STANDARDIZATION/INDIGENIZATION OF

ELECTRICAL
&
ELECTROMECHANICAL

METRO RAIL COMPONENTS

August 2018

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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 traveler 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 handicapped passengers in the stations at all times besides adding value to other systems by real time interface.

Electrical systems consist of mainly following four different streams:

1. **Power Supply & Traction (PST) system (25 kV AC & 750 V DC)**
2. **Electrical & Mechanical (E&M) system (Underground/Elevated)**
3. **Lifts**
4. **Escalators**
5. **Tunnel ventilation & Environmental control system (TVS & ECS)**

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. 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. EQUIPMENTS STANDARDIZATION/INDIGENIZATION:

1.0 Power Supply & Traction System (PST):

Mainly two types of Traction systems are being used for Metro systems in India/abroad. Selection of type of Traction system is decided by Metro based on their ridership/future traffic projection/cost etc criteria. Broadly, following systems are followed in Indian/International metros:

Type of Metro	PHPDT	Traction System (Desirable)
Light (LRT)	< 30000	750 V DC Third Rail, 25 kV AC, OCS
Medium	30000 - 45000	750 V DC Third Rail, 25 kV AC, OCS
Heavy	45000 - 75000	25 kV AC, OCS

i.	25 kV AC Traction (ROCS/FOCS)	In this system, Flexible Overhead conductor system (FOCS) is used for Elevated & at Grade section while Rigid Overhead Conductor System (ROCS) is used in Underground section accommodatable to tunnel bore diameter.
ii	750 V DC Third Rail Traction	In this system, 'Third rail system' is used for Traction for elevated, at grade and underground section.

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

1.0.1 For Elevated sections/ROCS system:

Key Item	DMRC	LMRC	Nagpur
Contact wire	150 sq.mm.	150 sq.mm.	150 sq.mm.
Messenger wire	65 sq.mm.	65 sq.mm.	65 sq.mm.
Auxiliary Main Transformer	35/45 MVA	30 MVA	10 MVA
Traction Transformer	15-30 MVA & 40/50 MVA	30 MVA	15 MVA
33 kV cable	300 sq.mm, XLPE, Al	400 sq.mm, XLPE, Al	240 sq.mm, XLPE, Al
25 kV cable	240 sq.mm, XLPE, cu	240 sq.mm, XLPE, cu	240 sq.mm, XLPE, cu
ATD type*	5 pulley, Gas type and spring type	5 pulley, spring type	5 pulley, spring type

***3 pulley is also used in Metro System**.

1.0.2 **For Underground sections/ROCS system**:

Key Item	DMRC	CMRL	MMRC
Al conductor Rail	2220 sq.mm.	2200 sq.mm.	2200 sq.mm.
Auxiliary Main Transformer	35/45 MVA	32/45 MVA	32/45 MVA
Traction Transformer	40/50 MVA	30/42 MVA	30/42 MVA
33 kV cable	400 sq.mm, XLPE, Cu	400 sq.mm, XLPE, Cu	400 sq.mm, XLPE, Cu
25 kV cable	240 sq.mm, XLPE, Cu	240 sq.mm, XLPE, Cu	240 sq.mm, XLPE, Cu

1.0.3 **For 750V DC Third Rail system:**

Key Item	KMRL	BMRCL
Power Transformer	2 x 20/25 MVA	2 x 20/25 MVA (in 66KV RSS) 2 x 50MVA & 2 x 75MVA (in 220KV RSS)
33 kV Cable	3 x 240 sq.mm, XLPE, Copper, Single Core	3R x (1C x 240sq.mm) XLPE Copper (FRLS - Elevated, FRLSOH - UG)
33kV Switchgear	Vacuum Circuit Breaker 1250A	Vacuum Circuit Breaker (1250A)
Auxiliary Transformer	2 x 500/630KVA elevated 2x x2500 KVA Depot	2 x 200kVA in RSS 2 x 500KVA in Elevated 2 x 2000KVA in Depot 2 x 2000KVA in UG 2 x 500KVA in OCC
Traction Transformer	2 x 2600 KVA	2 x 2850kVA (in all traction substation)

Key Item	KMRL	BMRCL
Rectifier Set	2 x 2500 KW	2 x 2500KW (in all traction substation)
Third Rail	Bottom Collection, 4500 A DC	Bottom Collection 4500A DC
750 V DC Positive Cable (3.3kV Grade)	6 x 400 sq.mm	6 x 400sq.mm (Ph-I) 8 X 300sqmm (Ph-II)
750 V DC Negative/Return Cable (1.1kV Grade)	6 x 400 sq.mm	6 x 400sq.mm (Ph-I) 8 X 300sqmm (Ph-II)
Sectioning Device	Insulated Joint	Insulated Joint
Structure Earth Conductor		200sqmm Cu BEC/ 346 sqmm AAAC BEC(Ph-1) 185 sqmm AAAC BEC(Ph-2)

1.1 **25 kV AC Traction (ROCS/FOCS):**

System shall be designed in conformity to CEA Safety Regulations (Amendment), 2018. (Draft published by CEA).

1.1.1 **Receiving Sub-Stations (RSS):**

i. Area Requirements: - Typical area requirement for a Metro RSS shall be limited to 4000 Sq. meters. However, compact RSS of 2200 mt2 size is feasible by adopting complete GIS technology for use in places having space constraints.

ii. The equipment should preferably be Gas insulated (GIS) to have space saving and near zero maintenance. However, it can be Air Insulated (AIS) or Hybrid type depending on availability of space/cost limitation.

iii. Use of Static Frequency Convertors (SFC) may be explored for limiting the effects of harmonic distortion, control of reactive power, elimination of Neutral Section etc.

iv. The earthing of RSS shall be with copper conductor complying with International Standard IEEE80. For connection of OHE return cable from viaduct, buried copper flats, with exothermic welded joints shall be used.

v. Traction Transformers: - The capacity of Traction transformer shall be 40/50 MVA for PHPDT greater than 45000 and 30 MVA in other cases. After discussion, it was decided that Tractions Transformers shall be generally designed for 15/25 MVA for 3-6 coach Metros and 30/42 or 40/50 MVA for 8-9 coach Metros.

vi. Auxiliary Main Transformers: - The capacity of Auxiliary Main Transformer shall be 15 MVA for sections having only elevated stations and 35/45 MVA is being used in DMRC and 32/45 MVA in CMRL & MMRC.

vii. HT Cables: Single core XLPE cables in trefoil arrangement shall be used.

viii. SCADA:

- Substation Automation Station (SAS) shall comply to IEC 61850.
- Traction SCADA system shall comply to IEC 60870-5-104 and complete SCADA network shall be on dedicated Fibre Optic (dual).
- The control and monitoring of the RSS shall be so designed to make it suitable for unmanned working with online control/monitoring from OCC as being followed in IR.
- "Communication scheme of SCADA system between remote terminal unit (RTU) & remote control center (RCC), between RTU and IEDs/Electrical equipment's at switching post, Architecture of RTU of Metro SCADA may be included".

1.1.2 **25 KV Flexible OHE System (Elevated Sections)**:

i.	**Cantilever Assembly)**	Modular design Aluminum Cantilever assembly shall preferably be adopted. The design can be double insulator (stay and bracket) type or single insulator type. Single Insulator Cantilever Assembly may also be studied and single insulator cantilever assembly design may be incorporated only for very limited trial.
ii.	**Contact Wire**	Material of contact wire and its sized is governed by power requirements. Therefore, from various Metro Experience, CuAg is recommended. Silver copper contact wire (CuAg 0.1) conforming to EN50149 of 150 sq mm (Preferable) or 107 sq mm cross-section shall be used based on load requirement.
iii	**Catenary Wire**	Copper Magnesium alloy, Catenary wire (CuMg 0.5) conforming to DIN 48201 of 95 sq mm (Preferable) or 65 sq mm cross section shall be used depending upon system requirement.
iv	**Booster Transformer**	Provision of Booster Transformers is to be avoided to the extent possible. If DOT survey requires provision of Booster Transformers based on EMI/EMC study, Booster Transformers of appropriate ratings to be provided.
v.	**Insulators**	All insulators e.g. stay insulator, bracket insulator, pedestal insulator, Tie-rod insulator (used for isolator), sectioning insulator to be of composite material complying to relevant standards. The creepage distance depending on pollution level, prevalent in the city, should be decided based on IEC 60815/ IS 13134.
vi.	**Earth Conductors**	Return Conductor (RC), Over-Head Protection Cable (OPC), Buried Earth Conductor (BEC) shall be used for earthing and bonding on viaduct. Sizes shall be determined from EMI/EMC study.
vii.	**Neutral**	Polytetra-fluoro-ethylene (PTFE) insulated, Short

	Section	Neutral Section (SNS) shall be used.
viii	**Power Cables (25kV)**	Single core copper cable of 240 sq mm size shall be used for 25kV feeders.
ix.	**Circuit Breaker/ Interrupters**	Vacuum type CBs/Interrupters, with appropriate ratings based on loading of the system, to be utilised.
x	**Tubular Pole**	As far as practicable tubular pole (not of concrete*) type mast instead of B-series mast to suit urban landscape and to avoid bird nesting may be adopted. Note: *Concrete Tubular Poles were tried in Indian Railway and were discontinued with limited trial due to poor feedback.

1.1.3 **25 KV Rigid OCS (For UG Tunnels):**

i.	**Aluminium Conductor Rail**	Aluminium Conductor Rail of suitable cross-section and complying to relevant standards.
ii.	**Static and dynamic clearances**	All static and dynamic clearances should comply with IEC-60913 latest version
iii	**Contact Wire:**	Silver copper contact wire (CuAg 0.1) conforming to EN50149 of 150 sq mm or 107 sq mm cross-section shall be used based on load requirement.
iv	**Switching Sub-Stations**	All switching posts (SS, SSP, SP) should be of GIS type.
v.	**Neutral Sections**	Overlap type neutral section shall be provided in underground sections.
vi.	**Insulated overlaps**	Preferably an Insulated overlap near (SSP/SS) transition locations (UG and Elevated) shall be provided in underground section to isolate underground and elevated OHE.
vii.	**Lightening arrestors**	Lightening arrestors of 42 kV shall be provided at transition locations (all tunnel faces). Dedicated Earth Pit for each LA to be provided.
viii	**Earthing Conductors**	Return conductor, Overhead Protection Cable, Tunnel Earth wire/Arial Earth wire shall be used for earthing and bonding in underground sections. Sizes shall be determined from EMI/EMC study.

1.1.4 **33 KV Auxiliary System:**

i.	**33Kv HT Breakers**	Gas Insulated Switchgears (GIS), conforming to IEC 62271/equivalent IS may be used.
ii.	**Dry Type Transformer**	Dry type transformers conforming to IEC 60076-11 to be utilised.
iii	**Power cable (33kV)**	• For 33kV system, 300 sq mm Aluminium cable will be used for exclusively Elevated/ At Grade section. • For system with Elevated and Underground both, 400 sq mm copper cable shall be used. • For U.G stations, cables with Halogen Free FRLS outer sheath, XLPE insulated type to be used. For, elevated stations, FRLS type XLPE insulated cables to be used
iv	**Earthing System**	Earthing system design shall conform to IEEE 80 and IS 3043.

1.1.5 **Retractable Overhead Conductor Rail System:**

Retractable Conductor Rail System to be preferred for use in Depot Inspection Bay lines with crane operation to facilitate ease of maintenance of Rolling Stock.

1.2 **750 V DC Traction System (With Third Rail):**

System shall be designed in conformity to CEA Safety Regulations (Amendment) 2017. (Draft published by CEA)

1.2.1 **Receiving Sub-Stations (RSS)**

i. Area Requirements: The Switchyard layout has to be made considering the minimum clearances as per the applicable standard laid down in IEC: 6193-1.

ii. The equipment should preferably be Gas insulated (GIS) to have space saving and near zero maintenance. However, it can be Air Insulated (AIS) or Hybrid type depending on availability of space/cost limitation.

iii. The Earthing of RSS shall be complying with International Standard IEEE80.

iv. To neutralize the induced voltages, cable sheath cross bonding conforming to IEC 60287 shall be provided for UG EHT cables.

v. Redundant sources shall be taken from Power supply authority at all terminal stations one working as priority and other hot standby with Bus coupler arrangement on HV side.

vi. Power Transformer: Two Transformers are provided in each RSS conforming to IEC 60076 in parallel configuration and each capable of meeting the connected Auxiliary & Traction Loads. The Capacity of the Power Transformer

shall be 20/25MVA for 66kV Incomer and 50 or75 MVA for 220kV Incomer which is being used in BMRCL.

1.2.2 **33KV Distribution:**

i.	**33Kv HT Breakers**	1250 A, Vacuum type Circuit Breaker, conforming to IEC 60694 to be used.
ii.	**33kV HT Interrupters**	1250 A, Vacuum type Interrupters conforming to IEC 62271 to be used for Loop-in-Loop-out of ASS ring main.
iii	**Dry Type Transformer**	Dry type transformers conforming to IEC 60076-11 to be utilized.
iv	**Power cable (33kV)**	For 33kV system, 240 sq mm Copper cable XLPE, FRLS to be used exclusively for Elevated/ At Grade Underground section and for U.G stations, Halogen Free FRLS to be used. Power cables conforming to IEC 60502 to be used.
v.	**33kV Distribution**	Distribution to various traction substations as well as Auxiliary substations located in Elevated/Underground stations, by means of a 33kV Ring main network having 4 circuits, using FRLS/FRLSOH cables of suitable cross-sectional area, in trefoil formation, two each for Traction Substation (TSS) and Auxiliary Substation (ASS).
vi	**33kV network**	33kV network inter connection shall be made for Auto transfer of traction power from one Reach to another in emergency situations in case of power failure of any RSS.
vii.	**Earthing system**	Earthing system design shall conform to IEEE 80 and IS 3043.

1.2.3 **Auxiliary Sub-Stations (ASS)**

1) All Auxiliary substations shall be provided with 33KV/415 V dry type transformers of required rating in redundant configuration conforming to IEC 60076-11 shall be used at RSS, depot, elevated/underground stations and OCC to meet auxiliary requirement.
2) Capacity of auxiliary transformers being used by BMRCL for various locations are as under:

Location	**Capacity**
Receiving Substations	2x200 KVA
Depot	2x2000 KVA
Elevated/at Grade Stations	2x500 KVA
Underground Stations	2x2000 KVA
Operation Control Centre	2x500 KVA

1.2.4 **Traction Sub-Stations (TSS)**

1) Each Traction Substation receiving power at 33kV from the 33kV ring feeder. The distance between adjacent TSSs is maintained as per the calculation of voltage drops during system study.
2) The feeding to TSSs is to be with close ring system-i.e. from the respective RSS two 33kV feeders to feed alternate TSSs. This arrangement of TSS feeding ensures that tripping of any breaker due to cable fault will not put any of the TSSs out of service.
3) Every TSS shall be provided with Two Switchgear feeders, for loop-in–loop-out of 33kV ring main feeder, which provides power to 33kV busbar. Rectifier/Traction transformers are to be fed from this busbar.
4) Three Winding (Delta-Star-Delta) Dry Type Traction Transformers of capacity 2850/2600 KVA conforming to IEC 60076-11 shall be provided.
5) Rectifiers: - 12 pulse or better with harmonics limits shall be used. The duty shall be class-VI as per IEC 60146-1-1 or any other equivalent standard as adopted
6) The 750V DC is fed to the third rail system through high-speed circuit breaker (HSCBs) conforming to IEC 61992 and disconnecting switches are incorporated for sectionalizing the third rail as per the operational requirements.
7) DC disconnector shall be provided in DC breakers for better maintainability.
8) OVPD, over voltage protection device shall be used to prevent higher voltage of running rail to ensure passenger safety as per EN 50122-1 or any other equivalent standard as adopted.
9) Provision of reversible substation for maximum regenerative energy recovery may be explored.
10) Dry type transformers for traction supply to be used shall be duty cycle class-VI as per EN 50329 in line with the Rectifiers duty class.

1.2.5 **Third Rail**

1) The conductor rails shall be manufactured in standard lengths (generally in 15 mtrs length pieces) considering ease of transportation and installations, which are joined together by special splice joints.
2) The conductor rail shall be manufactured of a high conductivity aluminium alloy body designed for the required nominal current and utilized with a stainless steel wearing face. The stainless steel shall be joined to the aluminum body by a molecular / co-extrusion process or by an alternate proven design meeting the specified requirements and parameters. The stainless-steel strip of required thickness shall have flat surface without milling groove. No welding in the cantilever of conductor rail head shall be permitted and it should be of minimum design life of 30 years.
3) The process used for the composition of conductor rail shall preferably ensure no gaps remain between the head of the aluminium section and the stainless steel wearing strip. Conductor rail is intended to be used up to complete worn-out of stainless steel without any delamination of the remaining stainless-steel strip.
4) Third Rail components: - Must be of proven type, and type tested.

1.2.6 **Stray Current, Earthing and safety**

1) Stray Current mitigation measures as per EN 50122-2 shall be provided. This includes insulation of track plinth at the base and insulation of shear connectors, insulation of running rails, use of track fitting suitable for DC system, short circuit devices (SCD), stray current cable, Stray current monitoring system (SCMS) as per design.
2) The track fitting used in the case shall be specifically designed for the DC system, which shall ensure floating rails with higher electrical insulation (The insulation shall be preferably more than 100 Ω.KM, or conductance of 0.01 Siemens/KM per track) which will prevent passage of stray current corrosion.
3) Platform up to a length of 2 meters shall be insulated to keep control over the step potential to ensure safety of passengers.
4) Structure Earth conductor shall be preferably Aluminium (AAAC) bare conductor and connected to pier and viaduct segment earth connections. Size of conductor shall be based on detailed design.
5) Rail and track bonding shall be made at frequent intervals for keeping the voltage drop at low levels.
6) Safety provisions as per NFPA 130/NBC-2017 (latest), including the provisioning of Automatic Gas flooding inside the Panels and Emergency Tripping System (ETS) at different locations shall be followed.

1.2.7 **SCADA**

1) Substation Automation Station (SAS) shall comply to IEC 61850.
2) All IEDs shall have redundancy in communication.
3) Thermal parameters of all transformers shall be interfaced with SCADA.
4) Traction SCADA system shall comply with IEC 60870-5-104 and/or IEC 61850 or any other equivalent standard as adopted and complete SCADA network shall be on dedicated Fibre Optic (dual). All electrical parameters shall be communicated to SCADA by digital link.
5) The control and monitoring of the ASS, TSS, RSS shall be so designed to make it suitable for unmanned working with online control/monitoring from OCC as being followed in IR.

1.2.8 **Protection philosophy**

The aim of the protection system is to provide protection in the event of fault conditions and abnormal operating conditions. The major objectives of the protection systems are:

- To isolate the affected portion as quickly and as expeditiously as possible while maintaining normal supply to the rest.
- To provide auto-reclosure circuits wherever applicable to minimize the duration and extent of power supply outage.
- To provide alternative circuits with automatic changeover wherever applicable to minimize the extent and duration of power supply outage.
- Limitation of the impact and damage to the affected equipment.
- Avoidance of arcing effects and energy released during faults.
- Contribution to the protection of person against indirect electric shock.

Protection relays shall comply to IEC 60255. Protection scheme with proper relay coordination shall be designed to ensure Selectivity, Stability, Speed, Sensitivity and Reliability.

All the above functions of protection, control, and monitoring of all equipment of RSS, TSS and ASS shall be achieved through Digital Protection Control System (DPCS) involving the state-of-the-art technology. DPCS will provide overall protection, control, interlocking, inter-tripping, and monitoring features of the entire power supply system. DPCS will have necessary interface with SCADA system. DPCS shall consist of two levels viz., Remote Terminal Unit (RTU) level and Protection and Control Unit (PCU) level.

1.2.9 **Protection Scheme**

The general protection scheme should be adopted at different levels of voltage as per CEA Regulation.

a) RSS (220/110/66 KV level I/C & 33KV O/G):

1) Incoming bays from power supply authorities shall be provided with Line differential and Distance Protection as Main and Over current/ Earth fault as Backup protection including under voltage, under frequency and Local Breaker Backup etc. in accordance with standard protection scheme.

2) Power transformers shall be provided with Differential Protection, Restricted & Standby E/F as Main and O/C, E/F, LBB as Backup protection including all mechanical protections as applicable for oil cooled transformers

3) Busbar protection shall be provided with zone selective tripping, bus differential as Main and with directional O/C, E/F, LBB as Backup (as applicable for single and double busbar arrangement)

4) For 220kV and above, Main 1 & Main 2 protection with different algorithm should be provided as per norms for the Incomers.

5) 33KV Outgoing feeders from the bus shall be provided with Cable Differential as main and O/C, E/F and LBB as back up protection. Synchronization feature for parallel operation of transformers/feeders from different sources shall be provided.

b) 33KV AC DISTRIBUTION

All Loop-in Loop-out / ring main circuits shall be provided with Cable differential as Main and OC/EF as Backup protection and Transformer feeder shall be provided with OC/EF Protection including thermal protections.

c) 750V DC DISTRIBUTION

1) Rectifier Protection: Diode failure, RC fuse failure, reverse current, Diode temperature, and Earth leakage current protection shall be provided as minimum requirement.

2) All DC breakers shall be provided with Time delay Over current, Over/Under voltage, Rate of rise of current protection, Inter trip/transfer trip,

Instantaneous Direct Over Current and Earth leakage current protection as minimum requirement.

1.3 Indigenization:

a) Procurement 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.

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

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:

Item	DMRC			CMRL	MMRC (Fully Underground)	KMRL	BMRCL
	Ph-1	Ph-2	Ph-3				
Auxiliary Transformer (in KVA)	2500 (UG)	2500 (UG)	3150 (UG)	400/630/1000 (Elevated) 2000 (UG)	2500/3150 (UG) 630 (Grade)	630/500	500 (Elevated) 2000 (UG)

b) Comparative Statement of rating of UPS:

ITEM	TYPE OF STATION	DAMEL	DMRC-P1	DMRC-P2	DMRC-P3	CMRL (Common for Electrical/ S&T)	KMRL	BMRCL
UPS (Elec)	UG	4x180 kVA (with PSD)	2X60 kVA	2X60 kVA	2X80 kVA (with PED)	02X60 kVA 02x80 kVA (for interlocked station) (2 Hrs Backup with PSD)	------	2x40 KVA
	Elevated	2X80 kVA	2X20 kVA	2X20 kVA	2X20/30 kVA	2X60 kVA (2 Hrs Backup)	2 x 15 KVA	2x20 KVA
UPS (S&T)	UG	2x120 kVA	2X30/60 kVA	2X30/ 60 kVA	2X30/ 60 kVA	-----	------	-------
	Elevated	---	2X30/60 kVA	2X30/ 60 kVA	2X30/ 60 kVA	------	2 x 60 KVA & 2 x 30 KVA	-------
	OCC, Depot	---	2X60 kVA	2X60 kVA	2X60 kVA	3X120kVA (2Hrs Backup)	2 x 120 KVA &	-------

c) Comparative Statement of rating of DG Sets:

ITEM	TYPE OF STATION	DMRC-P1	DMRC-P2	DMRC-P3	CMRL	Kochi Metro	BMRCL
DG	Underground	2X 1010	2X (750/ 900/ 1010)	2X900, 2X1010, 3X1010	910 kVA	---------	2X 900
	Elevated	1X 160/ 180 KVA	1X (160/ 180/ 200)	1X (160/ 180/ 200)	400 kVA	1X 125/ 160/250 / 300	2X 200
	Depot	1X 500	1X 500	1X 500 kVA	1000 kVA	1X 125/ 500	1X 500

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-4b Type-5.

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

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

iv. Panels shall have suitable numbers of Spare Breakers and Spare Space for future requirements.

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

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

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 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.

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 and Fire-Survival Cables shall be as per BS-7846 CWZ Category or better.

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

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-50525-3-41 and 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.

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

iv. Distribution of the Lighting shall be such that up to 50% of the lighting is fed by UPS System with a back-up of not less than 30mins in case of Power Supply Failure.

v. 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	20	2
3	Signalling & Telecommunication	175-200-225	2

	/Switchboard Room		
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

vi. Separate Lighting circuit distributed all over the station area shall be used for non-revenue hours for energy saving.

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 2 UPS in parallel-redundant configuration for the entire station.

iii. UPS units shall be installed with their own Battery Sets. Batteries shall be Sealed Maintenance Free Type Valve Regulated Lead Acid.

iv. UPS shall be as per IEC-62040 & Batteries shall be as per IEC-60896.

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. Separate Earth Pits for DG Neutral shall be provided as per requirement.

iv. Lightning Arrestor of the station/building shall be earthed through dedicated earth pits.

v. 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 IEC-61439 Part-1&6 and should be IP-65.

ii. Busduct shall also be provided for connection between DG Sets and LV Panel. The Busduct shall be Sandwiched Type with Aluminium Conductor as per IEC-61439 Part-1&6 and should be IP-67. In case the distance between DG Sets and LV Panel is within 15 mtrs, then suitable size cables shall be used instead of Bus Ducts.

i) **DG Set**

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

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

iii. DMRC is using DG Sets to give power supply to Fire Pumps & UPS System in case of Power Supply failure. Some metros have removed DG sets due to reliable standby power source of auxiliary power. It was decided that only one

DG set will be used at each station except metros having problem of prolonged supply cuts. Nature of load on DG set can be optimised as per local considerations as done by DMRC.

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 load 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
- 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):
- Fire-fighting and sprinkler pumps (Supplied from DG Set also)
- Station Ventilation Plant & Smoke Extract Fans
- Air conditioning for equipment rooms
- Tunnel Ventilation Fans
- Tunnel Booster Fans & Dampers
- Lifts
- Emergency exhaust fans at station
- Station Seepage drainage system
- Station Lighting
- UPS System (Supplied from DG Set also)

iv. Semi-essential Services (Supplied from both ASS in Manual Mode):
- Water Treatment Plant
- Station Sewage drainage system

v. Normal Services (Supplied from only one ASS):
- Water Cooled Chiller

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 services 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

l) **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 1 lakh litres 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 Commercial Zero Hardness suitable of use of Air-Conditioning equipment.

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 Under croft Level.
- This waste water is then pumped out of the station with the help of Submersible Pumps. The pumps shall comply with IS 9906.
- Generally, two pumps of adequate capacity in Working/Stand-by configuration are provided in each Sewage Pit.
- Submersible Pumps function AUTO MODE i.e. there is no manual intervention with the help of Level Controllers.

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 (1 no.).
- 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/Assit configuration.
- Submersible Pumps function in AUTO MODE (i.e. there is no manual intervention) with the help of Level Controllers.

m) Fire Suppression System

i. Fire suppression System provided at Underground Stations shall be as per NFPA 130(2017 or latest) or NBC Codes (2016 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 NBC 2016 (Annex J, 9.1.8) or latest 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.

iv. Fire Hydrants to be located as per NBC 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 etc. for automatic suppression of fire and also under platform for under carriage fire.

vi. Automatic Clean Agent based fire suppression system is also provided for LV Panels & Transformers.

vii. Fire Extinguishers of suitable type i.e. A, BC & ABC types are provided in each Fire Hose Cabinet, Rooms and other areas.

n) Fire Alarm & Detection System

i. Fire Alarm and Detection System provided at underground stations is as per NFPA-130 (2017 or latest), NFPA-72D or NBC- (2016 or latest).

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.

2.2 **Electrical & Mechanical System (For Elevated Stations):**

2.2.1 **Specifications:** Electrical and Mechanical System at Elevated Stations can be broadly divided into 3 sub-systems. These are:

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

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

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

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.

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 FRLS type or better.

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

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. All Conduits being used at Elevated Stations shall be of GI.

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.

iii. Lighting Control by the means of Occupancy Sensors for Manned Rooms & Equipment rooms shall be provided.

iv. Distribution of the Lighting shall be such that up to 30% of the lighting is fed from UPS System with a back-up of not less than 30 mins in case of Power Supply Failure.

v. Recommended Lighting Levels to be maintained at Stations and other areas shall be as per 2.1(b)5(v).

vi. Separate lighting circuit distributed all over the station area shall be used for the non-revenue hours for energy saving.

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 2 UPS in parallel-redundant configuration.

iii. UPS units shall be installed with their own Battery Sets. Batteries shall be Sealed Maintenance Free Type Valve Regulated Lead Acid.

iv. UPS shall be as per IEC-62040 & Batteries shall be as per IEC-60896.

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 ohms.

iii. Separate Earth Pits for DG Neutral shall be provided as per requirement.

iv. Lightning arrestor of the station / building shall be earthed through dedicated earth pit.

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

h) DG Sets

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

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

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 and tunnel

ii. Essential Services

- Fire-fighting pumps and sprinkler pumps
- Station Lifts

iii. Semi-essential Services

- Water Treatment Plant

iv. 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 each having its own Transformer and LV Panels.

ii. The transformers are supplied from dedicated 33kV twine 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.

2.2.3 **Fire Suppression System** -

i. Fire suppression System provided at Elevated Stations shall be as per latest NFPA-130, NBC, and Local Municipal / Panchayat 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 is to be provided for HV and LV Panels, including the fire pump & essential power panel.

iv. Fire Extinguishers of suitable type i.e. A, BC & ABC types are provided in Platform and other station areas.

2.2.4 **Fire Detection & Alarm System -**

i. Fire detection and Alarm System provided at Elevated Stations shall be as per latest NFPA-72, NBC and Local Municipal / Panchayat rules.

ii. Fire Detection and Alarm system provided 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 and devices viz. Monitor Modules, Control Modules, Hooters, Manual Call Points shall

be provided covering the entire station for detection and notification of Fire.

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

2.3 Indigenization:

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

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:

Sl.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)	241 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
Sl.No.	**Metro**	**No. of Lifts**	**Capacity /Passenger**	**Minimum Speed**
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 Lifts 27 Lifts	544Kg/8P 1000 Kg/13P	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	33 Lifts	27 Nos. – 26 P 6 Nos. – 29 P	1 m/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 and 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.
Door	Centrally Opened, Minimum 900 mm Door Width, 2100 mm Height. However, door width of 1000 mm is preferred.

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
Provision of Audio & Visual Remote Monitoring System	Yes. To be provided in the station controller room.

b) Philosophy for Quantity Assessment:

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

c) Indigenization:

a) Procurement shall be governed by ensuring minimum 50% 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.

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

4.0 Escalators:

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

SN	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	Jaipur	Phase 1	0.5 & 0.65 m/s	
6	Chennai	Phase 1 & 2	0.5 & 0.65 m/s	
7	Bangalore	Phase 1, 2 & 3	0.5 & 0.65 m/s	

8	Lucknow	Phase 1	0.5 & 0.65 m/s	
9	Hyderabad	L&T	0.5 & 0.65 m/s	
10	Mumbai Metro Line 1	Reliance Metro	0.5 & 0.65 m/s	
11	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 Step and Skirt Stop Switch	At Upper and Lower Curves and at 7.5 m interval along the incline of each 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, rail Drive Chain and Step Chain	Yes
Step Width and Step Height	Width of more than or equal to 400 mm and Height of less than or equal to 210 mm
Step	One Piece, Pressure Die Cast, High Wear and Corrosion Resistant Aluminum Alloy.
Rollers	The minimum diameters of the chain roller and the trailer / step rollers shall be 100 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 Track and Steps, Chain, Driving Machinery, = 8, 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

Provision of Audio & Visual Remote Monitoring System	Yes. To be provided inside the station controller room.

c) Philosophy for Quantity Assessment:

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) Indigenization:

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 (TVS & ECS):

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

SN	Item Description	DMRC	CMRL	BMRC
1	TVFs	85-100 CMS	80-120 CMS	65 CMS (Phase1) 85 CMS (Phase-2)
2	TEFs/OTEF	21-40 CMS	30-45 CMS	20 CMS
3	SEFs	11-12 CMS	7 CMS	N.A.

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

SN	Item Description	DMRC	CMRL	BMRC
1	Water Cooled Chiller	3 No (370 TR/ 400TR each)	3 No (200 TR each)	3 Nos (300 TR each)
2	Air Cooled Chiller	2 No. (66 TR each)	N.A.	2 Nos (34 TR each)
3	Cooling Tower	3 Nos	3 Nos	3 Nos
4	Air Handling Units	20-35 MS	1No, 20 CMS	4 Nos 25 CMS

5	VRV/VRF unit (For Elevated Stations)	66 TR	2 x 25 TR	N.A.

c. Environment 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, water coolers, Escalators, Fare Gates etc. working in the stations.
- Removing heat from air-conditioning plant and sub-station and other equipment, 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.

AMCA : Air Moving and Conditioning 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 Electrical Commission
ISO : International Standards Organization
NFPA : National Fire Protection Association (USA)
SMACNA : Sheet Metal and Air Conditioning Contractors National Association

UL **:** Underwriter's Laboratories, Inc.

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 ASHRAE-2009 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 and S&T Equipment rooms: 24 (+1) °C and RH not exceeding 60%

3) Tunnel Design Conditions
   Normal conditions: Max. 40°C Dry Bulb (DB)
   Congested conditions: Max. 50°C Dry Bulb (DB), that corresponds to maximum condenser air intake temperature.
   Minimum Fresh Air (In Station Public Area): 10% or 18 CMH/Person.

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 2 hours

6) Air Velocities
   Station Concourse or Platform - Peak 5 m/s
   Station Concourse or Platform - Average 3 m/s
   Public areas – Emergency Case- Not exceeding 11 m/s
   (Includes all areas where public exposed to airstream)

7) Terminal air velocity from over-ground shafts
   Non-Public Areas 5 m/s face velocity
   Public Areas 2.5 m/s face velocity

b) Noise Control:

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

At station concourse, platform areas	: 55 dB(A)
To boundary of nearest property	: 60 dB(A) (7am to 11 pm)
To boundary of nearest building	: 55 dB(A) (11pm to 7 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) The tunnel noise criteria is taken to be 80 dB(A) during operation of tunnel ventilation equipments.

c) Duct Work:

- Draft relief shaft area : 18-20m² (minimum) as per availability of space
- Duct velocity- Public area : 10 m/s

- Duct velocity Equipment room : 12.5 m/s
- Shaft Exits, Elevated : 5.0 m/s
- Shaft Exits/Louver area, (At ground Level) : 2.5 m/s
- TVS and TES shaft pressure loss : 150 Pa max
- Maximum duct friction loss : 1.23 Pa/m

d) Pipe Work:

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

- Maximum Friction Rate : 400 Pa/m
- Maximum Velocities : 2.5 m/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 Cooled Chilled Water System:

For Under-Ground Metro Stations, Water Cooled Chilled water system will be used. This system consists of Water cooled chillers, Cooling towers, Pumps (chiller & condenser), Expansion tank and Chemical dosing system.

Through primary refrigerant (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 (Depending upon the total heat load of the station)
- Evaporator:- Flooded, Shell and tube type
- Condenser: - Water Cooled, shell and tube type
- Pumps: - Vertical/Horizontal Split Casing Pumps.
- Cooling Towers: - Induced Draft

3) Air Cooled Chilled Water System:

During non-operational hours and in winter, very less air-conditioning is required in critical equipment rooms only, hence, operation of main water-cooled chiller plant may not be energy efficient. Therefore, during this time, critical equipment rooms will be fed through 100% redundant air-cooled chillers or any other energy efficient cooling system.

4) ECS for Elevated Stations:

The elevated metro stations are recommended to have Variable Refrigerant Volume/ Flow (VRV/VRF) type of environment control system. The complete VRV/VRF system including outdoor units, indoor units, copper piping and controls should be provided in Duty + Standby configuration for 24x7 operating rooms viz. TER, SER, UPS, SCADA etc. For non-24x7 operating rooms, running units to be provided.

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

5) Ventilation of Plant rooms:

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

6) 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.

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 train circulates from portal to portal.

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 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. This fresh air is redirected via Draft Relief Dampers towards the other tunnel where trains are still running.

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 10m in public area at both platform and concourse levels,
- Minimum smoke clearance height of 2.5m

5.4 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 12th July 2017 and as detailed in Roadmap for planning/increasing Indigenization is placed at Annexure-III for taking appropriate action.

b) R&D are 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) & CFD (Computational Fluid Dynamics) for tunnel ventilation system design.

6.0 **Summary of Key Recommendations:**

6.1 Power supply & Traction:

1.	**Silver copper contact wire** (CuAg 0.1) conforming to EN50149 of 150 sq mm size will normally be used for ROCS/ Elevated section (FOCS) and 107 sq.mm. for Depot lines.
2.	**Messenger/catenary wire** will normally be Copper Magnesium alloy, Catenary wire (CuMg 0.5) conforming to DIN 48201 of 65 sq.mm size. For exceptional cases, the size may be considered as 95 sq.mm on need base.
3.	**Auxiliary Main Transformers** (AMT) should generally be designed for 32/45 or 35/45 MVA capacity for UG system & 15/20/25 MVA for Elevated system in Metros,

	which shall be decided based on the section loads of the metro. Also based upon on average load requirement for system considering design and cost economy factor.
4.	**Auxiliary Transformers** shall generally be of capacity 400 KVA, 500 KVA & 630 KVA for Elevated stations and 2.5 MVA & 3.15 MVA for UG stations. Dry type transformers conforming to IEC 60076-11 to be used. Also based upon on average load requirement for system considering design and cost economy factor.
5.	**Traction Transformer (TT**) shall be generally designed for 15/25 MVA for 3-6 coach Metros and 30/42 or 40/50 MVA for 8-9 coach Metros in the case of 25KV AC traction system. Also based on average load requirement for system considering design and cost economy factor.
6.	25kV cable shall normally be single core, 240 sq.mm Cu, XLPE insulated, FRLS type for Elevated section and FRLSZH type for UG section. Also based on average load requirement for system considering design and cost economy factor.
7.	In general, RSS/Switching posts shall be of **Gas Insulated Switchgears** (GIS) technology to optimize space and have near Zero maintenance. In the case of ASS, AIS or hybrid type switchgear may also be used. Selection should be based on techno commercial requirements.
8.	**33kV Power cable:** 240/300 sq mm Copper / Aluminium cable shall be used for exclusively Elevated/ At Grade section. For system with Elevated and Underground both as well as only Underground systems, 400 sq mm copper cable shall be used. For U.G stations, cables with Halogen Free FRLS, XLPE insulated to be used. For, elevated stations, FRLS type XLPE insulated cables to be used.
9.	'**Retractable type OHE'** shall preferably be provided in Inspection bays line (IBL) for ease of maintenance in Car depot.
10.	Spring type **ATD** shall preferably be used for main line and 3 pulley ATD for Depot & At grade section. Decision can be taken as per local design criteria.
11.	Cu/Al conductor of 50, 65 or 93 sq.mm or steel strip of suitable size of equivalent resistivity can be used in lieu of copper conductor for Buried Earth Conductor (BEC) works.
12.	**Booster Transformer**: - **Provision** of Booster Transformers is to be avoided to the extent possible. If DOT survey requires provision of Booster Transformers based on EMI/EMC study, Booster Transformers of appropriate ratings to be provided.
13.	**Insulators**: - **All** insulators used in 25KV system to be of composite material complying with relevant standards. The creepage distance depending on pollution level, prevalent in the city, should be decided based on IEC 60815/ IS 13134.
14.	**SCADA:** Substation Automation Station (SAS) shall comply to IEC 61850. • Traction SCADA system shall comply to IEC 60870-5-104 and complete SCADA network shall be on dedicated Fibre Optic (dual).
15	**Harmonic Filter:** A harmonic Filer shall be used to eliminate the Harmonic distortion caused by appliances. Three phase harmonic filters are shunt elements that shall be used for decreasing voltage distortion and for power factor correction.
750V DC Third Rail system:	
1.	**Conductor rails** shall be manufactured in standard lengths (generally in 15 mtr. length pieces) considering ease of transportation and installations, which shall be joined together by special splice joints. The conductor rail shall be manufactured of a high conductivity aluminium alloy body designed for the required nominal current and utilized with a stainless steel wearing face. The stainless steel shall be joined to the aluminium body by a molecular / co-extrusion process or by an alternate proven design meeting the specified requirements and parameters. The stainless steel strip of required thickness shall have flat surface without milling groove. No welding in the cantilever of conductor rail head shall be permitted and it should be of minimum design life of 30 years. The process used for the composition of conductor rail shall

	preferably ensure no gaps remain between the head of the aluminium section and the stainless steel wearing strip. Conductor rail is intended to be used up to complete worn-out of stainless steel without any delamination of the remaining stainless steel strip.
2	**Power Transformer (PT**) shall generally be of Oil filled type with capacity of 2 x 20/25 MVA in 66/110KV substation & 2 x 50MVA or 2 x75 MVA for 220KV substation which shall be decided based on the section loads of the metro.
3	**Auxiliary Transformer (ASS):** shall generally be of dry type conforming to IEC 60076-11 . The capacity decided based on the section loads of the metro shall be provided.
4	**Traction Transformer (TT**) shall generally be of dry type with capacity of 2850/2600 KVA, in the case of 750 V DC system. It shall have duty cycle class VI as per EN 50329 in line with the Rectifiers duty class.
5.	**Stray Current mitigation** measures as per EN 50122-2 shall be provided. This includes insulation of track plinth at the base and insulation of shear connectors, insulation of running rails, use of track fitting suitable for DC system, short circuit devices (SCD), stray current cable, Stray current monitoring system (SCMS) as per design.
6	The track fitting used in the case shall be specifically designed for the DC system, which shall ensure floating rails, which will prevent passage of stray current corrosion.
7	**OVPD, over voltage protection device** shall be used to prevent higher voltage of running rail to ensure passenger safety as per EN 50122-1 or equivalent standard. Platform up to a width of 2 meters in Train operations area shall be insulated to keep control over the step potential to ensure safety of passengers.
8	DC disconnectors should be provided in DC breakers in TSS for better maintainability.
9	**Energy Recovery**: Provision of reversible substation for maximum regenerative energy recovery may be explored.
10	**Rectifiers**: - 12 pulse or better with harmonics limits shall be used. The duty shall be class-VI as per IEC 60146-1-1.
11	**Bottom current collection system** shall preferably be used for Third Rail Traction System.
12	**Bonding:** Rail and track bonding shall be made at frequent intervals for keeping the voltage drop at low levels. Generally, EN-50122-2 shall be followed for Electrical safety in DC Traction.
13	**ETS:** Safety provisions as per NFPA 130, including the provisioning of Emergency Tripping System (ETS) at different locations shall be followed.
14	**Structure Earth conductor** shall be preferably Aluminum (AAAC) bare conductor and connected to pier and viaduct segment earth connections. Size of conductor shall be based on detailed design.

6.2 **E&M:**

1.	**LV Panels –**LV Panels being installed in Underground Stations shall be as per IEC-61439 Part-1&2, IP-54 and Form-4b Type-5. Circuit Breakers used inside the LV Panels shall be as per IEC-60947 standard. Busbar Rating & Switchgear Sizing shall be as per Load and Fault Calculations.
2.	**Cables–** There are two types of Cables being used at Underground Stations. Normal FRLSZH cables and Fire Survival Cables. Normal FRLSZH cables being used at underground Stations shall be as per BS-6724 and Fire-Survival Cables shall be as per BS-7846 CWZ Category. Cables being used at Elevated Stations shall be as per IS-1554 & IS-7098. The cables

	used in stations shall be of FRLS type or better.
3.	**Distribution Boards –** Wall Mounted Distribution Boards (IP-54) shall be provided at the station of Lighting, Advertisement, Power Socket, Signages etc. at the station.
4.	**Wiring & Conduiting –** There are two types of Wires being used at Underground Stations. Normal FRLSZH wires and Fire Survival wires. Normal Wires FRLSZH wires being used at underground Stations shall be as per BS-50525-3-41 and Fire-Survival Wires shall be as per BS-6387. All Conduits being used at Elevated Stations shall be of GI.
5.	**Lighting System –** ▪ All Lights being provided at Underground Stations shall be of LED Type for Energy Efficiency. ▪ Lighting Control by the means of Occupancy Sensors for Manned Rooms & equipment rooms shall be provided. ▪ Distribution of the Lighting shall be such that up to 50%(for underground) and 30% (for elevated or at grade) of the lighting is fed by UPS System with a back-up of not less than 30mins in case of Power Supply Failure. ▪ Lux levels are recommended to be maintained at different places as per NBC 2016 (Part 8, Section 1, Table no. 4.) or latest. ▪ Use of 'Day-light harvesting technology' to be explored for elevated station and efforts to be made for tapping it for underground stations by using 'Optic fibre channels', where feasible. ▪ Lighting on elevated Via-duct may be provided for safe evacuation in emergency cases. Metro may decide based on local requirements.
6.	**Uninterrupted Power Supply System –** ▪ UPS System shall comprise of 2 UPS in parallel-redundant configuration for the entire station. ▪ Preferred capacity would be of 20, 60 or 80 KVA (as per load requirements for UG and Elevated stations) with 30 min back up to be provided. ▪ Batteries shall be Sealed Maintenance Free Type Valve Regulated Lead Acid. UPS shall be as per IEC-62040 & Batteries shall be as per IEC-60896. ▪ Efforts may be made in future projects to provide common UPS for E&M and S&T at stations (except Interlocking stations) to reduce number of equipment at station especially in UG stations due to space constraints.
7.	**Earthing System –** Earthing System of the Underground Stations shall be TN-S type. 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. Earthing system shall be as per IEEE-80 and IS-3043. Galvanized Iron Earth Strip of adequate sizes shall be provided for earthing of Equipment.
8.	**Bus Duct –** ▪ Busduct shall be provided for Connection between Transformers and Main LV Panels. The Busduct shall be Sandwiched Type with Copper Conductor as per IEC-61439 Part-1&6 and should be IP-65.

	▪ Busduct shall also be provided for connection between DG Sets and LV Panel. The Busduct shall be Sandwiched Type with Aluminium Conductor as per IEC-61439 Part-1&6 and should be IP-67. In case the distance between DG sets & LV panel is within 15 Mtrs, then suitable size Cables shall be used instead of Bus ducts.
9.	**DG Set –** ▪ DG Sets shall be as per ISO 8528 & BS 5514 and should also be compliant with latest CPCB norms in terms of Emission and Noise Levels. ▪ To feed essential loads during supply failure, only one DG set at each station shall be provided except metros having problem of prolonged power cuts.
10.	**Fire Suppression System** ▪ Fire suppression System provided at Underground Stations is as per latest versions of NFPA 130 (2017 or latest) or NBC (2016 or latest) Codes. ▪ There are two Fire Tanks provided at each underground station with a capacity of 1 lakh litres each (50000 litres in elevated section). Water from these Fire Tanks is pumped throughout the station with the help of Fire Pumps located in the Ancillary Building. ▪ There are six Fire Pumps (3 pumps in elevated) 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, the Fire Pumps & the Fire Tanks shall be considered as per the NBC-2016 (or latest) and local regulations (as applicable). ▪ Fire Hydrants are to be located as per NBC. Additionally, Sprinkler system is provided in certain rooms like store etc. for automatic suppression of fire and also under platform for under carriage fire. ▪ Automatic Clean Agent based fire suppression system is also provided for LV Panels & Transformers. ▪ Fire Extinguishers of suitable type i.e. A, BC & ABC types are provided in each Fire Hose Cabinet, Rooms and other areas. **Fire Alarm & Detection System:** ▪ Fire Alarm & Detection System provided at UG stations is as per NFPA-130, NFPA-72D or NBC. ▪ Fire Alarm & detection system provided at UG stations shall be addressable type with Main Fire Alarm Control Panel and Graphics Computer located inside the station control room. ▪ 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. ▪ Mimic and Repeater Panel shall be provided in the Firemen's Staircase for use by Fire Fighters.

6.3 Lifts & Escalators:

a) Escalators:	
1.	'**Outline specifications'** as given in clause 4(b) above will be adopted for procurement. (Preferably outside step chain link rollers will be used for heavy metros.)
2.	Quantity assessment of Escalators shall be done as per broad guidelines detailed in clause 4 (c)

3.	'Comprehensive Maintenance Contract' (CMC) for period of 15 years including DLP period is recommended with OEM.
4.	Escalators shall preferably have Remote Monitoring System with SMS Alert.
b) Lifts:	
1.	'**Outline specifications'** as given in clause 3(b) will be adopted for procurement.
2.	Lifts will preferably be equipped with features such as: ▪ Lifts shall preferably have Remote Monitoring System with SMS Alert. ▪ Seismic sensors -Primary wave
3.	Quantity assessment shall be guided as per broad guidelines detailed in clause 3.1(C).
4.	'Comprehensive Maintenance Contract' (CMC) for period of 15 years including DLP Period is recommended with OEM.

6.4 **TVS & ECS:**

a) TVS:	
1.	Tunnel ventilation fans (TVF) shall strictly comply NFPA 130/NBC 2016 (or latest) provisions and guided by following **Design Criteria:** • **Tunnel Design Conditions** ✓ Normal conditions: Max. 40°C Dry Bulb (DB) ✓ Congested conditions: Max. 50°C Dry Bulb (DB), that corresponds to maximum condenser air intake temperature ✓ Minimum Fresh Air (In Station Public Area): 10% or 18 CMH/Person • **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. • **Emergency Condition:** ✓ Temperature rating for equipment exposed to high temperature during emergency operations: 250°C for 2 hours ✓ Air velocity/Noise/Duct sizes: As given in clause 5(1.1). ✓ As far as possible, one train in one ventilation zone concept to be followed for public safety. To have more trains, provision of mid shaft to be considered to have separate ventilation zone.
2.	TVF capacity of normally 80 cms, 90 cms & 120 cms to be used subject to final validation of capacity by Simulation (SES/IDA tunnel) studies.
3.	VFDs to be preferably provided on TVFs/TEF/VSF for energy saving
b) ECS:	
1.	**External Design Conditions** ▪ Outside ambient conditions are based upon ASHRAE-2009 recommended design conditions for 1% criteria: **Inside Design Conditions** ▪ Platform & Concourse: 27.0 °C (Max) Dry Bulb (DB), 55% RH ▪ Back of House rooms and S&T Equipment rooms: 24 (+1) °C and RH not exceeding 60% **Water Cooled Chilled Water System** ▪ For Under-Ground Metro Stations, Water Cooled Chilled water system will be preferably used.

	Air Cooled Chilled Water System ▪ For non-operational hours and in winter where very less air-conditioning is required, Air cooled chilled water system shall be used. **ECS for Elevated Stations:** ▪ The elevated metro stations are recommended to have Variable Refrigerant Volume/ Flow (VRV/VRF) type of environment control system. **Ventilation of Plant rooms:** ▪ For ventilation of system plant rooms such as ECS plant rooms, TVS plant rooms, Chiller plant room, Pump room, ASS etc., proper ventilation or local cooling will be provided based on load requirements.
2.	Use of platform screen doors for UG stations is recommended for energy saving.
3.	Normally, primary side pumps only to be provided in Chiller plant.
4.	VFDs to be used in Chiller plants/pumps etc for energy saving.
5.	Magnetic bearing chillers may be experimentally tried being maintenance free.

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. At present, Achievement linked incentive are being provided by MNRE.

- 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 "Clip lock" type of sheets.

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.
- **Solar Project may be got registered with UNFCC to avail the benefits of CDM.**

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Annexure-II

SUGGESTED COST REDUCTION / INNOVATIVE FEATURES

i. Power supply & Traction:

- In depot, contact wire size to be taken as 107 mm^2 in place of 150 mm^2.
- Judicious provision of Capacitor banks considering significant contribution of capacitance by the 33 kV/25 kV cable/VFDs.
- Provision of regulated Tramway flexible OHE in depot except Test track and entry/exit tracks which are provided with conventional regulated OHE.
- Building of RSS to be 'Green Building'.
- Use of Synthetic insulators as a Techno commercial effective solution.
- An open access helps by ensuring regular power supply at competitive rates and helps to meet renewable energy purchase obligation also.

ii. TVS & ECS:

- Use of VFDs for AHUs/TEF/Primary pumps etc
- Use of Magnetic Type Chillers in phased manner.
- Use of Combined SCADA for ECS/TVS.
- Sensors in fresh air intake shafts to prevent outside smoke intake.
- Sensors in tunnel to optimize running of OTE fans.
- Combining functions of OTE with SEF.

iii. E&M:

- Adoption of star rating power equipments, lighting fixtures, Pumps, Air conditioners etc.
- Day Light harvesting using Optic fiber channel.

iv. Lift/Escalators:

- Remote monitoring on real time basis of Lifts/Escalators.

v. Misc.

- Experimental use of IoT (Internet of Things) for Condition based monitoring of Electrical items & for energy saving.

Annexure-III

ROADMAP 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 >50%**	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 >50%**	**3 Firms (Johnson/OTIS/KONE) are already having manufacturing units in India and other 3 firms (Schindler/ Thyssen/ Fujitec) are setting up units by 2019.** **Further indigenization**: Items like Motors/Fire rated doors are imported & can be indigenized gradually in future contracts.
	b. Escalators	Presently heavy-duty Escalators are being imported. **Local content is around 6 to 7 %.**	Firms like Johnson have already set up their factory and Schindler, OTIS & KONE are setting up factory in India and plan to start Heavy duty escalators manufacturing by the year 2018, 2020 & 2020 respectively. **Indigenization Plan:** Local content to be mandated as per following plan in future contracts: **10% - By 2018** (Cladding, Oil Pumps, lub. System etc.) **20% - By 2019** (Balustrade, Electrical system) **40% - By 2020** (Step Chain, VVVF Drives) **>50% - By 2021** (Trusses, Rollers)
3.	**TVS and ECS**	**Local content > 50% is feasible** by tendering TVS & ECS as one contract.	
	a. ECS	**Local content is already > 50%** It is around 65% and remaining 35% (Chiller, Fire rated paints etc.) also can be indigenized gradually.	Many reputed companies (Daikin/Blue Star/Voltas/Kirloskar/Carrier/Climaventa/Waves etc) already have their plants in India and manufacturing majority of the components of the ECS systems, except few items like Chillers and Fire rated paints. **Further indigenization**: Items like

			Water/air cooled Chillers are imported & can be indigenized gradually in future contracts in phased manner.
Sno.	**Package**	**Status of Indigenization (Local content: % of Supply cost**	**Remarks**
	b. TVS	**Presently most items** (TVF/OTE/Booster fans/Dampers etc) **are imported.**	**MANY INTERNATIONAL MANUFACTURERS (WITT & SON/ FLAKT WOOD/SYSTEM AIR/ZITRON/TLT) HAVE SET UP THEIR PLANTS IN INDIA FOR TVF/BOOSTER FANS/TEF ETC.** For TV damper/ Attenuator, Ruskin/Trox have unit in India. **Indigenization Plan**: Indigenization of following key items can also be gradually achieved in phased manner as per following plan in future contracts: a. TVF: Minimum 75% to be manufactured/assembled in India from 2019. b. Dampers (Other than TVF): Minimum 75% to be manufactured/assembled in India.
4.	**Traction & Power Supply**	**a) 25 KV AC Systems:** **Local content is already >50%** (for both ROCS as well as FOCS) **b) 750 V Third Rail system: ***** **Local content > 50% is feasible** by tendering Third Rail and RSS /Aux power supply system as one contract.	**1. 25 KV AC System** Most of the 25 KV AC traction system items are locally manufactured in India. **Further indigenization**: Few items in ROCS like Aluminum Conductor Rail and its associated fittings & 25 kV GIS are being imported & can be indigenized gradually in future contracts. **2. 750 V DC System** In 'Third Rail component' (excluding RSS/ASS portion), most items are imported like 3rd Rail, High speed circuit breakers & DC panels (NRP, OVPD, BY pass), Rectifier/Traction systems, Traction Transformers, SCMS (Stray Current Monitoring systems), DC-33KV & 66KV Cables, By pass panel etc. **Further indigenization**: 3rd Rail and associate auxiliaries can be indigenized gradually in future contracts by respective metros.

NB*:**

- For items that need to be indigenized in India over next few years, the local manufactures to be permitted to use credentials of their parent company for next 3-4 years so that they can develop indigenized product by technical assistance/transfer of technology from parent company.

c) 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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