. Provision of Spares

- 9.4.1. In accordance with Good Industry Practice, Supplier shall prepare the following priced list of spares & consumables (**the "Payable Spares"**) in coordination with the representative of Purchaser/Nominated Agency one (01) year from the start of DNP and supply the same three (03) months prior to the completion of DNP:
- (i) Capital Spares
 - (ii) Overhauling Spares

- (iii) Overhauling Kits
- (iv) Consumables for 2 years

9.4.2. Payable Spares provided by the Supplier under this Clause shall carry a warranty of 24 (twenty-four) months from the date of its supply, as the case may be, free of cost to the Purchaser/Nominated Agency. The terms of such warranty shall be determined in accordance with Good Industry Practice.

9.4.3. Supplier shall indicate the price of each Payable Spares as a percentage of the Train price and such costs arrived for the Payable Spares shall be paid over and above the Train price agreed, upon successful delivery and acceptance of the Payable Spares by the Purchaser/Nominated Agency.

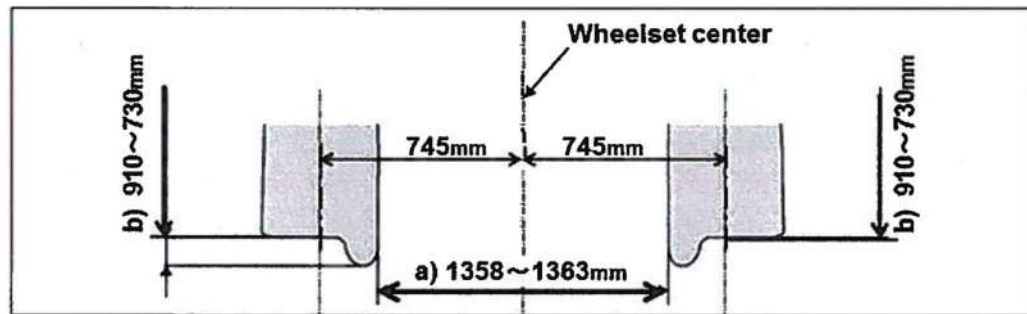
Annexure - I: List of Standards

1.	Electric traction - rolling stock - test methods for electric and thermal /electric rolling stock on completion of construction and before entry into service	IEC 61133
2.	Electronic equipment used on rail vehicles	IEC-61287
3.	Specific rules concerning the electronic control part of converters	IEC-60571
4.	Electric traction - electronic converter-fed alternating current motors	IEC 60349 –2
5.	Railway application - rolling stock - Part 1: Combined testing of inverter fed alternative current motors and their control system	IEC 61377-1
6.	Guide for the evaluation and identification of insulation systems of electrical equipment	IEC 60505
7.	Electric railway equipment-Train communication network	IEC 61375-1
8.	Rotating electrical machines: Functional evaluation of insulation systems	IEC 60034-18
9.	Railway applications - electromagnetic compatibility - Part 3-2: rolling stock - apparatus	EN 50121-3-2/ IEC 62236-3-2
10.	Railway applications - electromagnetic compatibility - Part 2: emission of the whole railway system to the outside world	EN 50121-2/ IEC 62236-2
11.	Railway applications – compatibility between rolling stock and train detection system	EN 50238 IEC 62427
12.	Transformer and chokes	IEC 60310
13.	Transformer oil	BS 148-1984
14.	High voltage AC circuit breaker	IEC 60077-4
15.	Rules for pantograph of electric rolling stock	IEC: 60494-1
16.	Relays, contactors and switches	IS 3231, IEC 60947
17.	Cables	IEC 60228, IS 10810, EN 50264
18.	Lightning arrestor	IEC 60099-4, IS 3070 Pt III
19.	Railway applications - rolling stock equipment – shock and vibration test	IEC 61373
20.	Programming languages for PLC	IEC 61131
21.	Railway applications - electric equipment for rolling stock	IEC 60077
22.	Electronic equipment used on rail vehicles	IEC 60571
23.	Power converter installed on board rolling stock – Part 1: Characteristics and test methods	IEC 61287-1
24.	Power converter installed on board rolling stock– Part 2: Additional technical information	IEC 61287-2
25.	Railway application - rolling stock protective provisions against electrical hazards	IEC 61991
26.	Auxiliary machines	IEC 60034
27.	Deleted	
28.	Environmental testing	IEC 60068
29.	Batteries	Relevant IECs
30.	Degree of protection provided by enclosures	IEC 60529
31.	Rules for installation of cabling	EN 50343
32.	Railway applications, welding of railway vehicles and components. Inspection, testing and documentation (The Supplier shall, no later than the 5th(fifth) anniversary of the Appointed Date, demonstrate compliance to the EN 15085)	EN15085
33.	Deleted	
34.	Reliability of electronic component	IEC 61709

35.	RAMS	EN 50126/ IEC 62278
36.	Deleted	
37.	Deleted	
38.	Railway applications - Current collection systems - Requirements for and validation of measurements of the dynamic interaction between pantograph and overhead contact line	BS EN 50317
39.	Railway applications - Current collection Systems - Validation of simulation of the dynamic interaction between pantograph and overhead contact line	BS EN 50318
40.	Railway applications - Current collection systems - Technical criteria for the interaction between pantograph and overhead line (to achieve free access)	BS EN 50367
41.	Railway Applications – Air conditioning for main line rolling stock. Comfort parameters and type tests.	BS EN 13129
42.	Deleted	
43.	Deleted	
44.	Tensional Strapping	EN 13891
45.	Railway applications-Aerodynamics- Part 4: Requirements and test procedures for aerodynamics on open track	EN 14067-4
46.	Commission Regulation (EU) No 1302/2014 of 18 November 2014 concerning a technical specification for interoperability relating to the rolling stock - locomotives and passenger rolling stock subsystem of the rail system in the European Union	TSI LOC & PAS
47.	Commission Regulation (EU) No 1304/2014 of 26 November 2014 on the technical specification for interoperability relating to the subsystem rolling stock - noise	TSI Noise
48.	Flat Bottom Railway Rails and Special Rails For Switches And Crossings Of Non-Treated Steel	JIS E 1101: 2012
49.	Resistance of copper materials for electrical purposes	JIS C 3001:1981
50.	Copper and copper alloy grooved contact wires	JIS E 2101:2021
51.	Cold rolled stainless steel plates, sheets and strip 50126	JIS G4305
52.	Loading of Coach bodies and their components	UIC 566
53.	Measures To Ensure the Technical Compatibility of High-Speed Trains	UIC 660
54.	Hot-rolled atmospheric corrosion resisting steels for welded structure	JIS G3114
55.	Hot rolled products of structural steels	EN10025

Annexure - II: Reference details of Wheel, Floor Height and MMD

A2.1	Wheel diameter (Specified for reference)	Maximum	910mm
	On the tread measured at 745 mm from	Minimum	730mm
	The wheelset center	Standard	860mm

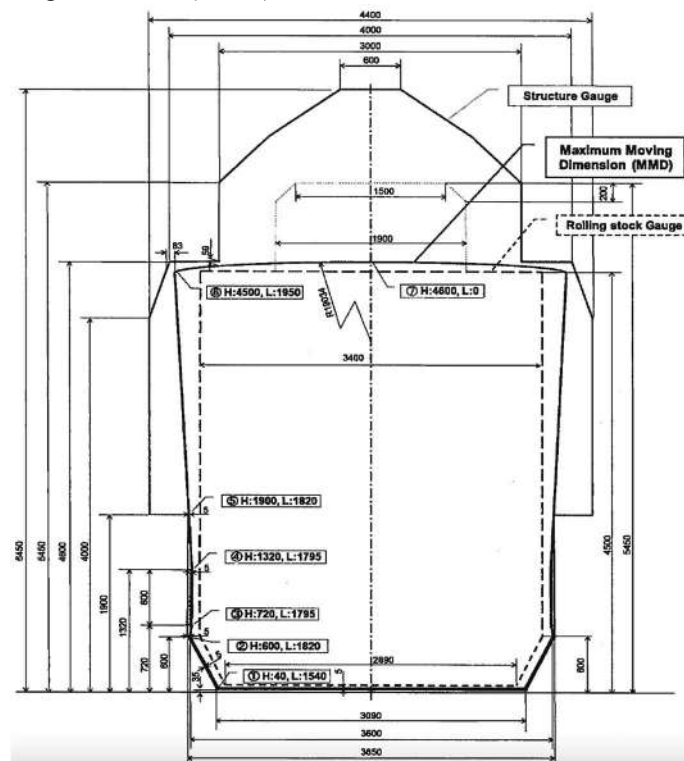


A2.2.	Width of wheel (Specified for reference)	120 mm~135mm
	Floor height	Standard 1,300mm

A2.3 Minimum Clearance from Rail Level

Limit line	Definitions	Part
60mm	Not move vertically: Unuspended part	Parts mounted on Axle box
85mm	Basic limit: Suspended part	Parts of Car body & Bogie frame

A2.4 Maximum Moving Dimension (MMD)



Note:

- All dimensions are in mm
- It shows Straight track on operational service line
- Dimensions are described as
- L: Horizontal distance from track center, H: Height from rail level
- For platforms facing the Loop line, not infringe the copings L=1760mm

A2.5 Permissible speed on curves

Radius of curve (meters)	Maximum permissible speed (km/h)
6,000 or more	350
5,000 to 6,000	340
4,500 to 5,000	320
4,000 to 4,500	300
3,500 to 4,000	280
3,000 to 3,500	260
2,800 to 3,000	250
2,500 to 2,800	235
2,200 to 2,500	220
2,000 to 2,200	210
1,800 to 2,000	200
1,500 to 1,800	185
1,200 to 1,500	165
1,000 to 1,200	150
900 to 1,000	140
800 to 900	135
700 to 800	125
600 to 700	115
500 to 600	105
400 to 500	95

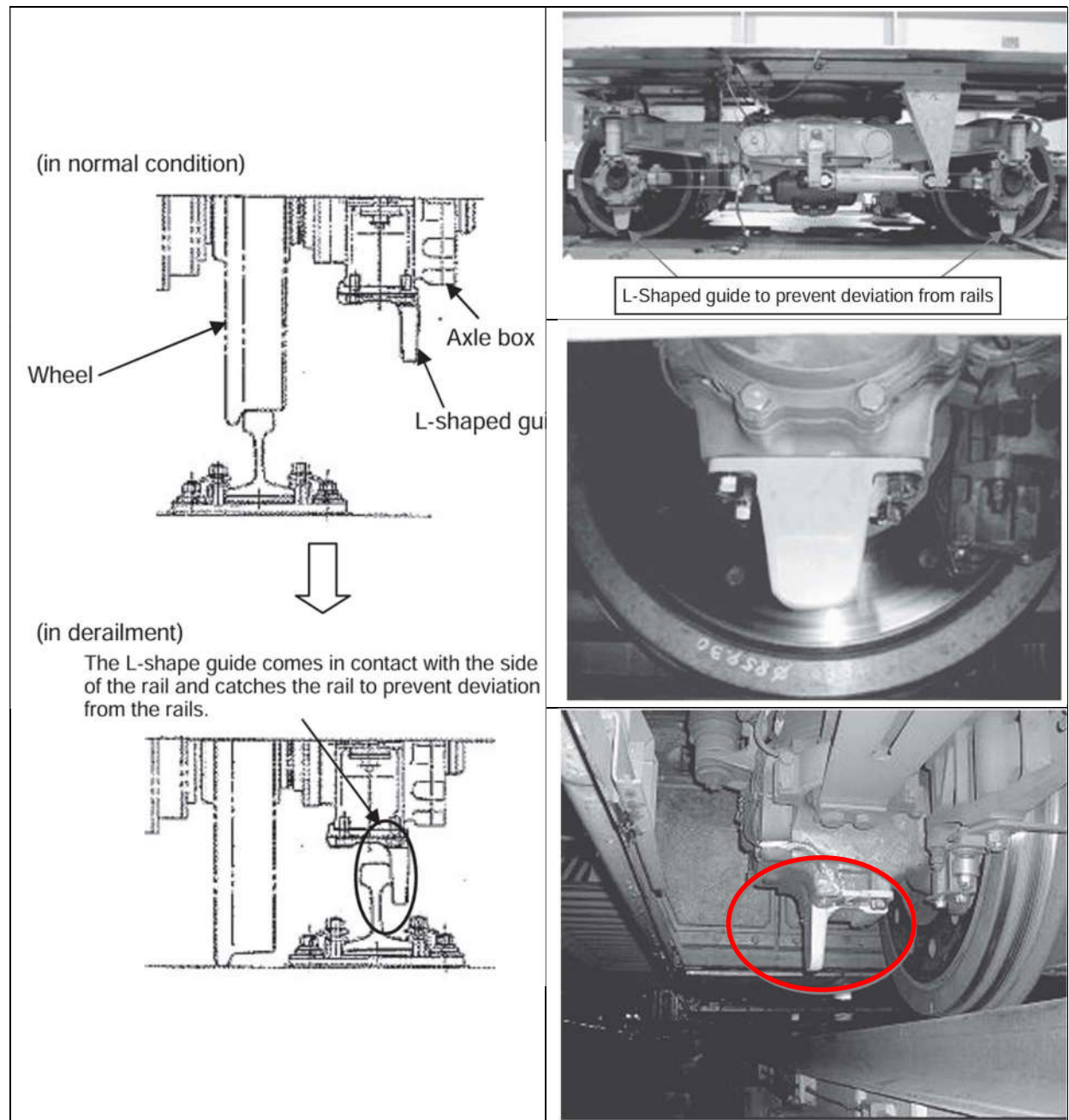
Note:

- (a) Figures for any intermediate radius of curvature may be obtained by adopting the value for sharper curve.
- (b) Cant provided is limited to desirable value of 180 mm.
- (c) Maximum cant deficiency is 90mm

Annexure - III: Axle box guide device

Supplier can refer the technical paper titled “Development of an L-Shaped Guide to Prevent Deviation from Rails for material and design related information of Axle Box guide device.

(Link: https://www.jreast.co.jp/e/development/tech/pdf_15/Tec-15-53-56eng.pdf).



Annexure - IV: Mandatory tests as per EN14363

S.No.	Test Type		Limit value (Locomotives, Traction units, Passenger Cars)	Test procedure
1	Wheel off-loading	$\Delta Q/Q$	0.6	Para 6.1.5 & Para A.9 of EN14363:2016
2	Sum of guiding forces of left and right wheel	$\Sigma Y_{j,\max}$ ($Y_{j1} + Y_{j2}$)	$k_1 (10 \text{ kN} + P_{F0}/3)$ $k_1 = 1.0$ where P_{F0} = nominal static vertical wheelset force	Table 4 of EN14363
3	Derailment coefficient	$(Y/Q)_{j,a,\max}$	$\leq 0.8^a$	Para 6.1 of EN14363:2016
4	Lateral axle box force	$H_{j,\max}$	$k_2 (10 \text{ kN} + P_{F0}/3)$, $k_2 = 0.90$ where P_{F0} = nominal static vertical wheelset force	Table 4 of EN14363
5	Lateral acceleration on bogie frame above axle box	(only bogie vehicles)	$12 \text{ m/s}^2 - (m+ / 5 \text{ t}) \cdot \text{m/s}^2$ where $m+$ is mass of bogie in Ton	
6	Lateral acceleration on vehicle body above running gear		Test zone 1, 2: 3.0 m/s^2 ^b Test zone 3: 2.8 m/s^2 ^b Test zone 4: 2.6 m/s^2 ^b	
7	Vertical acceleration on vehicle body above running gear		3.0 m/s^2 single suspension or deflated air spring: 5.0 m/s^2	
8	Bogie Rotational Resistance		Static test: Limit 0.1 for a rotational speed of 1deg/sec	6.1.5.3.3 of EN14363

^a In transition curves it is recognized that higher values than 0,8 may be encountered. The maximum limit value of 1,2 shall be respected, where 0,8 is exceeded. Each case shall be investigated and justified.

^b In some cases for partial on-track tests with the simplified measuring method a modified limit value shall be calculated as per EN14363.

Annexure - V: Interface Matrix between Rolling Stock and S&T

Item	Signalling	Telecommunication	Rolling Stock
<p>1. On board EVC (European Vital Computer) equipment</p> <p>2. Onboard ATO equipment</p> <p>3. Antennae for signaling including balise antenna and antenna for ETCS.</p> <p>4. Speed measuring sensors and speedometer for signaling and non- signaling modes.</p> <p>5. ATC Cab Displays (Train operators DMI, (hardware and software redundant DMI per cab) including special cables etc.</p> <p>6. On board radio equipment for ETCS.</p> <p>7. Antennae & radio for train radio including special cables etc.</p> <p>8. Train lines/Ethernet connection</p> <p>9. Speed sensing devices for non-signaling modes</p> <p>10. Wi-Fi access points with antenna (02 per cab), if required</p>	<p>To supply the equipment to the Rolling Stock Supplier's works (item 1 to 10 except item 7, 8 & 9)</p> <p>The train-borne signalling system will consist of Automatic Train Operation (ATO) system and Automatic Train Protection (ATP) as per ETCS Level 2 & 1.</p> <p>The Rolling Stock will be fitted with ETCS / ATO equipment, which will meet the redundancy requirements.</p> <p>The location of the onboard cab equipment (EVC, Radio , Wi-Fi access points etc.) shall be mutually agreed between Signalling contractor and Rolling Stock Supplier so as to optimize space for passengers duly considering maintainability and easy accessibility; however the onboard cab equipment (EVC, Radio Wi-Fi access etc.) shall not be placed in the underframe on account of maintainability issues and external equipment (like antennas) have to comply the static and the dynamic gauge.</p>	<p>To supply the equipment to the Rolling Stock Supplier's works as per item 7.</p> <p>The location of the onboard cab equipment shall be mutually agreed between Telecom contractor and Rolling Stock Supplier so as to optimize seating & standing space duly considering maintainability and easy accessibility; however, the onboard cab equipment shall not be placed in the underframe on account of maintainability issues and external equipment (like antennas) have to comply the static and the dynamic gauge.</p>	<p>To provide space in the Vehicle design for fixing and installation at the manufacturer's facility, by the Rolling Stock Supplier, under the supervision of the S&T contractor.</p> <p>The speed measuring sensor and odometer for non-signalling mode will be provided by Rolling Stock Supplier as per item-9.</p> <p>To provide train lines / ethernet Connection as per S&T requirement for item-8.</p>
<p>11. Power supply and earthing for on board signalling and train radio equipment.</p>	<p>Furnish required voltage values and earthing requirements to Rolling Stock Supplier for respective scope.</p>		<p>To provide the required voltages and earthing.</p> <p>Vehicle control circuit interfacing with signalling shall have a separate, redundant power supply arrangement.</p>

Item	Signalling	Telecommunication	Rolling Stock
12. Logging of on-board information from signalling.	Signalling and Train Control contractor to co-ordinate with Rolling Stock Supplier for signal levels and protocols. Signalling and Telecommunication contractor as well as Rolling Stock Supplier shall ensure that complete and detailed log of the signals exchanged between on-board ETCS / Onboard-ATO and TCMS shall be retrievable by Purchaser/Nominated Agency for diagnostics.	Signalling and Telecommunication contractor as well as Rolling Stock Supplier shall ensure that complete and detailed log of the signals exchanged between on-board ETCS / Onboard-ATO and TCMS shall be retrievable by Purchaser/Nominated Agency for diagnostics.	Provide the on board data logger in TCMS. All to and fro signals shall be logged in TCMS. Signalling and Telecommunication contractor as well as Rolling Stock Supplier shall ensure that complete and detailed log of the signals exchanged between on-board ETCS/Onboard-ATO and TCMS shall be retrievable by Purchaser / Nominated Agency for diagnostics. TCMS shall also log information / signals as received / delivered from / to ATP / ATO and Train Radio equipment supplied by the Signalling and Train Control contractor and Telecommunications contractor respectively. Rolling Stock Supplier shall also enable Signalling contractor to record similar data / signal interfaced between Rolling Stock and Signalling. During design and interface, additional signals may have to be interfaced with Signalling contractor to improve train performance. The same shall be implemented by the Rolling Stock Supplier.
13. Interface between onboard signalling with train braking and propulsion systems for automatic braking, acceleration and deceleration.	Zero Velocity Relay (ZVR) (if required) & Redundant Emergency Brake Relay (EBR) relays to be supplied by the Signalling and Train Control contractor		Rolling Stock Supplier shall co-ordinate with the Signalling and Train Control contractor to agree on levels and protocols for interface signals. There shall be no delay in braking from Rolling Stock during the transition from electric regenerative brake to friction brake at slow speed.
14. System master clock	Signalling and Train Control contractor to provide necessary inputs.		Rolling Stock Supplier to synchronize TCMS clock with the system master clock.

Item	Signalling	Telecommunication	Rolling Stock
			All sub-systems clock in Rolling Stock shall be synchronised with the TCMS clock.
15. On board next station information to the passengers	Shall provide necessary signals on-board to Rolling Stock Supplier. Both Signalling and Rolling Stock will interface for Train ID exchange.		Shall provide for necessary hardware interface, display for on-board passenger information system inside the Cars. Both Signalling and Rolling Stock will interface for Train ID exchange.
16. On board announcement from OCC including triggering of pre-recorded messages.		Shall provide necessary signals on-board to Rolling Stock Supplier.	
17. Climatic requirements for onboard signalling and radio cab equipment.	Signalling and Train Control contractor to specify at an early date, the total heat load wattage, and maximum permitted temperature		Rolling Stock Supplier to provide Driving Cab HVAC installation to maintain a nominal temperature of 25°C. Suitable ventilation shall be provided by the Rolling Stock Supplier for the backside area of the console. Rolling Stock Supplier to provide conditioning air from the saloon to all relevant signal & telecom installations to maintain a nominal temperature of 25°C. Conditioned air ventilation shall be provided by the Rolling Stock Supplier for the console.
18. Climatic requirements for on board Train Radio cab equipment.		Telecommunications contractor to specify at an early date, the total heat load wattage, and maximum permitted temperature	
19. EMI/EMC interface between the Rolling Stock and Signalling and Train Control, and Telecommunications.	Signalling and Train Control, and Telecommunications contractors shall advise EMI/EMC plan for signalling & radio equipment to Rolling Stock Supplier at early date. Regarding electromagnetic interference (EMI), Signalling contractors shall provide a list of frequencies and other sensitive requirements to the Rolling Stock Supplier, to enable Rolling Stock Supplier to avoid such frequency bands in design, and to provide devices to isolate the source of emission wherever required. Rolling Stock Supplier, S&T contractors shall ensure that the emission and immunity level of their respective equipment meet the requirements of EN50121-3-1 & EN50121-3-2. Rolling Stock Supplier and S&T contractors shall also jointly develop a test plan for verification of electromagnetic compatibility of traction and signalling and telecommunications systems. Rolling Stock Supplier and S&T contractors shall work		Rolling Stock Supplier shall ensure the compliance of the requirements of Signalling and Train Control, and Telecommunications contractors for on board signalling and radio equipment. Rolling Stock Supplier, Signalling and Telecommunication contractors shall ensure that the emission and immunity level of their respective equipment meet the requirements of EN50121-3-1 & EN50121-3-2.

Item	Signalling	Telecommunication	Rolling Stock
	<p>together to assure that all electronic and electrical equipment on the rolling stock works properly without interfering with signalling, or telecommunications sub- systems.</p> <p>The cable layout of the signalling and communication system in the cable ducts provided by Rolling Stock Supplier shall be jointly agreed. The separation between signalling and communications cables and power cables of 25kV, 415 V three phase AC, 230 V AC single phase, 110 V DC rating shall be in accordance with accepted international practice and jointly agreed.</p>		<p>Rolling Stock Supplier shall ensure that the return current in the track at the specified frequencies does not exceed the value specified by Signalling contractor.</p> <p>Rolling Stock Supplier and S&T contractors shall also jointly develop a test plan for verification of electromagnetic compatibility of traction and signalling and telecommunications systems. Rolling Stock Supplier and S&T contractors shall work together to assure that all electronic and electrical equipment on the rolling stock works properly without interfering with signalling, or telecommunications sub- systems.</p> <p>The cable layout of the signalling and communication system in the cable ducts provided by Rolling Stock Supplier shall be jointly agreed. The separation between signalling and communications cables and power cables of 25kV, 415 V three phase AC, 230 V AC single phase, 110 V DC rating shall be in accordance with accepted international practice and jointly agreed.</p> <p>The cable ducts shall be earthed at notionally at every two (02) m and also at the ends and shall be in accordance with accepted international practices.</p>
20. Train Integrity Information.			Train integrity information will be provided by Rolling Stock to onboard signalling.
21. Train Driver Identification reader	To supply the equipment to the Rolling Stock Supplier's works. Data communication between the Train Driver identification equipment and the ERTMS on board system will be provided by the S&T contractor.		To accommodate it in the vehicle design for fixing and installation at the Rolling Stock Supplier's facility, under the supervision of the Signalling and Train

Item	Signalling	Telecommunication	Rolling Stock
			Control and Telecommunication contractor.
22. TCMS - Remote diagnostic data and if the system for Automated wayside wheel profile measurement is installed	For trains on mainline and in Maintenance Depots – S&T contractor shall provide wi-fi coverage for TCMS and if the system for Automated wayside wheel profile measurement is installed. S&T contractor shall provide a link between TCMS and TCMS server in depot.		For trains on mainline and stabled in Maintenance Depots — Rolling Stock Supplier shall establish procedure for downloading through wi-fi. Rolling Stock Supplier shall provide server for TCMS data in the Depot.
23. Ground based Hot Axle Box Detection (HABD) for monitoring of axle box temperature (if required)	<p>The Telecom Contractor shall provide communication channel from station SER(Station Equipment Room) / TER (Telecom Equipment Room) to CER (Central Equipment Room) of OCC.</p> <p>The information received from HABD shall be displayed both on ATS and RSC workstation in OCC.</p>		The ground equipment and their connection to the closest SER/TER shall be provided by Rolling Stock Supplier, Rolling Stock Supplier shall interface with the S&T contractor to define the proper protocol interface.
24. Graphical User Interface (GUI) for Rolling Stock controller (RSC) in the OCC	<p>Signalling contractor shall be responsible for supplying RSC workstation and display of required information.</p> <p>Signalling contractor shall provide communication link between train and OCC for RSC GUI.</p>		<p>Rolling Stock Supplier shall be responsible for development of specialized GUI (if required) for the RSC in the OCC.</p> <p>The RS GUI workstation in the Maintenance Depots (if required) for maintenance use will be provided by Rolling Stock Supplier.</p>
25. Guaranteed Emergency Brake Rate (GEBR)			Rolling Stock Contractor shall furnish value of the GEBR to Signalling contractor for the complete speed range.
26. Signals for neutral section	Signalling system will protect the entry of train in neutral section in full supervision mode and above. Also, the Signalling system will provide necessary trigger signal to TCMS for pantograph management around neutral section in normal operation.		In case the trigger from the Signalling systems for pantograph management fails, the Rolling Stock Supplier will ensure neutral section detection through wayside permanent magnet/RFID etc. and also through the information available on TCMS.
27. Information to passengers on station Passenger Information Display System	Signalling contractor shall share the information of load of each train car with Telecom contractor and Telecommunication contractor shall display the load of each train car of at least two consecutive approaching trains.		Shall provide the load information of each train car to S&T contractor.

Item	Signalling	Telecommunication	Rolling Stock
(PIDS) regarding load of each car of approaching train (if required)			
28. Live streaming of CCTV camera from train. Buffering in Operation Control Centre (OCC) (if required).	<p>Signalling contractor shall provide suitable arrangement for live video streaming transmitted from the train to the OCC via signalling network and its display at CCTV workstation.</p> <p>For CCTV the S&T contractors will provide server in the OCC. These servers will be networked by the S&T contractor.</p> <p>The buffering arrangement in OCC via CCTV server shall be responsibility of S&T contractor.</p> <p>Signalling contractor shall interface for control and data transfer of CCTV images from the Train to OCC / Station Control Room (SCR) on the CCTV/ATS terminal and Large Video Screen. The levels and protocols shall be agreed between Signalling and Rolling Stock.</p>		<p>Rolling Stock Supplier shall provide cameras in train including supporting hardware.</p> <p>Rolling Stock Supplier shall also provide networking equipment like L-3 switches in train to interface with link provided by signalling contractor to transmit CCTV stream to OCC.</p> <p>The CCTV cameras shall be provided with an appropriate capacity of recording onboard, which shall be in the scope of Rolling Stock.</p> <p>Rolling Stock Supplier shall interface for control and data transfer of CCTV images from the Train to OCC/SCR on the CCTV/ATS terminal and Large Video Screen. The Levels and protocols shall be agreed between Signalling and Rolling Stock.</p>
29. Cable supply	<p>The S&T Contractor will provide the requirements to the Rolling Stock Supplier for the train line and/or Ethernet cables for the data flow.</p> <p>The S&T contractor shall supply the necessary disconnection and terminal blocks, device mounting brackets and plates, flexible conduit assemblies complete with connectors and cables from S&T equipment to the junction boxes.</p> <p>S&T contractors and Rolling Stock Supplier shall jointly certify relevant connections, cables to on-board signalling & telecom equipment after their assembling in first train of each type at Rolling Stock Supplier's premises.</p> <p>For rest of the trains, the joint certification will be done onsite.</p>		<p>Rolling Stock Supplier shall be responsible for providing the cables for the train lines and/or ethernet links required by the S&T contractor.</p> <p>The Rolling Stock onboard switch for ethernet will be sized to support the Telecom data.</p> <p>The Rolling Stock Supplier shall ensure the availability of adequate no. of train lines/ethernet considering the requirement of S&T contractors. Rolling Stock Supplier to ensure that adequate number of spare</p>

Item	Signalling	Telecommunication	Rolling Stock
			<p>train lines (minimum 10% for each type or 01 set for each type, whichever is more)) shall be available at the end of the Defect Notification Period (DNP).</p> <p>The Rolling Stock Supplier shall interface with the S&T contractors for provision of space, power, cable route etc.</p> <p>The Rolling Stock Supplier will provide the S&T equipment mounting brackets, conduits, support or clamping arrangements to ensure security and reliability.</p> <p>S&T contractors and Rolling Stock Supplier shall jointly certify relevant connections, cables to on-board signalling & telecom equipment after their assembling in first train of each type at Rolling Stock Supplier's premises.</p> <p>For rest of the trains, the joint certification will be done onsite.</p>
30. Location Information	Signalling contractor shall provide trigger to Rolling Stock at the time of departure from station for the purpose of location information.		Rolling Stock Supplier shall use the same for different distance based algorithms provided in the Rolling Stock.
31. Identification	<p>(a) Signalling contractor shall provide a Train Identification Number (Train ID) up to eight digits to Rolling Stock Supplier.</p> <p>(b) Train ID shall be allocated to train at suitable place and shall be maintained until it finishes its service. It shall be possible by the Purchaser/Nominated Agency to amend and / or modify the Train ID, subsequently, to suit the operational requirements.</p> <p>(c) Signalling contractor shall provide the necessary input signals (next station information code, platform side information, triggering signal, etc.) to Rolling Stock for displaying and making next station announcements to passengers on-board.</p>		<p>(a) Rolling Stock Supplier shall accordingly use the relevant information such as names of intermediate stations, stopping pattern, station stop door opening side information, skipping station information, keep door closed information, train going to depot information etc. for operation of on-train systems.</p> <p>(b) Rolling Stock Supplier shall provide suitable arrangement for Train Driver to</p>

Item	Signalling	Telecommunication	Rolling Stock
			view this information displayed on the Train information panel provided on front and other display information inside the Train from his seat.
32. Train Data Recorder	Signalling contractor shall provide the requisite signal to Rolling Stock for the recording purpose as per the requirements of functional interface specifications.		Rolling Stock shall interface with Signalling contractor for provision of data storage and other requirements.
33. Driver seating position	S&T contractor to provide signals design in mainline and at platform ends.		Rolling Stock Supplier shall develop his design ensuring that the driver's seating position and windows shall allow clear visibility and sighting distances, for all signals in accordance to the requirements provided by the signalling contractor. Rolling Stock Supplier shall provide evidence that the required visibility has been provided through design verification, considering the Rolling Stock geometry and the nominated limits for the anthropometric data.
34. Train detection/ Sanding equipment (if required)	Should the RS Contractor install on board the sanding equipment, the Signalling Contractor shall provide the electrical parameters to be met in order to ensure the safe train detection. For compatibility, the train detection system (axle counters), shall conform to EN 50238.		The RS Contractor shall be responsible to fix the constraints to the sanding system not to affect the train detection system. For compatibility, the Rolling Stock system shall conform to EN 50238.
35. 35. Driver seating position	S&T contractor to provide signals design in mainline and at platform ends.		Rolling Stock Supplier shall develop his design ensuring that the driver's seating position and windows shall allow clear visibility and sighting distances, for all signals in accordance to the requirements provided by the signalling contractor. Rolling Stock Supplier shall provide evidence that the required visibility has been provided through design verification, considering the Rolling Stock geometry

Item	Signalling	Telecommunication	Rolling Stock
			and the nominated limits for the anthropometric data.
36. Brake characteristics to be used by S&T contractor and interoperability requirement.	<p>The signalling system will work on ETCS Level 2. ETCS Level 1 signalling system may also be deployed as a backup.</p> <p>The interoperability requirements are based upon the latest Mandatory Specifications published by European Union Agency for Railways (ERA), ETCS Baseline 3 Release 2 or higher.</p> <p>The operation will be optimized under ATO modes developed on the latest available version of Subset-0125 and other relevant subsets.</p> <p>The ETCS Level 2 with ATO implementation shall be interoperable irrespective of any signalling vendor. The ATO interface will follow UNISIG subsets-139 as a minimum and relevant UNISIG subsets, for interface between Signalling and Rolling Stock. In case of any conflict, Engineer's decision shall be final.</p> <p>The system shall be so designed to meet the headway requirements, based on the characteristics of the vehicles and the track geometry.</p>		<p>Rolling Stock Supplier shall provide traction and braking characteristics of the actual Vehicles.</p> <p>Acceptance tests of the signal system will use the actual Vehicles supplied. Brake capacity of the Rolling Stock shall be used optimally to ensure its maximum utilization when full brake equipment is operational. In case of isolation of any brake system or bogie/car, Rolling Stock Supplier shall furnish requisite information to Signalling contractor.</p> <p>The Rolling Stock Supplier shall provide the Guaranteed Emergency Brake Rate (GEBR) in the complete speed range.</p>
37. Safe Braking Distance	<p>The design of Signalling system shall also take into account the effect of track geometry on the traction and braking characteristics provided by the Rolling Stock Supplier.</p> <p>The model for calculating the Safe Braking Distance (SBD) shall identify and take into account various system's response times and Train Driver's reaction times and shall be in accordance with internationally accepted standard.</p> <p>The Signalling contractor shall share all the interface signals and shall log /record these signals/data.</p>		<p>The Rolling Stock Supplier shall furnish the guaranteed braking rate at the normal braking efficiency, including brake deterioration to Signalling contractor. Rolling Stock Supplier shall also provide the speed / acceleration curves and speed / tractive effort curves, for all loading conditions.</p> <p>Rolling Stock Supplier shall furnish as a minimum the Rolling Stock parameters to be used by Signalling contractor for designing the ETCS Signalling system</p> <p>Rolling Stock Supplier shall also furnish a reasonable tolerance band for the identified performance parameters. Rolling Stock Supplier shall ensure that all the trains supplied perform within the tolerance</p>

Item	Signalling	Telecommunication	Rolling Stock
			band. The Rolling Stock Supplier shall share all the interface signals and shall log /record these signals/data.
38. Optimization of energy efficiency	The efficacy of the finalized run curves shall be jointly demonstrated by means of simulations as well as line trials. Optimization of energy efficient mode shall consider different TE (Tractive Effort) /BE (Braking Effort) curve for different loads as well. S&T contractors shall demonstrate optimization of energy with respect to different TE (Tractive Effort) /BE (Braking Effort) curve for different loads.		The Rolling Stock Supplier shall provide optimized energy efficient run curve pattern to Signalling contractor for incorporation in the ATO mode of operation. All associated information as requested by Signalling contractor shall be duly handed over by Rolling Stock Supplier.
39. S&T details to be used by Rolling Stock Supplier	The following requirements shall be provided by S&T contractor to Rolling Stock Supplier. (i.) The maximum power consumed by Signalling and Telecommunication contractor's equipment from the 110V DC supply under all specified operating conditions. (ii.) The number of train wires/ ethernet connections required, and the function of each. (iii.) All control logic outputs. (iv.) Electrical characteristics of the interconnection cabling and wiring. (v.) Sensitivity levels, and frequencies which must be avoided. (vi.) The specific heat load for air conditioning purposes. (vii.) The EMC /EMI requirements. (viii.) Details of the provisions required to enable the bidirectional transference of data from the train to the wayside; (ix.) Requested onboard environmental conditions.		Rolling Stock Supplier shall retrieve the requirements from S&T contractor and incorporate them in Design, Installation and T&C.
40. S&T equipment cubicle enclosure(s).	S&T contractor to provide requirements for mounting the cubicle and its equipment. S&T contractor to confirm the design and installation proposed by Rolling Stock Supplier. As a minimum, all electronic equipment to be mounted on rolling stock, including those provided by Signalling and Telecommunication contractors shall comply with latest IEC 60571 (or EN 50155): Electronic Equipment used on Rail Vehicles, for design,		Rolling Stock Supplier shall supply the onboard S&T equipment cubicle enclosure(s). Rolling Stock Supplier to ensure secure mounting, and access. Rolling Stock Supplier to design and install all supports, braces, mounting holes, cabling apertures, etc for S&T equipment.

Item	Signalling	Telecommunication	Rolling Stock
	<p>manufacture and testing, and shall use components purchased against an internationally recognized quality assurance and reliability certification procedure.</p>		<p>For housing of S&T equipment, suitable enclosed environment (minimum IP-52) needs to be provided by the Rolling Stock Supplier.</p> <p>As a minimum, all electronic equipment to be mounted on rolling stock, including those provided by Signalling and Telecommunication contractors shall comply with latest IEC 60571 (or EN 50155): Electronic Equipment used on Rail Vehicles, for design, manufacture and testing, and shall use components purchased against an internationally recognized quality assurance and reliability certification procedure.</p> <p>Rolling Stock Supplier shall also provide force cooling for onboard signalling and telecommunication equipment.</p>
<p>41. First set - Factory Installation and Testing</p>	<p>All the special equipment associated with the train borne signalling and radio system, including the interface cables / wires between the train borne signalling and Train Radio shall be designed by S&T contractor and supplied by S&T contractor, as applicable, to Rolling Stock Supplier's factory. Each contractor shall be aware of the locations of manufacturing plants, which could concurrently be manufacturing cars.</p> <p>S&T contractors shall be responsible for the provision of special test equipment and instrumentation.</p> <p>S&T contractors shall be responsible for providing all data and training of Rolling Stock Supplier's staff in all aspects of signalling and train radio installation and testing wherever applicable.</p>		<p>As leader contractor in the design stage for the Vehicle, the Rolling Stock Supplier shall:</p> <ul style="list-style-type: none"> • provide the design basis and on-board geometry to the Signalling contractor to allow him to design his equipment and installation arrangement; • validate and incorporate the design proposed by the design Signalling contractor or propose an alternative solution. <p>Rolling Stock Supplier shall provide facilities for comprehensive static and interface tests between the Rolling Stock, Signalling and Telecommunications systems at his premises.</p> <p>The first set of signalling equipment and</p>

Item	Signalling	Telecommunication	Rolling Stock
			<p>also Train Radio equipment shall be installed by Rolling Stock Supplier, under the supervision of S&T contractor representatives, including the wiring for the interface of the signalling equipment with Rolling Stock.</p> <p>Rolling Stock Supplier shall be responsible for installing wiring and equipment and it's testing on each car to the functioning standard agreed with S&T contractors.</p> <p>Testing of each car shall comply with the accepted international standards agreed between the contractors as agreed with the Purchaser / Nominated Agency. Initial integration tests (static) shall be done at the rolling stock factory and carried out by the test personnel of respective contractors jointly.</p>
42. Integrated test and trial runs.	<p>In this stage the S&T contractor will become the leader contractor and will drive the trial runs and the integrated test, preparing trial runs protocol and procedures to simulate normal, degraded, congested and emergency cases.</p> <p>A dedicated procedure will be arranged for rescuing the immobile train online.</p> <p>S&T will consider the comments raised by the Rolling Stock Supplier.</p> <p>The Rolling Stock Supplier, Signalling and Telecommunication contractors shall perform Integration Test and the tests shall include but not limited to traction and braking control, precision stopping, auto turn back, door operation. All contractors shall jointly produce a protocol document for Integrated Testing and Commissioning.</p> <p>The Rolling Stock Supplier and Signalling contractor(s) shall fully associate and render all necessary support during type testing of the respective systems. Rolling stock type tests may require "All-Out" mode of operation in GoA2 as per approved test specifications, the Rolling Stock Supplier & Signalling contractor(s) will jointly finalize such test plan and schemes/operational modes and ensure the satisfactory completion of type tests.</p> <p>Rolling Stock Supplier & Telecom Contractors shall assist Signalling Contractor to execute all the interface tests required between Rolling Stock & Signalling. It shall include</p>		<p>Rolling Stock Supplier will comment the procedures proposed by the S&T contractor.</p> <p>Rolling Stock Supplier will perform the procedures proposed by the S&T contractor.</p> <p>The Rolling Stock Supplier, Signalling and Telecommunication contractors shall perform Integration Test and the tests shall include but not limited to traction and braking control, precision stopping, auto turn back, door operation. All contractors shall jointly produce a protocol document for Integrated Testing and Commissioning.</p> <p>The Rolling Stock Supplier and Signalling contractor(s) shall fully associate and render all necessary support during type</p>

Item	Signalling	Telecommunication	Rolling Stock
	<p>static and dynamic tests. Test sheets shall be signed jointly for interface tests and joint certificate shall be issued for the same.</p> <p>Main line integration tests (static and dynamic) will be required to be carried out to ensure all train control functions and telecommunications between OCC and Train which will be required to be done jointly by Rolling Stock Supplier, S&T contractors at site. The test certificate subsequently shall be issued jointly by Rolling Stock Supplier, S&T contractor. The certificates will pertain to the respective areas of the contractor's responsibility and shall be decided during the detailed interface.</p> <p>In case of ATO, the Integration test between Rolling Stock Supplier and Signalling contractors shall include tests on mainline to confirm the realisation of demanded acceleration and deceleration rate by the ATO under various conditions.</p> <p>Should the need arise for modifications in the configurations of respective equipment or systems as a result of Integration Test or otherwise, the scope of work and division of responsibility shall be jointly agreed amongst the contractors and detailed procedure shall be developed.</p>		<p>testing of the respective systems. Rolling stock type tests may require "All-Out" mode of operation in GoA2 as per approved test specifications, the rolling stock contractor & Signalling contractor(s) will jointly finalize such test plan and schemes/operational modes and ensure the satisfactory completion of type tests.</p> <p>Rolling Stock Supplier & Telecom Contractors shall assist Signalling Contractor to execute all the interface tests required between Rolling Stock & Signalling. It shall include static and dynamic tests. Test sheets shall be signed jointly for interface tests and joint certificate shall be issued for the same.</p> <p>Main line integration tests (static and dynamic) will be required to be carried out to ensure all train control functions and telecommunications between OCC and Train which will be required to be done jointly by Rolling Stock Supplier, S&T contractors at site. The test certificate subsequently shall be issued jointly by Rolling Stock Supplier and S&T contractor. The certificates will pertain to the respective areas of the contractor's responsibility and shall be decided during the detailed interface.</p> <p>In case of ATO, the Integration test between RS and Signalling contractors shall include tests on mainline to confirm the realisation of demanded acceleration and deceleration rate by the ATO under various conditions.</p>

Item	Signalling	Telecommunication	Rolling Stock
			Should the need arise for modifications in the configurations of respective equipment or systems as a result of Integration Test or otherwise, the scope of work and division of responsibility shall be jointly agreed amongst the contractors and detailed procedure shall be developed. RS Contractor shall provide the requisite manpower to monitor and/or implement the modifications on the rolling stock for work involving.
43. Interface	<p>All designated contractors shall ensure that all requirements of the Specification pertaining to interfaces are based upon the latest Mandatory Specifications published by European Union Agency for Railways (ERA), ETCS Baseline 3 Release 2 or higher.</p> <p>There is possibility of having multiple Contractors for signalling, telecom.</p> <p>Rolling Stock Supplier and S&T contractors shall exchange information identifying the effective mode, the active or non-active status of each cab, the door status etc. The inputs shall be categorized as vital and non-vital. The levels and form of these inputs shall be coordinated between the Rolling Stock Supplier and S&T contractors. Rolling Stock Supplier and S&T contractors shall ensure that all the vital signals shall be exchanged in a safe way to comply SIL 4 requirements of S&T system.</p> <p>For ATO operation, the necessary train command, digital inputs signals shall be provided by the Signalling contractor.</p> <p>The ATP/ATO initiated signal demands will be redundant.</p>		<p>All designated contractors shall ensure that all requirements of the Specification pertaining to interfaces are based upon the latest Mandatory Specifications published by European Union Agency for Railways (ERA), ETCS Baseline 3 Release 2 or higher.</p> <p>Rolling Stock Supplier shall interface accordingly with more than one signalling /telecom and any other designated Contractor.</p> <p>Rolling Stock Supplier and S&T contractors shall exchange information identifying the effective mode, the active or non-active status of each cab, the door status etc. The inputs shall be categorized as vital and non-vital. The levels and form of these inputs shall be coordinated between the Rolling Stock Supplier and S&T contractors. Rolling Stock Supplier and S&T contractors shall ensure that all the vital signals shall be exchanged in a safe way to comply SIL 4 requirements of S&T system.</p>

Item	Signalling	Telecommunication	Rolling Stock
			<p>Rolling Stock Supplier to ensure that all doors related and other safety / train control related signals including brakes, position of safety cut out switches, direction related relays, suspensions, obstruction on track etc. are communicated to the Signalling Contractor.</p> <p>Rolling Stock Supplier shall provide the necessary hardware. Levels and protocols shall be agreed between Rolling Stock Supplier and S&T contractors. In By-pass/ Cut-out Mode/Isolation or any other mode, external indication light shall flash or occult which will be finalized during design stage.</p> <p>The redundancy shall also be provided on TCMS side by Rolling Stock Supplier. The form of these inputs shall be coordinated between Rolling Stock Supplier and S&T contractors.</p>
44. Issuing of Brake Commands	The Automatic Train Protection (ATP)/Full supervision mode system shall issue the braking commands to the Rolling Stock when safety limits are exceeded or when over-speed is detected.		The removal of traction power and the correct application of brakes shall be the responsibility of Rolling Stock Supplier.
45. Rescuing the immobile train	Shall Interface plan to address the procedures to be adopted for rescuing the immobile train at line by coupling the failure train with healthy train and clearing the line in Pull/Push mode with healthy train shall be finalized between contractors.		Shall Interface plan to address the procedures to be adopted for rescuing the immobile train at line by coupling the failure train with healthy train and clearing the line in Pull/Push mode with healthy train shall be finalized between contractors.
46. Modes of train operation	All the ETCS modes (as applicable) including ATO over ETCS (AoE), GoA2 & Automatic Turn Back (ATB)		Shall interface with signalling to decide mode selector position.
47. Equipment racks, connectors, VCC	Signalling contractor shall supply at Rolling Stock Supplier's factory pre-wired equipment racks with appropriate connectors for all wiring terminating inside on-board equipment, including wiring between on-board racks.		Shall interface with S&T contractor to incorporate the requirement.

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	<p>Telecom contractor shall similarly supply all the train radio equipment including the Train Radio Control Panel at the Rolling Stock Supplier's factory.</p> <p>Signalling and Telecommunication contractors, with the details provided by Rolling Stock Supplier shall ensure that the exterior finish and colours of the respective equipment suitably harmonize with that of the cab and the vicinity.</p> <p>Interfacing wiring for each module provided by Signalling and Telecommunication contractors including the interfacing wiring between Signalling and Telecommunication contractors' equipment shall terminate in a quick disconnect robust plug connector suitable for traction applications, with direct cable connection as far as possible. All cable connectors shall be identified within the cubicle using robust cable markers with distinctive colours for identification of e.g. safety function cables.</p> <p>For all relay contact interfaces Signalling and Telecommunication contractors shall provide auto contact-jam detection and contact bounce elimination function to ensure proper operation of the system. Relays for safety functions shall comply with the appropriate internationally accepted standard specification.</p> <p>Signalling and Telecommunication Contractors shall provide Rolling Stock Supplier with the number of wires and/or ethernet connections required between cars of a married pair and between married pairs to transmit signals from one end of the rake to the other end.</p> <p>Signalling and Telecommunication contractors shall provide specific observations on VCC circuits to Rolling Stock Supplier. Rolling Stock Supplier shall suitably incorporate these observations in the design.</p> <p>Screened cables for train borne signalling equipment shall be properly terminated so as to ensure that no return loops are formed to cause electrical noise.</p> <p>Train No. between the two systems shall be so designed so as to ensure that requisite information of train / car/ATC/ destination etc. is captured.</p>		<p>Provision of redundancy and spares shall be catered for by Rolling Stock Supplier for Train lines and/or ethernet connections.</p> <p>Vehicle control circuits shall be developed by the Rolling Stock Supplier. During the design stage, all the vehicle control circuits incorporating the identified interfaces shall be provided to Signalling and Telecommunication contractors, as applicable.</p> <p>Train No. between the two systems shall be so designed so as to ensure that requisite information of train / car/ATC/ destination etc. is captured.</p>
48. Train control functions and circuits	<p>To achieve the onboard signalling control functions, Signalling contractor shall identify any interfacing circuits specifically required for ATC operation and liaise with Rolling Stock Supplier. These include but not limited to start, door control, motoring, coasting, braking and emergency brake commands.</p> <p>For train control circuits, Signalling and Telecommunication contractors shall respectively identify the voltage free contacts to be provided by Rolling Stock Supplier, including the number and type of electrical signals required between the signalling equipment and the equipment provided by Rolling Stock Supplier.</p> <p>The contractors shall co-ordinate to agree on levels and protocols for each such signal.</p>		<p>Door control circuit design shall allow opening of doors in stand by position of mode selector under manual responsibility in case of non-availability of door opening authorization from signalling without losing the Full supervision mode.</p> <p>The contractors shall co-ordinate to agree on levels and protocols for each signal.</p>

Item	Signalling	Telecommunication	Rolling Stock
49. Train Driver's Display	<p>The equipment on driver's console used for signalling/non-signalling modes shall be ergonomically placed.</p> <p>Indications and alarms to the driver shall be displayed on the ETCS Cab Display supplied by the signalling Contractor in line with ETCS Driver Machine Interface (ERA_ERTMS_015560) and other relevant subsets. The train operator's display will be composed of an integrated display screen.</p> <p>Provision of audio alarms shall also be there in line with ETCS Driver Machine Interface (ERA_ERTMS_015560).</p> <p>Signalling contractor shall interface with Rolling Stock Supplier, to provide required inputs, like current speed, target speed, advisory speed, Normal Stopping Point (NSP) distance and mode of the train, as a minimum, to Rolling Stock HMI for display purposes.</p>		Shall coordinate for space and installation.
50. Space for Additional On-Board Equipment for future use.	<p>Signalling and Telecom contractors shall provide the details and supply the equipment in same philosophy as described in above requirements for a separate set of additional On-Board Equipment based <u>on indigenous technology for future use</u>.</p> <p>The detailed requirements and scope shall be worked out and co-ordinate to agree by Signalling & Telecommunication Contractors and Rolling Stock Supplier.</p>		<p>Shall be responsible for executing works in same philosophy as described in above requirements for a separate set of additional On-Board Equipment based <u>on indigenous technology for future use</u>.</p> <p>The detailed requirements and scope shall be worked out and co-ordinate to agree by Signalling & Telecommunication Contractors and Rolling Stock Supplier.</p>