STANDARDIZATION / INDIGENIZATION OF ELECTRICAL & ELECTROMECHANICAL METRO RAIL COMPONENTS

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A. INTRODUCTION:

The success of Metro rail systems lies in their ability to provide efficient, fast, safe and comfortable journeys in the urban conglomeration not only to the regular commuters, but also to the occasional traveller or tourist alike.

Electrical systems play a major role in any MRT system in achieving the desired objectives. While providing backbone of 'Traction system' on which whole train operation works, Electrical systems ensure passengers facilities like Lighting & Air- conditioning in the station and provide Life Safety systems like Firefighting systems & Tunnel Ventilation system in the UG Metro for safety of passengers.

Electrical System also provides facility like Lifts & Escalators for smooth movement of elderly as well as divyangjan passengers in the stations at all times besides adding value to other systems by real time interface.

Electrical systems consist of mainly following five different streams:

1. **Power Supply & Traction (PST) system (25 kV AC & 750 VDC)**
2. **Electrical & Mechanical (E&M) System (Underground/ Elevated)**
3. **Lifts**
4. **Escalators**
5. **Tunnel Ventilation, Environmental Control System and Building Management System (TVS, ECS & BMS)**

This document covers item nos. 2 to 5 above.

Need for standardization comes in as the world over, variant technologies are being used for the MRTS/LRT/High speed rails all of whom are equally reliable and meet required safety standards. With Indian cities having population of over 20 lakhs being planned to have metro systems and tier II cities aiming to have smaller sized metro systems, it is important to have uniform requirements/specifications of equipment followed across all metros in the country. Uniformity in general specifications at procurement stage leads to competitive prices, ease in O & M, shorter design finalization, quicker deliveries of material and last but not the least, the standardization will lead to more indigenization as OEMs will be assured of markets for their products developed and manufactured in India.

All the equipment selections shall also be guided by the following broad considerations:

- High reliability
- High Efficiency
- Maintenance friendly (less maintenance/ease of maintenance)
- Space optimization
- Make-in-India

B. KEY OBJECTIVE:

Key objective of this report is to achieve UNIFORMITY amongst "Technical Specification of Electrical Items" being used by different Metro Rail Systems with a view to have standardized procurement & Indigenization.

C. EQUIPMENT STANDARDIZATION / INDIGENIZATION:

2.0 Electrical & Mechanical System (E&M):

Comparative study of equipment rating of major items as presently being followed in different metros is tabulated below:

a) Comparative Statement of rating of Auxiliary Transformers (in KVA):

Item	DMRC				CMRL		MMRC (Fully Underground)	KMRL	BMRCL	Lucknow Metro	Kanpur Metro	Agra Metro
	Ph-1	Ph-2	Ph-3	Ph-4	Ph-1	Ph-2						
Auxiliary Transformer (in KVA)	2 nos. 2500 (UG)	3 nos. 1600 (UG)	2 nos. 3150 (UG)	2 nos. 2000/ 2500 (UG) 2 nos. 315/ 500 (Elevated)	400/ 630/ 1000 (Elevated) 2000 (UG)	2 no's- 315/ 500(Elevated) 2 no's- 1250/ 1600/ 2000 (UG & Depot)	2500/ 3150 (UG) 630 (Grade)	630/ 500	500 (Elevated) 2000 (UG)	3150 (UG) 500/630 (EL)	2000 (UG) 500 (EL)	2000 (UG) 500 (EL)

b) Comparative Statement of rating of UPS:

ITEM	TYPE OF STATION	DAMEL	DMRC				CMRL (Common for Electrical/ S&T)		KMRL	BMRCL	Lucknow Metro	Kanpur Metro	Agra Metro	Nagpur Metro
			DMRC-Ph1	DMRC-Ph2	DMRC-Ph3	DMRC-Ph4	Ph 1	Ph 2						
UPS (Elec)	UG	4x180 kVA (with PSD)	2X60 kVA	2X60 kVA	2X80 kVA (with PED)	2X80 kVA (S&T load Clubbed with E&M UPS)	02X60 kVA 02x80 kVA (For interlocked station) (2 Hrs Backup with PSD)	40/60 KVA	— —	2x 60 KVA	2X60 KVA	Clubbed with S&T UPS	Clubbed with S&T UPS	–
	Elevated	2X80 kVA	2X20 kVA	2X20 kVA	2X20/ 30 kVA	Clubbed with S&T UPS	2X60 kVA (2 Hrs Backup)	2x30/ 40 KVA	2 x 15 KVA	2x20 / 30 KVA	2X20 KVA	Clubbed with S&T UPS	Clubbed with S&T UPS	2X20 KVA
UPS (S&T)	UG	2x120 kVA	2X30/ 60 kVA	2X30/ 60 kVA	2X30/ 60 kVA	Clubbed with E&M UPS	----		—	2x30 / 60 KVA	–	–	–	–
	Elevated	---	2X30/ 60 kVA	2X30/ 60 kVA	2X30/ 60 kVA	2X45/60 KVA (E&M load Clubbed with S&T UPS)	----		2 x 60 KVA & 2 x 30 KVA	2x30 / 60 KVA	–	–	–	–
	OCC, Depot	---	2X60 kVA	2X60 kVA	2X60 kVA	–	3X120 kVA (2Hrs Back up)	120/160 KVA	2 x 120 KVA	2x 80 KVA	–	–	–	–

c) Comparative Statement of rating of DG Sets:

ITEM	TYPE OF STATION	DMRC				CMRL		Kochi Metro	BMRCL	Lucknow Metro	Kanpur Metro	Agra Metro	Nagpur Metro
		DMRC-Ph1	DMRC-Ph2	DMRC-Ph3	DMRC-Ph4	Ph1	Ph2						
DG	Under ground	2X 1010 KVA	2X (750/ 900/ 1010) KVA	1X380, 2X900, 2X1010, 3X1010 KVA	1X380 KVA	910 KVA	1X250 KVA	------	2X 900 KVA	2X1010 KVA	2X1010 KVA	2X500 / 750 KVA	—
	Elevated	1X 160/ 180 KVA	1X (160/ 180/ 200) KVA	1X (160/ 180/ 200)	1X (160/ 180/200) KVA	400 KVA	100 KVA (No permanent DG, only mobile DG of 100 KVA)	1X 125/ 160/ 250 / 300 KVA	1X 200 KVA only @ I/L & I/C Stations	1X160 / 180 KVA	1X160 / 250 KVA	1X160 KVA	1X250 KVA
	Depot	1X 500KVA	1X 500KVA	1X 500 kVA	1X500 KVA	1000 KVA	1X750 KVA	1X 125/ 500 KVA	1X625KVA	1X500 KVA	1X500 KVA	1X500 KVA	1X640 KVA

2.1 Electrical & Mechanical System (For UG Stations):

2.1.1 Specifications:

Electrical and Mechanical System at Underground Stations can be broadly divided into 4 sub-systems. These are:

- Electrical System
- Hydraulic System
- Fire Suppression System
- Fire Alarm & Detection System

2.1.2 Electrical System: Key Components of Electrical System are:

a) LV Panels

i. LV Panels being installed in Underground Stations shall be as per IEC-61439 Part-1&2, IP-54 and Form-4bType-5.

ii. The Electrical Panel shall pass the internal arc fault containment tests in accordance with IEC 61641 requirement.

iii. LV Panels shall be suitable for 415V, 3 Phase 4 Wire, 50 Hz system.

iv. LV Panels shall be used for Control and distribution of Power Supply throughout the station to various loads.

v. Panels shall have suitable numbers of Spare Breakers for future requirements.

vi. Circuit Breakers used inside the LV Panels shall be as per IS / IEC-60947 standard.

vii. Busbar Rating & Switchgear Sizing shall be as per Load and Fault level Calculations.

viii. All Panels shall be provided with surge protection device of rated equivalent to design fault level of Panel. Surge protection Devices shall confirm to IEC 61643-11: 2011 and NBC 2016.

ix. LV Panel feeders for major and continuous load shall have Energy meters to Control & Monitor Energy consumption and Benchmark the energy consumption.

x. Automatic Harmonic Filter (AHF) equipment of suitable capacity in LV System can be installed in each underground station to Filter Harmonics generated mainly by LEDs lights, Drivers & VFDs etc. to improve power quality & reduce Power loss and also maintaining Power Factor within the specified limits to avoid any penalty imposed by concern state DISCOM, if any.

xi. Lifts, Escalator, HVAC Pumps, Chillers, AHU, TEF and FAF etc. can be operated by VFD system instead of Starters to save considerable Power Consumption.

b) Distribution Boards

i. Wall Mounted Distribution Boards shall be provided at the station of Lighting, Advertisement, Power Socket, Signages etc. at the station.

ii. All wall mounted distribution boards shall be IP-54 (For Indoor application)/ IP-65 (For Outdoor application) or any other better suitable rating.

iii. Generally, the commercial loads are charged at commercial rate by the local Electricity Boards, and hence all the commercial loads shall be drawn from separate passenger amenities panel.

iv. Distribution Boards shall be provided with astronomic timer controlled feeder as per requirement.

c) Cables and Cable Containment

i. There are two types of Cables being used at Underground Stations. Normal FRLSZH and Fire Survival Cables.

ii. Normal FRLSZH cables being used at underground Stations shall be as per BS-6724/ IEC 60502-1 (For Al conductor FRLSZH Cable) and Fire-Survival Cables shall be as per BS-7846 CWZ Category or better.

iii. As a standard practice all the cables shall be of copper conductor. However, to further optimize the cost of an under-ground station, non FS cables of 16 sqmm. and above can be of Aluminium conductor as per IEC 60502-1.

iv. All FS cables shall be of copper conductor as per BS-7846 CWZ category or better.

v. Cable Containment System viz. Cable Trays, Raceways, Brackets of Galvanized Iron as per requirement shall be used.

vi. The fasteners, nut-bolts, washers and other hardware shall be electroplated (8 micron zinc coating as per IS 1367) with yellow passivation as per ASTM A 380/IS 10117(2000) or latest. Salt spray test report as per ASTM B117-2019/IS 9844 for 120 hours. Fasteners, nut-bolts shall bear the marking of the manufacturer. Alternatively, SS-304 fasteners, nut-bolts, washers and other hardware may be used based on local environment.

d) Wiring & Conduiting

i. Wiring and Conduiting shall be done at the station for giving Power Supply to Lighting, Power Sockets, Signages, Advertisements etc.

ii. There are two types of Wires being used at Underground Stations. Normal FRLSZH and Fire Survival Wires.

iii. Normal FRLSZH Wires being used at underground Stations shall be as per BS-50525-3-41and Fire-Survival Wires shall be as per BS-6387.

iv. All Conduits being used at Underground Stations shall be of Galvanized Iron.

e) Lighting System

i. Various Types of lights depending on the location of Installation shall be provided at Underground Stations.

ii. All Lights being provided at Underground Stations and Parking shall be of LED Type for Energy Efficiency. LED type luminaire should have efficiency more than 140 lumen / watt as per availability.

iii. Emergency Lighting Control by the means of Occupancy Sensors for Manned Rooms and Door Switches for Equipment Rooms shall be provided.

iv. Distribution of the Lighting shall be such that at least 30% of the lighting is fed by

UPS System in case of Power Supply Failure. Also, within closed rooms at least one light fixture should be connected to UPS power supply. The emergency lighting installation shall fully comply with NBC or other relevant safety standards.

v. Variable control through BMS to be adopted to save energy.

vi. It is desired to achieve reduced LPD requirement over minimum LPD requirements of ASHRAE 90.1 or ECBC 2017 or latest, whichever is stringent.

vii. Lighting Levels to be maintained at Stations and other areas are as below:

Recommended Illumination			
Sl. No.	**Type of Interior or Activity**	**Range of Service Illumination in Lux**	**Quality Class of Direct Glare Limitation**
A	**Passenger Areas**		
1	Circulating and Parking Areas	30	2
2	Entrance/Exit /Stairs/Mezzanine/Escalator	225-250-275	2
3	Customer Care/ Ticketing	225-250-275	2
4	Concourse/Corridors/Passages	175-200-225	2
5	Platform	175-200-225	2
6	Platform Edges	225-250-275	2
7	Lift	125-150-175	2
8	Train way, walk-way and walking surface	10	2
9	Toilets	175-200-225	2
B	**Operational Area**		
1	Staff Working Area/ Control Rooms/OCC	225-250-275	1
2	Tunnel	10	2
3	Signaling& Telecommunication/Switchboard Room	175-200-225	2
4	Mechanical Plant (Pump/Chiller/ECS/TVS) Room	175-200-225	2
5	Auxiliary Substation, TSS and LT Panel Room	175-200-225	2
6	UPS/ Battery Rooms/Cable Distribution Room	175-200-225	2
7	UG Track Area and Cable Galleries	10	2

viii. Lighting circuit shall be distributed all over the station area and shall be used for station lighting controlled through BMS for non-revenue hours energy saving.

ix. Design of lighting shall ensure Uniformity Factor not less than 0.4 (ratio of minimum to average) for indoor as per BS 12464. Reflection Factor, Glare Index, CCT, CRI, Light loss

factor shall be as per SP 72 (2010) National Lighting Code 2010.

x. Design of lighting shall be done using software Dialux, Relux, AGi32 & Revit etc.

xi. LED Driver shall be Constant Current Type should have minimum life of 50000 hrs.

xii. The driver shall be able to withstand surge (EFT+ESD interference) of minimum 4KV of 1.2 / 50 microseconds voltage waveform (IEC 61000-4-5) for all indoor luminaires. Outdoor Luminaires shall have surge protection of minimum 10 KV in common as well as differential mode.

xiii. Driver rating should be paired with luminaire that uses 20% less wattage than the maximum rated wattage of the driver.

xiv. Driver of luminaire shall be preferably in separate compartment other than luminaire compartment for ease to maintenance and preventing of IP rating of luminaries.

f) Uninterrupted Power Supply System

i. UPS System shall be provided at all underground stations for maintaining continuous and uninterrupted power supply to emergency Loads.

ii. The system shall comprise of UPS in parallel-redundant configuration for the entire station.

iii. UPS units shall be installed with their own Battery Sets. The battery bank system shall be of Pocket plate vented Nickel Cadmium/ Lithium Ion/ SMF type with a battery backup time of 30 min for each UPS.

iv. UPS shall be as per IEC-62040 & Batteries shall be as per IEC 60623, IS 10918.

v. Common UPS System for E&M and S&T system shall be adopted at underground Stations

g) Earthing System

i. Earthing System of the Underground Stations shall be TN-S type as per IEEE-80 and IS-3043.

ii. The combined resistance value of Earthing System for Electrical Equipment shall be less than 1 ohm and S&T Equipment shall be less than 0.5 ohms.

iii. Earthing for DG Neutral and Lightning Arrestor of the station/building shall be provided as per IS-3043 (2018 or latest).

iv. Galvanized Iron Earth Strip of adequate sizes shall be provided for earthing of Equipment.

h) Bus Duct

i. Busduct shall be provided for Connection between Transformers and Main LV Panels. The Busduct shall be Sandwiched Type with Copper Conductor as per IS / IEC-61439 Part-1&6 and should be IP – 54.

i) DG Set

i. DG Sets shall be as per ISO 8528 & ISO 3046 / BS 5514. DG Sets are used to supply power to Essential Loads in case of failure of Power Supply at the station. DG engine performance shall be as per BS 649.

ii. DG Sets to be installed at Underground stations should be compliant with latest CPCB norms in terms of Emission and Noise Levels.

iii. For metros with two independent and reliable sources of Mains Power, only one DG set will be used at each station to serve as a standby power for Emergency and Essential services as classified below.

iv. Nature of load on DG set can be optimized as per local considerations.

j) Classification of Loads

i. At Underground Station two transformers are provided which are fed from two different receiving substations which are taking supply from different grid substations. This arrangement complies with power supply arrangement required for different types of loads at an Underground station as per relevant codes and standards.

ii. **Emergency Services (Supplied from UPS):**

- Fire Detection, protection system and alarms
- Telecommunication, Signalling and Station Control Room
- CCTV & Public-Address System
- Security System
- BMS/SCADA System
- Automatic Fare Collection(AFC)
- Emergency illuminated signs, exits etc
- Emergency lighting at station and tunnel
- Control circuits

iii. **Essential Services (Supplied from both ASS in AUTO Mode & DG Backup):**

- Fire-fighting and sprinkler pumps
- UPS System

iv. **Semi-essential Services (Supplied from both ASS in Auto Mode):**

- Water Treatment Plant
- Station Sewage drainage system
- Tunnel Ventilation System
- Environment Control System (Air Side)
- Lifts
- Station Seepage drainage system
- Air Cooled Night Operation
- Station Lighting

v. **Normal Services (Supplied from both ASS in Manual Mode):**

- Water / Air Cooled Chiller/HVAC Pumps – Day Operation

k) Interlocking Scheme

i. There shall generally be two Auxiliary Sub-Stations at an underground station each having its own Transformer and LV Panels.

ii. The transformers are supplied from dedicated 33kV ring feeders. Transformer sizing should be such that in case of failure of any one 33kV supply or transformer the other transformer is able to take load of Emergency, Essential and Semi-essential services of the entire station. The interlocking shall ensure auto-changeover of transformers in case of failure of one.

In the case of failure of one transformer power supply, power supply will be extended through another transformer using Power contactor-based switching/ Interlocked motorized Air Circuit Breakers installed in the respective panel having supply from both transformers.

iii. In case of failure of both 33kV supplies or transformers, DG set shall give power supply to Emergency & Essential services of the entire station.

iv. However, any alternate distribution scheme complying to NFPA or other relevant standards can also be implemented

2.1.3 Hydraulic System: Key components of Hydraulic System are:

a) Water Treatment Plant–

i. Water Treatment Plant for filtration of Raw Water shall be provided at each underground station for supplying treated water for Air-Conditioning System and Toilets.

ii. Two Water tank viz. Raw Water Tank & Treated Water Tank each having a capacity of 80,000 litres (which will be further optimized in case of Air Cooled Chillers are installed at underground station) shall be provided at each Underground Station.

iii. Softener Plants having Dual Media Filter, Iron Removal Filter and Softener Vessel shall be used. The output of Water Treatment Plant shall have below 5 mg / lit or Commercial Zero Hardness suitable of use of Air-Conditioning equipment.

iv. Water meter shall be provided for measuring water consumption.

b) Sewage & Seepage System–

i. Sewage System

- Toilets are provided at each underground station. Waste Water from these toilets is collected in Sewage Pits generally located at Undercraft Level.
- This waste water is then pumped out of the station with the help of Submersible Pumps. The pumps shall comply with ISO 9906 .
- Generally, two pumps of adequate capacity in Working/Stand-by configuration are provided in each Sewage Pit.
- Submersible Pumps function in AUTO MODE (i.e. there is no manual intervention) with the help of Level Controllers.
- The Sewage pumps shall be of the non – clog type with open impellers with grinder / cutter having solid handling capacity of 40 mm.

ii. Seepage System

- There are Sump Pits Located in various parts of the station and tunnel for collection of water from Seepage, Cleaning, Fire-Fighting etc.
- Sump Pits are generally located at Undercroft Level (2 nos.), Ancillary Building (1 no.), at each Entry/Exit (1 each), Cross-Passages (1 each) and Ramp/Portals (1no.).
- This water is then pumped out of the station with the help of Submersible Pumps. The pumps shall comply with ISO 9906.
- Pumps provided in these Seepage Pits are in Working/Assist configuration.
- Submersible Pumps function in AUTO MODE (i.e. there is no manual intervention) with the help of Level Controllers.
- The dirty water (seepage) pumps shall be of the closed semi open impeller or vortex type with solid handling capacity of 65 mm.
- Merger of Seepage room can be considered.

2.1.4 Fire Suppression System

i. Fire suppression System provided at Underground Stations shall be as per

NFPA 130 (2020 or latest).

ii. There shall be two Fire Tanks provided at each underground station with a minimum capacity of 1 lakh litres each and provisions of NFPA shall be complied.

iii. There are six Fire Pumps Provided at each station viz. Main Fire Pumps (1 Hydrant + 1 Sprinkler), Stand-by Fire Pumps (1 Hydrant + 1 Sprinkler) and Jockey Pumps (1 Hydrant + 1 Sprinkler). These pumps shall be as per ISO 9906. However, no. of fire pumps may be varied, as per requirements of local Fire Bye Laws.

iv. Fire Hydrants to be located as per NFPA throughout the entire station and inside the Tunnels for discharge of water in case of Fire.

v. Additionally, Sprinkler system is provided in certain rooms like store,. for automatic suppression of fire and also under platform for under carriage fire.

vi. Fire Hose Cabinets located in a public area shall be of minimum 2mm thick Stainless steel (SS 316) box, equipped with fragile type glass front panel (frosted glass/ Glaze glass/ Partial glaze of 5 mm thickness) complete with lockable door.

vii. Automatic Clean Agent based fire suppression system as per NFPA 2001/ Aerosol based system as per NFPA 2010 is also provided for LV Panels & Transformers. Clean Agent should be used with below mentioned properties:

- The Clean Agent should have Zero Ozone Depletion Potential. (ODP = 0).
- The Clean Agent should not have Global Warming Potential of more than 1.
- The Clean Agent should be a low-pressure agent.

viii. Fire Extinguishers of suitable type i.e.CO2, CO2 Water Type, Mechanical Foam & ABC types are provided in each Fire Hose Cabinet, Rooms and other areas.

ix. Installation of Fire Pipes shall be preferred above the ground level. Buried installation of Fire Pipes shall be avoided.

x. Fire pipe shall be used of Heavy duty galvanized iron, zinc coating shall conform to IS 4736 (Hot dip zinc coatings on steel tubes).

xi. All piping shall have (UL / FM approved) grooved coupling joints or threaded joints as per requirement.

xii. The fasteners, nut-bolts, washers and other hardware shall be electroplated (8 micron zinc coating as per IS 1367) with yellow passivation as per ASTM A 380/IS 10117(2000) or latest. Salt spray test report as per ASTM B117-2019/IS 9844 for 120 hours shall also be submitted. Fasteners, nut-bolts shall bear the marking of the manufacturer. Alternatively, SS-304 fasteners, nut-bolts, washers and other hardware may be used based on local environment.

2.1.5 Fire Alarm & Detection System

i. Fire Alarm and Detection System provided at underground stations is as per NFPA-130 (2020 or latest), NFPA-72.

ii. Fire Alarm and detection system provided at underground stations shall be addressable type with Main Fire Alarm Control Panel and Graphics Computer located inside the station control room.

iii. Various types of detectors viz. Multi-Sensor, Heat & Duct and devices viz. Monitor Modules, Control Modules, Hooters, Manual Call Points shall be provided throughout the entire station for detection and notification of Fire.

iv. Mimic and Repeater Panel shall be provided in the Firemen's Staircase for use by Fire Fighters.

v. The Fire Alarm Control Panel shall interface with BMS through defined protocol.

vi. Electro Magnetic lock in Emergency Exit Staircase / Firemen's staircase / Mid Shaft Staircase shall be provided and it should be integrated with FACP Panel.

vii. Provision of emergency alarm system for Divyang toilet in line with Harmonised guidelines issued by MoHUA for Divyangjan.

2.2 Electrical & Mechanical System (For Elevated Stations):

2.2.1 Specifications: Electrical and Mechanical System at Elevated Stations can be broadly divided into 5 sub-systems. These are:

- Electrical System
- Fire Suppression System
- Fire Alarm & Detection System
- VAC System
- Building Management System (BMS)

2.2.2 Electrical System: Key Components of Electrical System are:

a) LV Panels–

i. LV Panels being installed in Elevated Stations shall be as per **IEC- 61439** Part-1&2, IP-54 and Form-4b Type-5.

ii. The Electrical Panel shall pass the internal arc fault containment tests in accordance with IEC 61641 requirement.

iii. LV Panels shall be suitable for 415 V, 3 Phase 4 Wire, 50 Hz system.

iv. LV Panels shall be used for control and distribution of power supply throughout the station to various loads.

v. Panels shall have suitable numbers of Spare Breakers for future requirements.

vi. Circuit Breakers used inside the LV Panels shall be as per IS / IEC-60947 standard.

vii. Busbar Rating & Switchgear sizing shall be as per Load and Fault level calculations.

viii. All Panels shall be provided with surge protection device of rated equivalent to design fault level of Panel. Surge protection Devices shall confirm to IEC 61643-11: 2011 or latest and NBC 2016 or latest.

ix. LV Panel feeders for major and continuous load shall have Energy meters to Control & Monitor Energy Consumption and Benchmark the energy consumptions.

x. Busbar of LT Panel shall be Tinned Aluminium Alloy / Aluminium, grade E91E bare tape and confirm to IS 5082.

xi. Lifts and Escalator can be operated by VFD system instead of Starters to save considerable Power Consumption.

b) Distribution Boards–

i. Wall Mounted Distribution Boards shall be provided at the station for Lighting, Advertisement, Power Socket, Signages etc.

ii. All wall mounted distribution boards shall be IP-54 or any other better suitable rating.

iii. Generally, the commercial loads are charged at commercial rate tariff by the local electricity boards, and hence, all the commercial loads shall be drawn from a separate passenger amenities panel.

iv. Provision of charging for e-vehicle at parking area of station through third party tie-ups / own supply based on local distribution company regulations.

v. Distribution Boards (for outdoor lighting) shall be provided with astronomic timer controlled feeder as per requirement.

c) Cables and Cable Containment–

i. Cables being used at Elevated Stations shall be as per IS-1554 & IS-

7098.The cables used in stations shall be of FRLSH type or better.

ii. Cables up to 10 sqmm shall have Copper conductor and Cable 16 sqmm and above shall have Aluminium conductor for non FS cables. All FS cables, if any shall be of copper conductor.

iii. Cable Containment System viz. Cable Trays, Raceways, Brackets of Galvanized Iron as per requirement shall be used.

iv. The fasteners, nut-bolts, washers and other hardware shall be electroplated (8 micron zinc coating as per IS 1367) with yellow passivation as per ASTM A 380/IS 10117(2000) or latest. Salt spray test report as per ASTM B117-2019/IS 9844 for 120 hours shall also be submitted. Fasteners, nut-bolts shall bear the marking of the manufacturer. Alternatively, SS-304 fasteners, nut-bolts, washers and other hardware may be used based on local environment.

d) Wiring & Conduiting–

i. Wiring and Conduiting shall be done at the station for giving Power Supply to Lighting, Power Sockets, Signages, Advertisements etc.

ii. FRLSH Wires being used at Elevated Stations shall be as per IS 694-2010.All Conduits being used at Elevated Stations shall be of Galvanized Iron.

e) Lighting System–

i. Various Types of lights depending on the location of Installation shall be provided at Elevated Stations.

ii. All Lights being provided at Elevated Stations and Parking shall be of LED Type for Energy Efficiency. LED type luminaire should have efficiency more than 140 lumen / watt as per availability.

iii. Emergency lighting Control by the means of Occupancy sensors for Manned Rooms and Door Switches for Equipment Rooms shall be provided.

iv. Distribution of the Lighting shall be such that at least 30% of the lighting is fed by UPS System in case of Power Supply Failure. Also, within closed rooms at least one light fixture should be connected to UPS power supply. The emergency lighting installation shall fully comply with NBC or other relevant safety standards.

v. Variable control through BMS to be adopted to save energy.

vi. It is desired to achieve reduced LPD requirement over minimum LPD requirements of ASHRAE 90.1 or ECBC 2017 or latest, whichever is stringent.

vii. Recommended Lighting Levels to be maintained at Stations and other areas are as below:

Sl. No.	Type of Interior or Activity	Range of Service Illumination in Lux	Quality Class of Direct Glare Limitation
A	**Passenger Areas**		
1	Circulating and Parking Areas	30	2
2	Entrance/Exit /Stairs/Mezzanine/Escalator	225-250-275	2
3	Customer Care/ Ticketing	225-250-275	2
4	Concourse/Corridors/Passages	175-200-225	2
5	Platform	175-200-225	2
6	Platform Edges	225-250-275	2
7	Lift	125-150-175	2

8	Train way, walk-way and walking surface	10	2
9	Toilets	175-200-225	2
B	**Operational Area**		
1	Staff Working Area/ Control Rooms /OCC	225-250-275	1
2	Signaling & Telecommunication / Switchboard Room	175-200-225	2
3	Auxiliary Substation, TSS and LT Panel Room	175-200-225	2
4	UPS/ Battery Rooms/Cable Distribution Room	175-200-225	2
5	Mechanical Plant Room	175-200-225	2

viii. Lighting circuits shall be distributed all over the station area and shall be used for station lighting controlled through BMS for Non-revenue hours energy saving. .

ix. Design of lighting shall ensure Uniformity Factor not less than 0.4 (ratio of minimum to average) for indoor as per BS 12464. Reflection Factor, Glare Index, CCT, CRI, Light loss factor shall be as per SP 72 (2010) National Lighting Code 2010.

x. Design of lighting shall be done using software Dialux, Relux, AGi32 & Revit etc.

xi. LED Driver shall be constant current type should have minimum life of 50000 hrs.

xii. The driver shall be able to withstand surge (EFT+ESD interference) of minimum 4KV of 1.2 / 50 microseconds voltage waveform (IEC 61000-4-5) for all indoor luminaires. Outdoor Luminaires shall have surge protection of minimum 10 KV in common as well as differential mode.

xiii. Driver rating should be paired with luminaire that uses 20% less wattage than the maximum rated wattage of the driver.

xiv. Driver of luminaire shall be preferably in separate compartment other than luminaire compartment for ease to maintenance and preventing of IP rating of luminaries.

f) Uninterrupted Power Supply System–

i. UPS System shall be provided at all Elevated stations for maintaining continuous and uninterrupted power supply to emergency Loads.

ii. The system shall comprise of UPS in parallel-redundant configuration for the entire station.

iii. UPS units shall be installed with their own Battery Sets. The battery bank system shall be of Pocket plate vented Nickel Cadmium/ Lithium Ion/ SMF type with a battery backup time of 30 min for each UPS.

iv. UPS shall be as per IEC-62040-1 & IEC-62040-2 & Batteries shall be as per . IEC 60623, IS 10918.

v. Common UPS system for E&M and S&T system shall be adopted at Elevated Stations.

g) Earthing System–

i. Earthing System of the Elevated Stations shall be TN-S type as per IEEE-80 and IS-3043.

ii. The combined resistance value of Earthing System for Electrical Equipment shall be less than 1 ohm and S&T Equipment shall be less than 0.5 ohm.

iii. Earthing for DG Neutral and Lightning arrestor of the station / building shall be provided as per IS-3043 (2018 or latest) requirement.

iv. For Lightning Protection, Expansion piece to be used for down conductor in order to compensate the expansion and contraction due to weather condition.

v. Galvanized Iron Earth Strip of adequate sizes shall be provided for earthing of Equipment. Alternatively, flexible copper wire for earthing connectivity from test link chamber to METs and further to equipment can also be used.

vi. Copper Bonded MS rod/ Copper rod (for burried earth mats and for the location with land constraint, if any) of adequate size shall be provided for Earth Mat to provide a low resistance path to ground and more working life. Interconnection / joints of rods shall be exothermic welded.

vii. Ground enhancement material may be used to reduce the Earth mat size if earth resistivity is high.

viii. Earth mat is provided as a standard preferred practice. However, based on local requirements, provision of cluster of inter-connected earth pits can be considered as an alternate option.

h) DG Sets

i. DG Sets shall be as per IS 8528 & ISO 3046/BS 5514. DG Sets are used to supply power to Essential Loads in case of failure of Power Supply at the station. DG Engine performance shall be as per BS 649.

ii. DG Sets to be installed at Elevated stations should be compliant with latest CPCB norms in terms of Emission and Noise Levels.

iii. Space layout for DG Set can be designed in such a way that same may be installed beneath the staircase from ground to concourse level.

i) Classification of Loads

i. Emergency Services

- Fire Detection and alarms
- Telecommunication, Signaling and Station Control Room
- CCTV & Public-Address System
- Security System
- SCADA System
- Automatic Fare Collection(AFC)
- UPS illuminated signage, fire exit signage
- UPS powered light at station

ii. Essential Services

- Fire-fighting pumps and sprinkler pumps
- Station Lifts (If considered in egress calculation for passenger evacuation)
- UPS

iii. **Normal Services:** Station Normal Lighting and fans, escalator, passenger amenities, external lights, ventilation system, air-conditioners, domestic water pump etc.

j) Interlocking Scheme–

i. There shall generally be one Auxiliary Sub-Station at an Elevated station having Two Transformers and LV Panels.

ii. The transformers are supplied from dedicated 33kV twin ring feeders. Transformer sizing should be such that in case of failure of any one 33kV feeder supply or transformer, the other transformer is able to take all loads of the entire station. The interlocking shall ensure auto- changeover of transformers in case of failure of one.

iii. In case of failure of both 33kV supplies or transformers, DG set shall give power supply to Emergency & Essential services of the entire station.

iv. However, any alternate distribution scheme complying to NBC or other relevant standards can also be implemented.

v. Unitized Sub-station can be provided for Light / smaller Metro station.

2.2.3 Fire Suppression System-

i. Fire suppression System provided at Elevated Stations shall be as per latest NBC and Local State government fire safety rules.

ii. The metro stations shall comply to the requirements of Assembly building category up to 30-meter height and of Business class building beyond 30 meters. Special requirement as applicable for property development area in metro stations shall be complied, as applicable.

iii. Automatic Clean Agent based fire suppression system as per NFPA 2001/ Aerosol based system as per NFPA 2010 is to be provided for HV and LV Panels, including the fire pump panel & essential power panel & Transformers. Clean Agent should be used with below mentioned properties :

- The Clean Agent should have Zero Ozone Depletion Potential. (ODP = 0).
- The Clean Agent should not have Global Warming Potential of more than 1.
- The Clean Agent should be a low-pressure agent.

iv. Fire Extinguishers of suitable type i.e.CO2, CO2 Water Type, Mechanical foam & ABC types are provided in Platform and other station areas.

v. Fire Hose Cabinets located in a public area shall be of minimum 2mm thick Stainless steel (SS 316) box, equipped with fragile type glass front panel (frosted glass/ Glaze glass/ Partial glaze of 5 mm thickness) complete with lockable door.

vi. Installation of Fire Pipes shall be preferred above the ground level. Buried installation of Fire Pipes shall be avoided.

vii. Fire pipe shall be used of Heavy duty galvanized iron, zinc coating shall conform to IS 4736 (Hot dip zinc coatings on steel tubes).

viii. All piping shall have (UL / FM approved) grooved coupling joints or threaded joints as per requirement.

ix. The fasteners, nut-bolts, washers and other hardware shall be electroplated (8 micron zinc coating as per IS 1367) with yellow passivation as per ASTM A 380/IS 10117(2000) or latest. Salt spray test report as per ASTM B117-2019/IS 9844 for 120 hours shall also be submitted. Fasteners, nut-bolts shall bear the marking of the manufacturer. Alternatively, SS-304 fasteners, nut-bolts, washers and other hardware may be used based on local environment.

2.2.4 Fire Detection & Alarm System-

i. Fire detection and Alarm System provided at Elevated Stations shall be as per latest NFPA-72, IS 2189, NBC and Local State government fire safety rules.

ii. Fire Detection and Alarm system provided shall be intelligent addressable type with Main Fire Alarm Control Panel and Graphics Computer located inside the station control room with fire zoning.

iii. Various types of detectors viz. Multi-Sensor, Heat and devices viz. Monitor Modules, Control Modules, Isolator modules, Hooters, Manual Call Points are provided covering the entire station for detection and notification of Fire. Installation and Maintenance of Automatic Fire Detection and Alarm System shall be as per IS 2189.

iv. Interfacing to be made with public address system for announcement, in case of detection of fire.

v. The Fire Alarm Control Panel shall interface with BMS through defined protocol.

vi. Electro Magnetic Lock in Fireman Staircase shall be provided and it should be integrated with FACP Panel.

vii. Provision of emergency alarm system for Divyang toilet in line with Harmonised guidelines issued by MoHUA for Divyangjan.

2.2.5 VAC System

i. VAC System provided at Elevated stations for removing heat from Technical rooms like as SER, TER, UPS rooms, SCR rooms and Sub-station etc.

ii. The Elevated metro stations are recommended to have Variable Refrigerant Volume / Flow (VRV / VRF) type of Environment Control System.

iii. VRV / VRF system shall be suitable for only cooling application for SER, TER, UPS and SCR rooms.

iv. Refrigerant to be used in the station are Eco Friendly and have No Ozone Depleting Potential (ODP).

v. The complete VRV / VRF system including outdoor units, indoor units, cooper piping and controls should be provided in Duty + Standby configuration for 24x7 operating rooms viz. TER, SER, UPS, SCADA etc. for 24x7 non- operating rooms, running units to be provided.

vi. The Heat exchanger, fins, cooper coil, joints etc. of all ODU and IDU shall be coated with Anti – corrosive treatment.

vii. Centralized remote controller to be provided for controlling, sequencing, scheduling the complete VRV / VRF system and to monitor the operation of units and its various parameters. The central remote controller to be interfaced with BMS through defined protocol.

viii. Percentage improvement in efficiency of HVAC equipment shall be over minimum efficiency requirement of ASHRAE 90.1 or ECBC 2017, whichever is stringent.

2.2.6 BUILDING MANAGEMENT SYSTEM-

i. To Control, Monitor and Supervision of the various system like Operation of lights, Hydraulic system, Low voltage switching Breakers, HVAC system, Fire Alarm system etc. from remote location also to be introduce in Elevated station.

ii. BMS system can be provided in Elevated Stations instead of SCADA system to simplify operation and Capital & Maintenance cost saving.

2.2.7 High Mast –

i. High Mast shall be used for lighting of Depot and Yard area.

ii. The Mast shall be fabricated as per PLG 07 of installation of lighting engineers, Galvanization shall be as per IS 4736/ EN ISO 1461.

iii. Lantern carriage for High Mast shall be of latching type.

2.3 Indigenization:

All E & M items i.e. UPS/DG sets/LED lightings/Cables/Panels to be sourced from indigenous sources/suppliers only.

2.4 Wherever Electronic cards are provided in the system the PCB should have conformal coating as per IEC-61086 suitable for class 3C2 (IEC 60721), to prevent the humidity, pollution affect and tracking due to dust.

3.0 Lifts:

The Lifts are to be provided at Metro stations as fireman lift and to facilitate Elderly, "differently-abled" persons, etc. in negotiating different levels (ground, concourse, platform, etc.).

This helps in providing "barrier free" environment at public places in line with "Accessible India Campaign" or "Sugamya Bharat Abhiyan" of Govt. of India.

a) Lifts Speed & Capacity in various metros in India:

S. No.	Metro	No. of Lifts	Capacity /Passenger	Minimum Speed
1	Delhi (Phase 3, Lot 1)	143 Lifts	1000 Kg/13 P	1 m/s
2	Delhi (Phase 3, Lot 2)	294 Lifts	1000 Kg/13 P	1 m/s
3	Chennai Package 9 (AES 01)	125 Lifts	1000 Kg/13 P	1 m/s
4	Kochi (KE-11)	84 Lifts	1000 Kg/13 P	1 m/s
5	Jaipur(JP/EW/E5)	42 Lifts	1000 Kg/13 P	1 m/s
6	Hyderabad	260 Lifts	1000Kg/13 P	1 m/s
7	Bangalore	100/27 Lifts (Ph1) 198/ 51 Lifts (Ph2)	544Kg/8P 1000Kg/13P (Ph1) 1000Kg/ 13P 1600 Kg/ 21P (Ph2)	1 m/s
8	Lucknow (LKE-03)	87 Lifts	1000 Kg/13 P	1 m/s
9	Mumbai Metro – Line 1	45 Lifts	544Kg/8P 1000Kg/13P	1 m/s
10	Delhi – Airport Line	37 Lifts	27 Nos. – 26 P 6 Nos. – 29 P	1 m/s
11	Delhi (Phase-IV)	179	1 Nos- 13P 167 Nos. – 20 P 11 Nos - 26 P	1m/s

b. 'Outline specifications' to be followed, is standardized as under

Applicable Standards	Machine room less passenger lift complying to, Latest Edition of EN 81, IS 14665, IS 15785 IS 15330. Latest Edition of NFPA-130/National Building Code, Local lift and escalator act / rules. In case of any conflict, stringent requirement shall prevail.
Passenger Capacity	Minimum 13 Passengers (1000 Kg) capacity is preferred. Minimum 20 Passengers (1500 Kg) capacity is being followed in DMRC PH-IV projects. Minimum 21 Passengers (1600 Kg) capacity is being followed BMRCL PH-II (UG) projects.
Door	Centrally Opened, Minimum 900 mm Door Width, 2100 mm Height. However, door width of 1000 mm is preferred for 13 Passengers &1100 mm for 20 Passengers Lift and 1200 mm for 26 Passengers Lift are preferred door width.
Operating Speed	Minimum speed of 1.0 m/s may be selected depending on travel height, subject to the provisions in IS 14665.

Lift Duty Cycle	Heavy Duty regularly operating for a period of not less than 20 hours a day, seven (7) days a week at a rate of 180 Motor Starts Per Hour
Driving Machine	Electric Traction with Gearless Motor having Variable Voltage Variable Frequency Drive Control and with optional Regenerative Drive/ Regenerative for lift can be optional as the vertical travel height is not significant in metro applications.
Provision of Audio & Visual Remote Monitoring System	Yes. To be provided in the station controller room.
Hoisting Rope	The diameter/dimension and specification of rope for the car and counterweight shall conform to latest version /amendments of IS: 14665 (Part 4/Sec. 80 and IS 15785. The factor of safety based on maximum static load for car and counterweight ropes shall be at least 12.
Automatic and Battery-operated rescue	To be provided as per IS 14665.
Homing feature	Automatically homes the respective elevator to the pre-assigned floors, after transporting passengers to the assigned floor. Auto Cut off light and fan when the lift is idle for more than 30 seconds (adjustable time)
Next Landing	The car shall automatically proceed to the nearest floor with a functioning landing door if car doors fail to open at the designated floor.
Hall call and car call buttons	To be provided with Braille marking for differently abled persons. Height of buttons should be as per IS 15330.
Door sensors	Lift doors to be provided with both 2D & 3D sensors.
Intercommunication system	3-way communication to be provided.
Landing door, Car door and car panel finishes	Stainless Steel Scratch resistant proof (SS 304) and for glass door, thickness shall not be less than 10mm with the SS 304 hairline/scratch resistant frame.
Integration of Lift with Station Building Management System (BMS)	Integration with Station BMS for Monitoring & Controlling during Normal and emergency conditions.
Integration with Fire Alarm System (FACP)	The lifts in elevated as well as in underground stations will be integrated with Fire alarm Control Panel.
Central Monitoring System (CMS)	A Central Monitoring System to be installed at Operational Control Centre (OCC) for Centralized monitoring of all Lifts
Provision of CCTV Camera	CCTV Camera to be installed inside all Lift Cars.

c) <u>Philosophy for Quantity Assessment:</u>

i. Following philosophy shall broadly be followed. All lifts in metro station shall fireman lift complying with NFPA 130.

ii. Platform to Concourse: Minimum One lift to be provided from each platform to concourse level, which shall be fireman lift. In case two lifts per platform is considered, one lift to be used as a standby for easy and safe transportation for the passengers.

iii. Concourse to Ground: Lifts to be considered from concourse to ground level as per the number of entry/exit points. However, minimum one lift on each side of road will be provided.

d) Indigenization:

a) Procurement shall be governed by ensuring **minimum 60% local content** in compliance to public procurement (Preference to Make in India) Order 2017 dtd 15.06.17 issued by DIPP and circulated by MoHUA vide letter K-14011/09/2014/UT-II/MRTS-Coord dated 12th July 2017 or latest.

b) Roadmap for planning/increasing Indigenization is placed at Annexure-III for taking appropriate action.

4.0 Escalators:

Escalator is used for transporting people in inclined plane and it has high capacity and therefore is preferred in areas / buildings where there is a spurt in traffic.

a) Speed / Step width of Escalators in Metros in India:

S. No	Metro	Phase/Line	Speed of Escalators (m/sec)	Step width (mm)
1	DMRC	Phase 1, Line1, 2, 3	0.5 & 0.65 m/s	1000
2	DMRC	Phase 2, Line 4 & 5	0.5 & 0.65 m/s	
3	DMRC	Phase 3, Line 6,7 & 8	0.5 & 0.65 m/s	
4	DMRC	Airport Line	0.5 & 0.65 m/s	
5	DMRC	Phase-IV: Line 7 (Ext), Line-8 (Ext) and Line-10	0.5 & 0.65 m/s	
6	Jaipur	Phase 1	0.5 & 0.65 m/s	
7	Chennai	Phase 1 & 2	0.5 & 0.65 m/s	
8	Bangalore	Phase 1, 2 & 3	0.5 & 0.65 m/s	
9	Lucknow	Phase 1	0.5 & 0.65 m/s	
10	Hyderabad	L&T	0.5 & 0.65 m/s	
11	Mumbai Metro Line 1	Reliance Metro	0.5 & 0.65 m/s	
12	Kochi	Phase-1	0.5 & 0.65 m/s	

b) 'Outline Specifications' to be followed is standardized as under:

Applicable Standards	Heavy duty escalator, for mass transit, complying to, Latest Editions of EN 115 and IS 4591. Latest Edition of NFPA-130 Local lift and escalator act / rules In case of any conflict, stringent requirement shall prevail.
Angle of Inclination	30°
Step Width	1000 mm
Nominal Operating Speed	0.50 m/s and 0.65 m/s
Number of flat steps (at top & bottom Landings)	04 minimum. (Change may be made under exceptional circumstances in compliance to applicable standards)
Truss	Deflection limits as per applicable standards. Shall be hot dip galvanized with minimum thickness of 85 µm.
Skirt Brush	Double Layer on both skirts adjacent to moving step and necessary overlapping at comb carrier. Non-combustible.
Provision of LED Comb & Step Gap LED Lights	Yes
Emergency Stop Switch	Minimum Three (Top, Middle and Bottom Landings) and distance between switches shall not exceed 15 m.
Provision of Skirt Safety	At Upper and Lower Curves and at 7.5 m interval along the incline of each

Switch	escalator.
Escalator Duty Cycle	Heavy Duty, regularly operating for a period of not less than 20 hours a day, seven (7) days a week with an alternating passenger load reaching 100% of Contract Load (120kg per step, including all horizontal steps) for 01 hour and 50% of Contract Load for the following 02 hours and so on for 20 hours a day, seven days a week.
Automatic Lubrication System for Main Drive Chain, Handrail Drive Chain and Step Chain	Yes
Step Width, Step Tread and Step Height	Step Width shall be at least 100 mm, Step tread Width of atleast400 mm, Height of less than or equal to 210 mm.
Step	One Piece, Pressure Die Cast, High Wear and Corrosion Resistant Aluminum Alloy.
Rollers (Step and Chain)	The minimum diameters of the chain roller and the trailer / step rollers shall be 75 mm for outside step chain link rollers (preferable) and 75 mm for inside step chain link rollers. The rollers shall have a minimum width of 20 mm.
Factor of Safety	Step Roller Tracks and Steps, Chain, Driving Machinery = 8 (for steel and bronze components) and 10 (for cast iron parts). Any other item as per Applicable Standards for Public Service Escalator
Operating and Safety Devices	Shall be provided as per EN-115
Auxiliary Brake	Shall be provided mandatorily for all escalators in addition to Applicable Standards.
Drive type	Shall be provided with V3F Drive. All downward moving escalators with rise band ≥ 10 meters should have regenerative drive to generate electricity during their downward movement by virtue of gravitational effect.
Provision of Audio & Visual Remote Monitoring System	Yes. To be provided inside the station controller room.
Drive Mechanism	The overall efficiency of the combined motor and gearbox shall not be less than 82% at full load.
Integration of Escalator with Station Building Management System (BMS)	Integration with Station BMS for Monitoring & Controlling during Normal and emergency conditions.
Integration with Fire Alarm System (FACP)	The escalators in elevated as well as in underground stations will be integrated with Fire alarm Control Panel.
Central Monitoring System (CMS)	A Central Monitoring System to be installed at Operational Control Centre (OCC) for Centralized monitoring of all Escalator. by Auxiliary Systems Controller.

c) <u>Philosophy for Quantity Assessment</u>:

i. Number of escalators to be provided to be based on forecast of passenger flow rates, vertical travel distance, structural limitations, and the availability of space.
ii. Quantity to be worked out between Platform to Concourse and Concourse to Street level as under:

(a) Platform to Concourse (To comply NFPA 130- 2017 in UG metro):
There to be sufficient egress capacity to evacuate the platform occupant load from station platform in 4 minutes or less.
(b) Concourse to Street level (For public comfort):

i. Normally one entry/exit on each side of road to be minimum provided with one escalator.
ii. Escalators to be provided for each exit/entry point (wherever feasible) if the vertical rise is more than 6 meters or as per local convenience of metro.

d) <u>Indigenization</u>:

Procurement of shall be governed in compliance to Public procurement (Preference to Make in India) Order 2017 dtd 15.06.17 issued by DIPP and circulated by MoHUA vide letter K-14011/09/2014/UT-II/MRTS-Coord dated 12th July 2017 and as detailed in the **Roadmap for Indigenization** is placed at Annexure-III for taking appropriate action.

5.0 Tunnel Ventilation, Environmental control system and Building Management System (TVS, ECS & BMS):

a. TVS equipment sizes in different metro rail systems operational/under construction in India:

SN	Item Description	DMRC				CMRL		BMRC	
		Phase-I	Phase-II	Phase-III	Phase-IV	Ph-I	Ph-II	Ph-I	Ph-II
1	TVFs	75-100CMS	75-100 CMS	85-100 CMS	70-100 CMS	80-120 CMS	55-100 CMS	65 CMS	85 CMS
2	TEFs/ OTEF	18-27CMS	18- 27 CMS	18-27CMS	21-27CMS	30-45 CMS	40 CMS	20 CMS	30 CMS (02 no)
3	SEFs	6.5-11CMS	11 CMS	11CMS	5-8 CMS	7 CMS	NA	NA	22 CMS (2W + 1S)
4	VEF	2.5-11 CMS	2.5-11CMS	2.5-11CMS	3-5 CMS	N.A.	NA	10 CMS (1W + 1S)	10 CMS (1W + 1S)

b. ECS/VAC equipment sizes in different metro rail systems operational/under construction in India are:

SN	Item Description	DMRC				CMRL		BMRC		UPMRCL
		Ph-I	Ph-II	Ph-III	Ph-IV	Ph-I	Ph-II	Ph-I	Ph-II	
1	Water Cooled Chiller	3 Nos. (200-450 TR)	3 Nos. (300-400 TR)	3Nos. (300-400 TR)	NA	3 No (200 TR each)	NA	3 Nos (300 TR each)	NA	2 No (250 TR each, for 3 No. of car / train set), 2 No (350 TR each, for 6 No. of car / train set)
	Air Cooled Screw Chiller	NA	NA	NA	3 Nos. 200-250 TR	-	NA	-	3 Nos (2W+1S) (200 TR each)	
2	Air Cooled Scroll Chiller	NA	2 Nos. (40 TR)	2 Nos. (66TR)	1No (40TR)	NA	50 TR (5 No Each)	2 Nos (34 TR each)	2 Nos (1W+1S) (35 TR each)	
3	Cooling Tower	3 Nos.	3 Nos.	3 Nos.	NA	3 Nos	NA	3 Nos	NA	
4	Air Handling Units	8-21 CMS	30-35 CMS	20-35 CMS	15-20 CMS	1No, 20 CMS	3No, 8-20 CMS	4 Nos, 25 CMS	4 No, 14 CMS	

5	VRV/VRF unit (For Elevated Stations)	NA	10-16 TR	8-20 TR	8-20 TR	2x 25 TR	30- 40 TR (For Elevated) 200-250 TR for UG	N.A.	NA	

Note: (i) Use of Water Cooled/ Air Cooled Chiller shall be based on life cycle cost basis.

(ii) For Tier-II cities, Single ECS room can be provided. No. of AHUs can be reduced from 4/Station to 2/Station with provision of augmentation for capacity enhancement in future based on ridership.

c. **Environmental control system (ECS)** constitutes the air-conditioning system; ventilation system & station smoke management and is necessary for the purpose of:

- Supplying fresh air for the physiological needs of passengers and the authority's staff.
- Removing body heat, obnoxious odours and harmful gases like carbon dioxide exhaled during breathing.
- Preventing concentration of moisture generated by body sweat and seepage of water in the sub-way.
- Removing large quantity of heat dissipated by the train equipment like traction motors, braking units and compressors mounted below the under-frame, lights and fans inside the coaches, air-conditioning units etc.
- Removing vapour and fumes from the battery and heat emitted by light fittings, Escalators, Fare Gates etc. working in the stations.
- Providing Ventilation to air-conditioning plant and sub-station and other Non Air Conditioned areas, if provided inside the underground station.

d. **The tunnel ventilation system (TVS) for underground metro system shall provide:**

- An acceptable/tenable environment in the tunnel and the station track way for the operation of the trains;
- Pressure relief during normal operation;
- Heat removal during congested/maintenance operation; and
- An effective means for controlling the smoke during emergency (incident) situation for safe evacuation of patrons.

e. **Codes and Standards:**

The design of the Environmental Control Systems (ECS) and Tunnel Ventilation System will be in accordance with all Indian and International codes, regulations, and standards, where they are relevant. Following codes and standards are mainly followed-

AMCA	:	Air Moving and Control Association Inc., USA
ARI	:	Air-Conditioning and Refrigeration Institute
ASHRAE	:	American Society of Heating, Refrigerating and Air- Conditioning Engineers
BS	:	British Standards
HVCA	:	Heating and Ventilation Contractors Association (DW-144)
IEC	:	International Electro technical Commission
ISO	:	International Organization for Standardization

NFPA	:	National Fire Protection Association (USA)
SMACNA	:	Sheet Metal and Air Conditioning Contractors National Association.
UL	:	Underwriter's Laboratories, Inc.
ASTM	:	American Society for Testing and Materials
EN	:	European Standard
IEEE	:	Indian Institute of Electrical & Electronic Engineers
IS	:	Indian Standard
IGBC	:	Indian Green Building Council
EUROVENT	:	Eurovent certified performance
NBC	:	National Building Code
ECBC	:	Energy Conservation and Building Code
ISHRAE	:	Indian Society of Heating, Refrigerating and Air Conditioning Engineers

The primary design codes used will be latest NFPA 130 (Standard for Fixed Guide way Transit and Passenger Rail Systems) and its related codes, National Building Code of India (NBC-latest version) and Bureau of Indian Standards/Local codes and laws.

5.1 Design Criteria for ECS &TVS:

a) Basic Design Parameters:

1) External Design Conditions:
Outside ambient conditions are based upon Latest ISHRAE Weather Data-recommended design conditions for 1% criteria.

2) Inside Design Conditions:
Platform & Concourse: 27.0°C(Max) Dry Bulb (DB), 55% RH
Back of House rooms: 26 (±1)^{0}C and S&T Equipment rooms: 25 (±1)^{0}C and RH not exceeding 60%
Inside design conditions in the S&T equipment rooms may further be optimized based on the manufacturer's recommendations.

3) Tunnel Design Conditions
Normal conditions: Max. 40°C Dry Bulb (DB)
Congested conditions: Max. 50°C Dry Bulb (DB) Stratified Temperature, that corresponds to maximum condenser air intake temperature.
Minimum Fresh Air (In Station Public Area): 10% or as per the latest ASHRAE/ Relevant Indian Standard.

4) Design Fire size:
The required air flow in the tunnel in the event of a train fire will be determined according to the design fire size provided by the rolling stock supplier.

5) Emergency Condition:

Temperature rating for equipment exposed to high temperature during emergency operations: 250°C for 2hours

6) Air Velocities

Station Concourse or Platform-	Peak 5m/s
Station Concourse or Platform-	Average 3 m/s
In evacuation path-	Not exceeding 11 m/s (Includes all areas where public exposed to air stream)

7) Terminal air velocity from over-ground shafts

Non-Public Areas	-	5 m/s face velocity
Public Areas	-	2.5 m/s face velocity

8) Refrigerant to be used in the stations are eco-friendly and have no Ozone Depleting Potential (ODP).
9) Percentage improvement in efficiency of HVAC equipment shall be over minimum efficiency requirements of ASHRAE 90.1 or ECBC 2017 whichever is stringent.

b) Noise Control:

1) The noise level in the various areas within the station box during normal operation shall be asunder:

At station concourse, platform areas: 65 dB(A)
(Normal Operation)

At station concourse, platform areas: 75 dB(A)
(TVF Running)

To boundary of nearest property : 65 dB(A) (6am to 10pm)

To boundary of nearest building : 55 dB(A) (10pm to 6 am)

Equipment noise : 85 dB(A) within plant room

These values shall be considered applicable during normal operation of the railway. During emergency or trains congestion situations, which are considered special, the maximum noise level in the stations concourse and platform areas shall not exceed 75 dB(A).

2) Tunnel noise: to meet the NFPA-130 tenability criteria

c) Duct Work:

- Draft relief shaft area : 18-20m² (minimum) as per availability of space
- Duct velocity-Public area : 10m/s
- Duct velocity BOH Area : 12.5m/s
- Shaft Exits, Elevated : 5.0m/s
- Shaft Exits/Louver area, (At ground Level) : 2.5m/s
- TVS and TES shaft pressure loss : 150 Pa max
- Maximum duct friction loss : 1.23Pa/m

d) Pipe Work:

The following parameters given in ASHRAE Handbook Fundamental shall be utilized.

- Maximum Friction Rate : 400Pa/m
- Maximum Velocities : 2.5m/s

5.2 Environmental control Systems (ECS):

1) **Air Conditioning:**

Air conditioning load is dependent on type of station i.e. with full height platform screen doors (PSD) or without PSD and is decided based on geographical location & capital/ operating cost analysis. Accordingly, heat load is derived from the subway simulations.

- When outside enthalpy is less than enthalpy required for station box cooling, chillers remain closed then AHU will work on 100% fresh air called open system.

- When outside enthalpy is more than enthalpy required for station box cooling, chiller will be operational then AHU will take 90% of their capacity as return air and 10% from atmosphere called close system.

- Provision of fresh air will be controlled through CO_2, PM 2.5/10, O_3 and VOC sensors installed.

2) Water/Air Cooled Chilled Water System (Day time / Normal Operation):

For Under-Ground Metro Stations, Water/Air Cooled Chilled water system will be used, based on life cycle cost analysis and availability of water.

(a) The water-cooled chilled water system consists of Water-cooled chillers, Cooling towers, Pumps (chiller & condenser), Expansion tank and Chemical dosing system.

(b) The Air-cooled Chilled Water System (Screw Compressor) consists of Air -cooled chillers, Chilled Water Pumps and Expansion tank.

Through primary refrigerant (R-134a or any latest environment friendly alternate) water is cooled to considerably low temperature and circulated to the AHU installed in ECS plant rooms and FCU placed in BOH rooms at different part/level of the station through chilled water pumps.

The chilled water is pumped to cooling coil inside air handling units to cool the air and this chilled dehumidified air is distributed to the different area that has to be air conditioned through ducting arrangement.

• Compressor	:	Screw type / Centrifugal type
• Evaporator	:	Flooded, Shell and tube type
• Condenser Chiller)	:	Water Cooled, shell and tube type(Water Cooled And Direct driven fans and Copper tube (Air cooled Chiller)
• Pumps	:	Vertical/Horizontal Split Casing Pumps.
Cooling Towers	:	Induced Draft/Cross Flow (Water Cooled Chillers)

3) Air Cooled Chilled Water System (Night/Winter):

During non-operational hours and in winter, very less air-conditioning is required in critical equipment rooms only, hence, operation of main water /air cooled chiller plant may not be energy efficient. Therefore, during this time, critical equipment rooms will be fed through a small air-cooled scroll chiller (40 TR maximum) installed in each under-ground station. Main water/ Air-cooled chillers will work as a redundant system, in case of failure of small air-cooled scroll chiller.

4) Ventilation of Plant rooms:

For ventilation of system plant rooms such as ECS plant rooms, TVS plant rooms, Chiller plant room, Pump room, ASS, TSS etc., proper ventilation or local cooling will be provided based on load requirements.

Cooling/ ventilation of plant rooms may be controlled through temperature sensors so that fans are operated in case of need only.

All plant rooms shall have mechanical ventilation for smoke extract.

5) Staircase & Escape Route pressurization:

Air Pressurization system will be designed for fireman and public escape staircase. Fifty (50) Pascal of positive pressure will be maintained in the fireman and public escape staircase. Pressure between 25 Pascal's to 30 Pascal's has to be

maintained to provide smoke free escape route out of the station box for occupants in case of fire.

The Airflow velocity through the doorway between the pressurized space and the accommodation shall be not less than 0.75 m/s, as defined in BS EN 12101 Part 6 (Class C system).

6) Key Components of ECS System are:

i. AIR COOLED CHILLERS WITH SCREW COMPRESSORS

- The air-cooled water chilling machine shall be self-contained type consisting of multiple screw compressors, squirrel cage induction motor, air cooled condensers, chiller, refrigerant piping, wiring and automatic controls all mounted on a steel base frame forming a compact assembly. The air cooled water chilling machine shall be complete with full charge of Zero ODP Environment friendly refrigerant R134a, oil, vibration isolators and accessories as per manufacturer's standards, factory assembled and tested for rated capacity.

- Chiller shall be selected and designed to give TR rating as per ambient temperature conditions of site specified along with anti-corrosion coating. However, Chiller should be capable of operating upto 50 deg Celsius or as per local ambient requirements.

ii. AIR COOLED CHILLERS WITH SCROLL COMPRESSORS

- The water chilling machine shall be self-contained type consisting of multiple scroll compressors, squirrel cage induction motor, air cooled condensers, chiller, refrigerant piping, wiring and automatic controls all mounted on a steel base frame forming a compact assembly. The water chilling machine shall be complete with full charge of Zero ODP Environment friendly refrigerant R134a/ R410A and oil, vibration isolation pads and accessories, factory assembled and tested for rated capacity.

iii. Chiller Plant Optimizer

- The microprocessor based multiple-Chiller Plant Optimizer System i.e. (CPO) shall render the operation of chillers automatic. The controls shall be designed to maintain the temperature of chilled water in the flow header to within +/- 0.5°C of the set point (i.e. 7°C unless otherwise mentioned in the equipment schedule) at all operating conditions including part load. Further, the CPO shall optimize the overall chilled water plant performance by operating the chillers at their most efficient operating conditions.

- It shall optimize energy use by shutting down chiller(s) when the cooling load does not require it to be enabled.

- Add additional chiller based on

  a. System chilled water set point
  b. System chilled water supply temperature
  c. % Full Load Ampere based control

- The chiller subtract algorithm based on:

  a. Actual system delta T Total available operating capacity (tonnage)
  b. The capacity available after next chiller is shut down.

iv. AHU

- The air handling units shall be of double skin construction, drawn through type shall include separate return/mixing air plenum, filter section, fan and coil section. Each AHU shall have minimum two Plug fans with internal Rotor Permanent Magnet Motor (PM) and full partition shall be provided between them.
- AHUs thermal performance and Mechanical strength shall be certified with Eurovent Standard EN;1886 or AHRI Standard: 1350.
- For Eurovent certified AHUs, rating and performance for AHU's units as a whole, components and section shall be as per EN 13053.
- For AHRI certified AHUs, AHU coil to be tested as per AHRI-410 and AHU fan to be tested as per AHRI-430.
- AHU Motor Efficiency shall be minimum IE-4 class.

v. FANS

- All fans, drives and accessories shall be designed, constructed, rated and tested in accordance with the recommendations and standards of AMCA / ISO.
- Fans shall have non-overloading characteristic, except for forward curved centrifugal, over their entire operating range. The characteristic curves shall be such that the fan operating point falls between the no flow pressure and the maximum mechanical efficiency. The fan characteristic shall also be such that for a 15% increase in total pressure over the specified value, the fan shall deliver not less than 85 % of the specified air volume flow rate. The stability of fan operation shall not be affected under such situation.
- For smoke extraction fan, adequate clearance shall be provided between blade tips and housing at all points to allow for expansion and contraction over a continuous operation in an air stream temperature range from 0 °C to 250 °C without developing interference to the specified flow capacity. The motors in case of smoke extraction fans shall be fire rated for 250°C, 2 hours.
- All Axial Flow fans with nominal rating above 7.5 KW shall have a minimum fan efficiency of 70%.
- All Centrifugal fans with nominal rating above 7.5 KW shall have a minimum fan efficiency of 80%.

vi. Sheet Metal Ductwork

- All sheet metal ducting shall be constructed to the recommendations of DW144 / SMACNA.
- The galvanization shall be minimum 275 GSM for all ductwork.
- Fire rated ductwork or equipment enclosure shall be fabricated from fire rated material to the requirements of BS 476 Part 24 ISO 6944. The galvanization shall be minimum 275 GSM for all ductwork.

vii. Air Filtration & Air Quality Monitoring:

All the AHUs shall be equipped with filter with Minimum Efficiency Reporting Value of 8 or Higher for treating the outdoor air. AHU shall be provided with bag/pocket type filter (EU-4) equivalent to MERV 8, UVGI lamp & drift eliminator.

5.3 Tunnel ventilation Systems (TVS):

The TVS has to handle the different operation scenarios, i.e. the normal, congested and fire emergency operation. For each type of operation scenarios, certain design criteria will be achieved to ensure the smooth operation of the railway system.

Simulation analysis i.e. Sub-way Environment Simulation (SES)/ IDA Tunnel and CFD, will be performed for different operation scenarios, which include normal, congested and fire emergency operation. Final equipment capacity, Fire size and location will be decided as per simulation recommendations and Geographical location.

1) Normal mode:

In normal mode simulation, the trains are moving through the system according to schedule.

Trains are dispatched in the route as per design headway and stops at each station with a design dwell time.

The tunnel ventilation fans are not operating. Draft relief dampers (DRD) located at both station ends remain open and allow the recirculation of air from one tunnel to the other tunnel or to the atmosphere and consequently reduces the heat load/ pressure generated in the platform.

2) Congestion Mode:

In congested mode, train(s) are stopped only in one route. The other route is still in operation.

The principle used is to supply fresh air in the same direction of the train movement. The tunnel ventilation scheme for congested scenario is to operate the tunnel ventilation fans in the push-pull mode creating a longitudinal air flow to ventilate the tunnel section. .

3) Emergency Mode:

In emergency, the smoke exhaust system (TVS/TEF/SEF) is intended to maintain smoke-free conditions in the tunnel, platform, concourse and escape stairs for the duration of the evacuation time.

In all cases the allowed maximum air temperature and visibility criteria should be fulfilled:

- Maximum allowed dry-bulb temperature must not exceed 60°C,
- Visibility of 10 metre public area at both platform and concourse levels,
- Minimum smoke clearance height of 2.0 m
- Smoke down stand may be installed based on the CFD simulation

In case of Tunnel emergency, velocity of air shall be exceeded the requirement of critical velocity in the tunnel criteria should be fulfilled.

4) Tunnel ventilation being lifesaving system, it is governed by NFPA 130 with Safety integrity level of SIL-2 for the PLC SCADA. The system shall be designed for 100% redundancy with no single point failure.

5) Fire Heat Release Rate (HRR):

The fire load for rolling stock shall be considered as 15 MW to 20 MW or Based on actual Rolling Stock design with HRR medium growth rate.
For platform / concourse baggage fire HRR shall be 1 MW (minimum), fast growth rate.

6) Open to sky type shaft opening for TVS system may be adopted wherever, feasible to save construction cost and time.

7) Key Components of TVS System are:

i. Tunnel Ventilation / Trackway Exhaust Fan (TVF/TEF):-

- Fan shall be axial flow type with reversible operation. Emergency fan-motor units shall be required to operate in the forward or reverse direction of airflow, with a capability of starting, stopping or reversing the direction of flow at any time. The trackway exhaust fans, those connected to the over track exhaust ducts, are not reversible fans.

- Impeller hub and blades shall be of rating 250 deg C for 2 hours fabricated of aluminium alloy castings or steel alloy castings (ASTM B686) or forgings (ASTM B247) or steel (ASTM A-588, Grade A and A-151, 1020 hot rolled or equivalent BS/EN/DIN standard), suitable for the specified performance and environment.

- Fan-motor units shall be direct-driven by internally mounted electric motors, with provision for manual adjustment of the pitch of the individual blades. Fan-motor units shall be statically and dynamically balanced and shall have non overloading characteristics. Fan motor unit shall be capable of withstanding 250 degree Celsius for two hours. Fan-motor unit shall be tested in accordance with the procedures specified in the AMCA 210 / ISO5801, latest edition.

- The motors shall conform to applicable ANSI, IEEE, ISO, IEC or NEMA. Motors shall not be provided with self-contained thermal protective devices.

ii. Tunnel Booster Fan (TBF):-

- TBF shall be of the axial-flow type, direct-driven by internally mounted single speed motors which are capable of delivering air in both the forward and reverse directions of airflow when the motor rotation is reversed. Permanently mark the forward direction of airflow in conspicuous location on the exterior of the fan housing.

- Fan housing to a true-round, concentric, cylindrical shape providing uniform clearance between the tips of the impeller blades and the housing. Provide adequate clearance between blade tips and the housing at all points to allow for expansion and construction over a temperature range from 0 degree C to 250 degree C without developing interference. Fan unit shall be capable of withstanding 250 degree Celsius for two hours. Fan-motor unit shall be tested in accordance with the procedures specified in the AMCA 250 / ISO 13350.

iii. Tunnel Ventilation Dampers(TVD):-

- Dampers shall be furnished complete with damper mounting frames / joining angles for each damper module and all components and incidentals as specified herein; with all structural support elements and hardware required for installation of the damper modules into composite damper units, and with any additional accessories which may be needed in order to meet the performance requirements.

- Dampers shall be so designed that the dampers will be fully operational in accordance with the performance requirements specified after exposure to an airstream temperature of 250 degrees C for two hours. Dampers and components shall be capable of withstanding the stresses caused by pressure transient pressures from train piston action, and by reversal of airflow and thermal shock caused by temperature changes of from 0 to plus 250 degrees C. The damper shall be tested in accordance with relevant AMCA/UL 555 S Class 1 standards, the latest edition.

iv. Vibration Isolators:-

- All rotating or reciprocating equipment shall be mounted on vibration isolation mountings or suspended from vibration isolation hanger. The selection of type equipment base and vibration isolator (mounting/hanger) for differing plant/equipment and on differing floor spans & levels may follow the requirements as indicated in the Selection Guide for Vibration Isolation as per AMCA 204-05/ASHRAE Application Handbook 2021 or later, and the static deflection of the vibration isolator selected shall provide a minimum isolation efficiency of not less than the corresponding values.

v. Compressor System:- (If pneumatic actuators are used)

- Dampers shall be operated by pneumatic actuators mounted outside of the damper frame wherever possible. The compressors shall be complete with all integral controls and safety devices and shall be rated at the performance stated in the Equipment Schedule with a tolerance of ± 3% (ISO1217 or equivalent).

- The compressors shall be suitable for 24-hours operation per day with control from pressure switches and full-capacity standby mode, and arranged so that automatic changeover takes place if the selected air compressor fails to start. The air/receiver shall confirm to ASME Sec. VIII or IS 2825 or BS5169 and BS5750.

vi. Sound attenuators:-

- The sound attenuators shall be selected to enable noise limits inside and outside to be achieved. The sound attenuators selected shall be suitably matched to the system and shall add as little as possible to system resistance. The geometry of selected attenuators shall not result in requirements for sharp transformation in adjacent ductwork, shall not interfere with adjacent services or with reasonable access to services and shall not adversely affect the aerodynamic performance of the system or encourage regeneration of noise local to the attenuator.

- The sound attenuators shall be tested on dynamic insertion loss performance in accordance with BS EN ISO 7235 or ASTM-E477 „Duct to reverberation room" method with air flowing through the sound attenuator at rated capacity, in both forward and reverse flow direction.

- Acoustic material for the sound attenuator shall be tested on sound transmission loss performance and sound absorption coefficients in accordance with ASTM E90-61-66 G70, E413-73 and ASTM C423-66 whichever is appropriate.

- The sound attenuators material shall be classified as non-combustible in accordance with BS476 or ASTM E84.

- The sound attenuators for Trackway Exhaust Fans, Booster Fans and Tunnel Ventilation fans shall be designed to withstand an airstream of 250°C for a minimum of 2 hours and maintain structural integrity and air tightness.

5.4 LINEAR HEAT DETECTION SYSTEM (LHDS in Tunnel) –

1. Fibre optic linear temperature sensing system shall provide a low maintenance means of monitoring, detecting and reporting the presence of a fire condition as well as increase in Tunnel temperature beyond the set limit at any and all points along a multiple km length of standard telecommunications grade dual fibre optic cables to be laid in the tunnels.

   The above system operation shall not be affected by adverse environments such as dirty, dusty, damp, corrosive etc or by electrically noisy (RFI, EMC) conditions.

2. The Linear Heat Detection System shall use either Raman based OTDR (Optical Time Domain Reflectometry) technology or OFDR (Optical Frequency Domain Reflectometry) technology that includes the Optical Fiber Linear Heat Sensing Cable and a Linear Heat Detection Control Unit that houses the electronics.

3. The optical fiber shall be connected to the Control Unit on either end to a single control unit to ensure redundancy and full coverage of the protected fire zones even if the cable is broken / cut / damaged at one point.

4. The thermoplastic (NON METTALLIC) sensor cables shall be tested and approved for functional integrity for 2 hours at temperatures up to 750 degrees C according to IEC 60331-25.

5.5 Building Management System (BMS)

- Building Management System (BMS) (including TVS SCADA work) shall include fully integration, control, monitoring and supervision of Environmental Control Systems, Low Voltage Power & Distribution System, Fire Alarm System, Hydraulic System (Seepage, Sewage, Bore Well Pumps etc.), and other nominated Building Services Systems and interface with Tunnel Ventilation System SCADA at the station level as well as at the OCC level, including all PLC Equipment, CPU's, Modules, Sub Modules, Power Supplies, Local Control Panels, Work Stations, Printers, Local Area Network (LAN), Ethernet Hubs and Switches, Cable containment and wiring systems, and other components necessary to deliver the requirements.

- The ECS, TVS, E&M equipment shall be monitored and operated from the OCC, Station Control Room, Ventilation Control Panel, local electrical panels as per the requirements. Necessary provisions to be made in the station control room and OCC to enable monitoring and control.

- Ventilation Control Panel (VCP)/ Station SCADA should have provision of giving command to emergency ventilation system for various fire and emergency modes of tunnel, trackway, platform public area, concourse public area and various other controls e.g. Lift, escalator, AFC, Emergency exists etc. VCP/ Station SCADA shall provide back-up for the operation of the TVS in the event of failure of automatic control of the SCADA from OCC and provides Manual activation of congestion and emergency operation modes from the station Control Room.

5.6 SCADA at OCC

- The Operation Control Centre (OCC) is the heart of the system as far as dealing with normal and emergency operation of the Metro system.

- At the OCC, redundant workstations are to be provided giving effective means of controlling the operation of TVS equipment for individual stations and group of stations.

- The System shall also provide effective means of monitoring the alarm from the electrical, fire, hydraulic and ECS systems, for individual stations and equipment.

- The OCC SCADA server shall maintain an historical database of all messages transmitted over the SCADA links and received from the Network management computers. There shall be a provision for means of accessing and processing that database.

- All messages shall be time stamped at origin from a time source linked to the system master clock and the database listing shall be maintained in chronological order of the originating time stamps.

Controls: -

- Following controls in order of operating priority shall be available:

1. Centrally at the OCC for entire section through SCADA workstation.
2. Centrally at Station Control Room for each station through local BMS / SCADA workstation.
3. Centrally at Station Control Room for each station Override provision through Ventilation Control panel (VCP)
4. Locally at each PLC location for each end of station through Local Control Panel (LCP) of BMS
5. Locally at each TVS MCC Room by operation of the "Local/ Remote" switch at MCC room.

5.7 Indigenization:

a) Procurement shall be governed in compliance to Public procurement (Preference to Make in India) Order 2017 issued by DIPP dtd 15.06.17 and circulated by MoHUA vide letter K-14011/09/2014/UT-II/MRTS-Coord dated 12thJuly 2017 and as detailed in Roadmap for planning/increasing Indigenization is placed at Annexure-III for taking appropriate action.

b) R&D is suggested to be considered in phased manner in association with some of the IITs/NITs/other accredited institutes/agencies in the Industry to facilitate / encourage indigenization of developing Soft capabilities for SES (Subway Environmental Simulation)/IDA Tunnel & CFD (Computational Fluid Dynamics) for tunnel ventilation system design.

6.0 Service life of Equipment

All equipment shall be manufactured and installed so as to secure a service life as shown below:

S.N.	Equipment	Service Life
1	Main Switchboards	30 Years
2	Transformer	30 Years
3	Sub-Main Switchboards	30 Years
4	Cables	30 Years
5	UPS	20 Years
6	Battery	15 Years
7	DG Set	20 Years
8	Luminaries	50000 Hours
9	Tray, Trunking and Supports	30 Years
10	Lightning Protection	30 Years
11	Sub-assemblies and components	30 Years
12	Chillers, Pumps, AHU, Fans, Dampers, PLC	20 Years
13	All BMS workstation	10 Years
14	All other equipment	As per manufacturing standard and Particular Specifications

7.0 Maintenance Management:

1. Provision of Defect Liability Period of twenty-four months (24) from the date of Operational Acceptance (taking over) shall be included in the Contract. DLP shall include Corrective/Preventive/Scheduled Maintenance of all the items. Price of DLP shall be full compensation for the maintenance by the Contractor staff including supply of spares as per DLP and all maintenance tools/tackles plants and equipment's supplied under the contract in accordance with the specifications during Defect Liability Period.

2. There shall also be a provision of Comprehensive Annual Maintenance for 3/ 5 years beyond 2 years of DLP for complete system with the same scope as mentioned for maintenance in DLP period.

3. Further Comprehensive Annual Maintenance for 7 years beyond 2 years DLP & 3 years CAMC with the same scope as mentioned for Maintenance in DLP for the following items shall be included in the contract:

   (a) UPS along with associated panels/accessories supplied by UPS manufacturer.

   (b) Air Cooled Screw and Scroll Chillers.

   (c) Complete BMS at Station and OCC level.

However, the items and time frame for CAMC provisions may be decided by the respective metro, based on their assessment.

8.0 Equipment Identified for Standardization

Ratings of some of the major items are enlisted for standardization. However, the capacities are indicative and may vary as per specific design conditions of individual Metro.

UPS -

Elevated (for E&M and S&T loads)

30 KVA (for Non interlocking)

60 KVA (for Interlocking stations)

Underground (for E&M and S&T loads)

80 KVA units

Depot - 60 KVA

DG Sets -

Elevated – 125 KVA / 160 KVA / 180 KVA

Underground - 380 KVA

Depot - 500 KVA

Transformer

Elevated – 315 KVA / 500 KVA (based on load requirement)

Underground –

2000 KVA (for typical UG station)

2500 KVA (for UG station with cross over /portal/interchange)

Chiller

Air Cooled/Water Cooled – 150 TR / 200 TR / 250 TR / 300 TR for UG stations. Nos. and size selection to be based on Ambient conditions, ridership, train headway and station size.

Air Cooled - 40 TR (with twin compressor) – for night operation

Lifts:

- Capacity: 13/20 passengers, as per ridership
- Operating Speed: 1.0 m/s

Escalators:

- Operating Speed: 0.5 & 0.65 m/s
- Step width: 1000 mm

Annexure-I

SOLAR ENERGY PHILOSOPHY IN METRO

Metrorail systems use electrical energy extensively. To reduce carbon footprint, harnessing of Solar Energy to meet energy requirements should be explored, based on difference in grid tariff and solar tariff. In a typical metro system, SPV plants can be installed on **Station roofs, Depot roofs/sheds, Office buildings, Parking areas, Sub-station buildings and Staff quarters** etc.

Since, most of the metro systems are capital intensive and being developed through loans from developmental banks of various countries, viz. JICA, AFD, ADB, KfW etc, Solar plants should be put on **RESCO model** (Preferably) where the complete capital cost for installing the plant will be borne by the Solar developer, the metro system shall provide only the rooftops for installation and will purchase the energy generated by the plant at the rates finalized through open tendering process.

The subsidy / central financial assistance being provided by MNRE, Govt. of India from time to time, should be availed.

- For MNRE assistance, solar plants should use solar panels made in India,
- Life of system must be specified as 25 years as per MNRE guidelines.
- Solar modules should be free from Potential Induced Degradation (PID) as per IEC 62804.

To promote deployment of solar plants, following actions may be taken: -

- Electrical panels shall have provision to connect solar power.
- During construction of roofs / sheds following features may be included to develop "solar ready" roofs: -
- Life line/Walkways, Ladders for roof access, Cable trays and "Clip lock" type of roof sheets. Location for placement of Solar Inverters, ACDB to be planned at station design stage.
- Standard maintenance checklist for module cleaning, tightening of all electrical and mechanical connections, regular monitoring of wear and tear of equipment etc. to be included in Solar Tender.
- Non penetrative type solar installation method (Using adhesive) may be adopted.

While commissioning the solar plant, following may be taken care of:

- Power Factor (PF) of solar system to be set in accordance with the load profile of the connected system, so that the overall PF is within DISCOM permissible limits.
- Net metering may be registered with the concerned DISCOM as per local guidelines,
- Uni-directional meter of existing system to be replaced by a bi-directional meter, where ever necessary.
- During Installation of Solar plants, it should be ensured that positive and Negative DC cables are laid in separate cable tray / Raceway / GI Conduit to avoid any short circuit between them.
- Standard maintenance checklist for module cleaning, tightening of all electrical and mechanical connections, regular monitoring of wear and tear of equipment etc. to be included in Solar Tender.
- Solar Project may be got registered with UNFCC (United Nations Framework Convention on Climate Change) to avail the benefits of CDM (Clean Development Mechanism).

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Annexure-II

ADDITIONAL RECOMMENDATIONS ON COST REDUCTION / INNOVATIVE MEASURES

- **Identification of Indian Standard Codes, wherever not available and development of roadmap for development of the same in consultation with the industry:**

  Equivalent Indian Standards for such items which are being imported need to be developed. An indicative list of standards needing standardization is placed at Appendix-1.

  Testing standards to be developed in India which will be applicable for all uniformly. The testing facilities/accredited labs are to be made available in India based on Indian standards.

  NBC in line with the latest NFPA-130 and other relevant international standards should be developed according to the requirement of underground and elevated sections so that entire station can be designed as per NBC only.

  Bureau of Indian Standards (BIS), the National Standards Body of India may be given the responsibility of developing the relevant Indian Standards in line with the international standards being followed by Metros.

- **Institutional framework for driving innovation and solving technical issues**

  MoHUA can setup a dedicated department with experienced manpower from different metros for driving innovation and solving technical issues and to look after the progress of standardization and indigenization of the Electrical and Mechanical equipment for Metros.

  i - Metro is another platform which can be leveraged for the purpose.

- **Opportunities for design optimization to reduce energy consumption**

  Provision of full height PSD to achieve design optimization in sizing of ECS equipment and to reduce energy consumption.

  Use of LED lighting for all Metros installations.

  Use of Occupancy Sensors for Emergency Lighting Control for Manned Rooms and Door Switches for Equipment Rooms.

  Use of VFDs with various ECS/TVS loads, lift, escalators etc. to optimize energy consumption.

  Use of CO2 sensor based fresh air fan control for optimizing intake of fresh air leading to reduced heat load in summer months and reduced air conditioning requirements.

  Use of EC plug fan motors in AHUs to optimize energy consumption.

- **Optimum utilization of assets leveraging infrastructure/ facilities across Metro Rail Corporations**

  DMRC/ BMRCL has a state of art academy for meeting the training needs of Metro personnel across all Metros in the country. Thus, training infrastructure of DMRC/BMRCL may be leveraged for meeting the training needs across Metro Rail Corporations.

- **Development of modular and leaner design of sub-systems without compromising augmentation as and when the ridership goes up**

Installation of Chiller and associated high side equipment can be done considering traffic projections of only next 10 years with the space provision for augmentation of the system later on when the ridership goes up.

- **Life Cycle Cost Optimization - Procurement on life-cycle costs — bundling of maintenance with procurement — maintenance philosophy**

  Life Cycle Cost Optimization and procurement on life cycle costs is needed for the design of the following systems:

  a. Air Cooled vs. Water Cooled Chillers

  b. Station Air conditioning with full height PSD vs. half height PED.

  c. Induction of any new technology should be evaluated based on life cycle cost analysis.

  d. Bundling of maintenance with procurement may be done for various systems like light fixtures, battery, clean agent-based fire suppression system for a period of 5 years from ROD.

  e. Provision of 3/ 5 years CAMC beyond 2 years DLP may be made for all E&M/ECS & TVS systems.

  f. Long term AMC of around 7/10 years for certain items/systems like Chillers, UPS, BMS can also be made along with procurement for a long term CAMC of critical items.

- **Integration between sub-systems**

  Integration of E&M and signaling loads in the UPS is a feasible option and has already been implemented in various metro projects.

- **Measures to reduce cost of MEP subsystem**

  Optimizing the air-conditioning load requirements of UG Stations by deployment of full height PSDs at platform level.

  Reduction in sizing of DG sets for UG Stations provided two independent and reliable sources of Main power are available to run the Metro systems at Stations.

  In case of Elevated station dispensing with DG Set can be considered, provided two independent and reliable sources of Main power are available to run the Metro systems at stations as per NBC.

  Merging of UPS, for E&M and S&T would lead to overall reduction of cost on account of UPS & battery as well as space requirement.

  As an alternate option, provision of Aluminum conductor Cables instead of copper conductor cables for all non-FS cables of size 16 sqmm and above. For cables of sizes 10 sqmm and below, use of copper conductor cables can continue.

  Removal of tie-feeder between main switchboards of UG stations has already led to cost reduction in cables.

  Necessity of the requirements of Fire pumps in elevated station need to be reviewed, accordingly, NBC and other relevant standards would require updation.

- **To reduce the space requirement associated civil structure and other system**

  Optimizing space planning of public areas e.g. removal of concourse from non-interchange stations can

further reduce equipment sizing of HVAC Systems apart from reduction of other system requirement. Station design should evaluate the necessity of concourse.

- **To suggest measures to promote generation/use of renewable energy**

  Installation of Solar panels above the via duct on elevated stretches can offer great potential for solar power generation. Further, rooftop solar at elevated stations, depots and other buildings are other options to promote generation of solar power.

- **To suggest appropriate energy efficient design in civil/systems like natural lighting and ventilation**

  Interconnection / Interchange of under-ground and elevated station area may be provided with natural lighting and ventilation or if required, High Volume Low Speed large fans may be used in place of conventional air-conditioning.

- **To suggest incorporation of Green Building, energy conservation norms in the equipment specification**

  The Specifications being used in the Metro sector are already comparable with the best industrial practices. Already metro stations are being certified by IGBC as Green buildings. Further, obtaining green building certification can be kept as an essential requirement in DPR.

- **To revisit Maintenance philosophy requirements- Schedules, least cost maintenance with minimum human intervention.**

  Maintenance philosophy may be integrated with BMS system in underground as well as in Elevated stations to optimize the maintenance schedule. Integration of maintenance with the BMS system reduces the manpower and helps in the Life cycle cost optimization.

Annexure-III

ROAD MAP FOR PROMOTING INDIGENIZATION FOR ELECTRICAL ITEMS: METRO RAILWAYS

[Ref: Public procurement (Preference to Make in India) Order 2017 issued by DIPP dtd 15.06.17 and circulated by MoHUA vide letter K-14011/09/2014/UT-II/MRTS-Coord dated 12th July 2017.]

Sl. No.	Package	Status of Indigenization (Local content: % of Contract cost)	Remarks
1.	**Electrical & Mechanical Systems**	**Local content is already >90%**	Most of the E & M items (Cables / DG sets/ light-fittings/ panels/ UPS/ Fire-fighting items) are being manufactured locally in India.
2.	**Lifts and Escalators**		
	a. Lifts	**Local content is already >60%**	**3 Firms (Johnson/OTIS/KONE) are already having manufacturing units in India.** **Further indigenization:** Items like Motors/ Guide rails, buttons are imported & can be indigenized gradually in future contracts. The OSG, Safety Gear, Suspension rope, stainless steels sheets, limit switches etc. are already indigenized.
	b. Escalators	Heavy-duty Escalators are started to be manufactured in India. **Local content is around 20 to 30%.**	Firms like Johnson have already set up their factory in India and have started Heavy duty Escalators. The Escalator Truss, V3F drive, Cables, skirts, balustrade, cladding, lubrication system are already indigenized. The step chain, drive chain, rollers, step, handrail drive system etc. can be indigenized gradually.
3.	**TVS and ECS**	**Local content > 60% is already there** by tendering TVS & ECS as one contract.	Most of the ECS items (Chillers, AHUs, Fans, Pumps Ducting, piping and accessories etc.) are being manufactured locally in India. However, TVS items like Tunnel Fans and Tunnel Dampers are still being imported. **Indigenization Plan:** Indigenization of these TVS items can also be gradually achieved in phased manner to achieve the local content of more than 80% for complete ECS, TVS and BMS contract by 2025.

	a. ECS	**Local content is already > 80%**	Many reputed companies (Daikin/ Blue Star/ Voltas /Kirloskar/ Carrier/ Climaventa/ Systemair/ Waves etc.) already have their plants in India and manufacturing majority of the components of the ECS systems.
	b. TVS	**Presently most items** (TVF/TEF/Booster fans/Dampers etc.) **are imported.**	Many International Manufacturers of Fans (Witt n Sohn, Flaktwood, Systemair, Zitron etc.) and manufacturers of Tunnel Ventilation Dampers (Ruskin, Greenheck) have their subsidiary in India and they have their plans for setting up manufacturing for Tunnel Ventilation Fans and Dampers. In addition, local Indian Manufactures also have the capabilities to manufacturer Tunnel Ventilation Fans and Dampers. **Indigenization of the TVS equipment can be gradually achieved in phased manner and to promote the indigenization of TVS equipment following can be considered by metro authorities for future contracts-** a. Manufacturer's to be allowed with type test certificate of their parent company to be used based on undertaking of quality of material from the parent company. b. The experience requirement for Indian subsidiary to be relaxed with provision of extended warranty in lieu of experience. c. Foreign manufacturer's to be encouraged to manufacture/ assemble 75% of the total requirement in India.

Appendix-1

Indicative List of Standards needing Standardization

S. No.	Name of Item(s)	Name of Main System where concerned Item is used	Relevant International Standards
1	Air Handling Units	Underground ECS	1. EN 1886 (Ventilations for buildings-AHU units-Mechanical Performance), 2. AHRI 1350 (Mechanical Performance Rating of Central Station Air Handling Units), 3. EN 13053 (Ventilation for buildings. Air handling units. Rating and performance for units, components and sections), 4. AHRI 410 (Forced-Circulation Air-Heating and Air-Cooling Coils), 5. AMCA 210 (Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating),
2	ECS/HVAC Pumps	Underground ECS	1. HI 1.6 (Centrifugal Pump Tests), 2. ISO- 9906 (Rotodynamic pumps — Hydraulic performance acceptance tests — Grades 1, 2 and 3)
3	Axial Fan	Underground ECS	1. AMCA-210 (Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating), 2. ISO 5801 (Fans — Performance testing using standardized airways)
4	Air Cooled Chillers	Underground ECS	1. AHRI 550/590 (PERFORMANCE RATING OF WATER-CHILLING AND HEAT PUMP WATER-HEATING PACKAGES USING THE VAPOR COMPRESSION CYCLE) 2. EN 14511 (Test methods and standards for air conditioners, liquid chilling packages and heat pumps)
5	TVS-FAN	Underground TVS	1. AMCA-210 (Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating), 2. ISO 5801 (Fans — Performance testing using standardized airways) 3. EN12101-3 (Smoke and heat control systems)

6	TBF	Underground TVS	1. ISO 13350 (Fans — Performance testing of jet fans) 2. AMCA 250: Laboratory Methods of Testing Jet Fans for Performance
7	BMS - Controller	Underground BMS	SIL-2 as per EN-50128 (Railway applications. Communication, signalling and processing systems. Software for railway control and protection systems)
8	LV Panels and Distribution Board	Underground Electrical system	1. IEC 61439(Low voltage switchgear and control gear assemblies) 2. IEC 60947(Low voltage switchgear and control gear).
9	Cables and Wires	Underground Electrical system	1. BS 6724(Thermosetting insulated, armoured cables of rated voltages of 600/1 000 V for fixed installations, having low emission of smoke and corrosive gases when affected by fire), 2. BS 7846(Electric cables – Thermosetting insulated, armoured, fire-resistant cables of rated voltage 600/1 000 V for fixed installations, having low emission of smoke and corrosive gases when affected by fire), 3. BS 50525-3-41(Low voltage energy cables of rated voltages up to and including 450/750 V (U0/U) Part 3-41: Cables with special fire performance - Single core non-sheathed cables with halogen-free crosslinked insulation, and low emission of smoke), 4. BS 6387(Test method for resistance to fire of cables required to maintain circuit integrity under fire conditions) 5. BS 7671- Requirement of Electrical installations.
10	UPS	Underground Electrical system	1. IEC 62040(Uninterruptible power systems (UPS) 2. EN 62040(Uninterruptible power systems (UPS) General and safety requirements for UPS),

11	Battery (NiCd) for UPS	Underground Electrical system	1. IEC 60623(Secondary cells and batteries containing alkaline or other non-acid electrolytes – Vented nickel-cadmium prismatic rechargeable single cells) 2. IS 10918(SPECIFICATION FOR VENTED TYPE NICKEL CADMIUM BATTERIES)
12	LED Light Fixture	Underground Electrical system	1. IEC 60598(General requirements of Luminaires), 2. IEC 61347-2-13(Particular Requirements for D.C. Or A.C. Supplied Electronic Control gear for LED Modules), 3. LM 79(Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products.)
13	Bus Duct	Underground Electrical system	IEC-61439-1 & 6 Low-voltage switchgear and control gear assemblies – Part 1: General rules Part 6: Busbar Trunking Systems (Busways)
14	Clean agent based Fire Suppression System for Transformer and Panels	Underground Electrical system	NFPA 2001(Standard on Clean Agent Fire Extinguishing Systems)
15	Fire Alarm System	Underground Fire alarm system	UL approved, NFPA-72 (National Fire Alarm and Signaling Code),
16	Motor for Plumbing and Fire service and other equipment	Underground Fire Fighting Plumbing system	IEC 60034 (International Electrotechnical Commission for rotating electrical machinery)
17	Pumps for Fire Fighting and Plumbing	Underground Fire Fighting Plumbing system	1. BS EN ISO 9906(Rotodynamic pumps. Hydraulic performance acceptance tests. Grades 1, 2 and 3), 2. NFPA 20(Standard for the Installation of Stationary Pumps for Fire Protection) and other relevant BS

18	DG Set	Underground Electrical system	1. BS 5514(Reciprocating internal combustion engines: performance), 2. BS 649 (THE PERFORMANCE OF RECIPROCATING COMPRESSION IGNITION (DIESEL) ENGINES, UTILIZING LIQUID FUEL ONLY, FOR GENERAL PURPOSES), 3. ISO 8528 (Reciprocating internal combustion engine driven alternating current generating sets) and other relevant BS complying latest CPCB norms
19	ECS Attenuator	Underground ECS	1. ASTM E-84 (Surface Burning Characteristics of Building Materials), 2. UL no. 723 (TEST FOR SURFACE BURNING CHARACTERISTICS OF BUILDING MATERIALS" AND FLAMMABILITY RATING).
20	TVS Attenuator	Underground TVS	1. BS EN ISO 7235 (Acoustics. Laboratory measurement procedures for ducted silencers and air-terminal units. Insertion loss, flow noise and total pressure loss), 2. BS 476 (Fire tests on building materials and structures), 3. ASTM E84 (Surface Burning Characteristics of Building Materials)
21	ECS VFD	Underground ECS	1. VFD UL 508c (Adjustable Speed Electrical Power Drive Systems), 2. IEC61800 (Adjustable speed electrical power drive systems) and Harmonics control as per IEEE 51
22	ECS/TVS Fire Duct	Underground ECS/TVS	1. BS 476 Part 24 (Fire tests on building materials and structures. Method for determination of the fire resistance of ventilation ducts) 2. ISO 6944 (fire resistance of vertical and horizontal ventilation ducts under standardized fire conditions).

23	Fire Dampers (MFD/FLFD/FMD)	Under ground ECS	1. UL 555S (Standard for Safety Smoke Dampers) 2. AMCA 500 (Laboratory Methods of Testing Louvers for Rating)
24	TVS Damper	Under ground TVS	1. AMCA 500 (Laboratory Methods of Testing Louvers for Rating) 2. AMCA 510 (Methods of Testing Heavy Duty Dampers for Rating)

List of Abbreviations:

ACB	Air Circuit Breaker
BS	British Standard
DLP	Defects Liability Period
E&M	Electrical & Mechanical
ECS	Environmental Control System
EMC	Electromagnetic Compatibility
EMU	Electric Multiple Unit
EN	Euro-Norm (European Standards)
FAT	Factory Acceptance Test(s)
GIS	Gas Insulated Switchgear
GS	General Specification (this document)
HV	High Voltage
IEC	International Electro-Technical Commission
IP	Ingress Protection
IS	Indian Standards
ISO	International Standards Organization
IoT	Internet of Things
NBC	National Building Code
NFPA	National Fire Protection Association
OCC	Operations Control Centre
OCS	Overhead Contact System (Rigid Conductor)
OHE	Overhead Equipment
PLC	Programmable Logic Controller
RAMS	Reliability, Availability, Maintainability and Safety
RESCO	Renewable Energy Service Company
RMU	Ring Main Unit
RTU	Remote Terminal Unit
SAT	Systems Acceptance Test(s)
SIL	Safety Integrity Level
SRS	System Requirement Specification
TVS	Tunnel Ventilation System
UG	Under Ground

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