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Public Private Partnership in Urban Rail Systems

Manual of Specifications and Standards

(Ministry of Railways)

Public Private Partnership

in

Urban Rail Systems

Manual of Specifications and Standards

Ministry of Railways (Railway Board)
Government of India

Index

Abbreviations

The following abbreviations are used in this Manual of Specifications and Standards:

Abbreviation	Full Name
AAR	Association of American Railroad
AASHTO	American Association of State Highway and Transportation
AC	Alternating Current
AFC	Automatic Fare Collection
AIS	Association of Information System
AREMA	American Railway Engineering and Maintenance-of-way Association
ASS	Auxiliary Sub-Station
ASTM	American Society for Testing and Materials
ATO	Automatic Train Operation
ATP	Automatic Train Protection
ATS	Automatic Train Supervision
BIS	Bureau of Indian Standards
BS	British Standards
CA	The Concession Agreement entered into between the Concessionaire and the Government
CATC	Continuous Automatic Train Control (system)
CBTC	Communication Based Train Control System
CEB/FIP	Comite Euro – Internationale du Beton (Euro-International Concrete Committee) – and Federation Internationale de la Pre-contrainte (International Federation of Pre–stressed Concrete)
CBI	Computer Based Interlocking
CC	Central Computer
CCH	Central Clearing House
CCTV	Closed Circuit Television
CEB/FIB	Model Code for Concrete structures. “CEB Bulletin”.
CENELEC	European Committee for Electro technical Standardization
CER	Communications Equipment Room

CIBSE	Chartered Institution of Building Services Engineers
CIE	International Commission on Illumination
CVMS	Central Voice Mail System
CVRS	Central Voice Recording System
CWR	Continuously Welded Rail
DC	Direct Current
DCC	Depot Control Center
DG	Diesel Generator
DTS	Data Transmission System
E&M	Electrical and Mechanical
EIA	Energy Information Administration
EN	Euro Norm (European) Standard
FFT	Fast Fourier Transform (method)
FRLSOH	Fire Retardant Low Smoke Zero Halogen
GPS	Global Positioning System
HV	High Voltage (as per Indian Electricity Rules)
IABSE	International Association for Bridge and Structural Engineering
IE	Independent Engineer
IEC	International Electro technical Commission
IEEE	Institution of Electrical and Electronic Engineers
IES	Illumination Engineering Society
IGBT	Insulated Gate Bipolar Transistor
IRC	Indian Roads Congress
IRS	Indian Railway Standards
IS	Indian Standard
ISA	Independent Safety Assessor
ISO	International Standards Organization
IT	Information Technology
ITU-T	International Telecommunications Union–Telecommunication Standardization Sector
JIS	Japanese Industrial Standards
Kmph	Kilometers per hour

LAN	Local Area Network
LED	Light Emitting Diode
LOMA	Limit Of Movement Authority
LV	Low Voltage (as per Indian Electricity Rules)
LWR	Long Welded Rail
MDB	Main Distribution Board
MOSRTH	Ministry of Shipping, Road Transport and Highways
MSS	Maximum Safe Speed
NBC	National Building Code (of India)
NFPA	National Fire Protection Association
NMS	Network Management System
OCC	Operations Control Center
OHE	Over Head Equipment
PABX	Private Automatic Branch Exchange
PIS	Passenger Information System
PTFE	Poly Tetra Fluoro Ethylene
PTZ	Pan/Tilt/Zoom
RCC	Reinforced Cement Concrete
RI	Ride Index
RSS	Rectifier Sub Station
SC	Station Controller
SCADA	Supervisory Control and Data Acquisition
SDH	Synchronous Digital Hierarchy
SEJ	Switch Expansion Joint
SIL	Safety Integrity Level
SMS	Station Management System
SOD	Schedule of Dimensions
SPL	Sound Pressure Level
TDR	Train Data Recorder
TETRA	Terrestrial Trunk Radio
TO	Train Operator
TOM	Ticket Office Machine

TSS	Traction Sub-station
UIC	Union Internationale des Chemins de Fer (International Union of Railways)
UPS	Uninterrupted Power Supply
VVVF	Variable Voltage Variable Frequency
WAN	Wide Area Network
XLPE	Cross Linked Poly Ethylene

Definitions

In this Manual of Specifications and Standards (the "**Manual**"), the following words and expressions shall, unless repugnant to the context or meaning thereof, have the meaning hereinafter respectively assigned to them:

Term	Definition
Alignment	shall mean the horizontal and vertical profile of railway track;
Automatic Train Operation (ATO)	shall mean the system which undertakes functions otherwise assigned to the TO;
Automatic Fare Collection (AFC)	shall mean the system which automates fare collection by automating the ticket selling and accounting processes and providing data on system usage;
Automatic Train Control(ATC)	Shall mean the system for automatically controlling Train movements and directing Train operations. The ATC shall *inter alia*, incorporate Automatic Train Protection (ATP) subsystems and shall have features to enhance operational safety;
Automatic Train Protection(ATP)	shall mean the sub system of the ATC which alerts the TO regarding speed and automatically applies brakes if there is no reaction from the TO;
Automatic Train Supervision(ATS)	shall mean the top-level system in real time Train control which regulates performance levels, monitors and controls the Trains in service and provides data to controllers to adjust the Train services to minimize the inconveniences caused by Train operation disruptions;
Auxiliary Equipment	shall mean auxiliary power supply equipment providing power for Train lighting, air conditioning, passenger facilities and emergency battery systems in the Trains;
Auxiliary Power Converter	shall mean the converter that converts the traction supply voltage into more appropriate supplies for use by Auxiliary Equipment:
Auxiliary Power Supply	shall mean supply for lighting and power sub-network, required by all fixed low voltage electrical installations including electro mechanical installations at Stations;
Availability	shall mean the probability that an equipment or system can perform a required function under given conditions over a given time interval or similar measurement:
Bi-direction	shall mean the operation of Trains in either direction over the same section of track subject to built in safety systems:

Term	Definition
Bogie	Shall mean a four wheeled truck used in pairs under the rail car. The Bogie has a central pivot on which the car is supported which allows it to guide the car into curved tracks:
Buffer Stop	shall mean the structure at the end of a track to prevent cars from proceeding beyond the end of the railway line;
Cab Signalling	shall refer to the signalling in the Train cab which governs the movement of the Train by conveying the limit of movement authority (LOMA) and the authorized speed, target distance / speed as deduced from the most restricting ATP condition, signalling mode etc;
Cant, or super elevation	shall mean the amount by which the outer rail is raised over the inner rail on horizontal curves;
Car or Coach	shall mean a passenger carrying rail vehicle, either powered or non-powered;
Civil Speed Limit	shall mean the permanent maximum speed limit determined by the track geometry for all Trains upon a particular section line, which speed limit shall not be exceeded at any time;
Command	shall refer to the facility to perform or modify a function of the System;
"COD" or Commercial Operation Date	shall have the meaning ascribed to the term in the Concession Agreement;
Construction Works	shall mean all works and things necessary to complete the Rail System in accordance with the requirements of the Concession Agreement and includes tracks, Signalling systems and communication systems;
Correct Stopping Position	shall refer to the point at which Trains are required to stop in a station platform;
Cross over	Shall refer to the means by which two juxtaposed tracks are connected;
Degraded	shall refer to all states or conditions, other than "normal";
Delay	shall mean a delay caused due to the inability of a Train to move or due to reduction in the speed of such Train resulting from failures in the system;

Term	Definition
Depot	shall mean the area designated for train stabling and maintenance of Trains and other sub-systems of the Rail System;
Design Headway	shall mean the minimum time interval between successive Trains operated at the permitted line speed, such that the speed of a following Train is not reduced by the Train ahead;
Detection	shall refer to the ability to determine that a track section or block is occupied by a Train, or the ability to verify that a point or signal has operated correctly as part of interlocking;
Direction of Travel	The Normal (N) direction of travel shall be the left-hand track, as viewed by a TO in the lead cab. The Reverse (R) direction of Travel shall be the right-hand track, as viewed by a TO in the lead cab;
DISCOM	shall mean a distribution company which is licensed to sell electric power;
"Document" or "Documentation"	shall mean documentation in printed or written form, or in tapes, discs, drawings, computer programmes, writings, reports, photographs, films, cassettes, or expressed in any other written, electronic, audio or visual form;
Earthing or Grounding	shall mean the connection of equipment enclosures and noncurrent carrying metal parts to earth to provide safety to personnel, public and to the equipment;
Electro pneumatic brake	Shall refer to an air brake that will allow for immediate application of brakes throughout the Train length. (Brakes are applied or released by electric/electronic signal on each Coach);
Emergency	shall mean a condition or situation that is likely to endanger the security of the individuals on or about the Rail System, including Users thereof, or which poses an immediate threat of material damage to any of the Project Assets;
Emergency Brake	shall mean the automatic brake system fitted to attain a restrictive braking distance/speed performance, which is applied continuously in emergency overriding any other control in operation;
Fail Safe	shall mean a design feature which enables a system (or element of a system) to revert to the safe condition in case of its failure;
Failure	shall mean an event which causes loss of function or performance within any part of the signalling and/or Train control system and requires a maintenance intervention to restore full functionality and performance;

Term	Definition
Fare Gates	Shall refer to the barrier between the "paid" and "unpaid" area. The fare gate will read a ticket and release the gate when a valid ticket is presented;
Good Industry Practice	shall mean the practices, methods, techniques, designs, standards, skills, diligence, efficiency, reliability and prudence which are generally and reasonably expected from a reasonably skilled and experienced operator engaged in the same type of undertaking as envisaged under this Agreement and which would be expected to result in the performance of its obligations by the Concessionaire in accordance with the Concession Agreement, Applicable Laws and Applicable Permits in reliable, safe, economical and efficient manner;
Government	shall mean the Central Government;
Horizontal Curve	shall mean a track which is curved in plan;
Interlocking	shall refer to the system to prevent setting up of conflicting routes;
Kinematic gauge	shall indicate the dimensions measured from the track center, beyond which no part of the vehicle or Coach in motion may protrude;
Lifting System	shall mean a system by which Coaches are lifted from under their Bogies to an ergonomic working height, to facilitate Bogie disconnection, the vehicle body being supported by body supports at specific locations points when the Bogies are removed;
Limit of Movement Authority	shall refer to a section of line ahead of a Train which is clear for the Train to proceed;
Maintainability	shall mean the probability that a given maintenance action for a given equipment or system under given conditions of use, can be carried out in a stated time interval when the maintenance is performed under stated conditions using stated procedures and resources;
Maintenance	shall include visual inspection, adjustment, replacement or repair carried out on equipment, sub-systems or systems which results in the item undergoing attention being preserved within maintenance tolerances or returned to its design tolerances;
Manual	shall mean this Manual of Specifications and Standards;

Term	Definition
Modes of Driving	Automatic Mode (AM); is the Normal Operating mode of driving enabled by ATO and supervised by ATP; Coded Mode (CM); is a degraded operating mode of driving supervised by the ATP System; Restricted Mode (RM); is a degraded operating mode of driving during equipment failures, restricting the Train speed to 25 kmph;
OHE	The electrical conductors over the track together with their associated fittings, insulators and other attachments by means of which they are suspended and registered in position.
Operating Headway	Shall mean planned service intervals between all Trains offering passenger service. Operating headway should allow a defined margin over design headway;
Overlap	shall refer to the safe distance provided beyond a signal in case the Train fails to stop at the signal when it is showing a danger aspect;
Parking brake	shall mean a brake designed to hold a stationary Train indefinitely with no air or electrical energy source available;
Permanent Way	shall mean railway track;
Points or Switch or Turn out	shall refer to the track mechanism operated to divert the Train where a single track splits to become two tracks and equipped with moving rails to change the route;
Project	shall mean the construction, operation and maintenance of the Rail System in accordance with the provisions of the Concession Agreement, and includes all works, services and equipment relating to or in respect of the Scope of the Project;
Rail System	shall have the meaning ascribed to the term in the Concession Agreement;
Receiving Sub Station	shall mean the sub-station, which receives 220kV/132 kV supply from Local Utility Agency and supplies power network of TSS and ASS at 33 kV;
Regenerative Brake	shall mean the use of traction motors as generators when in braking mode to brake the Train by returning electrical energy to the OHE;
Reliability	shall mean the probability that an equipment or system can perform a required function under given conditions for a given time interval or given number of operations or similar measurement parameter;

Term	Definition
Restraining rail	shall mean the additional rail fixed inside the track and by the side of the inner rail at an appropriate distance;
Right of way	shall mean the constructive possession of the Site, together with all way leaves, easements, unrestricted access and other rights of way, howsoever described, necessary for construction, operation and maintenance of the Rail System and Real Estate Development in accordance with the Concession Agreement;
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 Manual are interchangeable;
Route	shall mean a part of the line originating at a signal for which the points have been set and secured to enable the safe passage of a Train;
Safety Critical	shall mean a failure of the system, sub-system or equipment that will directly lead to a situation with the potential to cause harm, injury, damage to property, plant or equipment, damage to the environment, or economic loss;
Service	shall mean the metro railway service available for the use of fare paying passengers;
Specifications and Standards	shall mean the specifications and standards relating to the quality, quantity, capacity and requirements for the Rail System, as set forth in this Manual, and any modifications thereof, or additions thereto, as included in the design and engineering for the Rail System if the Concessionaire can demonstrate to the IE, prior to use by him, that such modification or alterations are superior or more pertinent to the Project than the specifications and standards specified in this Manual
Station	shall mean a place in the Rail System where Trains stop for the purposes of transporting passengers;
Structure Gauge	shall indicate the dimensions of a structural cross section within which no outside object, such as signal masts, sign boards etc. may protrude;
Sub station	shall include the RSS, TSS and ASS where electric equipment are located that receives and converts or transforms the received electrical energy into usable electrical energy;
Tests	shall mean all the tests necessary to determine the completion of Rail System in accordance with the provisions of the Concession Agreement;
Ticket	shall mean a card or token which has an electronically encoded data content indicating the validity and/or use of the ticket;

Term	Definition
Ticket Office Machines (TOMs)	shall mean the equipment or devices used by Rail system officials to issue tickets at stations;
Ticket Vending Machines (TVMs)	shall mean the equipment or devices where passengers can get valid travel ticket for their journey;
Track form	shall mean the track supporting structure (and includes elevated guideway structure) and rail bearers/plinth beams as applied to ballastless track and excludes rails and fastenings;
Track Gauge or Gauge	shall mean the distance between the inner faces of the head of rails of a railway track measured 14mm below top of rails;
Traction System	shall mean the system which provides electric power for movement of Trains;
Track work	shall mean the Permanent Way system as defined in paragraph 3.1.2 of this Manual;
Train	shall mean a series of railway Coaches that is hauled as a single unit by a locomotive or by integral motors for transporting users on the Rail System and includes a single Coach;
Train Operator (TO)	shall refer to the person in the cab in control of Train operation;
Transition curve	shall mean a curve connecting sections of track laid to different radii;
Traction Sub- station	shall mean a sub-system of traction power supply which provides operational power supply to the Trains via third rail and receives return current via running rail;
Vertical curve	shall mean a track which is curved in elevation;
Works	shall refer to all labour, materials and equipment to be fitted into the stations and structures that are necessary to implement the Operation and Maintenance requirements;
Others	Any capitalized term used herein not specifically defined shall have the meaning ascribed to such term in the Concession Agreement;

SECTION 1

GENERAL

1.1 This Manual is applicable for Planning, Design, Construction, Operation and Maintenance of Urban Rail System ("the Project") through Public Private Partnership (PPP) mode. The scope of the work shall be as defined in the Concession Agreement. This Manual shall be read harmoniously with the intent of the Concession Agreement.

1.2 The Project and the project facilities shall conform to the requirements of design and specifications set out in this Manual, which are the minimum prescribed. The project report and other information provided by the Authority shall be used by the Concessionaire only for its own reference and for carrying out further investigations. The Concessionaire shall be solely responsible for undertaking all the necessary surveys, investigations and detailed designs in accordance with good industry practice and due diligence, and shall have no claim against the Authority for any loss, damage, risk, costs, liabilities or obligations arising out of or in relation to the project report and other information provided by the Authority.

1.3 At least 2 weeks prior to commencement of the work, the Concessionaire shall draw up a Quality Assurance Manual (QAM) covering the Quality System (QS), Quality Assurance Plan (QAP) and documentation for all aspects of the Project works and send three copies each to the Independent Engineer (IE) for review. The QAM shall conform to Applicable Laws, Good Industry Practice in vogue and the provisions of the Concession Agreement.

1.4 The codes, standards and specifications applicable for design of the components of the Rail System and for its operation and maintenance are:

(i) European Norm (EN);

(ii) International Electro Technical Commission Standards (IEC);

(iii) International Standards Organization (ISO);

(iv) Japanese Industrial Standards (JIS)/Japanese society of Civil Engineers;

(v) American Industrial Standards (AIS) and Association of American Railroad Standards (AAR);

(vi) British Standards (BS);

(vii) Indian Standards (IS);

(viii) German Standards (DN);

(ix) UIC Standards;

(x) Indian Railway Standards (IRS);

(xi) NFPA–130-'Standard for Fixed Guideway-Transit and Passenger Rail System';

In the event of conflict between codes, standards and specifications prescribed in two or more of the aforesaid codes, the following standards shall apply in order of priority:

(i) Specifications and Standards set out in this Manual;

(ii) EN; and

(iii) British Standards.

1.5 The latest version of the aforesaid codes, standards and specifications, which have been published before the last date of bid submission shall be considered applicable.

1.6 The terms '**Inspector**' and '**Engineer**' used in codes, standards or specifications shall be deemed to be substituted by the term "**Independent Engineer**", to the extent it is consistent with the provisions of the concession Agreement and this Manual. The role of the Independent Engineer (IE) shall be defined in the Concession Agreement.

1.7 In the absence of any specific provision on any particular issue in the aforesaid codes, standards or specifications read in conjunction with the Specifications and Standards contained in this Manual, the Concessionaire shall be at liberty to rely on any International Standard in consultation with IE.

1.8 The following codes, standards and specifications shall apply to all systems and equipments, as the case maybe, forming part of the Project:

(i) NFPA–130: Standard for Fixed Guideway - Transit and Passenger Rail System.

(ii) EN 50126: Railway applications- The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS);

(iii) EN 50121-1 to 5: Railway applications - Electromagnetic compatibility

(iv) EN 50119: Railway Applications - Overhead contact lines

(v) EN 50122: Railway Applications - Protective provisions for electrical safety and earthing and against the effects of stray currents.

(vi) EN 50163: Railway Applications - Supply voltages of traction systems

(vii) IEC 60364 (4-41): Electric installation of Buildings- Electric Shock

(viii) IEEE 80: Guide for Safety in AC Substation Grounding

(ix) IEEE 519: Recommended Practices and Requirements for Harmonic Control in

Electric Power Systems

(x) BS 6853: Code of Practice for Fire Performance of Materials Used in Rolling Stock Vehicles.

(xi) IS 1893: Criteria for earthquake resistant design of structures

1.9 All items of building works shall conform to the standards specified in the National Building Code (NBC) and the relevant codes issued by BIS. For this purpose, building works shall be deemed to include station buildings, Depot and workshop, OCC, buildings comprising Project Facilities, traffic integration works, landscape elements and/or any other works incidental to the building works.

1.10 The Concessionaire shall develop fire-fighting system in consultation with IE complying with the local fire safety regulations and Good Industry Practice in vogue. Egress/fire evacuation measures shall be as per NFPA-130 and fire detection and suppression shall generally be as per NBC-2005.

1.11 The design of a rail system shall be fully integrated and compatible with all other sub-systems that constitute the Rail System so that the overall requirements of the Rail System are met. As far as possible, uniformity of design standards shall be maintained throughout the rail system.

1.12 **Alternative Standards and Specifications**

The requirements stated in the Manual are the minimum. The Concessionaire will, however, be free to adopt international practices, alternative specifications, materials and standards to bring in innovation in the design and construction provided they are better or comparable with the standards prescribed in the Manual. The specifications and techniques which are not included in the codes, standards or specifications shall be supported with authentic standards and specifications reflected in other internationally recognized codes, standards and specifications. Such a proposal shall be submitted by the Concessionaire to the Independent Engineer. In case, the Independent Engineer is of the opinion that the proposal submitted by the Concessionaire is not in conformity with any of the international codes, standards and specifications, then he will record his reasons and convey the same to the Concessionaire for compliance. A record shall be kept by the Independent Engineer, of the non-compliance by the Concessionaire of the minimum Specifications and Standards specified in the Manual. Adverse consequences, if any arising from any such non- compliance, shall be treated as "**Concessionaire Default**" and shall be dealt in accordance with the provisions of the Concession Agreement.

1.13 **General considerations for planning, design and construction**

The Concessionaire shall take measures to overcome the physical and operational constraints and plan, design and construct the Project using appropriate methods, management techniques and technologies. General consideration shall, without being

limited to, be as follows:

(a) The constraints

The physical constraints in the existing Project are in the form of limitation of right of way, suburban train services inadequate approach roads and underpasses, at- grade yards & stations etc. The operation constrains arise out of the necessity or possibility of closing a portion of the road or suburban train services for construction and/ or diverting the traffic to temporary diversions, thereby reducing the capacity and safety of the existing network. The solutions evolved by the Concessionaire shall be such that these operational constraints are overcome through appropriate planning, design and construction method, techniques and technologies and by adopting suitable traffic management measures.

(b) Safety of design

All designs shall be safe to ensure that the Project or any part thereof (for example embankment, pavement, retaining structures, bridges, tunnels, culverts, etc.) does not collapse (global stability) nor its serviceability/performance (for example settlement, roughness, undulations, deflections, etc) deteriorates below acceptable level as prescribed in relevant schedule of the Concession Agreement.

(c) Durability

The Project shall not only be safe but also durable. This would mean that the deteriorating effects of climate and environment (for example wetting and drying, freezing and thawing, if applicable, temperature differences, aggressive environment leading to corrosion, etc) in addition to the traffic shall be duly considered in design and construction to make the Project durable.

(d) Mitigating disruptive effects of construction

The planning, design and construction of the Project shall be such that the construction does not have adverse impact on the environment and does not disrupt the lives and business activities of the people living close to the Project.

1.14 General considerations for rail systems design

The rail systems including all the subsystems designed to be utilized by the Concessionaire shall be of proven technology and should have been in service in other similar systems for at least 03 years.

1.15 Safety during Construction and Operation & Maintenance

1.15.1 The Concessionaire shall develop, implement and administer a surveillance and safety program for providing a safe environment on or about the Project, and shall comply with the safety requirements set forth in the Concession Agreement.

1.15.2 Before taking up any construction or maintenance operation/work, the Concessionaire shall prepare a Traffic Management Plan for each work zone and furnish it to the Independent Engineer for comments duly incorporating the following:

(i) Designate a Site Safety Team headed by a qualified Safety Officer.

(ii) Traffic safety devices as per IRC:SP:55 with the following specifications:

(a) Signages of retro-reflective sheet of high intensity grade.

(b) Delineators in the form of cones/drums (300 to 500 mm dia and 1000 mm high) made of plastic/rubber having retro reflective red and white band, at a spacing of maximum 5 m along with a reflective tape (red and white band) to be tied in between the gaps of cones/drums. A bulb/flasher using solar energy is to be placed on the top of the cone/drum for night delineation.

(c) Barricades using iron sheet (plain) with adequate iron railing/frame painted with retro-reflective paint in alternate black and white (or yellow and black) strips. Warning lights at 5.0 m spacing shall be mounted on the barricades and kept lit in the dark hours and night.

(iii) The arrangement of traffic during construction and maintenance shall conform to the requirements of Clause 1212 of MORTH Specifications. Ensure availability of 6 m paved carriageway for traffic without potholes or other defects. At locations where available carriageway is less than 7 m, provide round the clock traffic signals with marshals carrying mobile/walky-talky at both ends to control both directions of traffic.

(iv) Sprinkling of water for dust control at work zones, haul roads and plant/camp sites.

(v) Noise/Pollution suppression measures at work zones haul roads and plant/camp sites.

(vi) Mechanical, electrical and fire safety practices.

(vii) Safety measures like PPE (Personal Protection Equipment) for workers engaged.

(viii) First Aid and Emergency Response Arrangements i.e. First aid Box, Ambulance,

paramedical staff, alarms, etc.

(ix) Safety training/awareness programmes.

(x) Formats to maintain the accident records/emergency response provided during accidents.

(xi) A penalty scheme for violations in provision of adequate traffic control devices and proper traffic management should be proposed by the Concessionaire. In case of default, the amount of penalty shall be paid by the Concessionaire to the Authority.

(xii) A compensation scheme including insurance cover for third party for works, road users and road side residents in case of death/injury/damage to the vehicle/property resulting from accidents on the Project, irrespective of the person at a fault should be proposed by the Concessionaire.

1.15.3 The Concessionaire shall also be responsible for ensuring compliance of all labour laws and regulations including those relating the welfare of workers engaged both directly and indirectly on the Project, besides their occupational safety and health.

1.16 The Concessionaire shall set up field laboratory for testing of materials and finished products as stipulated in QAM. It shall make necessary arrangements for additional/ conformity testing of any materials/products at the government accredited laboratory, for which facilities at site laboratory is not available.

1.17 **Environment Mitigation Measures**

The Concessionaire shall carry out tests/monitor various parameters impacting the environment of the Project keeping in view the guidelines of the Ministry of Environment and Forests and submit proposals for mitigation of adverse environment impact including provision of noise barriers, etc. for review and comments of the IE, if any and undertake implementation of the proposals in consultation with the IE.

The Concessionaire shall take measures as may be necessary in accordance with the Applicable Laws and Good Industry Practice in vogue to control and mitigate the noise and vibration arising from the Rail System and their impact on the users and the neighbourhood. Noise mitigation measures shall be employed to ensure that the prescribed noise limits within the neighbourhood buildings and rail vehicles are not exceeded.

1.18 **Utilities**

The details of the new utilities which are to be constructed or provided for along or

across the Project shall be as specified in relevant schedule of the Concession Agreement.

1.19 **Review and comments by the Independent Engineer**

In cases where the Concessionaire is required to send any drawings or documents to the Independent Engineer for review and comments, and in the event such comments are received by the Concessionaire, it shall duly consider such comments in accordance with the Concession Agreement and Good Industry Practice in vogue for taking appropriate action thereon. The correspondence between the Concessionaire and the Independent Engineer shall be deemed valid only if a copy thereof endorsed to and received by the Authority.

1.20 **Definitions and Interpretation**

1.20.1 Unless specified otherwise in this Manual, the definitions contained in the Model Concession Agreement (MCA) for Public Private Partnership (PPP) in Urban Rail System as published by the Planning Commission, Government of India shall apply.

1.20.2 Built up area shall mean sections of the Project that are situated within the limits of a municipal town and shall include sections of 200 m or more in non-municipal areas where dwellings/shops have been built on one or both sides of the Project on at least 50 per cent of the total length comprising such section. The Built up areas shall be as specified in relevant schedule of the Concession Agreement.

SECTION 2

ROLLING STOCK

2.1 General

2.1.1 This section lays down the technical and performance requirements of the Rolling Stock covering its design, manufacture, testing, commissioning, operation and maintenance.

2.1.2 Rolling Stock safety systems shall conform to IEC 62278, IEC 61508 and NFPA 130.

2.1.3 The static & dynamic profile of coach shall conform to the Schedule of Dimensions.

2.1.4 Rolling stock design axle load shall not exceed 17t with dense crush load standing user density of 8 per m2 and all fixed seats occupied.

2.2 Speed and haulage capacity

The train shall be capable of sustaining a minimum design speed of [100 kmph] with ATP on track with curve of radius [500 m] and flatter with dense crush load standing user density of 8 per m2 and all fixed seats occupied. A train shall have the capacity to haul a loaded failed train at a minimum speed of 20 kmph.

2.3 Design Requirements

2.3.1 Coach Body

2.3.1.1 In order to deliver structural crashworthiness, the coaches shall be designed to meet the requirements of EN 15227- Railway applications – Crash worthiness requirements for railway vehicle bodies. Coach body shall conform to EN 12663-'Railway applications-Structural requirements of railway vehicle bodies', Category P-II.

2.3.1.2 Mechanical design of Coaches shall conform to EN 15663-'Railway application-definition of vehicle reference masses'.

2.3.1.3 Anti-climbing devices shall be provided on all Coaches in accordance with Applicable codes and Good Industry Practice to prevent over riding or telescoping of vehicles into one another in case of derailment/crash.

2.3.1.4 DOOR

2.3.1.4.1 Each Coach shall have exterior sliding doors conforming to EN 14752-'Railway applications-Body side entrance system' with sensitivity of obstacle detection as follows:

i. When a rod with a maximum rectangular cross section of 30mm×60mm is trapped with its lory 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.

ii. An obstacle with maximum dimension of 10mm×50mm trapped with its vertically 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.

2.3.1.4.2 The EMU Railcar(s) shall have minimum 08 (eight) electrically/pneumatically powered, sliding bi-parting doors, 04 (four) on each side.

2.3.1.4.3 The free passing through height of open door shall be 1900 mm minimum and the minimum door width shall be 1400 mm.

2.3.1.4.4 The doors shall be vibration free and insulated against heat and sound transmission.

2.3.1.4.5 The doors shall be sealed against draughts and water. There should be no ingress of water. However, any ingressed water shall drain rapidly without affecting surrounding equipment or systems.

2.3.1.4.6 The doors shall be as light and rigid as possible.

2.3.1.4.7 The passenger body side door shall fully open in less than 4.5 (four point five) seconds and shall close within 6 (six) seconds from the instance the Train Operator operates the door.

2.3.1.4.8 The end of the closing stroke (e.g. approximately 100 mm) shall be damped or cushioned to reduce impact and minimize possible injury to passengers.

2.3.1.4.9 Obstacle detection shall be provided by the Supplier.

2.3.1.4.10 The door mechanism shall have safety provision whereby the EMU Train shall not start unless all doors have been closed and electrically locked.

2.3.1.4.11 It shall be possible to manually push back each closed door leaf to enable entrapped objects such as clothing and other articles, to be withdrawn, even after the mechanical lock has engaged. The force required to push back each door leaf shall not be less than 80 N nor more than 120 N.

2.3.1.4.12 The strength or the sliding door shall be as per EN 14752 and the doors shall be able to resist the loads without deformation or damage.

2.3.1.4.13 Provision shall be made for passengers to open Railcar doors to permit evacuation from a stopped EMU Train in an emergency. There shall be an internal and external manual release mechanism on two doors per side in each Railcar.

2.3.1.4.14 It shall be possible to monitor the status of each door on the TCMS.

2.3.1.5 All windows shall be provided with double-glazed safety glass conforming to GM/RT 2456-Structural Requirements for Windscreens and Windows on Railway Vehicles and UIC 564-1: ‘Coaches - Windows made from safety glass’.

2.3.1.6 The Coach shall have a gangway connecting to the adjoining Coaches excluding the TO cab conforming to BS EN 16286-'Railway applications. Gangway systems between vehicles. Main applications.

2.3.2 Coach Interior

2.3.2.1 The lighting inside the coach shall be in accordance with BS EN 13272-'Railway applications-Electrical lighting for rolling stock in public transport systems'. The emergency lighting system or luminaries shall be supplied from vehicle battery as well as equipped with its own power source.

2.3.2.2 Headlight and side marker lights in driving motor Coach shall conform to BS EN 15153-'Railway applications-external visible and audible warning devices for train, head, marker and tail lamps'.

2.3.2.3 The Coach interior shall have resistance to fire and conform to NFPA-130 – 'Standard for Fixed Guideway - Transit and Passenger Rail Systems'. The Coach interior furnishing material should have fire retardant properties confirming to European Standards EN 45545. Alternatively, the fire properties values as specified below are also acceptable.

Sl. No.	Material	Resistance to spread of flame	Deterioration of visibility due to smoke	Limiting oxygen index	Toxicity
1	LP sheets to RDSO Spec C-K514	Class A	Class A	Min. 35	Less than 1
2	Fire retardant curtain fabric to RDSO Spec C-9911	Class A	Class A	Min. 35	Less than 1
3	Fire retardant upholstery to RDSO Spec C-9901	Class A	Class A	Min. 35	Less than 1
4	UIC Vest. to RDSO Spec RDSO/2007/CG-05	Class A	Class A	Min. 35	Less than 1
5	PU Foam to RDSO Spec RDSO/2007/CG-04	Class A	Class A	Min. 35	2.5 – This is subjected to use of fire barrier cloth while making seats
6	DTBPB to RDSO	Class A	Class A	Min. 35	Less

	Spec C-K607				than 1
7	PVC Flooring to RDSO Spec C-K604	Class A	Class A	Min. 35	Less than 1
8	PVC Flooring to RDSO Spec RDSO/2006/CG-12	Class A	Class A	Min. 35	Less than 1
9	NFTC Roof Ceiling to RDSO Spec C-K511	Class A	Class A	Min. 35	Less than 1
10	Compreg to RDSO Spec C-9407 (Rev.3)	Class A	Class A	Min. 35	Less than 1
11	Pre-laminated shaded compreg to RDSO Spec C-K513	Class A	Class A	Min. 35	Less than 1
12	Vinyl coated upholstery fabric to RDSO Spec RDSO/2007/CG-07	Class A	Class A	Min. 35	Less than 1
13	FRP Windows	Class A	Class A	Min. 35	Less than 1

2.3.2.4 The following standards should be adopted for testing of above items in case it is to be tested as per EN 45545:

S.No.	**European Norms**
1.	Critical Flux at Extinguishment (CFE) (ISO 5658-2)
2.	Maximum Average Rate of Heat Emission (MARHE) (ISO 5660-1)
3.	Specific Optical Density of Smoke, Ds (EN ISO 5659-2)
4.	Cumulative value of specific optical densities in the first 4 min. of the test, VOF4 (EN ISO 5659-2)
5.	Conventional Index of Toxicity (CIT) (EN ISO 5659-2)
6.	Critical Heat Flux at Extinguishment (CHF) (EN ISO 9239-1)
7.	Maximum Average Rate of Heat Emission (MARHE) (ISO 9705) (Complete passenger seat test)
8.	EN ISO 12952-3/-4 (Bed Cloths i.e. Blankets, Pillows, Sheets etc.)
9.	EN 60332-1-2, EN 50266-2-4, EN 50305-2002, 9.1.1, EN 50305-2002, 9.1.2 (Unburned length for cables for interior)
10.	EN 61034-2 (Transmission, % for cables for interior)
11.	NF X 70-100-1 and -2, 600^{o}C (Conventional Index of Toxicity (CIT) for cables for interior)

2.3.3 Ventilation and Air conditioning

The air-conditioning in coach, including TO's cab, shall conform to EN 14750-1&2- 'Railway applications-Air conditioning for urban and suburban rolling

stock'.

2.3.4 TO's Cab

TO's cab shall be designed in accordance with BS EN 16186-1-'Railway applications - Driver's cab : Visibility, layout, access', BS EN 16186-2-'Railway applications - Driver's cab: Integration of screens, controls and indicators' and BS EN 16186-3- 'Railway applications - Driver's cab Design of displays'.

2.3.5 Bogie

The Bogie stability Tests shall be carried out in accordance with the requirements of UIC 515.

2.3.5.21 Wheels shall conform to BS EN 13262 – 'Railway applications - wheel sets and bogies - wheels - Product requirements' and Wheel sets shall conform to EN 13260 – 'Railway applications-Wheel set and bogies - wheel sets – Product requirements'.

2.3.5.2 The structural design of the Bogie frame shall conform to BS EN 13749 – 'Railway applications - method of specifying structural requirements of bogie frame'.

2.3.5.3The design of Bogies of powered Coaches (Driving Motor and Motor Coaches) shall conform to BS EN 13104 - 'Railway applications - Wheel sets and bogies - Powered axle design method' and tested as per UIC 615-4 'Motive Power Units – Bogie and running gear - Bogie frame structural strength test'.

2.3.5.4 The design of Bogies of non-powered Coaches (Trailer Coaches) shall conform to BS EN 13103-'Railway applications - wheel sets and bogies - non-powered axle design method' and tested as per UIC 515-4 'Passenger rolling stock - Trailer bogies - Running gear - bogie frame structural strength test'.

2.3.5.5 Axle box bearing shall conform to following standards:

Sl.No.	Spec. No.	Description
1	EN 12080	Railway Applications Axle Box – Rolling Bearings
2	EN 12081	Railway Applications Axle Box – Lubricating Grease
3	EN 12082	Railway Applications Axle Box – Performance Testing
4	EN ISO 6508-1 to 3	Metallic materials – Rockwell hardness test – Test method, verification & calibration of testing machines and calibration of reference blocks respectively.
5	ISO 281	Rolling Bearings – Dynamic load rating and rating

		life.
6	UIC 515-1	Powered and trailing stock Bogie-running gear "Test for Axle-Boxes".
7	UIC 515-5	Passenger rolling stock – trailer bogies-running gear – General provisions applicable to the components of trailers bogies.
8	UIC 814	Technical Specification for official testing and supply of grease intended for the lubrication of railway vehicle roller bearing axle boxes.

2.3.5.6 The concessionaire shall provide the following information pertaining to axle box bearing:

i) Endurance test of bearing
ii) Life rating calculation of axle box bearing

2.3.6 Couplers and Draft-gears

i) The DMC intermediate ends and trailer car ends shall be equipped with semi-permanent couplers at each end to ensure a permanent connection of cars which in traffic form a train and therefore do not need to be separated during normal operation activities, unless in an emergency situation or in the workshop.

ii) Means shall be provided for vertically aligning the couplers, at the intermediate ends, to facilitate coupling. After coupling, such means shall not limit normal operating movement of the coupler. This arrangement shall accommodate the full range of height variation between adjacent vehicles when being coupled.

iii) The semi-permanent coupler and draft-gear shall, in conjunction with the inter-car gangway, be capable of gathering, engaging and coupling units on all track conditions detailed in the specification. Under these track conditions, coupling shall be achieved with the most adverse mismatch of car heights, caused by wheel wear, passenger loading, air spring deflection, and service tolerances.

iv) Electrical end connections shall be semi-permanent by means of jumpers or jumping cables. Uncoupling or re-coupling shall not damage these connections. It shall not be necessary to give preventative maintenance attention to these connections between vehicle overhauls. Electrical connections between cars shall be provided manually. Pneumatic continuity will be done by means of flexible hoses or through the semi-permanent coupler.

v) The coupler shall be maintained horizontal by means of easily adjustable supports, which shall take care of loss of coupler height within the car body.

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

application.

vii) Time to couple and to uncouple cars including gangways support shall not exceed more than 30 minutes to 45 minutes in workshop.

2.3.7 Brake System

The complete brake system shall conform to EN 13452-1-'Railway application-Braking- Mass transit brake system performance requirements' and EN 13452-2-'Railway application- Braking-Mass transit brake system-Methods of test'.

2.3.7.1 The brake system shall be complete in each three car unit and shall consist of:

i) EP brake system
ii) Electro regenerating brake system
iii) Provision of smooth and continuous blending of EP and regenerating braking
iv) An spring applied for air release parking brake
v) Brake pipe control back up brake system

2.3.7.2 It shall be possible to isolate the brake system individually on each bogie.

2.3.7.3 Brake electronic control unit of proven design shall be provided to ensure redundancy.

2.3.7.4 The build-up of pneumatic force shall be jerk limited for change in brake demand to increase passenger comfort. The jerk limitation is adjustable between 0.7 ± 0.05 m/sec^3.

2.3.7.5 If required the brake shall be provided with WSP in all braking modes in all cars. Slide detection shall be on par axle basis with correction on upper bogie basis. The wheel slide unit shall be approved by UIC and is to meet corresponding requirement specially UIC 541-05.

2.3.8 Electric Propulsion System

2.3.8.1 Powered Coaches shall be provided with IGBT based VVVF traction system. It shall have total traction and regenerative braking control.

2.3.8.2 Traction motor shall be naturally cooled fully suspended three phase AC motors. Other electrical and electronic equipment shall be air cooled (natural or forced).

2.3.8.3 The electronic equipments provided in Rolling stock shall conform to BS EN 50155-'Railway application-Electronic equipment used on rolling stock' and BS EN 50207-'Railway application-Electronic power converters for rolling stock'

2.3.9 Circuit Protection

Traction circuits shall be protected in accordance with the requirements of IEC 60077- 'Railway Applications-Electric Equipment for Rolling Stock'

2.3.10 On Board Communication System

The concessionaire shall provide on board communication system, which shall include Passenger Information System, Public Address System, Passenger Alarm and Surveillance Cameras.

2.3.11 Train Data Recorder

2.3.11.1 Train Data Recorder (TDR) equipment and its installation shall conform to BS EN 60529 and shall meet the crash protection requirements of RGS GM/RT/2472.

2.3.11.2 TDR shall be fitted at each driving end of the Train to record at least the following parameters:

(i) speed of Train;

(ii) location of Train;

(iii) direction of travel;

(iv) power controller position;

(v) brake controller position and brake equipment response;

(vi) the driver's safety operator position;

(vii) status of line power; and

(viii) status of head lights, marker lights & flasher light.

2.3.11.3 The TDR shall have the memory to store the records of at least 15 days. The data recorded should be capable of indefinite retention. All data should be date and time stamped.

2.3.12 Auxiliary Power Supply backup

(a) All Trains shall be equipped with a stand-by battery power source to supply emergency load for at least 60 minutes in case of failure of normal power supply.

(b) Emergency loads shall include, but not limited to:

(i) emergency lighting;
(ii) all exterior lights;
(iii) ventilation fans but not air conditioners;
(iv) communication systems including public address, emergency alarm, surveillance system and Train radio;
(v) propulsion and brake controls;
(vi) door controls;
(vii) electric horn;
(viii) cab console indicators, lighting and interlocking; and
(ix) ATP Train-borne equipment.

(c) In the event of loss of traction or auxiliary supply, battery supply should automatically get connected to supply emergency loads.

2.4 Testing and Certification of Rolling Stock

2.4.1 A static test on the car body as per EN 12663, Category P-II should be done to validate the design and crash worthiness of the vehicle body shall be in accordance to EN 15227-'Railway application- Crashworthiness requirement of the railway vehicle body'.

2.4.2 The trains shall be tested in accordance with IEC 61133-'Railway applications – Rolling stock –Testing of rolling stock' on completion of construction and before entry into service

2.4.3 Before each type of Rolling Stock is deployed in actual service, it shall be subjected to trials as indicated in relevant schedule of Concession Agreement.

2.4.4 The bogies rotational resistance (X factor) test under inflated and deflated air spring conditions would be carried out under tare conditions, the value of which should not exceed 0.08 at rotational speed of 0.8 degrees/second for bolstered bogies. These test should be made according to the EN 14363.

2.4.5 The bogie suspension, in conjunction with the car body, shall be designed to enable cars to operate satisfactorily on track with the maximum specified track twist. The maximum offloading of wheels '△Q/Q' shall not exceed 60% of nominal wheel load in inflated and in deflated conditions up to maximum permissible speeds. The test shall be carried out in accordance with EN 14363.

2.4.6 The Sperling Ride Index (R.I.) of the coach under all loading conditions shall not exceed 2.75 in both vertical and horizontal direction in inflated condition and 3.0 in deflated condition. The R.I. calculations shall be done as per para 2.1 of ORE Report C116 using FFT method (Fourier Transform Method) and UK-513 E-Guidelines for evaluating passenger comfort in relation to vibration in Railway Vehicles. The Bogie Stability Test shall be carried out in accordance with the requirement of UIC 515.

2.5 Computer Simulation Results

2.5.1 A computer simulation run of the designed Train composition (in crush loading condition) under the specified voltage and wheel conditions with the use of a Train schedule software programme shall be conducted and simulation results with the following details shall be provided:

(i) inter-station running time for each corridor, each way;

(ii) actual schedule speed with the specified dwell time at each Station; and

(iii) percentage coasting achieved in terms of time and distance, if any.

In addition, a complete computer generated master chart showing Trains possible to be run on each corridor with the prescribed headway shall be generated. The Concessionaire shall hand over to the IE a copy of the software package employed by him and any hardware/software too required for the software.

2.5.2 Vehicle Dynamic Simulation: The Dynamic Characteristic of Vehicle should be made according to EN 14363 and Dynamic Analysis, to evaluate the running behaviour of the cars with the proposed bogie design, shall be carried out by means of theoretical calculations applying multi-body simulation techniques. The following parameters, at a minimum, shall be evaluated/ analyzed.

(i) Vehicle model
(ii) Natural frequency of the suspension
(iii) Stability/safety of the bogie
(iv) Wheel/Track offloading
(v) Bogie rotational resistance
(vi) Wheel wear index at the tread and flange
(vii) Lateral force and derailment quotient (Y/Q)
(viii) Ride index lateral and vertical
(ix) Acceleration values of car body and bogie frame
(x) Criteria for assessment of riding behaviour of vehicle

Vehicle Dynamic Simulation may be conducted on one of the following vehicle dynamic analysis software: NUCARS, ADAMS, SIMPACK, VAMPIRE and GENSYS etc.

SECTION 3

ALIGNMENT AND TRACK WORK

3.1 General

This section lays down the standards for the Permanent Way system to be designed, constructed, commissioned, operated and maintained by the Concessionaire for the Rail System. The Schedule of Dimension (SOD) at Appendix-I is only indicative.

3.2 Design Requirements

3.2.1 The geometric design of track work shall conform to the minimum standards set out in this section and as applicable for a minimum design speed of 100 kmph. The concessionaire shall submit the complete design documents to IE for review and comments.

3.2.2 Track Gauge: Track shall be laid to gauge of 1435 mm i.e. the distance between the inner sides of the head of rails measured 14 mm below top of rails. Track Gauge on curve shall confirm to UIC 710 – 'Minimum track gauge in curves'.

3.2.3 Rails: Rail profile shall conform to UIC 60 and Rail material shall conform to IRS-T-12-2009 class A, including manufacturing and testing in accordance with IRS-T-12-2009 with latest amendments. 1080 Head Hardened rail shall be used on curves and approaches of stations for main line track.

3.2.4 Fastenings: Fastenings shall be in accordance with EN 13146-1to 7-'Railway applications- Tracks-Test methods for fastening systems' and EN 13481-5-'Railway Applications- Track Performance-fastening systems for slab track with rail on the surface or rail embedded in channel'.

3.2.5 The normal track including turnouts shall be laid with rail cant of 1:20. In case of any deviation, detailed technical justification will be given for such adoption.

3.3 Track Structure Requirements

3.3.1 Track shall be designed to conform to the appropriate load category according to UIC 700-'classification of lines-Resulting load limits for wagons' and UIC 774-3R: 'Track-Bridge interaction; recommendation for calculations'.

3.3.2 Ballastless track shall be adopted for the viaduct, underground and for inspection lines and washing plant lines. For remaining areas, the track system can be either ballasted track or ballastless track.

3.3.3 The sub ballast shall comply with UIC Leaflet 719R-'Earthwork and track bed construction of railway lines'.

3.3.4 Noise and Vibration - The design of vibration attenuating track forms shall be in accordance with DD ENV 13481-6-'Railway Applications-Track - Performance requirements for fastening systems- Special fastening systems for attenuation of vibrations'.

3.3.5 The complete track including turn outs shall normally be jointless. The joints as far as practicable, shall be flash butt joints.

3.3.6 Restraining rails shall be provided on all curves with a centre line radius of 190^{m} or less on main line and radius of 140^{m} or less on depot.

3.3.7 Rail welding shall conform to Indian Railway Specifications Manuals and Technical Instructions.

3.3.8 RCC derailment guards shall be designed such that in case of derailment the wheels of a derailed vehicle under crush load, moving at maximum speed are retained on the viaduct.

3.3.9 Special Layouts- Turnout shall be selected from UIC Standard arrangement to suit the design alignment and speeds as follows:

(i) On main lines, 1:9 type turnout with a minimum lead radius of 300 m, providing a permissible speed on divergent track of not less than 40 kmph; and

(ii) On depot lines, 1:7 type turnout with a minimum lead radius of 190m.

3.3.10 In case of curves of 500m and sharper, pre-curved rails shall be used.

3.3.11 Glued Joints and Junction Rails wherever used will conform to IR standards.

3.4 Track Alignment

3.4.1 Track alignment shall generally follow the alignment in the Concession Agreement.

3.4.2 Grade - Grades shall not exceed the limits as indicated in Schedule of Dimensions.

3.4.3 Track tolerances for ballasted as well as ballastless track shall conform to BS EN 13231 and measured in accordance with series EN 13848.

3.5 Clearances

Clearances shall conform to the following UIC codes and International practices as applicable.

(i) UIC 505-1-'Railway Transport stock- Rolling stock construction gauge'.

(ii) UIC 505-4-'Effects of the application of kinematic gauge defined in the 505series of leaflet on the positioning of structures in relation to the track'.

(iii) UIC 505-5-History, justification and commentaries on the elaboration and development of leaflets of series 505 and 506 on gauges.

3.6 Track Monuments

Permanent track monuments/indications complete with track data should be planted along the track at suitable location. These include:

(i) Kilometer boards;

(ii) Gradient posts

(iii) Curve reference markers;

(iv) LWR/CWR/SEJ reference markers;

(v) Fouling point markers; and

(vi) Turn out markers.

And such other monuments considered necessary for the operation and maintenance of the system.

All permanent markers proposed to be used and markers proposed to be painted on rails including the colour scheme shall be in consultation with IE.

3.7 Inspection and Testing

The concessionaire shall submit to the IE a schedule of the type of testing or inspection proposed at each stage of completion or part completion of the system covering manufacture/procurement, and testing and installation to meet his obligations with respect to the quality control requirements specified in this manual. The Inspection and Testing Plan (ITP) shall be approved by IE.

Acceptance of track works shall be by testing with dynamic track recording at speed not less than [100 kmph] as per Inspection & Testing Plan finalized in consultation with IE. Track recording shall be in both digital and analog.

Appendix-I (Chapter 3)

Schedule of Dimensions for Standard Gauge

1. General

The dimensions given under are only indicative. The Concessionaire shall finalize the SOD in consultation and with the approval of IE.

2. Static Car Profile

It is the profile of the maximum cross sectional dimension of the car at rest on straight and level track. This profile should provide for tolerances in manufacture and effect of load on the suspension. This is the basic profile on which other profiles are built, and depends on the car supplier. A maximum limit of 3.2 m width and 4.0 m height has been fixed within which the static car profile has to be accommodated.

3. Kinematic Profile

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:

(a) Rolling Stock profile.

(b) Track and vehicle tolerances.

(c) Allowances for curvature and super elevation.

(d) Dynamic effects.

The Kinematic envelope of the Train shall be calculated in accordance with UIC505 series.

Track effects to be considered for working out the kinematic profile are:

(a) 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.

These values depend on track curve, car length and Bogie Centers which needs to be developed as part of the design by the Concessionaire.

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.

Other dynamic effects are:

(a) Deviation due to wind loading.

(b) Unequal loading of vehicles.

4. Structure gauge

The structure gauge indicates the dimensions of a structural cross section within which no outside object, such as signal masts, sign boards etc may protrude.

5. Clearances

The actual clearance required between Coaches and structures is influenced by Train speed, track irregularity, and maintenance condition of Coaches. The kinematic and structure gauge depend on the Coach design, particularly the Coach width, Coach height, Coach length, and distance between Bogie centers. Absolute values for the clearances are to be finalized by the Concessionaire, in consultation with the IE.

6. General principles

Minimum clearance between kinematic envelope and structure gauge on tangent track shall be 126 mm in case of ballastless track in underground section and 176 mm in case of ballasted track and ballastless track on at grade/elevated sections, which includes 26 mm allowance for nosing.

7. Spacing of tracks on straight alignment and on curves of 1000 m and flatter

(i) Ballastless track in underground section – 2 (KE width from centre of track at 1000 m radius curve + 126 mm) or 3600 mm whichever is more.

(ii) Ballasted track and ballastless track on elevated/at grade sections – 2 (KE width

from centre of track at 1000 m radius curve + 176 mm) or 3700 mm whichever is more.

8. **Curve radius**

(a)	Absolute minimum radius of horizontal curves on main line	120 m
(b)	Absolute minimum radius of curves in depot	100 m
(c)	Minimum radius of horizontal curves in station	1000 m
(d)	Minimum radius of vertical curves	1500 m
(e)	Minimum straight length between two transition curves	25 m
(f)	Minimum curve length between two transition curves	25 m

Transition curve – The length of transition curve shall be worked out from the consideration of rate of change of cant and cant deficiency limited to 28 mm/sec, as well as cant gradient limited to 1:400.

9. **Extra clearance on curves**

A. <u>Inside of curve</u>

(i) Curvature effect

(a) Mid throw at the centre of the vehicle = V (in mn) = 125 C^2/R where C is bogie centre in m and R is curve radius in m.

(b) Allowance due to gauge widening on curves.

Note: Lateral shift of 26 mm due to nosing is included in KE for tangent track and shall be subtracted from total extra allowance worked out as at para A above. In case value of mid throw (V) is less than 26 mm, the curvature effect shall be due to widening of gauge only, taking (V-26 mm) as zero.

(ii) Allowance for superelevation

(a) Underground (box structures), Elevated and At Grade Sections – The lean 'L' due to cant (Ca) at any point at height (h) above rail level is; L = Ca × h/g (all in mm), g is c/c distance of rails in mm.

(b) Circular Tunnels – In case of circular tunnel, the cant is provided by raising the outer rail and suitably shifting the centre of the circular tunnel towards inside of curve and upwards. This has same effect as assuming rotation of the circular tunnel about midpoint of top to inner rail resulting in shift of tunnel centre laterally towards inside of curve and also vertically upwards. The rigid OCS shall also be rotate with the tunnel so as to be along the centre line of canted track.

(iii) Allowance for vertical curve (vertical throw)

V1 (with vehicle centre in sag or vehicle end on summit) = 125 × C^2/R

V2 (with vehicle centre on summit or vehicle end in sag) = (125 × C^2_1/R − 125 C^2/R) (where C_1 is coach length in mm)

B. <u>Outside of curve</u>

(i) Curvature effect

(a) End throw at the end of the vehicle = V0 mm = (125 × C21/R) − (125 ×

C2/R)

(b) Allowance due to gauge widening on curves

(c) Additional nosing due to gauge widening on curves

(ii) Allowance for superelevation

(a) Elevated, At Grade and Underground box sections –

$$L = \pm C_a \times h/g \text{ (all in mm)}$$

In case there is a structure adjacent to track, relief for lean is taken only if cant provided is more than 50 mm and shall be limited to $(C_a - 50) \times h/g$

(b) Circular Tunnel – Same as for Inside of curve.

(c) Allowance for vertical curve – Same as for Inside of curve.

10. Minimum track spacing on curves

The most adverse position will be when the end of a Coach on the inner track is opposite the centre of a similar Coach on the outer track.

A. Without any structure between tracks. This will be the sum of:

(i) Net horizontal shift on inside of curve;

(ii) Gross horizontal shift on outside of curve;

(iii) Cant effect; and

(iv) Minimum clearance between adjacent kinematic envelopes shall be :

(a) 252 mm for ballastless track in Underground sections including nosing of 26 mm.

(b) 352 mm for ballasted/ballastless track in Elevated and At Grade sections including nosing of 26 mm.

For sharper curves, and for situations with structure between tracks, track spacing may be decided by the Concessionaire in consultation with the IE.

B. With a structure between adjacent tracks –

The minimum track spacing on curves with a structure between tracks shall be the sum of the following:

i) $(E_1 + T_1)$ Minimum clearance to the structure from centre line of track on inside of curve (for outer track).

ii) $(F_1 + T_2)$ Minimum clearance to the structure from centre line of track on outside of curve (for inner track).

iii) Width of structure between adjacent tracks (measured across the tracks).

Where,

E_1 is the horizontal distance from vertical axis of centre line of canted track to canted Structure Gauge on inside of curve for a given cant,

F_1 is the horizontal distance from vertical axis of centre line of canted track to canted Structure Gauge on outside of curve for a given cant,

T_1 is extra lateral allowance due to curvature on inside of curve, and

T_2 is extra lateral allowance due to curvature on outside of curve.

Notes:

(a) The values of E_1 and F_1 for a given cant Ca, shall each be the maximum of values at different heights of structure from rail level. In case the cant provided is greater than 50 mm on inner track, the value of F_1 shall be for the cant of (Ca-50) mm. In case the cant provided is 50 mm or less on inner track, the value of F_1 shall be for ZERO cant.

(b) Minimum track spacing, so worked out with a structure between the adjacent tracks shall not be less than that calculated as per para (a) above for tracks without any structure between adjacent tracks.

11. Cant

Cant maximum	125 mm
Cant deficiency maximum	100 mm
Maximum cant gradient	1 in 400
Maximum lateral acceleration	0.65 m/sec^2
Maximum rate of change of lateral acceleration	0.3 m/sec^3

12. Platforms

(i)	Maximum horizontal distance from centre of track to face of platform coping	:	KE width from centre of track at specified speed +15 mm.
(ii)	Minimum horizontal distance from centre of track to face of platform coping	:	KE width from centre of track at specified speed +5 mm.

Transition curves shall not be provided in platform length. No cant shall be provided on curves on platform length.

13. Gradients (maximum)

(a) At stations – 1 in 1000

(b) Mid-section – 1 in 25

There shall be no change of grade within 30 m of any points. Vertical curves shall be provided where algebraic difference of change in adjacent gradients exceeds 0.4%.

14. Additional lateral clearance for platforms on curves

(a) On inside of curve – Mid throw

(b) On outside of curve – End throw Note:

1. Since minimum radius permitted for platforms on curves is 1000 m, there will be no gauge widening on curves at Stations.

2. Since track in station area shall not have cant, lean due to cant has not been provided for while working out lateral clearance.

15. Rolling Stock

(a) Maximum height above rail level for floor of Coaches – 1130 mm

(b) Minimum height above rail level for floor of Coaches – 1105 mm

16. Other Clearances

The clearances pertaining to:

(i) Traction system;

(ii) Rolling Stock;

(iii) Signalling; and

(iv) Turnouts.

shall be provided by the Concessionaire to suit the systems and equipment he proposes to deploy.

SECTION 4

SIGNALLING AND TRAIN CONTROL

4.1 General

This section lays down the standards for the Signalling and Train Control System to be designed, constructed, commissioned, operated and maintained by the Concessionaire for the Rail System.

4.2 Design Requirements

4.2.1 The revenue line Signalling and Train Control System shall be a communication Based Train Control System (CBTC) conforming to IEEE Std. 474.

4.2.2 The Signalling and Train Control System shall work on the principle of moving block system capable for Train operation with headway of 90 seconds or less. It shall comprise of Continuous Automatic Train Control System (CATC), having Automatic Train Protection System (ATP),Automatic Train Supervision System (ATS) and Automatic Train Operation (ATO) System and shall provide bi-direction working over each main line track.

4.2.3 No single point failure shall cause failure of an equipment or sub system that has impact on the safe operation, at least for the following sub-systems:

(i) ATP System (on board and track side);

(ii) Interlocking system; and

(iii) ATS system.

4.2.4 Line side signals of LED type along with track vacancy detection system shall be used for protection of junctions and also as a fallback system in case of failure of CBTC system.

4.2.5 All safety critical Signaling and Train Control equipment shall be designed, manufactured and validated to appropriate Safety Integrity Level (SIL) as per applicable CENELEC/IEC standards listed at 4.3.10. The Concessionaire shall submit a certificate from accredited Independent Safety Assessor (ISA) to this effect before commissioning of system.

4.2.6 Signaling and Train control system should generally comply with functionality specified in IEC 62290-Part 1 & 2.

4.2.7 Adequate Redundancy shall be built in critical systems including telecom and networking elements that support signaling systems to ensure required level of system availability for enabling identified level of passenger traffic per hour.

4.2.8 Simulation studies shall be carried out at design stage itself to validate designed headway and system availability against predicted peak time/normal time passenger traffic requirements.

4.3 Equipment specifications

4.3.1 Cabling

The Concessionaire shall provide Fire Retardant Low Smoke Zero Halogen (FRLSOH) cabling as a minimum in confined public areas, tunnels and equipment rooms conforming to IEC 60331 & 60332.Outdoor cables shall be steel armored or equivalent.

4.3.2 Points

The point machines shall meet the following standards, where applicable:

(i) BS 4575: 'Fluid power transmission and control systems'; and

(ii) IEC/EN 60204-1: 'Safety of Machinery-Electrical Equipment of Machines'.

4.3.3 The CBTC system shall be controlled from the Operations Control Center (OCC). During periods that the OCC is unavailable the supervision of the CBTC shall automatically transfer to the Local Control Operator at each interlocked station without any loss of control capability.

4.3.4 Uninterrupted Power Supply (UPS) shall be provided to support all essential Train control functions at the stations, Depot and OCC. UPS shall be capable of supporting the rated load for minimum period of 02 hours.

4.3.5 The CBTC system shall provide the interfacing with platform screen doors.

4.3.6 Equipment and locations that may need to be identified in emergencies (including all stations, signals and ends of points) shall be uniquely and indelibly named or numbered in a way that is visible to Train Operators (TOs) and these numbers shall be co-ordinated with the associated control equipment and the displays in the OCC and DCC.

4.3.7 Provision shall be made at Station Control Room and OCC for stopping trains during emergency on detection of potentially unsafe situations.

4.3.8 The ATO function shall be implemented independently from the ATP function so that no malfunction of the ATO equipment can inhibit the ATP function

4.3.9 Test track in the Depot shall be equipped with ATP and ATO to main line standards and programmable for different test scenarios. It shall provide a controlled environment for testing the Train borne parts of the CBTC.

4.3.10 The signalling and train control system shall be designed, developed and

validated using Good Industry Practices including but not limiting to the following CENELEC/equivalent IEC standards with their latest versions issued:

S. No.	CENELEC	IEC	Subject
1	EN 50121	IEC 62236	Railway applications- Electromagnetic compatibility (Part 1 to 5)
2	EN 50124	IEC 62497	Railway applications – Insulation Coordination (part 1 to 2)
3	EN 50125	IEC 62498	Railway applications – Environmental conditions for equipments (part 1 to 3)
4	EN 50126	IEC 62278	Railway applications – The specification and demonstration of Reliability, Availability, Maintainability and safety(RAMS)
5	EN 50128	IEC 62279	Railway applications - Communications, signalling and processing systems - Software for railway control and protection systems
6	EN 50129	IEC 62425	Railway applications - Communication, signalling and processing systems - Safety related electronic systems for signalling
7	EN 50159	IEC 62280	Railway applications - Communication, signalling and processing systems - Safety-related communication (Part 1 & 2)
8	EN 50238	IEC 62427	Railway applications - Compatibility between rolling stock and train detection systems
9	EN 50155	IEC 60571	Railway applications – Electronic equipment used on rolling stock
10	EN 62290	IEC 62290	Railway Applications-Urban guided transport management and command/control systems
11	EN 60529	IEC 60529	Specification for degree of moisture provided by enclosures(IP codes)
12	EN 60204	IEC 60204	Safety of Machinery- Electrical equipment of machines Part 1(for Point machines)
13	EN 50289-4-16	IEC 60331	Tests for electrical cables under fire conditions-circuit integrity
14	EN 60332	IEC 60332	Tests on electric and optical fibre cables under fire conditions

SECTION 5

ELECTRIC POWER SYSTEM

5.1 General

5.1.1 This section lays down the standards for the High Voltage (HV) Electric Power System to be designed, constructed, commissioned and operated by the Concessionaire for the Rail System.

5.1.2 Sub Stations shall be finalized by the Concessionaire in consultation with TRANSCO/ DISCOM.

5.2 Design Criteria

5.2.1 General

5.2.1.1 The traction system shall be designed to operate Trains at designed speeds over the operating routes and include starting from stand still on the steepest grade defined and under the crush load conditions.

5.2.1.2 The power supply system shall cater to normal operations and contingency operations. The following non-coincidental contingencies shall be assumed to:

(a) Worst case Train delays and Train bunching.

(b) Failure of one traction sub-station.

(c) Power feedback from regenerative braking.

(d) Failure of one utility supply point/interface.

(e) Abnormal power supply system configuration caused by, but not limited to, outright failures of equipment including feeders, circuit failures and failures of transformers and rectifiers.

5.2.1.3 The system shall have sufficient reserve whereby failure of any one electrical equipment does not lead to dislocation of supply warranting intervention.

5.2.1.4 The system design shall permit augmentation of traction and auxiliary power supply by way of appropriate and acceptable means.

5.2.1.5 The system shall permit operation allowing bunching of crush loaded Trains in an Emergency when headway may get reduced to [90] seconds or less.

5.2.1.6 The electrical protection system shall be so designed that a single failure does not lead

to unsafe conditions in all of the above conditions. Any condition which can impact electrical safety shall be suitably factored in and efforts for monitoring of such conditions shall be provided to the extent possible.

5.3 Equipment specification

5.3.1 Traction and Auxiliary Supply Substations (ASS)

5.3.1.1 Power Transformers

Power Transformers shall be in accordance with principles followed by RDSO and provided with on load tap changer.

5.3.1.2 Switchgear

The switchgear shall conform to appropriate IEC standards.

5.3.1.3 Electrical Protection System

Protection facilities with fast discrimination and reliable operation, based on micro-processor technology, shall provide the protection scheme logic. The zones of protection shall overlap providing back-up protections. The scheme for protection shall be fully coordinated. The protection relays shall conform to IEC 60255. The protection system should communicate with other supervisory and control system on standard controls.

5.3.2 Traction Power System

5.3.2.1 Traction supplies shall be distributed at 750Vdc / 1500Vdc or 25kVac or at any other proven standard in accordance with IEC 60850 / EN 50163 Railway Applications – Supply Voltages of Traction Systems or an appropriate standard.

5.3.2.2 The capacities, ratings and number of equipment proposed to be connected as determined by the Concessionaire, shall be demonstrated to the IE by simulation study and proper engineering for the services envisaged considering the possibility of equipment failures / malfunctioning.

5.3.2.3 The short circuit levels and load flow studies on the system during normal and abnormal working and failure conditions shall be determined and coordinated for his design of the Traction Sub-station equipment/Power distribution and RSS arrangements.

5.3.3 Conductor rail/OHE

The conductor rail/OHE design shall be in accordance with BS 7865/IEC 60913, EN

50122-1 and EN 50122-2.

5.3.4 Cables

All HV power cables shall be XLPE insulated or equivalent, in accordance with IEC 60332–Part3 and NFPA130.In constrained areas FRLSOH cables shall be provided.

5.3.5 SCADA System

5.3.5.1 The Supervisory Control and Data Acquisition (SCADA) System shall be provided for remote monitoring and control of the traction power supply system from Operations Control Center (OCC). It shall monitor the entire Traction Power System and Auxiliary Power System and automatically reconfigure the equipment in the event of a failure or maintenance activities, so as not to affect safety or normal operation of the metro services.

5.3.5.2 The SCADA system shall record any events caused by faults, malfunctions, warnings or alarm information generated automatically by the selected equipment.

5.3.5.3 The SCADA system, equipments and software shall be in accordance with IEC 60870-1-1, 60870-2-1, 60870-3, 4 and 5. The SCADA should have energy management functionality and necessary provisions to permit full control in the event of restoration following grid disturbances.

5.3.6 Standby Diesel Generator (DG) Sets

Standby silent type DG sets shall be provided at the Stations to cater to Essential lighting, signaling & telecommunications, fire fighting system, lift and escalator operations, fare collection system, security system and UPS loads.

5.4 System Earthing

5.4.1 The Concessionaire shall engineer the earthing system on the basis of safety for people against hazardous touch and step potential and fire hazards and in accordance with provisions of IEC-619361:‘ Power Installations exceeding 1kVAC’,IEC 60364-4-41: ‘Low voltage Electrical Installations, Part4-41 ’Protection for Safety against electrical shocks’ and NFPA 130.

5.4.2 In case of 750Vdc traction system, the Earthing system shall conform to EN50122-1:‘ Railway Applications- Fixed Installations Protective Provisions Relating to Electrical Safety and Earthing and EN50122-2 ’Railway Applications-Fixed Installations-Protective Provisions against the effects of stray currents caused by DC

traction systems'.

5.4.3 The Earthing System for Stations, Depot and Line-side structures shall comply with the BS 7430 Code of Practice for Earthing.

5.4.4 Insulation Coordination

Equipment shall have insulation levels according to EN50124: 'Railway Applications – Insulation co-ordination'.

SECTION 6

COMMUNICATION SYSTEMS

6.1 General

This section lays down the standards for the communication systems to be designed, manufactured, installed, tested and commissioned by the Concessionaire.

6.2 Data Transmission System

6.2.1 The Data Transmission System (DTS) for Signaling and Train Control system shall be integrated with seamless Ethernet IP network as per IEEE 802.11 including both wire line and wireless component and must have redundancy for high reliability and availability.

6.2.2 The DTS shall have backbone of SDH-STM16 (minimum) / Combination of SDH & GE confirming to ITU-T/IEEE standards and capable of transporting all of the user communication interfaces. The SDH transmission network equipment shall have the ability to switch to another timing reference if the selected timing reference is lost, under the criteria as stipulated in ITU-T G.782.

6.2.3 Fiber Backbone Network

The communication bearer to be based on the backbone Optic Fiber cable. Keeping in view the continuous train operating environment, the optic fiber cable is to be laid on path diversity basis (Both up & down side) with ring configuration and protection switching. The 0 F cable shall support STM4/STM16 Synchronous digital Hierarchy with expandable capability to STM-64. The system should have a built in Network Management System (NMS) to monitor the overall system performance and have capability for system reconfiguration.

6.2.4 Fast Ethernet/Ethernet Network

(a) The characteristics of LAN and WAN cables shall follow ISO/IEC 8802-3.
(b) The characteristics of 50/125 µm multimode graded index optical fiber cable shall follow ITU-T G.651.

6.3 Clock System

6.3.1 The Clock System shall provide synchronized time for the whole Rail system. The time source shall be the Global Positioning System (GPS).The synchronized time information shall be displayed on slave clock units and provided to other interfacing

systems via the Data Transmission System.

6.3.2 Performance Specification

(a) The free run accuracy of the master clock units shall never be more than 30 milliseconds different from the GPS reference.

(b) Network time synchronization over the data network shall be using NTP, with an accuracy of ±0.1s per 24 hours to the reference.

(c) The system shall have a minimum accuracy of 1 second a day when they do not receive signals from the master clock.

6.4 Telephone System

6.4.1 The telephone system shall conform to applicable ITU-T standards.

6.4.2 A digital central voice recording system (CVRS) shall be provided in OCC to record all telephone conversations of all controllers in OCC, depot, stations, call centers and attendant consoles.

6.4.3 A centralized voice mail system (CVMS) shall be provided and integrated with the switch to enable PABX users to leave, retrieve and broadcast voice messages to and from this single message centre.

6.5 Closed Circuit Television

6.5.1 The closed circuit television (CCTV) System shall provide video surveillance and recording function for the operators to monitor all the sensitive areas at all the stations and Depot.

6.5.2 Two types of cameras shall be provided:

(a) Fixed cameras with fixed focal length lens and fixed orientation.

(b) Pan/Tilt/Zoom (PTZ) cameras with variable focal length lens with adjustable orientation in both the vertical and horizontal directions.

6.6 Public Address System

6.6.1 The characteristics to be specified and the methods of measurement for the equipment shall be in accordance with IEC-268 Part1to17-Sound System Equipment.

6.6.2 All PA equipment in equipment rooms shall be rack-mounted on equipment cabinets conforming to EIA 310-C.

6.7 Radio System

6.7.1 The Radio System shall provide wireless voice and data communications

channels between the various parties to support the operational and maintenance requirements of the Rail System.

6.7.2 The Radio System shall be a digital trunkradio system (e.g., TETRA system, other proven digital radio systems) offering high reliability, fast call setup, flexible call configuration and dynamic channel assignment to efficiently utilize the radio channels. It shall support both voice and data communications.

6.7.3 The call setup time shall be better than 0.5 s and response time on the screen of the workstation shall be better than 0.2 s.

6.8 Station Management System

6.8.1 The Station Management System (SMS)shall integrate the control, status monitoring and failure alarm of Station based E&M facilities into a computer based system.

6.8.2 The SMS shall receive Train approaching information for each platform and the Train ID of a berthed Train for each platform from the Signalling System and shall trigger the appropriate public address announcement and Passenger Information Display automatically.

6.8.3 The SMS shall record any events caused by faults, malfunctions, warnings or alarm information generated automatically by the selected equipment. A central recording system shall be provided to record the events to be classified, sorted and filtered as finalized in consultation with IE.

6.8.4 Positive Train Identification (PTI) with interface between ATS and Train Radio.

6.9 Passenger Information System

6.9.1 Passenger Information System (PIS) shall allow the operators to send visual messages to the Users while they are in the Stations.

6.9.2 At the OCC, a Central PIS Controller and Workstation shall be provided for handling central message input and dispatch. At stations, the control shall be via the Station PIS Controller (SPC).

6.9.3 Display boards shall be located in station public areas such as platforms, above ticket gates and at the entrances. The boards and corresponding software shall support English and local languages.

6.9.4 At Platforms, high brightness LED Boards with visibility up to 45 m shall be provided, with viewing angle of ± 40 degrees. The display boards shall meet the following minimum specification and shall be clearly visible on elevated station platforms:

(i) Viewing angle: 160 degrees (horizontal and vertical);

(ii) Brightness : 1000 cd/m² or better;
(iii) Contrast` :1000:1 or better.

6.10 Train borne Communication System

6.10.1 On-Board Wi-Fi system including Train Destination Board.

6.10.2 The Train-borne Communications System shall provide the various audio and visual communications facilities on the Trains as per the Good Industry Practices.

6.10.3 The performance specification for the Train borne PA system shall be:

(i) Sound Pressure Level(SPL):9dB±1dB above the ambient noise level measured between 1m and 2m above the floor level;

(ii) Frequency response:300 Hz to 7 KHz (0, -3dB);

(iii) Distortion :< 1% at 1 KHz; and

(iv) Signal to noise ratio :> 60 dB.

SECTION 7

AUTOMATIC FARE COLLECTION SYSTEM

7.1 General

7.1.1 This section lays down the standards for the Automatic Fare Collection (AFC) System to be designed, installed, commissioned, operated and maintained by the Concessionaire for the Rail System.

7.1.2 The contactless ticket media (smart cards and single journey ticket) shall be to ISO/IEC 14443 standard.

7.2 Technical Requirements

7.2.1 Station Computer (SC)

(a) Station Computer (SC) shall enable the overall control and monitoring of each item of AFC equipment within the Station and transfer of data to the Central Computer (CC).

(b) The SC shall be able to monitor all the critical functions of the AFC system and collect data for warnings and alarms.

(c) If there is loss of communication between the SC and AFC equipment (Gates, TOM etc.) then the equipment shall operate in stand-alone mode utilizing the most recent data from the SC. AFC equipment (Gates, TOM etc.) shall store data up to seven days for transmission when SC communication is restored.

(d) In the event of loss of communication with the CC, the SC shall utilize the most recent operational data received from the CC and shall be capable of storing at least thirty days of transaction data.

7.2.2 Gate Design

(a) Gate arrays may be bi-parting leaves, centre flaps, end flaps or other configuration. The gate shall be capable of operating either in normally open or normally closed mode.

(b) Where required, barriers shall be provided to separate paid and unpaid areas of the concourse.

(c) In the event of total power failure, the gates shall open to allow unrestricted user access.

7.2.3 Gate Enclosure

The degree of protection provided by the enclosure against dust, splashing, and intrusion of foreign objects shall meet or exceed the standard IP54 (IP43 for token acceptor slot, if any), as defined by British Standards.

7.2.4 Security

7.2.4.1 Revenue protection

The AFC machines shall resist tampering by either Users or unauthorized staff.

7.2.4.2 Revenue security

(a) The AFC machines and system shall provide a complete audit trial of all transactions, transfers of cash and other payments.

(b) Cash handling equipment and systems shall be an integral part of the audit trail.

7.2.4.3 Data Security

(a) In the event of SC fails, each item of equipment shall be able to operate autonomously without loss of data.

(b) Security of communications between the AFC equipment, SC and CC system shall ensure no loss of data in transmission.

SECTION 8

ACCOMMODATING STRUCTURES

8.1 General

8.1.1 This section lays down the standards for geometric design, general features, specifications and requirements for accommodating structures forming part of the Metro system.

8.1.2 Accommodating structures shall include, inter alia, the following:

(i) Elevated guide way or viaduct;

(ii) Tunnels and bridges;

(iii) Stations and auxiliary buildings;

(iv) Depot area and buildings for maintenance facility;

(v) Other buildings/structures required for operation and maintenance; and

(vi) Other civil works as required for proper functioning of the Rail System.

8.2 Codes and Standards

The following codes may be used as applicable; however this list is not exhaustive. In case of conflict between IRS & IRC Code, the provision of IRS Code will prevail.

Indian Railway Standards (IRS)

IRS - Bridge Rules for loading (Min. of Railways)

IRS - Code of practice for steel bridges

IRS - Code of practice for plain, reinforced and pre-stressed concrete for general

Bridge construction, latest revision

IRS - Code of practice for the design of substructures and foundation of bridges

IRC Codes

IRC: 5 Standard Specification & Code of Practice for Road Bridges-General features of Designs (Sixth Revision)

IRC:6 Standard Specification & Code of Practice for Road Bridges- Loads and Stresses (Third Revision)

IRC:18 Design criterions for Pre-stressed concrete Road bridges

IRC:21 Standard specifications & code of practice for road bridges IRC:SP-67

Guidelines for use of external pre-stressing in bridge structures

IRC: 112 Code of Practice for Concrete Road Bridges

IRC: 78 Standard Specifications & Code of Practice for Road Bridges—Section Foundations & Sub-Structure.

IRC-37 Guidelines for the Design of Flexible Pavement

IRC-45 Recommendations for Estimating the Resistance of Soil below the maximum Scour Level in the Design of Well Foundations of Bridges

IRC: 83 Pt.I -Standard Specifications & Code of Practice for Road Bridges, Part-I Metallic Bearings

IRC: 83 Pt.II- Standard Specifications & Code of Practice for Road Bridges, Part-II Elastomeric Bearings

IRC: 83 Pt.III - Standard Specifications & Code of Practice for Road Bridges, Part-III Pot, Pot-Cum-PTFE, Pin and Metallic Guide Bearings

IRC-SP-33 - Guidelines on Supplemental Measures for Design, Detailing & Durability Of Important Bridge Structures (only Clause No- 1, 2, 3.1, 4.3.7, 4.3.8 & 4.3.9 are Applicable)

IRC-22 -Composite Construction for Road Bridges

IRC-78 -Foundation and Substructure

IRC-SP -47Guidelines on Quality Systems for Road Bridges (Plain, Reinforced, Pre-stressed and Composite concrete)

International Standards

AASHTO - Guidespecifications for Design and Construction ofsegmental concrete Bridges

Structural Engineering Documents mno.6 of IABSE, 2002 : Structural Bearings and Expansion Joints for Bridges

BS 410: Specification for test sieves

BS 812: Testing aggregates

BS 1154: Specification for naturalrubber compounds

BS 1137: Methods of test for soils for Civil Engineering purposes

BS 5400: Steel concrete and composite bridges BS 5930: Code of Practice for Site

Investigations BS 5950: Structural use of steel work in buildings

BS 6177: Guide to selection and use of Elastomeric Bearings for Vibration Isolation in Buildings

BS 8007: Code of Practice for Design of Concrete Structures for Retaining Aqueous Liquids

BS 8110 Pt. I & II: Structural use of Concrete
Part 9 Sec. 9.1: Code of Practice for Design of Bridge Bearings

Other Publications

(i) CEB - FIP Model Code

(ii) Indian Standard Hand Book on Steel Sections (Part I)

(iii) Indian Railways Manual on Design and Construction of pile foundations

(iv) UIC/772-R the International Union of Railways Publication

(v) IEC: International Electro technical Commission

(vi) AREMA Manual

(vii) CIRA Report 80 A review of instruments for gas and dust monitoring underground

(viii) CIRA Report 81 Tunnel Water proofing

(ix) CIRA Report 44 model code of practice for work in compressed air Swedish standard 05 59 00

(x) PCI STD-112-84

(xi) CIRIA C660 – 2007 – Early Age Thermal Crack Control in Concrete.

(xii) UIC -774-3R – Track/Bridge Interaction-Recommendations for calculations

(xiii) Standard specifications for Tunneling-2006: Cut and Cover Tunnels -Japanese society of Civil Engineers

(xiv) Standard specifications for Tunneling-2006: Mountain Tunnels -Japanese society of Civil Engineers

(xv) Standard specifications for Tunneling-2006:Shield Tunnels -Japanese society of Civil Engineers

The design relating to fire safety and escape shall be in accordance with the requirements of NFPA 130: 'Standard for Fixed Guideway Systems'.

8.3 Bearings

Bearings shall be designed in accordance with the requirements of UIC 772 / IRC

8.4 Protection to Piers against impact

Protection shall be necessary for piers against accidental impact from road vehicles on a case by case basis. BS 5400 Part 2 and UIC 777-1 shall be applied.

SECTION 9

STATION PLANNING AND DESIGN

9.1 General

This section lays down the standards for planning and design of stations.

9.2 Station Design Requirements

9.2.1 Station Configurations

Stations shall be designed for peak flow of User traffic and the requirements of future Train services and shall follow NFPA 130.

9.2.2 The Station design shall conform to the following standards:

(i) The Persons with Disabilities Act;

(ii) National Building Code;

(iii) NFPA 70-'National Electrical Code';

(iv) NFPA 72-'National Fire Alarm Code'; and

(v) NFPA 130-'Standard for Fixed Guideway Transit and Passenger Rail Systems'.

9.2.3 Emergency Egress

9.2.3.1 Station design should allow safe evacuation of occupants in an Emergency.

9.2.3.2 For egress/fire evacuation measures, the Station design shall meet the requirements for Stations as provided in NFPA 130- 2007 Edition, Section-5, Item 5.5 - Means of Egress. Fire detection and suppression shall be generally as per NBC - 2005.

9.2.4 Fire Precautions

9.2.4.1 An electrical fire alarm should be provided for manual operation by Users/ staff, and installed in accordance with IS 3218: Code of Practice for Fire detection and Alarm Systems. Public Address System should be protected as per provisions of IS: 3218.

9.2.5 Elevators, Escalators and Stairs

9.2.5.1 Elevators

(a) Elevators shall comply with NBC-2005 and BS-EN 81 and other appropriate international codes and standards and relevant statutory

requirements. Elevators shall be type Class A for passenger loading and shall comply with NFPA 101 Fire Life Safety requirements.

(b) The elevators shall comply fully with the National Policy for Persons with Disabilities - 2006.

(c) Elevators shall comply with BS 7255 - "Code of Practice for safe working of lifts", or equivalent to allow for the emergency release of Users at nearest landing.

(d) Additional codes and standards applicable, are as follows: IS: 14665; IS: 15330; IS: 7759; IS: 1860; IS: 15785:

9.2.5.2 Escalators

Escalators shall conform to BS EN 115: 'Safety rules for the construction and installation of escalators and passenger conveyors'. They shall be suitable for service as public service escalators /passenger conveyors. The angle inclination of the escalators shall be not more than 30° to the horizontal with two tread band speeds of 0.5 and 0.65 m/s. During periods of no occupancy, the speed shall automatically reduce to 0.2 m/s and come to halt if not occupied for 5 minutes.

SECTION 10

BUILDING SERVICES

10.1 General

This section lays down the standards for the building services to be designed, installed, tested and commissioned by the Concessionaire.

10.2 Electrical Services

10.2.1 Low Voltage Distribution

(a) All cables shall comply with IEC 331-1. The distribution system shall comply with national and international standards with respect to electromagnetic compatibility, corrosion protection, stray current corrosion and radio frequency interference (RFI) criteria, EN 50121-2,EN 50081 and EN 50082 for electronic equipment and CENELEC EN 50121 for fixed power supplies.

(b) The 415V 3-phase 50Hz power supply shall be connected to the main distribution board (MDB) at each Station. From there it shall be distributed as required and shall include the provision of feeders to the plant rooms from the Station UPS.

10.2.2 LV Switchgear

All assemblies of LV switchgear and control gear shall comply with EN 60439-1.

10.2.3 Circuit Breakers

(a) Circuit breakers shall comply with IEC 890, IEC 947, and EN 60947.
(b) Low voltage air break switches shall comply with IEC 408.
(c) The circuit breaker shall comply with IEC 947-1.

10.2.4 Switchboards

(a) Switchboards shall comply with IEC standard 439/1.

(b) Adequate degrees of protection shall be provided for the equipment dependant on their location. Typically these would be the following:

(i) IP 54 for outside installations but installed within an enclosure rated to IP 65;

(ii) IP 54 for installations at mid-section;

(iii) IP 54 for installations at platforms; and

(iv) IP 43 for installations at concourse level or in plant rooms.

10.2.5 Cabling

(a) All cabling materials and installation shall comply with the requirements of IEC-3311.

(b) Armoured XLPE insulated underground cables shall comply with BS 6346.Heat resisting cables shall comply with BS- 6007.

10.2.6 Protection Circuits

Protection circuits shall be provided for all main and sub circuits and discrimination shall be in accordance with BS 88, BS EN 60898,BS 7375 and any other applicable Standards.

10.2.7 Station lighting

10.2.7.1 Lighting Standards

The lighting system requirements shall comply with following standards:

(i) BS 5266 - Emergency Lighting;

(ii) EN 13201- Road Lighting;

(iii) BS-EN 60598 - Luminaires;

(iv) National Building Code;

(v) Recommended practice of Illuminating Engineering Society (IES) of North America;

(vi) Code of Practice for Interior Lighting (as per CIBSE)and CIE recommendations for Glare Control; and

(vii) NFPA 101- Life Safety Code.

10.2.7.2 Emergency Lighting

Emergency lighting shall comply with IS 3217 - Code of Practice for Emergency Lighting. In the event of power failure, emergency lighting shall define a path of egress to assist in safe evacuation.

10.2.8 Earthing and Bonding

10.2.8.1 General: Earthing systems shall comply with the following standards:

(i) BS 7671 Requirements for Electrical Installations;

(ii) BS 7430 Code of Practice for Earthing;

(iii) BS EN 50122-1 Protective Provisions relating to Electrical Safety and Earthing;

(iv) BS EN 50122-2 Protective Provisions against the effects of Stray Currents on DC systems;

(v) BS 7375 Code of Practice for Distribution of Electricity on Construction Sites;

(vi) IEEE S 80 Guide for Safety in AC Substation Grounding; and

(vii) IEEE 1100 Recommended Practice for Powering and Grounding of Sensitive Electronic Equipment.

10.2.8.2 Supplementary Bonding

Bonding shall comply with the requirements of BS 7617.

10.2.9 Lightning Protection Design

The lightning protection system shall be designed to comply with:

(i) BS 6651: Code of Practice for protection of Structures against lightning;

(ii) BS 7430: Code of Practice for Earthing; and

(iii) BS 7671: Wiring Regulations for Electrical Installations in Buildings.

10.2.10 UPS

The UPS shall be a dual redundant, on-line type conforming to IEC 62040-1 to 5-Uninterruptible power systems (UPS).

10.2.11 Diesel Generator

(a) The diesel engine which may be a two or four stroke, direct injection diesel shall conform to BS 5514 or equivalent.

(b) The alternator shall be 4-pole, 3-phase, salient pole, revolving field, brushless type, self-regulating, continuously rated and manufactured in accordance with IEC 60034.

(c) The alternator shall be screen protected, fan ventilated and vertical drip proof to not less than IP 21.

(d) The smoke, noise and vibration emitted & radiated from DG set shall meet the

requirement of National Building Code-2005 & Central Pollution Control Board.

10.3 Fire Detection and Suppression Systems

10.3.1 All means of egress shall be in conformity with NFPA 130.The fire-fighting system is to be designed in accordance with IS 3218, National Building Code-2005, local codes and relevant Indian/International Standards.

10.3.2 Fire mains

10.3.2.1 The design of the fire mains shall comply with the local fire authorities' regulations, National Building Code-2005, and relevant Indian/ International Standards.

10.3.2.2 The hydraulic design of the fire main and hydrant system shall comply with the NFPA 14 in respect of flow and pressure requirements for the maximum simultaneous operation of two hydrants.

10.3.2.3 Booster pumps shall comply with the requirements of NFPA 20.

10.3.3 Hand held portable fire extinguishers

Portable fire extinguishers shall be located at strategic positions as agreed with the local fire authorities. The type of fire extinguishers shall be appropriate for the risk at that location. Portable fire extinguishers shall comply with NFPA 10.

10.4 Water Supply System

10.4.1 The water supply shall include all the incoming water supplies and the systems they supply, which shall be as per NBC-2005, and shall include the following:

(i) Cold water supply;

(ii) hose reel supply; and

(iii) sprinkler supply.

10.4.2.2 All sprinkler pipes shall be hot-dipped galvanized to BS EN ISO 1461 to achieve a galvanizing thickness of 100 microns. The pipe and fittings shall be designed for a minimum pressure of 16 bars.

10.4.2.3 Isolation valves may be either butterfly type of the wafer pattern in accordance with BS 5155 with corrosion resistant disc and stainless steel shaft or gate type complying with BS 5150 with resilient covered disc.

10.4.2.4 Check valves shall comply with BS 5153 and shall be of the swing type suitable for vertical use.

10.5 Drainage System

10.5.1 Separate storm water and sewerage systems shall be provided for Stations which shall be designed to comply with the following requirements:

(i) BS EN 752: Drains and sewer systems outside buildings; and

(ii) BS 8301: Code of practice for building drainage.

10.5.2 Sewerage pipe work

(a) All ductile iron pipes and fittings shall be lined internally with a lining of high alumina cement mortar in accordance with BS EN 598. Where zinc coating is proposed for the external finish, it shall be in accordance with BS EN 598 and be followed by an epoxy finish. This shall cover the internal surface of the socket.

(b) Flanged pipes shall comply with BS EN 545. Ductile iron flanges shall have the dimensions given in the relevant tables in BS EN 1092-2. All bolts and nuts for flange joints shall be of grade 4.6 of BS 4190 and shall be hot-dipped galvanized in accordance with the requirements of BS EN 1461.