

PART 2: EMPLOYER'S REQUIREMENTS

CHAPTER 9A: TRACTION NETWORK

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Note: These specifications are the bare minimum requirement. The PST Contractor must verify the design and should fulfil system requirements while selecting system/equipment/components & its executions. The final requirements of the specifications will depend upon the simulation studies and based upon that the PST contractor must provide the material over and above to these specifications which shall be finally approved by Engineer / Employer. However, payment for any extra material requirements over and above to these specifications, if needed, and not covered in the BoQ shall be governed by clause no. 13.3.3(B)2 of section-IX PCC.

1. SPECIFICATION FOR TRACTION NETWORK

1.1. PREAMBLE

The aim of this document is to define the specifications of the Traction Network of BI-RIDE Phase 1, Corridor-2 & Corridor-4 covered under this contract.

1.2. DESCRIPTION

The Traction Power Supply Network transforms the High voltage 220 kV into 25 kV by means of transformers and distributes the 25 kV through adequate protecting and sectioning equipment to the Overhead Catenary System (OHE) which feeds the Metro trains.

It is mainly composed of Feeding Posts (FP), Sectioning Post (SP), Sub – Sectioning Post (SS) and Sub-Sectioning & Paralleling Post (SSP), collectively referred to as 'Switching Stations'.

1.3. Switching Stations

1.3.1. Corridor-2:

The Traction Power for Benniganahalli to Chikkabanavara: Corridor-2 is derived from Traction Substations, proposed to be located at

- Benniganahalli
- Mathikere
- Soladevanahalli.

The feed for the Corridor is further divided into Sub-sections, with the help of Switching Stations, location / chainage is given below:

Location of Switching Station for Corridor-2		
Name of Switching Station	Switching Station Type	Approx. Chainage*
Benniganahalli	Sub Sectioning Post (Supply from C-4 Benniganahalli TSS)	(-)0+830
Benniganahalli	Sectioning Post (Supply from C-4 Benniganahalli TSS)	(-)0+010
Banaswadi	Sub Sectioning & Paralleling Post	4+585.5
Kanaka Nagar	Sub Sectioning & Paralleling Post	9+700
Mathikere	Feeding Post	14+980
Mathikere	Sub Sectioning Post	16+506

Location of Switching Station for Corridor-2		
Name of Switching Station	Switching Station Type	Approx. Chainage*
Yesvantpur	Sub Sectioning & Paralleling Post	17+897
Myadarahalli	Sub Sectioning & Paralleling Post	22+916.5
Chikkabanavara	Sub Sectioning Post	24+270
Soladevanahalli	Sectioning Post (Supply from Depot TSS)	25+350
Soladevanahalli	Sub Sectioning & Paralleling Post (Supply from Depot TSS)	At the end of corridor
* Chainages are marked as continuous for Corridor-2 with (-)1+413 being the starting chainage of the Corridor i.e. at Benniganahalli end.		

Table 1 Location of Switching Stations for Corridor-2

Further there is provision of 25 kV Cable feed from Benniganahalli TSS to Benniganahalli Station of Corridor-2, which is near the end of the Corridor-2 which can feed complete Corridor- 2 in case of failure of Mathikere TSS.

Benniganahalli Station of Corridor-2 shall be fed from Corridor-4 TSS (Benniganahalli) to cater the hassle-free movement of Rolling stock from one corridor to another as & when required.

Similarly, at Yesvantpur there is an inter crossing from Corridor-2 to Corridor-1, inter free movement of rolling stock is to be made sure without compromising operations time.

Soladevanahalli depot shall be fed from the TSS located inside depot.

Feeding post in the depot shall segregate the power to Depot lines, typical drawing is referred here KRDD01-TDR-CR02-SLD-OCS-SEC-00001.

Also, there is a provision for back feed of supply from Main Line in case of outage of Depot TSS outage.

To achieve this, a neutral section arrangement is proposed between Main Line & Depot so that main line supply can be extended to depot in case of emergency & vice versa.

Corridor-4: The Traction Power for Corridor-4 is derived from Traction Substation, proposed to be located at Yelahanka & Benniganahalli TSS. The feed for the Corridor is further divided into Sub-sections, with the help of Switching Stations, location/chainage is given below:

Location of Switching Station for Corridor-4		
Name of Switching Station	Switching Station Type	Approx. Chainage*
Heelalige	Sub Sectioning & Paralleling Post	(-)0+500
Singena Agrahara	Sub Sectioning Post	2+759.5
Ambedkar Nagar	Sub Sectioning & Paralleling Post	7+775
Belanduru	Sub Sectioning & Paralleling Post	14+254.5

Location of Switching Station for Corridor-4		
Name of Switching Station	Switching Station Type	Approx. Chainage*
Doddanekundi	Sub Sectioning Post	18+103.5
Benniganahalli	Feeding Post	23+125
Horamavu	Sub Sectioning Post	25+464.5
Thanisandra	Sectioning Post	29+525
Jakkur	Sub Sectioning Post	33+607.5
Jakkur	Alternate NS arrangement	34+275 (Approval for its provision shall be decided by Engineer / Employer)
Yelahanka	Neutral Section Arrangement	36+150
Yelahanka	Feeding Post (C-4 TSS)	38+525
Yelahanka	Alternate NS arrangement	39+500 (Approval for its provision shall be decided by Engineer / Employer)
Muddanahalli	Sub Sectioning Post	41+973.5
Rajankunte	Sub Sectioning & Paralleling Post	46+200
* Chainages are marked as continuous for Corridor-4 with (-)0+633 being the starting chainage of the Corridor-4 at Heelalige end.		

Table 2 Location of Switching Stations for Corridor-4

1.4. TRACTION FEEDING DIAGRAM

Corridor Ref.	Name of Corridor	Traction Feeding Drawing No.
1	25 kV SECTIONING DIAGRAM OF MAINE LINE FROM BENNIGANAHALLI TO CHIKKABANAVARA (CORRIDOR-2)	KRDD01-TDR-CR02-GEN-OCS-SEC-00002
2	25 kV SECTIONING DIAGRAM OF MAINE LINE FROM HEELALIGE TO RAJANKUNTE (CORRIDOR-4)	KRDD01-TDR-CR04-GEN-OCS-SEC-00002
3	25 kV SOLADEVANAHALLI DEPOT SECTIONING DIAGRAM	KRDD01-TDR-CR02-SLD-OCS-SEC-00001

2. TRACTION SUBSTATIONS

2.1. DESCRIPTION

Traction Substations (TSS) located in Receiving Substations in Corridor-2 and Corridor-4, performs the task of converting the 220 kV incoming power supply to 27.5 kV single phase

power supply and of supplying this power to the traction overhead equipment (OHE) via cables through appropriate switchgear and protection arrangements.

2.2. Scope of Work

2.2.1. In the TSS

The supply and erection of below TSS items is within the Scope of this Tender.

- All the 25kV cables including accessories from TSS(s) exit point up to the Interrupter located on the viaduct or At-grade section, for feeding the OHE.
- All the return cables including accessories from the ITL to the buried rail/RCMB (return Current Marshalling Box) at respective TSS(s).
- Cable routing/path from TSS(s) exit points up to respective Main Lines.

2.2.2. Traction Feeder Protection

The Protection relays required for the protection of Traction Feeders (IDMT Over Current, Distance, VDOC with DMT, Emergency/Back-up Over Current, Auto Reclose, WPC & PFR etc) and for protection against 'Panto flash Over' and Wrong-Phase-Coupling' at Neutral Sections, are also within the Scope of this contract. This is broadly covered in the section -Technical specifications of RSS.

25kV power supply to the Soladevanahalli depot shall be fed from the depot TSS at Soladevanahalli and back feed from the mainline (as a backup). Therefore, one breaker to be provided at the depot feeding post along with protection functions as described below.

- Distance Protection (21)
- Fuse Failure Monitoring for Distance Protection
- IDMT Over current protection (51)
- VDOC (Voltage Dependent Over Current) Protection with DMT Characteristic.
- Emergency/Back-up Over Current.
- Auto-Recloser
- Wrong Phase Coupling (Not applicable for depot)
- Pantograph Flashover Protection (Not applicable for depot)
- Under Voltage (27)
- Master Trip (86)
- DC U/V tripping (Control Supply failure)

2.3. Manning of Commissioned Switching Stations

The Employer may call upon the PST contractor to provide suitable manning staff in the already commissioned (SS/SP/SSP/FP) and handed over to the Employer, for manning the installations, before commencement of the revenue operation of the line. The PST contractor shall provide the necessary staff team for the purpose. The staff team deployed at the SS/SP/SSP/FP shall be thoroughly conversant and competency certificate staff to operate the various switchgear, providing / removing discharge rods and systems and shall be able to provide traction power, if so desired by the client, to other Agencies working in the Station area or elsewhere and also to provide power shutdowns of the commissioned systems, if so, directed by the client. It shall also be ensured by the PST contractor that deployment of such staff team will not, in any way, affect completion of other works within the specified Key Dates.

For measurement purposes, a period of 8 hours of deployment of one skilled staff shall be considered as one-man day. Three shifts per day shall be provided as approved by Client.

The PST contractor shall be responsible for ensuring minimum wages, as prescribed by the Ministry of Labour, State Government and/or Central Government, provisions of Minimum Wages Acts and other statutory provisions irrespective of rates quoted.

2.4. Specification & Construction Features of 25 kV Traction Power Cable

2.4.1. Specification

The 25 kV Cables shall conform to IEC 60840 with specified voltage as 26/45 kV (52 kV) grade. The cables shall be of dry-insulated, radial-field cable, based on proven technology. They shall be constituted of single core cables of 2 runs per feeder for mainline (1 run per feeder for depot lines), compact circular stranded class-2 Aluminum Conductor for the cables as specified. The cable shall be XLPE insulated with semi-conducting screen over conducting core, insulating envelope, metallic screen, Aluminum Tape armored and suitable protective sheath. The traction cables shall be supplied and tested as per the data sheets. The final GTP of traction cables shall be approved by Engineer in charge. 25 kV Cable shall be totally Fire retardant Low smoke including insulation and inner and outer sheath.

The 3.3 kV Cables shall conform to IEC 60502-1 with specified voltage as 1.8/3.0 kV (3.6 kV) grade. The cables shall be of dry-insulated, radial-field cable, based on proven technology. They shall be constituted of single core cables of 2 runs per feeder for mainline (1 run per feeder for depot line), compact circular stranded Class-2 Aluminium Conductor for the cables as specified. The cable shall be XLPE insulated over conducting core, Aluminum Tape armored and suitable protective sheath. The traction cables shall be supplied and tested as per the data sheets. The final GTP of traction cables shall be approved by Engineer in charge.

2.4.2. Constructional Features

2.4.2.1. Conductor:

The conductor shall be formed from compact circular stranded class-2 Aluminium Conductor / copper complied with IEC 60228 latest version.

2.4.2.2. Conductor Screen:

The conductor screen for 25 kV Cable shall be provided as per IEC 60502-2 latest version. It shall be easily removeable from conductor during jointing. The conductor screen shall be provided over the conductor by extrusion of semi-conducting compound. A semi conducting tape(s) shall be provided below the extruded semi conducting conductor screen to prevent penetration of compound in to the under lying conductor.

2.4.2.3. Insulation:

The insulation shall be cross linked polyethylene (XLPE), free from contaminants and air voids and shall be applied by the extrusion process. The nominal thickness of insulation shall not be less than 10mm for 25kV cable and 2mm for 3.3kV cable and subject to tolerance as per IEC – 60840, clause 10.6.2.

The insulation compound shall be of high quality, heat, moisture, ozone & corona resistant. XLPE compound should be from reputed manufacturers with satisfactory service experience of more than 5 years. The insulation shall be suitable for operation in wet or dry locations at conductor temperature not exceeding 90 deg. C for normal operation, and 250 deg. C for short circuit conditions. For this purpose, short circuit current in conductor is to be considered as 14 kA for 3 seconds.

The Insulation shall be applied by triple extrusion and vulcanized using dry curing process to

form a compact homogenous body, free from micro voids and contaminants. Make of XLPE, shall be approved by the Engineer, before giving manufacturing clearance. Approved cable manufacturer shall have a procedure to check and record the eccentricity and ovality of the insulation of the entire cable length while manufacturing. Same shall be checked during FAT.

2.4.2.4. Insulation Screen

The Insulation screening for 25kV cable shall be applied direct upon the insulation and shall be of a layer of extruded semi conducting thermosetting compound firmly and totally bonded to the insulation. Semi conducting compound shall be from reputed manufacturers with satisfactory service experience of more than 5 years. Make of the same shall be approved by the Engineer, before giving manufacturing clearance.

The conductor screen, insulation & insulation screen shall be extruded in a single process (triple extrusion).

2.4.2.5. Semiconducting Tape:

The water barrier shall be semi conducting water swellable tape(s) to be applied over the extruded insulation screen to block and prevent moisture propagation in a longitudinal direction. The semi-conducting tape shall be suitable for the operating temperature of the cable and compatible with the insulation.

2.4.2.6. Metallic Screen:

The metallic screen for 25kV cable shall be plain aluminium round wires applied helically over the semi-conductor bedding tape(s). Aluminium binder tape shall be applied in the form of an open helix, over the aluminium wire screen. The nos. and diameter of the aluminium wire/tape should be able to withstand specified earth fault current (14kA for 3 sec). Vendor to submit the calculations giving details of the area of metallic screen w.r.t earth fault current.

2.4.2.7. Inner Sheath:

For 25kV cable an inner layer of semi-conducting water swellable tape shall be applied over metallic screen followed by Polyethylene laminated Aluminium tape that shall be acting as a radial water barrier. Extruded black FRLS (for elevated) / FRLSZH (for underground) layer shall be provided as a separation sheath.

2.4.2.8. Armouring:

Double layer of Aluminium Tape armouring should be applied over the inner sheath and the thickness of the same should be as per IEC 60502. A layer of FRLSZH / FRLS binder tape shall be applied over armor.

2.4.2.9. Outer Sheath:

For Elevated / At grade location

The outer sheath shall be extruded black colour FRLS PVC conforming to requirement of IEC specifications and extruded continuously.

For Underground location

The outer sheath shall be extruded black colour FRLSZH PVC conforming to requirement of IEC specifications and extruded continuously.

For 25kV cable outer sheath to be provided as per IEC 60502-2. A conductive layer shall be provided on outer sheath to comply over sheath electrical testing requirement as per IEC 60840.

For 3.3kV cable outer sheath to be provided as per IEC 60502-1. The minimum thickness of outer sheath of the cable shall be strictly as per the attached GTP of the cable i.e. 3.5 mm for 25kV cable and 2mm for 3.3kV cable.

The cable shall be manufactured by a company having ISO accreditation for quality. The manufacturing process of XLPE cable shall consist of conductor screen, insulation & insulation screen shall be extruded in a single process (triple extrusion) and cross linked by VCV Process to ensure homogeneity and absence of micro voids. The cables shall be manufactured by "Dry Curing" Process.

Note - 25 kV Cable shall be totally Fire-retardant Low smoke including insulation and inner and outer sheath

2.4.3. Between TSS and OHE

Normally, each connection between the 25 kV Outgoing Circuit Breaker/Interrupter/Isolator at TSS and the OHE pole mounted Interrupter shall be realised by means of 2x400 sq.mm. Aluminium cables.

Each Feeder will consist of

- 1) Phase cable (25 kV) made up of 2x400 sq.mm. Aluminium cables / 2 x 240 sq mm Copper Cable
- 2) Return cable (3.3 kV) made up of the same number of cables and cross section, as the phase cable.
- 3) For depot feeder, 2 feeders of 1 no. phase cable (25 kV) made up of 1x400 sq.mm Aluminium Cable / 1 x 240 sq.mm copper along-with return cable (3.3 kV) of the same cross-section and same numbers shall be provided.

Note – for 25 kV , if the distance between source and feeding point is more than 500 m then the PST contractor shall calculate the induced emf in the metallic sheath of the cable due to the flow of rated current in the 25 kV current. If the voltage is more than the prescribed limit , necessary mitigation steps like earthing of metallic sheath along with mid pint Sheath voltage limiter (SVL) shall be invariably taken .

2.4.4. Between Running Track and the Buried Rail/RCMB in TSS

For this purpose, ITL made up of GI / Aluminium alloy plate having adequate cross-section shall be provided on the Viaduct / At-grade near the track. The size should be enough to cater the return current and all the termination of return current cables.

The mid-point of the Earthing rail of each track shall be connected to the above ITL, by means of 4x400 sq.mm Aluminium cables. The connection between the ITL on the Viaduct / at-grade and the Buried Earthing Rail / RCMB in the TSS/RSS and relevant locations shall be realised by means of 8x400 sq.mm Aluminium cables with thermite welding as per ACTM.

2.5. Cable Paths

The scope of cable path will cover providing cable trenches as per specifications, providing HDPE pipes wherever required for track crossing, nallah crossing inclusive of GI supports, road crossing, etc., cable route markers, trenchless cable path, cable supports on the structures, GI structure for raising cables from ground to viaduct, restoration of roads, paths in the cable route, test pits, route survey, interface with local authorities if required, protective slab/warning tapes, cable brackets. Client will not provide any cable path and same will be in the scope of PST contractor.

Note: Cable path means all cables will be laid as per the Instruction mentioned in data sheet and payment will be made on as per meter basis for all the cables. i.e. No individual path will be considered for each cable.

2.5.1. Between TSS and OHE

Between TSS and FP, feeders will be laid down in a cable trench according to drawings and as per site condition. The cable shall be laid without damaging it. These cables shall be laid along with 33kV cables as per specification for Auxiliary Network. The PST Contractor shall survey the route of cable path.

Note: For 33kV and 25kV cable the path will be considered as a single path. The

following indications must be fulfilled:

- The path will be as far as possible from existing utilities.
- The path will avoid changes of direction which make sharp bends of conductors. It is admissible a bend radius of 20 times of conductor diameter.
- HDPE pipes of 160mm of outer diameter. Concrete Grade shall be min M15 type.
- C&M cables from TSS to main line FP will be laid for interlock between CB at TSS and motorised isolator/BM at FP, wherever required.

2.5.2. The cables rising from ground to viaduct shall be enclosed in a protective metallic fence up to viaduct soffit, tubular hollow section tubes. Elements will be made of hot dip galvanised steel as per relevant standards. Anti-climbing (G.I) arrangement shall be provided in viaduct.

In viaduct, feeders from TSS's to feeding posts will be laid down in viaduct on brackets provided on the viaduct along the tracks or in the cable troughs wherever provided.

2.5.3. Between TSS's and Depots' Feeding Posts and between Main Line & Depot FP

In Corridor-2, from Benniganahalli TSS, Mathikere TSS & Soladevanahalli TSS to Benniganahalli SP, Mathikere FP & Main line, feeder will be laid in a cable trench according to drawings (to be prepared by PST Contractor) along sections placed out of viaduct & At grade. Cable brackets for 25kV cables to be provided by civil contractor. Cables will be laid buried in trenches or in HDPE Pipes (at least NP 4 grade) for track crossings. If any other arrangements like HDD or other type is to be done for cable crossings, the same is to be done by PST Contractor.

In depot, 25kV cables from main line OHE to Depot FP shall also be laid on cable brackets to be provided by civil contractor. Inside depot cables will be laid buried in trenches or in HDPE Pipes. For track crossings civil contractor will lay HDPE pipes along with construction of pulpits, or other type of method for track crossing, The PST contractor will interface with civil contractor.

In Corridor-4, from Benniganahalli TSS & Yelahanka TSS to respective FPs, feeder will be laid in a cable trench according to drawings (to be prepared by PST Contractor) along sections placed out of viaduct & At grade.

2.5.4. Between Depots' Feeding Posts and Depot's elementary sections

Feeders from Feeding posts in depots to each elementary section foreseen in depots will be laid down also in a buried cable trench. For track crossings HDPE Pipes within pulpits shall be provided by depot civil contractor. The PST contractor will prepare the drawings and interface with civil contractor.

2.6. Cable Sealants

The Cable Sealant shall be provided at each cable entry and exit (cut-outs at viaduct/station area, gland holes on various traction equipment like CB, BM, Isolators etc.) as approved by the Client.

2.7. Cable Jointing/Termination

The drum schedules of cables shall be selected in such a way that minimum cable joints are required. Where the requirement of cable joints cannot be dispensed of, the cable joints shall be heat/cold/hybrid shrinkable or pre-moulded joints of bimetallic type as approved by Client.

2.8. SVL in 25 kV Cables

For the higher cable lengths, multiple Sheath voltage Limiter (SVLs) shall be installed on regular intervals as per arrangements approved by Client. The bonding of all 25 kV cables shall be done as per the scheme approved by Client. PST contractor shall prepare all the calculations and drawings for the same.

3. Switching Posts

3.1. Function

For operation and maintenance purpose, the Traction Overhead Equipment between two (02) Traction Substations is subdivided into several smaller sections by introducing switching stations. Switching stations fall mainly under 3 Categories:

3.1.1. Sectioning Post (SP)

The function of Sectioning Post is to segregate the power supply feeds from adjacent substations, since the 2 feeds will have a phase difference between them and cannot be coupled together. The Sectioning Post will have a Short Neutral Section (SNS) in front of it and the OHE on either side of the Neutral Section will not be bridged under normal operation. Under N-1 scenario (i.e. failure of one TSS) bridging interrupters (normally open) provided at SP are closed to extend the feed between the two sections.

3.1.2. Sub Sectioning and Paralleling Posts (SSP)

At strategic intervals, the OHE is Sub Sectioned by means of an insulated overlap or section insulators (rarely) depending upon the space availability and other site constraints, which is normally bridged by an interrupter. In addition, the UP and Down track OHE's are paralleled at these SSP's by means of Interrupter. The SSP provides a Sectioning facility and helps to improve the voltage regulation because of paralleling.

3.1.3. Sub Sectioning Station (SS)

With a view to limiting the length of any section of OHE, which can be affected by a fault or an electrical isolation for maintenance, the OHE is further Sub Sectioned by means of insulated overlap or section insulators, so that generally not more than 2 or 3 Metro Stations fall in one Sub-Section. No paralleling facility is provided at these Sub-Sectioning Stations.

3.2. Locations

The locations of the Switching Posts in various Corridors have been shown in Para 1.3 of this document.

3.3. General Schematic Drawings

The General Schematic Diagrams of different types of Switching Stations are shown in the relevant tender drawings, details given below.

Sr. No	Switching Stations	Tender drawing no.
1	Sectioning Post (SP)	KRDD01-TDR-GEN-GEN-OCS-DWG- 00025
2	Feeding Post (FP)	KRDD01-TDR-GEN-GEN-OCS-DWG-00023
3	Sub Sectioning and Paralleling Posts (SSP)	KRDD01-TDR-GEN-GEN-OCS-DWG- 00022
4	Sub Sectioning Station (SS)	KRDD01-TDR-GEN-GEN-OCS-DWG-00024

3.4. 25 kV Switchgear

3.4.1. Common Part

3.4.1.1. Operating Conditions

Equipment must be designed to operate under the environmental conditions specified in General Specifications and Equipment Specifications:

- Electromagnetic specific environment (complying with EN 50121-5)
- Plus 10% minus 15% supply voltage variations (complying with IEC 62271-1)

3.4.1.2. Protections against corrosion

All metal pieces (including bolts & screws) shall be realised with stainless materials. Protection category shall be IP-55 or higher. RDSO Specification No. TI/SPC/OHE/Fasteners/0120, latest version shall be referred for all stainless-steel fasteners. Stainless could be obtained either:

- By using natural stainless material, or
- Hot dip galvanising in accordance with RDSO Specification No. ETI/OHE/13(4/84) with A&C, latest version.

3.4.1.3. Earthing

All non-live metal pieces including support shall be connected to the earthing collector (BEC), which shall have sufficient section to withstand short circuit currents and shall be corrosion protected and labelled in conformity with the latest IEC standard 60617-2, latest version.

3.4.1.4. Paint Work

The paint work if required to be done on any part of the equipment shall only be done with Power coated paint. The painting work shall be suitable for dusty, sandy, highly polluted atmosphere, and must comply with IEC 60721-2-5.

After baring, all metal surfaces shall receive anti-corrosion process:

- Natural stainless for bolts & screws and support
- Rust-proofing and anti-corrosive-paint for other metal surfaces
- Then all metal surfaces other than stainless steel shall be painted in accordance with the rules of art with three coats of non-metallic paint of the same quality as that used for outdoor transformers, total thickness should not be less than 120 µm.
- This protection shall be fully guaranteed for five years starting from provisional taking over.
- Should any noticeable deterioration by rust or corrosion appear before this time elapses, the PST contractor should be responsible for repainting at his own expense and for renewing his guarantee for the work performed.

3.4.2. Circuit Breakers, Interrupters, Isolators, VT, VCS & LA

3.4.2.1. General

These apparatuses shall be pole mounted with the switching part at pole top level, separated from the control equipment located at hand level and base pole mounted, both connected with a transmitting mechanism.

They shall consist of:

- a switching apparatus, top pole mounted
- a motorised and manual monitoring box, base pole mounted
- a transmitting mechanism.

All apparatuses shall follow the same electrical and mechanical characteristics and must be in accordance with IEC standards IEC 62271-1, 62271-100, 62271-102, 62271-103, 62271-200, 60694, 60044-1, 2, 60099-4 latest version and RDSO specification ETI/OHE/16/ (1/94) with A&C, latest version.

All parts shall withstand at least 10,000 operations without any signs of detriment. All the measuring instruments, in the panels shall be of digital type only. All electronic components, sub-components of equipment's shall be of industrial grade only. All electronic equipment shall withstand surges, electrostatic discharge and transient burst as per IEC 62236-3-2. The suitable surge protection device conforming to relevant standard shall be provided as per the requirement and approval of Client.

RDSO specifications for electric power connectors ETI/PSI/72/ (9/85) with A&C, latest version shall also be applicable. Spacing of holes of the BM/CB's flange must be matching with jumper connector. Jumper connector will be the four holes type of connector used in Indian Railway design, so BM/CB's flange design must allow that four holes can be used for connection with the help of 4 nos. bolts of proper size as shown below/ RI number 1009: -

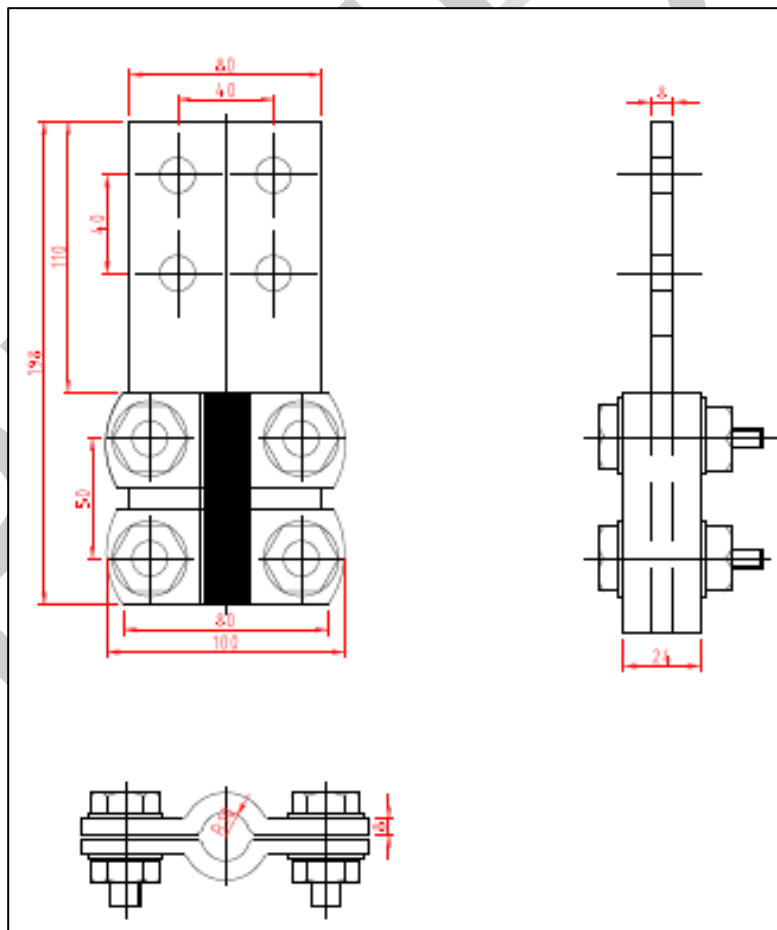


Figure 1 Aluminium Bronze Four bolt Terminal Connector for OHE Jumpers

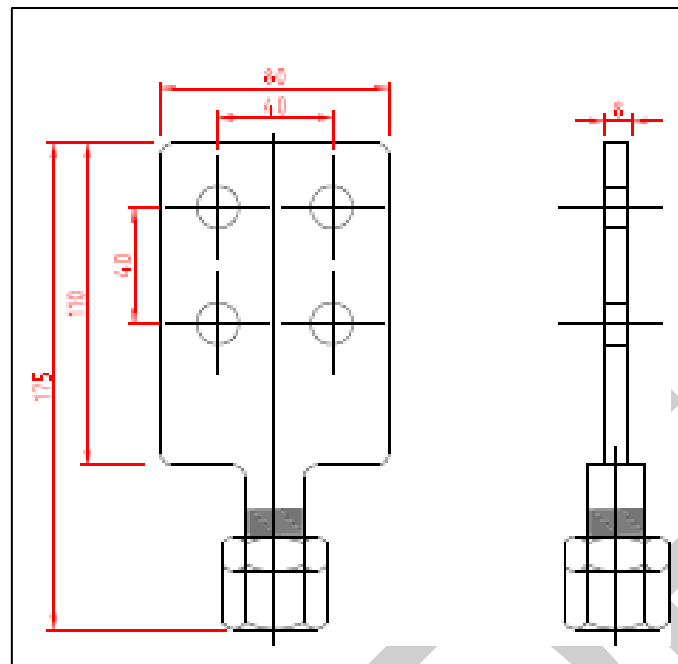


Figure 2 Aluminium Bronze Four bolt Terminal Connector for 18mm Cu solid Bus Bar

The bimetallic strips required for connection in any case shall be provided by the PST Contractor.

To withstand the impact of shock & vibration due to its own operation, the Interrupter/CB on viaduct should be properly supported & mounted on rubber type sandwich arrangement to be approved by the engineer/employer. It should also withstand vibrations due to train movement. The 25 kV Switchgears shall be subjected to vibrations on account of running trains on the nearby Railway tracks as well as due to its own operation.

The amplitude of these vibrations lies in the range of 30 to 150 microns, with instantaneous peaks going up to 350 microns. These vibrations occur with rapidly varying time periods in the range of 15 to 70ms. All 25 kV switchgears shall be tested to cater the impact of these vibration level.

3.4.2.2. Apparatus

3.4.2.2.1. Circuit Breakers / Interrupters

Each Circuit Breaker / interrupter shall be Vacuum type, with a proven technology and shall be of latest state of art and shall include:

- Up & down stream connectors
- Life sealed unit pole
- Energy accumulation type actuation system (electromechanical springs or magnetic actuated mechanism)
- Electric and manual arming capability (Tripping and closing coils motor)
- Under-voltage tripping coil (Auxiliary voltage off)
- Locking and interlocking devices
- Open / Closed auxiliary contacts
- Low voltage multi-pin connector and flexible cable
- SCADA integration compatibility
- Vibration Pad

- a) In view of the train running in the viaducts, the CB/BM erection to be suitably modified with the provision of anti-vibration measures.
- b) The provision of anti-vibration dampers/monitoring is to be made.
- c) The approved vendors of 25kV CB/BM are to be adopted and encourages to modify the design for the specific requirement on the installation of these breakers on the viaduct.
- d) All CB/BM shall have provision of copper plates (pre-drilled) to receive the feeding aluminium cables (2x400sq.mm). The bimetallic strips required for connection in any case shall be provided by PST Contractor.

3.4.2.2.2. Isolators (Manual)

All manual Isolators shall follow the same electrical and mechanical characteristics and must be in accordance with Latest RDSO spec ETI/OHE/16(1/94) including rated voltage level of 27.5 kV, 1600mm creepage distance for all insulators (pedestal & tie rod) and 250 kV (peak) Basic Insulation Level (BIL) which are to be followed.

The Isolator shall be air insulated type and shall include:

- Up & down stream connectors
- Vertical break and Vertical operating mechanism
- Motor operated where required and manually operating capability
- Locking and interlocking devices
- Open / Closed auxiliary contacts
- Low voltage multi-pin connector and flexible cable
- Composite Support Insulator
- SCADA integration compatibility

All isolators shall have provision for pre-drilled copper plates to receive 2 x 400 mm² aluminium cables. Bimetallic connections must be used wherever required. The bimetallic strips required for connection in any case shall be provided by PST Contractor.

The Installation of isolators shall be carried out in the supervision of supplier or alternatively post inspection should be carried out by OEM after installation. Any deficiency observed during inspection shall be rectified.

Following points shall be ensured at the time of installation.

- Surface contact resistance of every isolator shall be recorded in closed condition, before commissioning which must be ensured within limits after improving alignment and surface contact area.
- All nut bolts of isolator shall be tightened with torque wrench only.
- There shall be a gap of minimum 500 mm between male & female contact of the isolator when in open condition.
- Provision of arcing horns must be ensured at the time of installation by the PST contractor.
- Provision of earthing heel shall be provided.

The isolator operation must be toggling spring assisted in such a way that it does not get stuck in mid-position. It must either be completely open or completely closed. In case of failure to provide adequate power during opening or closing - the switch must go back to its original position with the help of the toggle spring mechanism. The spring must be compressed and released with the help of the provided operating mechanism (motor or manual) and should work without the help of any external secondary source.

3.4.2.2.3. Isolators (Motorised)

All motorized Isolators shall follow the same electrical and mechanical characteristics and must be in accordance with Latest RDSO spec ETI/OHE/16(1/94) including rated voltage level of 27.5 kV, 1600mm creepage distance for all insulators (pedestal & Tie Rod) and 250 kV (peak) Basic Insulation Level (BIL) which are to be followed.

The Isolator shall be air insulated type and shall include:

- Up & down Stream connectors
- Vertical break
- Motor operated where required and manually operated capability
- Composite type Support Insulators
- Locking and interlocking devices
- Open / Closed auxiliary contacts
- Low voltage multi-pin connector and flexible cable
- All isolators to be procured from RDSO approved source only.
- SCADA integration compatibility.

All isolators shall have provision for pre-drilled copper plates to receive 2 x 400 mm² aluminium cables. Bimetallic connections must be used wherever required. The bimetallic strips required for connection in any case shall be provided by PST Contractor.

The Installation of isolators shall be carried out in the supervision of supplier or alternatively post inspection shall be carried out by OEM after installation. Any deficiency observed during inspection shall be rectified.

Following points shall be ensured at the time of installation.

- Surface contact resistance of every isolator shall be recorded in closed condition, before commissioning which must be ensured within limits after improving alignment and surface contact area.
- All nut bolts of isolator shall be tightened with torque wrench only.
- There shall be a gap of minimum 500 mm between male & female contact of the isolator when in open condition.
- Provision of arcing horns must be ensured at the time of installation by the PST contractor.
- Provision of earthing heel must be made.

The isolator operation must be toggling spring assisted in such a way that it does not get stuck in mid-position. It must either be completely open or completely closed. In case of failure to provide adequate power during opening or closing - the switch must go back to its original position with the help of the toggle spring mechanism. The spring must be compressed and released with the help of the provided operating mechanism (motor or manual) and should work without the help of any external secondary source.

3.4.2.3. Monitoring Box

Mounted on the pole at hand level, it shall be made of Stainless steel with mirror finish enclosure (compact enclosure). The stainless steel shall be of grade SS 316, minimum 1.25mm thick sheet. Folded and welded from a single piece with protection channel around the door opening. Door shall be of 1.5 mm or 2mm thick stainless steel, flush-mounted, with foamed-in seal, concealed hinges, 130° opening angle as per VDI, cam lock with double-bit insert as per DIN43668. Mounting plate: 2-3 mm sheet steel with system punching, depth adjustable stud mountings, zinc plated. Surface finish shall not be less than 240 Grain size brushed. Totally enclosed, dust-proof and watertight type (IP55 as per IEC 69529), equipped with:

- Access doors with padlocks
- 415/230 V heating device.
- 110 V DC control and monitoring relays and motors
- Remote control and monitoring multi-pin connector.
- Internal lighting controlled by door position
- 230 V AC plug
- 3 positions switch (Remote / local / manual)
- Handle (Facade or beside)
- apparatus position indicator (Facade)
- Label (Facade)
- Easy to maintain

Note:

- Any handle operation shall disable motor supply.
- All equipment shall withstand 2000V 50Hz for 1mn.

Box should be delivered with 4 pre-drilled cable holes of 30 mm diameter and a free space for releasing coil.

The earthing connectors shall be located externally.

If it is provided mounted at height requiring maintenance through ladder, it will be mounted in such a manner that its door opens towards the track so that can be maintained safely by maintenance personnel.

The earthing connectors shall be located externally.

Vibration Pad

- a) In view of the train running in the viaducts, the Monitoring Box erection to be suitably modified with the provision of anti-vibration measures.
- b) The provision of anti-vibration dampers/mounting is to be made.

3.4.2.4. Transmitting Mechanism

The transmitting mechanism components (operation rods, articulations, etc.) shall be able to withstand 10,000 operations without any maintenance (except greasing).

3.4.3. Voltage Transformer

The Voltage Transformer shall be mast mounted.

- a) The capacity of voltage transformer should be 30VA.
- b) The structure of 25kV 50Hz railway electrification network may easily generate ferro-resonance phenomenon.
- c) The inductive voltage transformer shall have the necessary characteristics to avoid generation of ferro-resonance phenomenon and withstand the overvoltage caused by same.
- d) Inductive voltage transformer should comply with EN 50152-3-3 i.e. use of Single-Phase Inductive Voltage Transformer in AC Traction System.
- e) To prevent generation of ferro-resonance following shall be adopted:
 - Minimum resistance of primary winding: 50k Ohm
 - Flux density such that at U_{max2} (see EN 50163) the saturation point is not reached.
- f) Features to be adopted for prevention of damages in Voltage Transformer

- Ability to withstand without damage on primary side a voltage wave obtained by summing a sinusoidal wave at rated frequency with a square wave at 1/3 of rated frequency, with a total peak value of approx. 1.6 Un.
- Suitability to operate continuously

All voltage transformers shall follow the same electrical and mechanical characteristics and must be in accordance with IEC standard 61869.

As 25kV 50Hz traction system may easily get ferro resonance phenomenon, the 25kV inductive VT shall comply to EN 50152-3-3.

As the primary is connected directly to the catenary, which is designed for 14kA short-circuit current, voltage transformers shall be able to guarantee electrostatics and thermal stresses resulting from this level of short circuit current.

The Feeding Posts / SPs & the sections with Neutral Sections shall be provided with PT.

Features to be adopted for prevention of damages in Voltage Transformer.

- Ability to withstand without damage on primary side a voltage wave may be at rated frequency with the square wave at 1/3 of rated frequency and rated voltage
- Voltage Factor of 1:9
- All voltage transformers shall follow the same electrical and mechanical characteristics and must be in accordance with IEC 61869 with latest version.
- As the primary is, connected directly to the catenary, which is designed for 14 kA short-circuit current, voltage transformers shall be able to guarantee electrostatics and thermal stresses resulting from this level of short circuit current.

3.4.3.1. Accessories

Each voltage transformer shall consist of primary connectors, transformer and a connecting box.

Any metal part, which is not live, shall be connected to the earth separately.

3.4.3.2. Primary Connectors

25kV connectors shall be made of bronze and shall be approved by Engineer In charge.

3.4.3.3. Secondary Connecting Box

Secondary winding connection shall be realised through a dust-proof and watertight type (IP55) connecting box fitted with a 6.3A fuse and able to receive 2x10 m² screen-cable. This cable shall enter the connecting box through a cable seal.

3.4.3.4. Transformer

Voltage transformer shall have a ratio of 25000/110V and shall be dry resin type. It shall be ensured that self-heating is less than 1°C per hour

The self-heating must comply with the climatic conditions defined in General specifications

The maximum temperature rises shall be in accordance with the insulation class, as defined in the IEC 61869-3 with latest version.

The core shall be built up of high grade cold rolled grain oriented non-ageing steel laminations

3.4.4. Voltage transformer connections

One end of primary windings shall be connected to the catenary and the other end to the separate earth collector (BEC). As the primary is connected directly to the catenary, which is designed for 14 kA short-circuit current, voltage transformers shall be able to guarantee electrodynamics and thermal stresses resulting from this level of short circuit current.

Secondary windings shall be connected to the auxiliary networks via the connecting box. Support shall be pre-drilled for pole fixation and fitted with carrying devices (hook or ring).

Safety Screen is to safeguard against the shattered pieces & shall be provided at each Voltage Transformer, VCS and other equipment locations as per instructions mentioned in technical data sheets.

3.4.5. Voltage capacitive sensors

The voltage capacitive sensors shall be masts mounted & shall be provided at all locations other than FP, SP & NS sections such that each elementary section is sensed by one VCS. Their constructive features are:

- 1) External silicon coating that provides low weight and better resistance to shocks and ensures a longer life.
- 2) A central cylinder made of fibreglass, which provides adequate levels of electrical insulation, mechanical strength, humidity absorption, etc.
- 3) Aluminium caps features located at the top, two located at the bottom, and a central stud, on the bottom from where the secondary signal is obtained.
- 4) Operation - continuous operation
- 5) Rated frequency - 50 Hz
- 6) Nominal network voltage - 27,5 kV AC/50Hz
- 7) Max. Service voltage - 50 kV AC/50Hz
- 8) Test voltage - 95kV AC/50Hz/ 1 min
- 9) Test voltage of shock wave - 170kV peak, 1,2us/50us
- 10) Response time, detection of presence or absence of tension - Less than 0.1sec
- 11) Type of measurement - RMS precision of 2%

It will be equipped with current loop converter equipment which will adapt voltage levels from any unit of measurement and converts to a proportional value of current loop (4-20 mA). It will enable control centres to receive line voltages measurements in real-time.

Current loop converter will be in a sealed box adapted to the sensor support. The converter will transform the voltage from the sensor to the corresponding current of current loop converter 4-20 mA.

It will connect to the sensor to sample the voltage reading and it will have a power strip with four terminals (two inputs of auxiliary voltage and two that send level output 4-20 mA). All the printed circuit board will be coated with silicone which makes it completely waterproof.

The electrical features of Current Loop Converter will be:

- | | |
|--------------------|-------------------------|
| 1) Supply voltage: | 0 – 376V dc, 0-276 V ac |
| Output: | 4-20 mA |
| Consumption: | 2 W |
| Input/ Output: | 0 - 110 V DC/4 - 20 mA |
| Linear: | 5% |

Precision:	2%
Response time:	0.5 sec.
Output limit:	24 mA

3.4.6. Current transformers

3.4.6.1. Primary connectors

Consist of up & down stream connectors, made of pre-drilled copper plates to receive connector fittings rated at 1250 Amps 2 x 400mm² Al cable or bus bar connection. The connectors shall be able to handle at least 2500A for 5 min without overheating.

3.4.6.2. Secondary connecting box

Secondary winding connection will be realised through a dust-proof and watertight type (IP55) connecting box and able to receive 2x10mm² copper screen cable This cable will enter the connecting box through a cable seal.

3.4.6.3. Transformer

Current transformers shall be dry resin and shall ensure that self-heating shall be less than 1°C per hour. The self-heating must comply with the climatic conditions defined in General Conditions.

The maximum temperature rises should be in accordance with the insulation medium, as defined in the IEC standard 61869-2.

3.4.7. Connectors for Traction System

The connectors should be fired C – wedge boltless and shall confirm Electrically to Extra Heavy Duty, Class AA and Mechanically to Class 3 as per ANSI C 119.4. It also shall confirm to Indian Standard – IS 5561; Latest Version and RDSO Specification No. ETI/PSI/72(9/85), Latest Version.

3.4.8. Lightning Arrestor

Lightning Arrestor shall be as per IEC 60099-4 with latest version and RDSO Specification No. ETI/PSI/71 (1/87) with A&C slip no. 1 to 7 or Latest Version of RDSO Specification. Only composite insulators to be used.

These are made to protect the transformers and 25kV cables against operating over-voltage and eventually against lightning impulses on OHE. For this reason, they shall be installed immediately upstream feeding post isolators.

They shall be metal-oxide types and they shall contain a string of resistor, whose active part shall be composed of perfectly homogenous resistors.

The ceramic enclosure shall be long creepage distance to ensure good insulation with a high-level pollution.

They shall correspond to the class discharge 3 of the IEC 60099-4. (20 long duration current impulse of 1200 A-2ms – 9.5 kJ/kV)

A surge counter shall be installed on each lightning arrester to indicate the number of functioning of each device. They shall also indicate the value of the leakage current.

They shall be well insulated and shall be suitable for outdoor use. They shall be placed in such a manner such that it should be visible from the loco-pilot cab. The earthing of Lightning Arrestor

shall also be in the scope of work of the PST Contractor.

3.5. Marshalling Box

3.5.1. General Description

At every Switching Station a Marshalling Box shall be provided. The Marshalling Box for Switching Stations in Elevated lines shall be provided on the parapet of the viaduct or at a suitable place near the track (viaduct & At-grade). Suitable holding down bolts are provided on the parapet by the Viaduct Contractor.

The Marshalling Box shall be provided with suitable base arrangement, so that the box can be properly placed on the parapet and bolted with the help of nuts, washers and locknuts as necessary. It shall be ensured that the box rests properly on the surface of the parapet. For this purpose, if required at site the PST Contractor shall provide grouting mix (GP2 or equivalent) for ensuring that there are no gaps between the bottom of the box and top of the parapet.

The Marshalling box shall be made of Stainless steel (Grade SS 316, minimum 1.25mm thick sheet) with mirror finish enclosure (compact enclosure). The Marshalling box shall be of category IP55 as per IEC 69529. The Marshalling box shall be made by folded and welded from a single piece with protection channel around the door opening. The Door shall be easily openable and maintainable with flush-mounted, with foamed-in seal, concealed hinges, 130° opening angle as per VDI, cam lock with double-bit insert as per DIN43668.

Separate Marshalling box shall be provided for UP and Down Line.

3.5.2. Size of Box

The 'width across track' of the Box shall not exceed 0.60 m and the max height shall not be more than 1.1 m. The size of Marshaling box with doors (in open condition) shall not infringe with BI-RIDE SOD.

3.5.3. Connections

All C&M cables from the pole mounted switchgear including potential transformer and LT and DC Wiring between the apparatus and Marshalling Box shall be suitably terminated in the Terminals inside the Box. From the Marshalling Box, connections shall be taken to the relevant equipment installed in the nearest ASS, including but not limited to the following:

LT Wiring from the LT source (ACDB / DCDB) inside ASS to the Marshalling Box.

DC cables (2-core) with copper conductors of not less than 10 sq.mm. cross section.

C&M cables to the Switching Station RTU, located in the ASS and both RTU at stations and RTU at switching post are connected through C&M cables.