No. K-14011/05/2022-MRTS-Coord (E-9123553)
Government of India
Ministry of Housing and Urban Affairs
(MRTS Coord Desk)

301-B, Nirman Bhawan, New Delhi,
Dated the 14th January, 2025

To,

All the concerned stakeholders
(Through website of M/o Housing and Urban Affairs)

Subject: Revision of Standard Specifications of Traction System of Metro Rail in view of Budget Announcement FY 2022-23 – seeking feedback/comments reg.

Sir/Madam

This Ministry, in August, 2018, had issued standard specifications of Electrical & Electromechanical components of Metro Rail in which traction system of Metro Rail component was also defined. However, in the Budget Speech for FY 2022-23, it was announced that *design of metro systems, including civil structures, will be re-oriented and standardized for Indian conditions and needs*. In view of this, this Ministry had decided to revise/re-orient the standard specifications of various metro rail components including Traction System.

2. After detailed and extensive deliberations, a draft report on "Standardization/Indigenization of Traction System of Metro Rail Components" has been drafted and is enclosed herewith for feedback/comments of all stakeholders.

3. Any comments/inputs/feedback on the report may be sent to this Ministry by 15.02.2025 at the email - mrtscoordmoud@gmail.com

Yours faithfully,

(Ravi Kumar Choudhary)
Under Secretary to the Goverment of India
Tel: 23062935

STANDARDIZATION OF

ELECTRICAL (POWER SUPPLY & TRACTION)

METRO RAIL COMPONENTS

Feb 2024

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Abbreviations

Abbreviation	Definition
AAAC	All Aluminium Alloy Conductor
AIS	Air Insulated Switchgear
ASS	Auxiliary Sub station
ATD	Auto- tensioning Device
BCC	Backup Control Centre
BEC	Bare Earth Conductor
BFB	broad flanged beam
BIL	Basic insulation level
BMRCL	Bangalore Metro Rail Corporation Limited
CCTV	Closed-circuit television
CD	Creepage Distance
CEA	Central Electricity Authority
CRGO	Cold-rolled grain-oriented steel
CT	Current Transformer
DBR	Dynamic Braking Resistors
DC	Direct Current
DCC	Depot Control Centre
DIPP	Department of Industrial Policy and Promotion
DMRC	Delhi Metro Rail Corporation
DOT	Department of Telecommunication
ECS	Environment Control system
EJ's	Expansion Joint
E&M	Electrical & Mechanical
EMC	Electromagnetic compatibility
EMI	Electromagnetic interference
EN	European Standards
ESP	Emergency stop plunger
ETP	Electrolytic tough pitch copper
ETS	Emergency Tripping System
FOCS	Flexible Overhead conductor system
FRLS	Flame Retardant Low Smoke
FRLSZH	Flame Retardant Low Smoke and Halogen
GIS	Gas Insulated Switchgear
HSCBs	High Speed Circuit Breaker
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronics Engineers
IGBT	Insulated Gate Bipolar Transistor
IR	Indian Railways
ITL	Inter Transverse Link
KMRL	Kochi Metro Rail Limited
KVA	Kilovolt-amps
LA	Lightning Arrestor

LMRC	Lukhnow Metro Rail Corporation
LRT	Light rail transit
LV	Low Voltage
MEGA	Metro Link Express for Gandhinagar and Ahmedabad
MOHUA	Ministry of Housing and Urban Affairs
MRTS	Mass Rapid Transit System
MTR	Master Trip Relay
MVA	Megavolt Ampere
NBC	National Building Code of India
NFPA	National Fire Protection Association
NIFPS	Nitrogen Injection Fire Protection System
OCC	Operational Control Centre
OCS	Overhead Contact System
OD	Outer Diameter
ONAF	Oil Natural Air Forced
ONAN	Oil Natural Air Natural
OPC	Overhead Protection Conductor
PHPDT	Peak Hour Peak Direction Traffic
PST	Power Supply & Traction System
PT	Potential transformer
PTFE	PolyTetraFluoroEthylene
RDSO	Research Designs & Standards Organisation
ROCS	Rigid Overhead Conductor System
RSS	Receiving Sub station
SAS	Substation Automation station
SCADA	Supervisory Control and Data Acquisition
SCD's	Short Circuit Devices
SCMS	Stray Current Monitoring System
SFC	Static Frequency Convertors
SNS	Short Neutarl Section
SP	Sectioning Post
SS	Switching Station
SSP	Sub-Sectioning and Paralleling Post
STATCOM	Static Synchronous Compensator
SVL	Sheath Voltage Limiter
TPN	Triple Pole with Neutral
TRED	Automated motorized short circuit earthing device
TSS	Traction Substation System
TVS	Tunnel Ventilation System
UG EHT	Underground Extra High Tension
VCB	Vacuum Circuit Breaker
XLPE	Cross-linked polyethylene

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 differently abled 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 & Escalators**
4. **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, shorter design finalization time, ease in O & M, quicker deliveries of material.

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

- High reliability
- High Efficiency
- Minimum Maintenance (Maintenance free /less maintenance)
- Space optimization

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.

C. Traction Systems Followed in Indian Metros :

1.0 Power Supply & Traction System (PST):

Following 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:

1	25 kV AC Traction (FOCS/ROCS)	Flexible Overhead conductor system (FOCS) is used for Elevated & at Grade section while Rigid Overhead Conductor System (ROCS) is used in Underground section accommodable to tunnel bore diameter.
2	750 V DC Third Rail Traction	'Third rail system' is used for Traction for elevated, at grade and underground section.
3	1500 V DC Traction	Flexible Overhead conductor system was in use in Indian and still being used in some countries.

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

1.1.1. 25 kV AC Traction (FOCS) / (ROCS) System:

Key Item	Sizing/Rating	Adopted by
Contact wire	150 sq.mm Copper 150 Sq. mm Copper Silver (Cu-Ag 0.1)	DMRC, LMRC, Nagpur Metro, Pune Metro
Catenary wire	65 sq.mm. Copper Cadmium 65 sqmm Copper magnesium 120 sqmm Copper magnesium	DMRC, LMRC, Nagpur Metro, Pune Metro
Auxiliary Main Transformer	20/25 MVA 30 MVA 32/45 MVA 30/45 MVA	DMRC, LMRC, Nagpur Metro, Pune Metro
Traction Transformer	15-30 MVA 21.6/30.24 MVA 30/42 MVA 40/50 MVA	DMRC, LMRC, Nagpur Metro, Pune Metro
33 kV cable	300 sq.mm, XLPE, Al 400sqmm XLPE, Cu 400 sq.mm, XLPE, Al 240 sq.mm, XLPE, Al	DMRC, LMRC, Nagpur Metro, Pune Metro
25 kV cable	240 sq.mm, XLPE, Cu 400sqmm XLPE, Al	DMRC, LMRC, Nagpur Metro, Pune Metro
	5 Pulley type	DMRC, LMRC,

ATD type	Gas type Spring type 3 pulley type in depot	Nagpur Metro, Pune Metro
Al conductor Rail	2282 sq.mm 2300 sq.mm 2200 sq.mm	DMRC, CMRL, MMRCL, LMRC

1.1.2. For 750V DC Third Rail system:

Key Item	Voltage/ Current rating	Sizing	Adopted by
Power Transformer	66 KV	20/25 MVA 25/31.25 MVA 40/50 MVA 20/30 MVA	BMRCL, KMRL, MEGA
	132 KV	20/25 MVA 25/31.25 MVA 40/50 MVA 30/40 MVA	KMRL, Agra Metro MEGA, Bhopal
	220 KV	50 MVA 75 MVA	BMRCL, Kanpur Metro
HV Power Cable	220 KV	1C X 1000 Sq.mm XLPE Cu, Al 1C X 800 Sq.mm XLPE Cu, Al	BMRCL, Kanpur Metro, Bhopal
	132KV, 66 KV	1C X 630 Sq.mm Al, XLPE 1C X630 Sq.mm CU, XLPE 1C X 1000 Sq.mm CU, XLPE	BMRCL
	33 KV	1C x 240sqmm, Cu, XLPE 1C x 400sqmm, Cu, XLPE 1C x 300sqmm, Al, XLPE	BMRCL, KMRL Agra Metro, MEGA, Bhopal
DC Power Cable		(3.3 kV for +ve, 1.1 kV for – ve) 1C x 300 sq.mm, Cu, XLPE,	BMRCL, KMRL, MEGA
Structure Earth Conductor		185 sqmm AAAC BEC	BMRCL, KMRL, Agra Metro, MEGA, Bhopal
Earthing & Bonding connection cables		95 sq.mm or 120 Sq.mm Aluminum cable	BMRCL, KMRL, Agra Metro, MEGA, Bhopal
33kV Switchgear	33 KV	AIS/GIS VCB 1250 A or 1600 A	BMRCL, KMRL, Agra Metro, MEGA, Bhopal

Key Item	Voltage/ Current rating	Sizing	Adopted by
Auxiliary Transformer	33KV/415 V, 3 Phase	200 / 500 / 630 / 800 / 1000 / 2000 / 2500 KVA	BMRCL, KMRL, Agra Metro, MEGA, Bhopal
Traction Transformer	1. 33KV/292V/292V Dd0Dy5 2. 33KV/585V/585V Dd0Dy5 3. 33kV/0.630-0.630kV AC, D(+7.5)d0y11 & D(-7.5)d0y11.	33KV/585V/585V 33kV/630V/630V Rating: 2x2850 kVA or 2x2600 kVA	BMRCL, KMRL, Agra Metro, MEGA, Bhopal
Rectifier Set	2500KW, 12 or 24 Pulse Series or parallel Rectifier	2500KW, 12 Pulse Parallel Rectifier 2500KW, 24 Pulse Parallel Rectifier	BMRCL, KMRL, Agra Metro, MEGA, Bhopal
Third Rail	4500 A DC	Bottom or Top Collection	BMRCL, KMRL, Agra Metro, MEGA, Bhopal
Sectioning Device	750 V DC	Insulated Joint or Air Gap (2 meter)	BMRCL, KMRL, Agra Metro, MEGA, Bhopal
DC Switchgear (Incomer)	900 V DC	6000 A High-Speed Circuit Breaker.	BMRCL, KMRL, Agra Metro, MEGA, Bhopal
DC Switchgear Feeder & Bypass	900 V DC	4000 A High-Speed Circuit Breaker.	BMRCL, KMRL, Agra Metro, MEGA, Bhopal
Negative Return Panel (NRP)	1800 V	6000A	BMRCL
Over Voltage Protection Device (OVPD)	900 V	900 A 800 A	BMRCL, MEGA
Disconnector Switch	1800V 750 V	4000A	BMRCL, MEGA
Track Earthing Device	Manual or Automatic Short Circuit Device 100 kA for 35ms or 100 ms	Automatic Short Circuit Device 100 kA for 35ms or 100 ms	BMRCL, MEGA
110V DC Battery Bank	110 V DC	100AH / 180AH / 300AH	BMRCL
Float Cum Boost Battery Charger	415/ 110V DC	80A 50A with C8 Discharge	BMRCL, MEGA

Key Item	Voltage/ Current rating	Sizing	Adopted by
		100A with C8 Discharge	
Bus Duct for auxiliary Transformer	For >1000 KVA Transformer	1600A TPN Sandwich Busduct for 1000KVA 3200A TPN Sandwich Busduct for 2000KVA 4000A TPN Sandwich Busduct for 2500KVA 3000A TPN Sandwich Busduct (Elevated) 3500A TPN Sandwich Busduct (UG)	BMRCL, MEGA
Bus Duct for Traction Transformer		1600A TP Sandwich Busduct	BMRCL
33 KV Ring Circuit		Two Circuit common to both Traction and Auxiliary with Bus coupler Arrangements.	BMRCL
33 KV Bus Configuration		• Independent bus for Traction and Independent Bus for Auxiliary with Bus Coupler arrangement. • Common bus for both Traction and auxiliary on either side of Bus Coupler. • Hybrid Bus with Traction & one auxiliary on one side and other Auxiliary on other side of bus coupler.	BMRCL

D. EQUIPMENTS STANDARDIZATION:

1.2 25 kV AC Traction (ROCS/FOCS):

System shall be designed in conformity to CEA Safety Regulations (Amendment), 2023 or latest.

1.2.1 Receiving Sub-Stations (RSS):

i. Area Requirements: - Typical area requirement for a Metro RSS shall be limited to 6000 Sq. meters. However, compact RSS of 3000 sq.m size is feasible by adopting complete GIS technology for use in places having space constraints.

ii. The equipment can 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 with copper/GI conductor complying with International Standard IEEE 80 and IS 3043. The connection of OHE return cable from viaduct to buried rail to be connected with GI flats risers welded to buried rail & nut-bolted in cable side in the steel/concrete box. The return cable connections joint shall be accessible for maintenance checks.

Depending on demography & buried rail corrosion factor, the earthing of RSS shall be with copper conductor complying with International Standard IEEE 80 and IS 3043. The return cable from viaduct shall be connected to the RCMB (Return Current Marshalling Box). The return cable connections joint shall be accessible for maintenance checks. The Return Current Marshalling Box (RCMB) further connected to the Main Earth Mat and four nos. of independent Earth Pits.

Core CTs shall be provided on each Return Current cable from track to monitor the return current on individual cables & this shall also be monitored through the SCADA for its healthiness.

iv. Traction Transformers: - The capacity of Traction transformer shall generally designed for 21.6/30.24 MVA for 3-6 coach Metros and 30/42 MVA or 40/50 MVA for above 6 coach metros.

v. Auxiliary Main Transformers: - The capacity of Auxiliary Main Transformer shall be a standard rating 15 or 25 or 35 or 50 MVA (with suitable dual rating ONAN/ ONAF)

vi. EHV cables: Single core colour coded armour cable of required cross section shall be used.

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

viii. 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.

1.2.2 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. Modular design Aluminum Cantilever assembly is to be double insulator (stay and bracket) type. Since OHE is on viaduct and maximum implantation is always within 3.00m, Cantilever Aluminium Tube sizes can also be standardized as below for better interoperability: Stay Tube – 55mm OD Bracket tube – 70mm OD RT – 55mm OD Steady Arm – Box Type riveted Aluminium.

ii.	**Contact Wire**	Material of contact wire and its sized is governed by power requirements. Therefore, from various Metro Experience, Cu Ag or ETP, Round Bottom Contact wire is recommended. Silver copper (Cu Ag 0.1) or ETP contact wire conforming to EN50149 of 150 sq mm (Preferable) for mainline & 107 sq mm cross-section for depots shall be used based on load requirement.
iii.	**Catenary Wire**	Cadmium Copper (Cu-Cd) of 65sqmm cross Section is recommended. Insulation at vulnerable locations to be provided. Crimped typed PG clamps to be used instead of bolted type. Based on experience and specific project requirement 120 sqmm Cu-Mg material can also be adopted.
iv.	**Booster Transformer**	Provision of Booster Transformers is to be avoided to the extent possible.
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. Composite Insulators of 1600mm creepage distance is recommended.
vi.	**Earth Conductors**	Lightning arrestors at all the switching Posts are recommended to be installed to take care of lightning and surge protections. In view of this, continuous run of OPC can be avoided. However Individual Metro's may opt for OPC based on their experience's. All mast & nearby steel structures shall be earthed via BEC. 2x93.3 Sqmm ACSR shall be used depending upon EMC/EMI study no. of runs of BEC may be decided based on the current distribution.
vii.	**Neutral Section**	Polytetra-fluoro-ethylene (PTFE) insulated; Short Neutral Section (SNS) shall be used.
viii.	**Power Cables (25kV)**	Single core, Copper, 240 sqmm Cu, FRLS, XLPE, Armoured of required cross section shall be used for 25kV feeders. Or Single core, 400sqmm Al conductor, XLPE based on demographic requirement on account of theft cases of Copper cables. FRLSZH, XLPE, Armoured cables of 240sqmm Cu/400 sqmm Al in UG section. Cable sheath Short Circuit rating of 14 KA for 1 sec.

ix.	**Circuit Breaker/ Interrupters**	Vacuum type CBs/Interrupters, with appropriate ratings based on loading of the system, to be utilised.
x.	**OHE Mast**	B-series/BFB mast may be used as per requirement. GI tubular portal can also be adopted to suit urban landscape in view of aesthetic and to avoid bird nesting. Steel Structures Galvanization shall be 1000 g/sqm.
xi.	**Section Insulators**	Light weight Section insulators with 1200/1600 mm Creepage Distance (CD) shall be used.
xii.	**Load Break Switch in place of Motorized Isolators.**	Load break switch to be preferred instead of normal off-load isolators. Isolators to be avoided on main line. To improve the safety performance of Depot Control Centre (DCC), live status of each elementary section of the Depot OHE shall be provided at the DCC through localized SCADA (without control).
xiii.	**42kV Lightning Arrester**	LA to be provided at switching posts and neutral section (Against PT & feeding cables).
xiv.	**Jumpers**	Jumpers of necessary cross section to be used as per OHE current carrying capacity. Double jumper of standard cross section may be provided as per requirements. Crimped PG clamps to be used instead of nut-bolt type. Provision of 'C' Jumpers are not required as current carrying droppers are provided.
xv.	**Droppers**	Current carrying Flexible droppers to be used
xvi.	**Return Current Connections at TSS**	Instead of conventional buried rail connection of the return cable circuit, the return current cable connection between the traction transformer secondary earthed terminal to the return current earthing arrangement may be standardized and shall be in a Stainless steel/ concrete box as per standard drawings. CTs along with digital meter measuring arrangement shall be provided to monitor the return currents, in all the cables from the mainline tracks. The return current measured values shall also be available in SCADA.
xvii.	**ATD**	5 Pulley ATD / Spring type (Helical) in mainline. Spring Type ATD having the benefits of almost zero maintenance cost, no risk of counter weights breakdown, more aesthetically suited for urban landscape.

		5 pulley type ATDs may also be adopted with the protective anti falling device.
xviii.	**Potential Transformer / Capacitive Voltage Sensor**	Dry type cast resin PTs shall be used along with suitable PT screen for interlocking & measurement purpose. Wherever only indication is required, Capacitive Voltage sensors shall be used instead of PTs.
xix.	**Emergency Trip System (ETS)**	The requirement of ETS in OHE system is not recommended.

1.2.3 25 KV Rigid OCS (For UG Tunnels):

i.	**Aluminium Conductor Rail**	Aluminium Conductor Rail of 2200 sq.mm. 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) or Cu ETP conforming to EN50149 of 150 sq mm cross-section, round bottom shall be used.
iv	**Switching Sub-Stations**	All switching posts (SS, SSP, SP) should be of GIS/AIS type. AIS can also be used in UG section to optimize the cost where adequate clearances are available. GIS can be used depending upon space constraint. Load Break Switch to provide between cable & conductor.
v.	**Neutral Sections**	Overlap type neutral section shall be provided in underground sections.
vi.	**Insulated overlaps**	An Insulated overlap near (SSP/SS) transition locations (UG and Elevated) shall be provided in underground section to isolate underground and elevated OHE.
vii.	**Lightning arrestors**	Lightning 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**	Lightning arrestors at all the switching Posts are recommended to be installed to take care of lightning and surge protections. In view of this, continuous run of OPC can be avoided. All mast & nearby steel structures shall be earthed via BEC. OPC can be avoided. ITL cables shall be of aluminum and maintenance free wedge type clamps/RDSO PG Clamps (suitable RI nos.) shall be used for BEC connections. 2x93.3 Sqmm ACSR shall be used depending upon EMC/EMI study no of runs of BEC may be decided based on the current distribution.

1.2.4 33 KV Auxiliary System:

i.	**33Kv HT Breakers**	Air Insulated Switchgear (AIS)/Gas Insulated Switchgear (GIS) to be used depending on space availability, conforming to IEC 62271/ equivalent IS. Standby relays are providing little reliability & more complexity to the system. The Standby relays to be avoided. Sufficient spares for each type of relays may be ensured. Differential protection with Pilot wire to be provided (to reduce down time in case of cable failure)
ii.	**Dry Type Transformer**	Dry type transformers conforming to IEC 60076-11/IS11171 to be utilized. • Ratings of 2-3 types according to station requirements (315, 400, 500 KVA of elevated and 2000, 2500 KVA for UG & Depot) • Transient voltage protector or any protective devices to be provided in all Dry type transformers to have immunity against switching surges. • Delta-Star configuration, Insulation F-class Aluminum wound. • The Core used shall be of Hi-grade HiB steel to limit the inrush current during switching operation. • 2 KV AC Core-Bolt Isolation Test shall be performed both at shop and site. • Screen shall be provided between HV & LV winding. • Fire safety F1 class compliance should be mandatory.

iii.	**Power cable (33kV)**	• For 33kV system, Single core, Aluminium FRLS, XLPE cables of required cross section in elevated for exclusively Elevated/ At Grade section. 33kV Armoured Cable for the section from RSS to first ASS. 33kV Unarmored/Armoured cable along the Metro corridor. • For Underground Section, Single core, Copper/Aluminium FRLSZH, XLPE cables required cross section shall be used.
iv.	**Earthing System**	Earthing system design shall conform to IEEE 80 and IS 3043.
v.	**33 kV network**	Redundant arrangement - Double circuit with 2 Dry type transformers in each ASS.

1.2.5 Retractable Overhead Conductor Rail System:

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

1.2.6 Power Supply System (Sub Stations)

i.	**Auxiliary Main Transformer / Power Transformer**	Ratings may be standardized to minimize type test requirement. For ratings differing based on Simulation studies, Type test reports will be required. 20/25 MVA, 25/35 MVA, 30/45 MVA. With Onload Tap Changer.
ii.	**Traction Transformer**	ratings may be standardized to minimize type test requirement. 21.6/30.24 MVA, 30/42 MVA, 40/50 MVA. With Onload Tap Changer.
iii.	**66/132/220 kV Cables/Transmission lines**	Cable sheath shall be PE instead of PVC. Sheath Integrity test to be carried out. Laying in Trefoil formation. single core color coded underground cable shall be used.
iv.	**25 kV cables**	Single core, Copper, FRLS, XLPE, Armoured of required cross section. FRLSZH, XLPE, Armoured cables required cross section in UG section. Cable sheath Short Ckt rating of 14 KA for 1 sec. For the cable length more than 1000m SVL (sheath voltage limiter), must be provided with sending end sheath earthed. For the cable length less than 1000m, sending end sheath shall be earthed and other end shall be kept open (but suitably protected for safety)

v.	**Switch gears 132/220 kV**	GIS/AIS Double Bus GIS must for single RSS per corridor. standby relay. Not recommended. Sufficient spares of each type of installed relay shall be ensured. Selection of GIS/AIS shall be the prerogative of Metro. Dedicated core in CT & PT or dedicated CT & PT of Incomer bays to be kept for supply authority metering.
vi.	**33 kV Switchgear Panel**	Air Insulated Switchgear (AIS)/Gas Insulated Switchgear (GIS) to be used depending on space availability, Standby relays are providing little reliability & more complexity to the system. The Standby relays to be avoided. Sufficient spares, for each type of relay, may be ensured.
vii.	**25 kV Switchgear Panel**	Air Insulated Switchgear (AIS)/Gas Insulated Switchgear (GIS) to be used depending on space availability, With bus sectionalizer. PT Disconnection availability. Gas pressure visibility. LA for PT. BIL - 200kV Standby relays are providing little reliability & more complexity to the system. The Standby relays to be avoided. Sufficient spares, for each type of relay, may be ensured.
viii.	**NIFPS**	To provide for Power & Traction Transformer. Main points to mention: 1. Above 10 MVA or greater 2000 ltr oil & below 100 MVA: 6/10 m2 gas at pressure of 150 kg/cm2 2. System shall have interlock to ensure operation of system only after transformer to avoid nitrogen injection in energized transformer.
ix.	**Protection (at RSS/TSS)**	Panto Flashover relay to be provided. di/dt protection is also preferable.
x.	**RSS**	• Air Insulated Switchgear (AIS)/Gas Insulated Switchgear (GIS) to be used depending on space availability, The earthing of RSS shall be complying with International Standard IEEE80. Earthing Shall be with GI strips. 75x8 / 80x10 GI strips are sufficient for meeting earthing requirement of substation. Life of good quality GI strips are enough. Copper clad earth rods loses its advantage at all welding joints. MS / Copper rod can be used based on the expert opinion. Depending on demography, if earth value is not being achievable, Earthing shall be of copper strip of suitable size, based on the fault level. • Metro may opt for Dynamic reactive power compensation devices based on their State Electricity Board regulations. • As per para 3 of part IV of CEA regulation 2007 i.e the total harmonic distortion for current drawn from the transmission

		system at the connection point shall not exceed 8%. To fulfill this requirement, suitable measures to limit the current harmonics be taken. Harmonic limiting device may be installed. IGBT based dynamic power factor & harmonic correction devices are available. Combination of reactor and active filters based on the load survey to be adopted. Location of PF correction equipment is to be standardized. • 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. • Return current connections at RSS/TSS. A box type arrangement at ground level with sufficient earthing flats connection from buried rails/earth pits may be provided where Transformers negative cables & return track cables may be connected. This will ease cable connections and monitoring. Instead of conventional buried rail connection of the return cable circuit, the return current cable connection between the traction transformer secondary earthed terminal to the return current earthing arrangement may be standardized and shall be in a stainless steel/ concrete box as per standard drawings. CTs along with digital meter measuring arrangement shall be provided to monitor the return currents, in all the cables from the mainline tracks. The return current measured values shall Also be available in SCADA.
xi.	**SCADA**	• Substation Automation Station (SAS) shall comply to IEC 61850. • All parameters of Transformers including Thermal parameters shall be interfaced with SCADA. • Traction SCADA system shall comply with IEC 60870-5-104 and/or IEC 61850 or equivalent standard & complete SCADA network shall be on dedicated Fibre Optic (dual). • All electrical parameters shall be communicated to SCADA by digital link either on dark Fibre or telecom back bone to OCC/BCC. • 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. • Cyber Security system as per CEA guidelines shall be provided to avoid external threats. • Redundancy of IED's (backup relays) generally may not be considered apart from exceptional cases based on experience. Sufficient spares, for each type of relay, may be ensured. • To improve the safety performance of DCC, live status of each elementary section of the Depot OHE shall be provided at the DCC through localized SCADA without control. • Exclusive SCADA for traction power control to be provided. Separate SCADA for BMS, CCTV, telecom and other systems for monitoring from OCC.

		• Disturbance recorder system shall be provided at OCC and BCC for fetching the disturbance records & stored data in the relays/IEDs and analysis of the faults waves.
xii.	**Disturbance Recorder**	Provision of Centralized Disturbance Recorders for all IEDs of Traction Power System for downloading of events/disturbances to analyze the faults and quick rectification.
xiii.	**Batteries**	110V, Ni-Cd maintenance free batteries with 10 years' service life. Minimum Capacity: 300Ah for RSS, AMS, TSS, 150 Ah for ASS with FP, 125 AH for ASS with SP/SSP/SS & ASS (only) may be adopted for less inventory.
xiv.	**DC network**	110 V, 2 no's DC sources with redundant battery bank & Battery Chargers

1.3 750 V DC Traction System (With Third Rail):

System shall be designed in conformity to CEA Safety Regulations (Amendment) 2023 or latest.

1.3.1 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. Typical area requirement for the RSS shall be limited to 4000 Sq. meters.

ii. The equipment can 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. Dedicated Core in CT's & PT's or Dedicated CT's & PT's for incomer bays to be kept for Supply authority metering.

iv. The Earthing of RSS shall be complying with International Standard IEEE 80 and IS 3043.

v. To neutralize the induced voltages, cable sheath cross bonding, if required conforming to IEC 60287 shall be provided for UG EHT cables. Single Core armoured XLPE cable of required Cross section in trefoil arrangement shall be used. The Cable sizing shall be designed to meet the power requirement in case of failure of ine RSS. Cable sheath shall be of PE and Sheath integrity test to be carried out before charging.

vi. RSS shall be designed with 100% redundant in incoming bays, outgoing bays & transformers.

vii. 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 of 20/25MVA for 3-6 coach Metros and 40/50 MVA for above 6 coach Metros can be adopted. However, the rating shall be selected depending upon the simulation studies.

viii. NIFPS system shall be provided for all power transformers in accordance with CEA Regulation.

ix. Short circuit current rating: All equipment's considered in RSS shall have the short

circuit rating of 50 kA/Sec for 220 kV, 40 kA/Sec for 132kV & 66kV, considering increase in fault level of power supply authorities.

x. Earthing system: Earthing system design shall conform to IEEE 80 and IS 3043.

xi. Static/Dynamic/STATCOM Reactors (based on their State Electricity Board regulations) & filters to be used at the point of common coupling & ASS locations based on load study for limiting the effect of Harmonic Distortion, Control of reactive power etc.

1.3.2 33KV Distribution:

33KV Distribution:		
1.	33kV HT Breakers	Gas Insulated Switchgears (GIS)/AIS, conforming to IEC 62271/equivalent IS may be used. In ASS – 33kV, 1250 A/1600 A, Vacuum type Circuit Breaker, conforming to IEC 60694 to be used based on loading of the system. Differential protection with Pilot wire to be provided (to reduce down time in case of cable failure) Standby relays are providing little reliability & more complexity to the system. The Standby relays to be avoided.
2.	33kV HT Interrupters	Not recommended. Instead, Circuit Breakers with 1250 A shall be used considering 33kV cable protection.
3.	Dry Type Auxiliary Transformer	Dry type transformers conforming to IEC 60076-11 to be utilized. • Ratings of 2-3 types according to station requirements (400, 500 KVA of elevated and 2000, 2500 KVA for UG & Depot) • Transient voltage protector or any protective devices to be provided in all Dry type transformers to have immunity against switching surges. • Delta-Star configuration, Insulation F-class for HV winding and H-Class for LV Winding, Aluminum wound. • The Core used shall be of Hi-grade HiB steel to limit the inrush current during switching operation. • 2 KV AC Core-Bolt Isolation Test shall be performed both at shop and site. • Screen shall be provided between HV & LV winding. • Fire safety F1 class compliance should be mandatory.
4.	Power cable (33kV)	For 33kV system, Copper cable of required cross Section (meeting load & fault current requirement) XLPE, FRLS in trefoil formation for Elevated/ At Grade section and for

		U.G stations, Halogen Free FRLSZH in trefoil formation to be used. Power cables shall conform to IEC 60502 to be used.
5.	33kV Distribution network	Distribution to various traction/auxiliary substations located in Elevated/Underground stations, shall be by means of a 33kV Ring main network having 2 circuits with Bus Coupler in each ASS & TSS Stations. Bus Coupler is not required for stations having ASS only. 33kV network inter connection shall be made for Auto transfer of traction power from one section to another in emergency situations in case of power failure of any RSS.
6.	Earthing system	Earthing system design shall conform to IEEE 80 and IS 3043.

1.3.3 Traction Sub-Stations (TSS)

1) Each Substation receiving power at 33kV from the 33kV ring feeder. The distance between adjacent stations is maintained as per the calculation of voltage drops during system study.
2) Every station shall be provided with Two Switchgear feeders in each circuit Bus for loop-in–loop-out of 33kV ring main feeders. Auxiliary & Rectifier/Traction transformers are to be fed from this Bus as per 33 kV Power supply distribution Scheme adopted.
3) The 750V DC is fed to the third rail system through high-speed circuit breaker (HSCBs) conforming to IEC 61992, EN 50123-1, EN 50123-2.
4) DC disconnector shall be provided in series with the feeder HSCB's in Bypass Panel for high reliability of off load operation. The interlocking between Feeder HSCB and Isolator shall be available.
5) Disconnecting switches are incorporated for sectionalizing the third rail as per the operational requirements in Main line and Depot.
6) Provision of reversible substation for maximum regenerative energy recovery shall be made based on Simulation Studies.
7) The traction substations shall be designed taking into consideration of design year load (15-20 Years) with N-1 Criteria.
8) For the connection between secondary of traction transformer to rectifier 600 V, 3-phase, 50 Hz sandwich TP bus duct conforming to IEC-61439 with aluminum bus conductors suitable for 1600 A continuous current rating and short time overload rating similar to rectifier i.e., Class-VI duty cycle as per EN – 50328 shall be used.
9) 415V, 3-phase, 50 Hz sandwich TPN bus duct conforming to IEC-61439 with aluminium bus conductors of suitable continuous current ratings (for 1000 KVA and above) shall be used for the connection between auxiliary transformer of Depot ASS/Underground stations and Main Distribution Board (MDB).

i.	Dry Type Traction	Three Winding (Delta-Star-Delta) Dry Type Traction Transformers of capacity 2850 KVA

	Transformers	conforming to IEC 60076-11, IEC 60146-1-1, IEEE 1653.1 shall be provided. The duty cycle shall be class-VI as per EN 50329 or equivalent standard as adopted in line with the Rectifiers duty, class
ii.	Rectifiers	Two sets of Rectifier Bridge each with a capacity of 2500 KW, 750 V DC shall be used to the extent possible. 12 pulse or better parallel rectifiers with harmonics limits shall be used. The duty shall be class-VI as per EN 50328/IEC 60146-1-1, IEEE 1653.2 or equivalent standard in line with Transformer Duty Class.
iii.	Over voltage protection device	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 as adopted. OVPD shall have the feature of Auto Re-closing.
iv.	DC switchgear	The feeder HSCBs shall have feature of auto reclosing. Provision for remote reset for HSCB in case of lock out shall be available. It shall be possible to bypass any TSS and restoring power to third rail by a single command from OCC.
v.	Positive & negative cables	300 sqmm armored copper cable shall be used having 3.3kV Grade for positive circuit and 1.1 kV Grade for negative circuit. Number of runs in each circuit shall based on load requirement.
vi.	Automatic motorized Short circuit and earthing device	Automatic motorized Short circuit earthing device (TRED) shall be installed in TSS and Depot instead of Manual SCD's to reduce maintenance man-hours and ease of Motor Trolley movement during inspection.

1.3.4 Third Rail

1.	Conductor rails	• Material: high conductivity aluminium alloy and utilized with a stainless-steel wearing face. • Standard lengths of 15 mtrs length pieces. • Rated nominal resistance of maximum: 0.007 ohm/km at a current of 4500A. • The junction bend strength shall not be less than 70N/mm2. Alternatively, 90mm piece of conductor rail shall withstand 60kN force without damage. • The stainless-steel strip shall have flat surface

		without milling groove. • The interface resistance between Steel and Aluminum shall not exceed 30 μΩ.
2.	Expansion Joint	Single gap (100-200 mm) EJ's or Double Gap (two gaps of 100-200 mm) EJ's shall be used depending upon the requirement.
3.	Insulated Joints	Insulated joints or air gaps shall be used to provide sectioning of third rail.
4.	Third Rail Brackets	Steel or FRP/composite material Brackets of proven and type tested shall be used
5.	Stringer system	Stringer system shall be used in Inspection Bay Lines having two/four trolleys for each 3/6 car trains and stinger system shall be also provided in RBL either Static type or Movable type.

1.3.5 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) Platform up to a length of 2 meters shall be insulated to keep control over the step potential to ensure safety of passengers.
3) Rail to Rail and track cross bonding shall be made at frequent intervals for keeping the voltage drop at low levels based on the results of DC Simulation studies.
4) Safety provisions as per NFPA 130/NBC-2017 (latest), including provision of Automatic Gas flooding inside the Panels and Emergency Tripping System (ETS) at different locations shall be followed.

i.	Track fastening system fitting	The insulation shall be preferably more than 100 Ω.KM, or conductance of 0.01 Siemens/KM per track for a new track measured under dry conditions. As per EN 50122-2 Insulation value of 2 Ohm.km or conductance of 0.5 s/km per Track shall be maintained during the system life time.
ii.	Earthing & Bonding	Structure Earth Conductor shall be preferably 185 sqmm Aluminium (AAAC) bare conductor and connected to pier and viaduct segment earth connections. Earthing & Bonding connection cables shall be of 95/120 sqmm Aluminum cable.
iii.	Track fastening system	Shall have following minimum features: ▪ An insulator between rail and tension clamp ▪ A base plate which is not at rail potential

		▪ An insulating rail pad ▪ An insulating bush between base plate and anchor bolts • An insulating intermediate pad providing a creep age distance of >12mm between base plate and concrete

1.3.6 SCADA

i.	SCADA	• Substation Automation Station (SAS) shall comply to IEC 61850. • All parameters of Transformers including Thermal parameters shall be interfaced with SCADA. • Traction SCADA system shall comply with IEC 60870-5-104 and/or IEC 61850 or equivalent standard & complete SCADA network shall be on dedicated Fibre Optic (dual). • All electrical parameters shall be communicated to SCADA by digital link either on dark Fibre or telecom back bone to OCC/BCC. • 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. • Cyber Security system as per CEA guidelines-2023 or latest shall be provided to avoid external threats. • Redundancy of IED's (backup relays) generally may not be considered apart from exceptional cases based on experience. • Exclusive SCADA for traction power control to be provided. Separate SCADA for BMS, CCTV, telecom and other systems for monitoring from OCC. • Disturbance recorder system shall be provided at OCC and BCC for fetching the disturbance records & stored data in the relays/IEDs and analysis of the faults waves.

1.3.7 Protection philosophy & Scheme

i.	Protection relays	Protection relays shall comply to IEC 60255

ii.	Rectifier Protection	Diode failure, RC fuse failure, reverse current, Diode temperature, and Earth leakage current protection shall be provided as minimum requirement.
iii.	DC breakers	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.

1.4 Cost Reduction and/or Innovative Measures:

SN	Sub-system	Suggestion/Improvement
	25 kV AC Traction System	
1	**Load Break Switch in place of Motorized Isolators.**	Load break switch to be preferred instead of normal off-load isolators. Isolators to be avoided on main line. SCADA in depot with load break switch is preferable.
2	**42kV Lightning Arrester**	LA to be provided at switching posts and neutral section. OPC can be avoided with the provision of above LA & earthing of Mast/Portal through BEC
3	**Jumpers**	Jumpers of necessary cross section to be used as per OHE current carrying capacity. Double jumper of std cross section may be provided as per requirements. Crimped PG clamps to be used instead of nut-bolt type. Provision of 'C' Jumpers are not required as current carrying droppers are provided.
4	**Droppers**	Current carrying Flexible droppers to be used. "C"/ "H" Jumpers can be avoided.

5	**Return Current Connections at TSS**	Instead of conventional buried rail connection of the return cable circuit, the return current cable connection between the traction transformer secondary earthed terminal to the return current earthing arrangement may be standardized and shall be in a stainless steel/ concrete box as per standard drawings. CTs along with digital meter measuring arrangement shall be provided to monitor the return currents, in all the cables from the mainline tracks. The return current measured values shall also be available in SCADA.
6	**ATD**	5 pulleys/Spring type (Helical Spring) ATD in mainline. Spring/Pulley type in depot.
7	**Potential Transformer**	Dry cast resin type PTs shall be used along with suitable PT screen. Need Discussion/performance on capacitive sensors is required. It can replace all indication PT along the corridor.
8	**Load Break Switch**	25kV feeding cables from GIS to ROCS to terminate on the conductor rails through Load Break Switch with remote control through SCADA.
9	**ETS**	The requirement of ETS in OHE system is not recommended
10	**Development of common SoD & DBR for identified speed and coach width**	Optimization of viaduct width for common SoD for ease of maintenance and center/ side evacuation required.
11	**Unmanned operation of RSS**	For unmanned operation of RSS, electrical reset of all relays & master trip relay (MTR) after trip to be provided from SCADA
12	**Depot Control Centre (DCC)**	Using Motorized isolators & separate SCADA for status only, (without control) for depot
13	**SCADA**	RTU shall support interoperability and capable to exchange information with other SCADA system over IEC 60870-5-104, IEC 61850 and other standard communication protocols for receiving/transmitting signals such as inter-tripping. No proprietary protocols shall be permitted.
Third Rail Traction System		
1	**33kV distribution network**	33kV distribution network with Two (2) circuit configuration instead of Four (4) circuit configuration.

2	**Earthing & Bonding**	Use of Aluminum cables instead of Copper cables for Earthing & Bonding connection cables.
3	**Inverter based TSS**	Provisions of inverter-based Traction Sub-stations at feasible locations to facilitate for feeding the regenerative energy back to the grid.
4	**Motorized Short Circuit Device/ Track Earthing Device**	Use of Motorized Short Circuit Device/ Track Earthing Device instead of conventional Manual SCDs which saves maintenance time.
5	**Training Simulator for Traction**	Training Simulator for Metro Operation for effective traction power control.
6	**Relay testing Laboratory & Centralised Disturbance recorders**	Centralized relay testing Laboratory including DR Work station shall be provided for calibration of all IED's (AC&DC), Transducers/ meters, auxiliary relays and down loading of Disturbance records for up keeping of traction assets and minimize time for rectification.
7	**DG Sets**	At all stations, UPS to be provided & At Interlocking stations, DG sets also to be provided to meet the emergency load requirements. However, individual Metro's may opt for DG sets at elevated & UG stations as per their experience/requirement.
8	**Power Quality analyser**	Power quality analyzer preferred to be installed at all points of common coupling for real time measurement of Harmonics to take remedial measures
9	**ETS/ESP**	Activation of ETS shall initiate ESP (Emergency stop plunger) to ensure stopping of trains before entering platforms. This is required for all stations where screen doors are not provided.
Measures to minimize type defects, traction equipment failures:		
1	**Auxiliary & Traction Transformers (Dry Type Transformers)**	Dry Type Transformers shall be provided with Transient voltage protector or any protective devices like Surge Arrestors etc to avoid switching surges Using of high-grade HiB CRGO steel for Dry Type Transformers to reduce inrush current.
2	**Solid State Fault Limiting Devices**	One of the major reasons for poor reliability of 25kV Overhead Traction system is very high fault currents in Metro networks (about 14kA against the 7kA in Indian Railway network). During any external grounding fault of OHE, there are extensive damages to the OHE, particularly to the Catenary and jumper wires, contributing more than 50% of the failures of the OHE. Solid State Fault Limiting Devices are available in the market for HT networks. With the development of such systems for 25kV

		traction system, it will go in a long way to improve the reliability of 25kV OHE.
		Power Factor Correction Measures:
1	**Auxiliary Mains supply at RSS**	**Provision of Active Filter & Shunt Reactor for reactive power compensation due to the long length of 33kV cable network.** Metro may opt for Dynamic reactive power compensation devices based on their State Electricity Board regulations. Dynamic Compensator: - The power supply system in Metro Rail has extensive 132kV, 33 kV and 25 kV cables in its distribution network. Lightly loaded or unloaded cables generate the reactive power. Effect of the reactive power injection from all the cables is quite significant. In view of cables and leading power factor operation of electrical system. It is necessary mitigate the leading power factor operation issue and to maintain unity power factor as well as to eliminate the harmonic content at the point of common coupling by using Dynamic compensator. Installation of Reactor/Active filter/STATCOM on LV/MV Side shall be made after real time measurements.
		Energy Management System
1	**Energy Management System**	Energy Management System in SCADA system may also be explored to monitor the energy related data.

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