

PART 2: EMPLOYER'S REQUIREMENTS

CHAPTER 11A: Auxiliary Substations

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Note: These specifications are the bare minimum requirement, PST Contractor must verify the design and should fulfil while selecting system/equipment/component & executions. The final requirements of the specifications will depend upon the simulation studies and based upon that the PST contractor has to provide the material over and above to these specifications which shall be finally approved by Engineer / Employer.

1. AUXILIARY NETWORK

1.1 GENERAL

The various electrical and electro-mechanical installations in passenger stations are required to be provided with electrical power at 415 V, 3 phase. For this purpose, power at 33 kV from the Auxiliary Main Substations (AMS) located in the premises of the High Voltage Receiving Substations (RSS), is transported to the Auxiliary Substations (ASS) located in the premises of passenger stations, through duplicate feeders made up of 33 kV insulated cables. The 33 kV power is transformed to 415 V power by means of 33 kV / 415 V Cast Resin Dry type transformers of suitable capacity installed in the ASS's. The Auxiliary power Network essentially consists of the following:

- 33 kV duplicate feeder from the AMS to a designated ASS in the Corridor, in appropriate cable path, wherever applicable
- A 33 kV cable Network, comprising of duplicate 33 kV insulated cables of suitable capacity, laid in cable trenches, on brackets, in pipes, etc., in the Viaduct, tunnel, at-grade or inside station premises, as applicable.
- Connection of the 33 kV cables to the 33 kV panels/transformers located in the ASS 33 kV / 415 V Auxiliary Transformers of suitable capacity and associated 33 kV and 415 V Switchgear and other Auxiliary Equipment, installed in the ASSs at various passenger stations.

In this document Medium Voltage is referred to 33 kV, High Voltage to the incoming Voltage at the RSS (220 kV) and Low Voltage are under 1,100 V.

1.2 NETWORK DETAILS

This tender document covers the following Corridors of K-Ride Project: -

Corridor-2 Benniganahalli — Chikkabanavara

Corridor-4 :Heelalige — Rajanakunte

1.2.1 Benniganahalli — Chikkabanavara (Corridor-2)

Benniganahalli — Chikkabanavara corridor consisting of 12nos. stations, which consists of 10Nos. elevated stations & 4nos. at grade stations and 1 depot. Depot for Corridor-2 is located at Soledavanahalli Depot. The tentative loop configuration and the ASS's connected thereto shall be as follow: (refer to drawing no. KRDD01- TDR-GEN-GEN-TPS-DWG-00026)

Name of ASS	Tentative Approx. Chainage (M)	Tentative No. of transformers to be catered for at each ASS	Remarks
Benniganahalli	-0.548	2 x 630 kVA	Elevated
Kasturi Nagar	1.109	2 x 500 kVA	At Grade
Seva Nagar	2.880	2 x 500 kVA	At Grade
Banaswadi	4.140	2 x 500 kVA	At Grade
Nagawara	7.123	2 x 500 kVA	At Grade
Kanaka Nagar	8.534	2 x 500 kVA	At Grade
Hebbal	10.921	2 x 500 kVA	At Grade

Name of ASS	Tentative Approx. Chainage (M)	Tentative No. of transformers to be catered for at each ASS	Remarks
Mathikere	15.700	2 x 500 kVA	Elevated
Yeshwantpur	16.900	3 x 630 kVA	Elevated
Shettyhalli	20.369	2 x 500 kVA	At Grade
Mydarahalli	23.259	2 x 500 kVA	At Grade
Chikkabanavara	24.306	2 x 500 kVA	Elevated

Note: At Yeshwantpur station 1 no. 630 kva Trafo extra considered for OCC and Admin Building.
The 33 kV Network of the entire Corridor-2 derives 33 kV power from 01 Auxiliary Main Substations (AMS) located at Mathikere, Soldevanahalli and Beeniganahalli.

Mathikere AMS, under normal conditions, feeds 33 kV power to all the ASS distributing on both side of the AMS. The following "Loop definition Table" shows the details of ASS fed from Mathikere to Chikkabanavara, via the particular Loop.

In outage condition Soldevanahalli AMS feeds 33 kV power to all the ASS distributing on both side of the AMS and also in some emergency conditions the 33 kV power can be feed to all the ASS distributing on both side of the Benniganahalli AMS .

Loop Definition Table

AMS	Corridor 2 section fed by the AMS	Remarks
Mathikere	From Mathikere to Chikkabanawara and Mathikere to Beeniganahalli (Benniganahalli ASS normal feed will be from corridor 4)	Benniganahalli and Yeshwantpur are interchange station for Corridor-2.

1.2.2 Heelalige — Rajanakunte (Corridor-4)

Heelalige — Rajanakunte corridor consisting of 20nos. stations which consists of 3Nos. elevated stations, 17nos. at grade. The tentative loop configuration and the ASS's connected thereto shall be as follow: (refer to drawing no. KRDD01-TDR- GEN-GEN-TPS-DWG-00026)

Name of ASS	Approx. Chainage (M)	Tentative No. of transformers to be catered for at each ASS	Remarks
Heelalige	-0.125	2 x 500 kVA	At Grade
Singena Agrahara	3.000	2 x 500 kVA	At Grade
Huskur	5.068	2 x 500 kVA	At Grade
Ambedkar Nagar	7.950	2 x 500 kVA	At Grade
Karmelaram	9.626	2 x 500 kVA	At Grade
Belandur Road	13.810	2 x 500 kVA	At Grade
Marathahalli	15.860	2 x 500 kVA	Elevated
Doddanekundi	18.408	2 x 500 kVA	At Grade
Kaggadasapura	20.700	2 x 500 kVA	At Grade
Benniganahalli	22.300	2 x 630 kVA	Elevated
Channasandra	24.107	2 x 500 kVA	At Grade
Horamavu	26.178	2 x 500 kVA	At Grade
Hennur	27.580	2 x 500 kVA	At Grade
Thanisandra Station	30.170	2 x 500 kVA	At Grade
R.K.Hegde Nagar	32.115	2 x 500 kVA	At Grade
Jakkur	33.890	2 x 500 kVA	At Grade

Yelahanka	37.152	2 x 630 kVA	Elevated
Muddanahalli	42.250	2 x 500 kVA	At Grade
Rajanakunte	45.875	2 x 500 kVA	At Grade

The 33 kV Network of the entire Corridor-4 derives 33 kV power from 02 Auxiliary Main Substations (AMS) located at Yelahanka and Benniganahalli RSS respectively.

Yelahanka AMS and Benniganahalli RSS, under normal conditions, feeds 33 kV power to all the ASS located on either side of the AMS. The following "Loop definition Table" shows the details of ASS fed from Benniganahalli-Hennur and Yelahanka to Hennur.

AMS	r 4 section fed by the AMS	Remarks
Benniganahalli	Benniganahalli-Hennur	Benniganahalli and Yelahanka are interchange station for Corridor-4.
Yelahanka	Yelahanka -Hennur	Benniganahalli and Yelahanka are interchange station for Corridor-4.

1.3 33 KV CABLES

1.3.1 General Description

For 33 kV, 3 Phase Auxiliary Power Distribution, three single core cables, in twisted or cloverleaf pattern will be used. The cables will be with aluminium conductor as specified, of the specified cross-sectional area and insulated with chemically cross-linked polyethylene (XLPE), with semi-conducting screen over conducting core, and insulating envelope and. All cables shall be Fire Retardant Low Smoke (FRLS) class for elevated section & Fire-Retardant Low Smoke Zero Halogen (FRLSOH) for underground section.

1.3.2 Short Circuit Rating

The metallic screen of 33 kV cables (3 Single core cables) shall have a short circuit current carrying capacity of 1 kA for 3 sec. However, 3 phase short circuit capacity of the 33 kV cable shall be minimum 8 kA for 1 sec.

1.3.3 Specifications

Detailed specifications of the 33 kV cables are described in a different chapter of this Document.

1.4 BROAD SCOPE OF WORK

A general description of the broad Scope of Work relating to 33 kV Auxiliary Network covered in this document is given below:

It shall, however, be clearly understood that the description is for the purpose of general guidance only and is not exhaustive. For complete appreciation of the Scope, the Specifications, Bills of Quantities along with their Explanatory Notes, Drawings and other relevant paragraphs of the Documents shall be referred to.

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1.4.1 In the Auxiliary Main Substations (AMS)

The Auxiliary Main Substation (AMS) is located in the RSS premises. PST Contractor will provide the necessary HV System including HV Switchgear, Bus bar etc. and also the 220 kV / 33 kV, 3 phase transformers. PST Contractor will also construct the AMS room and supply and install the 33 kV switchgear and other equipments in the AMS.

PST Contractor will be required to supply and install the 33 kV cables from the outgoing 33 kV Switchgear RCCB/MVCB/MCCB at the AMS, up to the designated ASS. Cable paths for installation of 33 kV cables inside the AMS Room and in the RSS premises will be provided by PST Contractor. Cable paths beyond the boundary walls of the RSS, will be required to be provided by PST Contractor which is covered

along with laying of 25 kV Cables from TSS to the designated Feeding Post/Switching Station. The sealing of the cable cut-outs will be done by PST Contractor.

1.4.2 In the Viaduct and at Grade of Corridor-2 & 4 The following works shall form part of this Tender:

Supply, laying, jointing, termination, protection, testing and commissioning of all 33kV cables between ASSs (elevated), between ASS and AMS and Depot and any other interconnection links, if any.

1.4.3 In the Auxiliary Substations (ASS) of Corridor-2 & 4 The following works shall form part of Tender:

Supply, erection, testing and commissioning of all equipments at all ASS, including, but not limited to,

- 33 kV / 415 V Cast Resin Dry Type transformers
- 33 kV Panels and Switchgear
- 33 kV cables, 415 V LV Cables & DC cables for control supply of ASS equipment and RTU.
- All measuring and protective devices including Pilot wire relay protection.
- Communication cable with end side terminations & equipments from RSS to nearby station shall be supplied and laid in HDPE pipes by Traction contractor. but in RSS permissive, it shall be laid under supervision of RSS contractor.
- Batteries and battery chargers
- ACDBs & DCDBs
- Earthing from MET to ASS equipment. Earth mat risers will be provided by Station Building Contractor (SBC) and earthing from earth risers up to and including MET will be provided by E&M contractor.
- Safety equipment as per CEA Regulation 2010.
- Traction contractor will provide C&M cables from the ASS equipment to be monitored and controlled up to the RTU in designated terminal board inside the RTU. AC and DC supply from ACDB and DCDB shall also be extended up to RTU by Traction contractor.
- Communication cables from RTU to TER shall be laid by Traction contractor. Earthing from the MET to RTU shall be done by Traction while MET shall be provided by E&M contractor.
- In elevated station ASS cable brackets from platform to ASS (inside shaft etc.) and inside ASS shall be provided by Traction contractor. Cable brackets in elevated sections shall be provided by viaduct contractor. Cable trays/brackets in underground sections for laying all ASS 33 kV, C&M, AC/DC cables shall be provided by E&M Contractor.
- The cable path for laying of Telecom cables from RSS to nearest elevated station shall be provided by Traction Contractor.
- All other items required for successful and satisfactory working of the ASS, at all elevated/at grade & underground ASS shall be within the scope of this Tender.
- The PST contractor shall interface with station building contractor for cable routing and cable bracket installation work.
- Each Electrical Panels/ transformer/ battery/ battery charger/ ACDB/ DCDB shall be provided with insulating mats of ribbed surface and suitable voltage levels, complying to IS 15652, laid in front of and at the rear of the switch board.
- The insulation mats shall be continuous sheets of minimum thickness as per relevant IS standard, each of same length as the switchboard and minimum width of not less than 1000 mm or the width of the space between the fronts or back of the switchboard to the adjacent wall.
- 1000 mm wide of required length as required for applicable voltage or as per approval of Engineer-In-charge.

1.4.4 MANNING OF COMMISSIONED ASS

The commissioning of ASS will be first activities at any station. The manning of ASS from commissioning to taking over shall be responsibility of contractor. However, if manning required from taking over to ROD shall be paid by the employer as per BOQ item. Traction Contractor shall provide the necessary staff team for the purpose. The staff team deployed at the ASS shall be thoroughly conversant and competent to operate the various switchgear and systems and shall be able to provide auxiliary power, if so desired by KRIDE, to other Agencies working in the Station area or elsewhere and also to provide power shut-downs of the commissioned systems, if so directed by Employer/Engineer, to other Agencies working in the Station area or elsewhere and also to provide power shutdowns of the commissioned systems, if so directed by Kride.

The qualification of manning staff shall be as per the BOQ schedule (Manpower- Intervening Period).

PST Contractor shall be paid under the relevant BOQ item, for the services. It shall also be ensured by Traction 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 days. Three shifts per day shall be provided. The roster of manning staff shall be approved by Engineer in-charge.

The competency certificate of each manning staff shall be approved by Engineer In- Charge.

The Traction 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. AUXILIARY MAIN SUBSTATIONS

2.1 BROAD SCOPE OF WORK IN THE AMS

The Auxiliary Main Substations (AMS) are located in the premises of Receiving Substations (RSS). The PST Contractor will provide the necessary HV System including HV Switchgear, Busbars etc., and also the 220 kV / 33 kV, 3 phase transformers. The PST Contractor will also construct the AMS room and supply and install the 33 kV Switchgear and other equipments in the AMS.

The PST Contractor will be required to supply and install the 33 kV cables from the outgoing 33 kV Switchgear at the AMS, upto the designated ASS. Cable paths for installation of 33 kV cables inside the AMS Room and in the RSS, premises will be provided by the PST Contractor. Cable paths beyond the boundary walls of the RSS upto the entry point/ upto the Viaduct/Elevated/At grade & Tunnel/Underground stations, will be required to be provided by the PST Contractor.

Cable path, including cable brackets, cable entry shafts, suitable cable trays, cable ladders, cut-outs etc. for travel of 33 kV and control cables from the entry point on the viaduct & into the tunnels upto the entry point into the ASS will be provided by the Station Building Contractor/Station E&M Contractor. Cable paths for cables inside the ASS Room shall be provided by the PST Contractor in elevated/at grade section.

2.2 25KV CABLES FROM RSS/TSS TO THE TRACTION FEEDING POST

The PST Contractor will be required to supply and install 25kV Traction cables from the outgoing 25kV Switchgear at the TSS, up to the 25kV Feeding station located in the Elevated/at grade station. Cable paths for installation of 25kV cables inside the TSS and in the RSS premises will be provided by the PST Contractor. Cable paths beyond the boundary walls of RSS up to the entry points into the Viaduct/Elevated/At grade & Tunnel/Underground station, will be required to be provided by the PST Contractor. Cable path, including cable entry shafts, suitable cable trays, cable ladders, etc., for travel of 25kV cables & 3.3kV Return Cables (Main Line & Depot) and control cables from the entry point into the Viaduct/Elevated & Tunnel/Underground station, up to entry point into the Feeding Station, shall be provided by Station Building Contractor.

The PST Contractor shall interface with Station Building Contractor for Cable Cuts- out and Cable path along the Viaduct.

2.3 LAYING ALTERNATIVES,

From 2.1 and 2.2 above, it could be seen that the PST Contractor is required to provide cable paths for both 33kV and 25kV cables, between the RSS boundary and entry points into the Viaduct/Elevated/At-grade & Tunnel/Underground stations.

Depending upon the route finally selected for the 33kV cables and 25kV cables with Return Cables (for Main Line and Depot), if it is approved by the Employer, both the types of cables may be laid in the same cable path or alternatively, in different cable paths. The prices for cable paths for different alternatives

shall be included in the relevant sub-items of the BOQ.

3. AUXILIARY SUBSTATIONS

3.1 GENERAL

Auxiliary Substations (ASS), located in passenger stations are meant for transformation of power from 33 kV to 415 V through the 33 kV / 415 V Dry Type distribution transformer and the 415 V protection.

Traction Contractor is required to install equipments of Corridor-2 & 4 as per BOQ & specification in all these ASS.

3.2 LOCATIONS OF ASS

The following are the locations of ASS in the Elevated portion of the corridor.

Name of ASS in Corridor-2	Approx. Chainage (M)	Tentative No. of transformers to be catered for at each ASS	Remarks
Benniganahalli	-0.548	2 x 630 kVA	Elevated
Kasturi Nagar	1.109	2 x 500 kVA	At Grade
Seva Nagar	2.880	2 x 500 kVA	At Grade
Banaswadi	4.140	2 x 500 kVA	At Grade
Nagawara	7.123	2 x 500 kVA	At Grade
Kanaka Nagar	8.534	2 x 500 kVA	At Grade
Hebbal	10.921	2 x 500 kVA	At Grade
Mathikere	15.700	2 x 630 kVA	Elevated
Yesvantpur	16.900	2 x 630 kVA	Elevated
Shettyhalli	20.369	2 x 500 kVA	At Grade
Mydarahalli	23.259	2 x 500 kVA	At Grade
Chikkabanavara	24.306	2 x 500 kVA	Elevated
Heelalige	-0.125	2 x 500 kVA	At Grade
Bommasandra	1.480	2 x 500 kVA	At Grade
Singena Agrahara	3.000	2 x 500 kVA	At Grade
Huskur	5.068	2 x 500 kVA	At Grade
Ambedkar Nagar	7.950	2 x 500 kVA	At Grade
Carmelaram	9.626	2 x 500 kVA	At Grade
Belandur Road	13.810	2 x 500 kVA	At Grade
Marathahalli	15.860	2 x 500 kVA	Elevated
Doddanekundi	18.408	2 x 500 kVA	At Grade
Kaggadasapura	20.700	2 x 500 kVA	At Grade
Benniganahalli	22.300	2 x 630 kVA	Elevated
Channasandra	24.107	2 x 500 kVA	At Grade
Horamavu	26.178	2 x 500 kVA	At Grade
Hennur	27.580	2 x 500 kVA	At Grade
Thanisandra Station	30.170	2 x 500 kVA	At Grade
R.K.Hegde Nagar	32.115	2 x 500 kVA	At Grade
Jakkur	33.890	2 x 500 kVA	At Grade
Yelahanka	37.152	2 x 630 kVA	Elevated
Muddanahalli	42.250	2 x 500 kVA	At Grade
Rajanakunte	45.875	2 x 500 kVA	At Grade

3.3 GENERAL TECHNICAL REQUIREMENTS

3.3.1 For ASS in Elevated/at grade

3.3.1.1 Location of ASS vis-à-vis Electrical Switch Room

The ASS equipment in those ASS which are located in the elevated sections will be installed in a suitable room, either at the concourse or ground level, in the passenger stations

The ASS Room is inclusive of the LT Panels (which will be provided by E & M contractor). Traction Contractor in addition to providing 33 kV cables, equipments etc. on the 33 kV side, will be required to:

- In case of 415V cable connection on secondary side, multiple (4 runs) 3.5Core, 415V armored cables shall be provided by E&M contractor. Traction Contractor shall provide suitable termination arrangement with required no. of terminals for each cable, so that E&M contractor can directly terminate 415V cables without any modification work on transformer. The connecting links shall be provided by Traction contractor.
- PST Contractor shall provide and ensure suitable interlocking arrangements between the above 415 V Incoming and HT transformer Panel and the Auxiliary Transformer enclosure door.
- PST contractor shall ensure that Auxiliary Transformer is fully protected against any downstream electrical faults on the 415 V Distribution system in the station premises.
- Instantaneous and IDMT, over current and Earth fault Protection (50, 50 N, 51 and 51 N) shall be provided to ensure that the Auxiliary Transformers are fully protected against any downstream electrical faults on the 415 V Distribution system in the station premises.
- Pilot wire relay protection with necessary CTs will be provided for all 33 kV cable links between ASS within a station or between two ASS of adjacent stations for cables laid in underground/elevated sections.

3.3.1.2 Room size

The Room for accommodating the ASS (and ESR) equipment's will be built by other Agencies. Room sizes and shapes may be different in different ASS. Nevertheless, an approximate area with a minimum height of 4.0 m (in the Transformer and Panel area) will be provided for accommodating ASS Transformers, panels and equipment's. Typical Equipment Layout Plans for ASS are indicated in specified ASS drawings. Traction Contractor will, however, be required to submit Equipment Layout Plans for every ASS in Coordination with Civil & E & M Contractor, depending upon the types, sizes etc. of the ASS equipment's proposed to be used by him.

The ASS located in the station may have bottom or Top entry of cables depending upon availability of space. Traction Contractor should interface with civil contractor and Architect in this regard.

3.3.1.3 Cable cut-outs and Sealant System

Cable cut-outs for entry/exit of HT, LT and C&M cables will be provided by the Station Building Contractor (SBC). For this purpose, Traction Contractor shall interface with SBC contractor and furnish detail of Cut out required in ASS Slab for top/bottom entry of Power and Control cables. If due to the Traction Contractor changing the Equipment layout or for any other reason, the location of cut-outs are required to be changed, the Traction Contractor, interfacing with the Station building Contractor shall ensure necessary changes to be made or if the cut-outs are already provided at site, shall make his own arrangements for providing new cut-outs and closing the cut-outs already made at site.

All the cables entry into Viaduct, Station building, ASS, Control Buildings & Panel / equipment, switching posts equipment, SCADA equipment etc. shall be sealed by Traction Contractor with EPDM based modular cable sealing system. The Cable Sealing System shall provide foolproof protection against "Fire, Water, Dust, Dirt, Humidity, Vibrations, Temperature Variations, Pull Tension, Noise as well as Rodents. The system must meet the following requirement: -

- The system shall be based on Multidiameter technology and shall made up of halogen free EPDM

- (Ethylene Propylene Diene Terpolymer) cross-link able rubber compound with Low Smoke Index.
- The system must be type tested for the Water/Fire/gas tightness.
- The system shall conforming to IP 66/67 for Buildings & IP 55 for Cabinets/Panels as per IEC: 60529.
- The System shall be Fire Resistance for 3 Hrs with Single side installation only as per UL- 1479 along with UL Certificates No back- to-back installation is allowed.
- Fire Flammability resistance shall be of UL (V-0) as per UL94 and Insulation & Integrity EI 120 as per BS 476.
- Fire hazard levels HL3 according to EN 45545.
- Total Halogen Content shall not > 1500 ppm in totality as per EN/IEC 61249-2-21 and Toxic Index, Shall not > 15 ppm as per NF X70- 100:2006.
- The System should be CE Certified & Complied to ETAG 026 Part 1 and 2 for fire resistant walls and floors in buildings
- The System shall be Vibration proof and conform to Category- A, Class 1 as per IEC 61373.
- Heat radiation classification - M2 class as per NF-P 92-512.
- The system shall be UV protected and shall meet the requirement of 1000 hrs as per ISO 815-1 and ISO 4892-2.
- The system shall be an rodent and certificate shall be from reputed NABL accredited lab /institution.
- The sealing system must have built —in spare capacity i.e. option for adding more cables in to the same system.
- Lubricants / Assembly gel should not have the property of adhesiveness.
- One single module can seal a cable of several different diameters simply by peeling away layers.
- All the relevant Test Certificates shall be issued from NABL accredited LAB with scope of testing facility or issued from International reputed agency like UL, SP, LNE and RST.

3.3.1.4 Cable paths

The cable path for HT equipment in station areas including ASS shall be provided by the Traction contractor. The path shall be comprised of cable support, cable hangers, cable trays, cable dropping etc. The steel to be used for cable path shall be hot dip galvanised as per IS-4759 (latest revision) with minimum Zinc coating of 610 gm/m². Since precast structures shall be used in station building, proper interface with Station building contractor shall be done for cable paths.

The cable path from RTU to Telecom Equipment Room (TER) and wind speed sensor shall be provided by the E&M contractor. Traction contractor shall do necessary interface with E&M contractor.

3.3.1.5 Equipment handling

Heavy equipment, such as transformers and 33 kV panels shall be brought by road by Traction Contractor. Wherever required, they shall be lifted to the loading/unloading platforms or Shafts with the help of crane etc, by Traction Contractor. The equipment shall be moved to their respective position/foundations, with the help of Trolley/ rollers. Lifting Hooks, if required by Traction Contractor for shifting / installing the equipment shall be provided by SBC contractor, for which Traction contractor will interface with SBC. All equipment shall have provision of lifting eyebolts for lifting of equipment.

The lifting of equipment shall only be done as per the approved method statements duly vetted manufacturer and approved by KRIDE.

Due to construction work near ASS, the surrounding shall be dust prone. All equipment in ASS shall be covered from removable dust proof cover till the charging to avoid dust accumulation in equipment. The covers shall only be removed only when to work on equipment and before energization of equipment.

3.3.1.6 Equipment mounting

The Station Building Contractor (SBC) will provide a finished floor. Traction contractors shall fix equipment on the floor with the help of anchor fasteners on mounting channels/pedestal having clearances from floor of at least 30 40 mm. The ASS shall be painted with epoxy paint by station building contractor therefore if any concrete pedestals/foundations are required to be provided to mount transformers/equipment, the same shall be provided before epoxy paint by Traction contractor, after

obtaining approval from Employer. If any damage to the epoxy paint shall be done Traction contractor, penalty shall be imposed, and restoration of epoxy paint shall be done by Traction contractor up to satisfaction of employer.

3.3.1.7 Earthing in the ASS

The Traction Contractor shall provide an earth bus inside the ASS, using 50x6 mm G I. flats. The construction design and layout of the earth bus shall be submitted by the Traction Contractor for Employer's approval. The Main Earth Terminals (MET) will be provided by the System Vide Contractor (E&M), as required by Traction Contractor. The Traction Contractor shall make connections of the Transformer Neutral; Metallic bodies of equipments etc to the earth bus/MET, as per approved drawing. The Traction Contractor shall comply the standards and rules and regulations as applicable: -

- IEEE -80 'IEEE Guide for Safety in AC Substation Grounding'
- IS 3043 'Indian Standard Code of Practice of Earthing'
- BS 7430 'Code of Practice of Earthing'

3.4 EQUIPMENT SPECIFICATIONS

3.4.1 33 kV / 415 V Auxiliary Transformers

- 3.4.1.1** The dry type of auxiliary transformer shall be supplied as per annexure-A3 attached with specified voltage as 33kV/415V.
- 3.4.1.2** The transformer should be designed for best service life in the industry and not less than 40 yrs for all types of installation & under prescribed environmental conditions
- 3.4.1.3** The transformers shall be commissioned in the presence of the OEM representative as per the installation, testing and commissioning plan vetted by OEM and approved by O&M.
- 3.4.1.4** The Transformers shall be provided with Snubber Circuit/ surge arrester in phase to phase (48KV) and phase to earth (36KV) with surge counter
- 3.4.1.5** The transformer cubical shall be provided with Aerosol based Automatic Fire Protection System (indirect Low-Pressure Type). Depending upon the rating and size of transformer in the ASS and the total volume content, the quantity requirement of Fire Protection element shall be calculated by the Contractor and submitted to the Employer's representative, for approval.
- 3.4.1.6** The GTP of transformer, surge arrester and fire suppression system shall be approved by Engineer in charge.

3.4.2 33kV Switchgear

3.4.2.1 For Elevated Stations — Air Insulated Switchgear (AIS)

3.4.2.2 General

The Switchgear in ASS shall be 36 KV, 3 phase, 50 Hz air insulated Metal clad / Metal enclosed indoor VCB type switchgear unit having SCADA/SAS Compatible facilities. All the equipment shall be suitable for satisfactory operation in tropical climate and dry dust laden atmosphere.

The equipment shall be able to withstand wide range of temperature variation (-5° to 50°C). Temperature rise shall be guided by as per IEC: 600694.

The plant/apparatus/equipment supplied shall comply in all respect with the requirement of Indian Electricity Rule 1956 / ISS / IEC with latest amendment.

Basically, the Switchgear will comprise of:

- 33 kV Cut-off Circuit Breaker Cubicles for Ring Main Network.
- 33 kV Circuit Breaker Cubicles for feeding transformers
- 33 kV Coupling Breaker Cubicles, for looping circuit 1 and 2. along with Bus riser wherever required.

The switchgears shall conform to latest revision with amendments available of relevant standards, rules and codes some of which are listed herein for ready reference.

Sr. No	Standard	Item
1	IEC-60056	Circuit Breaker
2	IEC-62271-100,200; IEC- 600298 / 600694	Indoors switchgear and control gear
3	IEC 60185	Current Transformers

4	IEC 60186	Voltage Transformer
5	IEC 60255	Protective Relays
6	IEC 60051-2	Digital Ammeter & Voltmeter
7	IEC 60129	Alternating current disconnectors (isolators)
8	IEC 60529	Classification of degrees of Protection
9	IEC-687/CBIP Report	Tri Vector Meter
10	IEC 61850	Protocol for communication

3.4.2.3 Switch gear cubicles

3.4.2.3.1 General Data

The Switchgear shall be factory assembled, totally enclosed, metal clad, dead front cubicle. All Switchgears cubicles shall be of the same type. All non-welded assemblies shall be assembled by means of bolts and nuts with mandatory use of lock-washers.

The Switchgear shall be dust, moisture and vermin proof complying with degree of protection of not less than IP-4X. The panels shall be of Metal Clad compartmentalized design with all the compartments viz. Circuit Breaker, Bus Bar etc. separated by metallic partitions. The switchgear panels shall be rigid without using any external bracing.

The switchgear shall be complete with all necessary wiring fuses, auxiliary contacts, terminal boards etc.

The observation window on the CB compartment door shall be provided. Observation window shall be of same material and construction as the type tested design/construction.

The design of the panels shall be such that no permanent or harmful distortion occurs either when being lifted by eye bolts or when moved into position by rollers or transpallets.

All panels, separating partitions and accessories shall be mounted similarly, in such a way so as to withstand indefinitely the vibrations transmitted, in particular by the resetting mechanism of the circuit-breakers and their actuation.

Each cubicle shall be equipped with anti-condensation heater controlled by thermostat in each chamber

Only one type of lock & key (square key/Allen Key) except (castle locks and keys) of minimum SS-304 grade for different type of doors of all equipment of 25 kV and 33 kV (MK/CB/Isolators /LBS/RTU/ Battery Charger/ ACDB/ DCDB/ Other panels etc.) of reputed make as approved by Engineer In-charge shall only be used

The measuring meters in 33 kV panels shall be of digital type only.

The rack in/rack out handles, earth switch handle, CB mechanical handle and spring charge handle shall be supplied individually for each 33 kV Circuit Breaker. Two set of PT rack in/rack out ramp, CB rack in/rack out ramps and Busbar earthing trolley (withdraw-able type) shall be supplied with each ASS. 10% of spare nuts and bolts per distribution board of panels shall also be supplied. One set of spares of each type castle lock arrangement per ASS shall be supplied.

The price of spare items has been included in BOQ of 33 kV panels. The Traction contractor shall advise to quote the prices accordingly.

3.4.2.3.2 Electrical characteristics

The service voltage is 33 kV.

The insulation level is 36 kV minimum

All parts of the cubicle (busbars, sliding connector, partition passages) shall be capable of permanently withstanding the temperature rise caused by the currents and shall match the nominal rating of the circuit-breaker provided.

The cubicles shall be capable of withstanding without any damage the loads generated by 1500 MVA peak short-circuits.

The number and frequency of those are not limited in time.

3.4.2.4 Cubicles common part

3.4.2.4.1 Make-up / construction feature

Each cubicle will be metal clad type, air insulated, made of:

- Bar set compartment
- Cable end compartment
- Low voltage (measure, protection & monitoring) compartment
- Apparatus connector compartment with shutter
- Withdrawal trolleys
- Metal clad envelope with appropriate hanging devices

Compartments will have physically separated each other by metal partitions, which shall not heat up due to induced magnetic fields action.

All panels, separating partitions and accessories shall be mounted similarly, in such a way so as to withstand indefinitely the vibrations transmitted, in particular by the resetting mechanism of the circuit breakers and their actuation.

All non-welded assemblies shall be assembled by means of bolts and nuts with mandatory use of lock-washers.

All nuts & bolts used for sealing of compartments/chambers shall be minimum as far as possible without affecting the maximum vibration level of the panels.

Internal and external metal partitions are connected to the earth, high voltage electrical links are realized with bushing.

Auxiliary voltage shall be 110 Vdc (+10%, -20 %) for motors, monitoring and control circuits, Note that all parts of the cubicle (busbars, sliding connector, partition passages) shall be capable of permanently withstanding the temperature rise caused by the currents and shall match the nominal rating of the apparatus.

All MV Panels shall be placed in ASS with the direction of station from where 33 kV incoming supply is coming and also 33 kV Outgoing supply is going.

The gap between different distribution boards in ASS shall properly be sealed with robust arrangement as approved by Engineer in-charge.

3.4.2.5 Equipment

Cubicles will mainly be equipped with:

3.4.2.5.1 Trolley receptacle compartment:

- Fixed earthing plug-in / scrapping type contact
- A shutter automatically protecting live pieces when the apparatus is plugged out. The arrangement for locking of shutter to avoid its opening during maintenance shall also be provided. The shutter shall also be provided with suitable reflective danger signage grounding of the frame of the trolley
- A safety interlocking access to the fixed insertion connectors if the circuit breaker is not in the cubicle or if it is in the withdraw position.
- A precise device for displaying the end of insertion travel with limit switch.
- A fixed plug-in socket enabling the flexible connection to be made for control and monitoring of the circuit-breaker

- The interlocking corresponding to the function of the cubicle.
- A general connecting terminal for low voltage circuits of the cubicle. The terminals shall be tightened by screws; no other connecting device shall be used. An annunciation device for 33 kV voltage on, by mean of a capacitive divider with LED lamps (one per phase), glowing permanently in live conditions. LED lamps shall indicate the presence of 33 kV voltage on incoming & outgoing side. In case of common bus voltage, indication for presence of 33 kV Supply shall be provided in cut — off Circuit Breaker only.
- Safety caution board shall be provided.

3.4.2.5.2 Bar set compartment:

- 33 kV, 1250A bar set, mounted on insulators, suited to withstand 1500 MVA peaks short-circuit.
- Inter-cubicles high-voltage connectors.
In principle, the bus bar shall be a rectangular cross-section. To earth the Busbar during maintenance, a bus bar earthing trolley (withdraw-able type) shall also be provided.
An annunciation device for 33 kV voltage on, by mean of a capacitive divider with LED lamps (one per phase), glowing permanently in live conditions.
The clearance from Busbar to any earthed part shall strictly be conforming to latest IEC standard.
- Cable end compartment:
One or two sets of three current transformers for protection and measurement.
- Three display lamps for voltage on fed by capacitive dividers, annunciation lamps being installed on the front face of the cubicle (LED lamps included). LED lamps shall indicate the presence of 33 kV voltage on incoming & outgoing side. In case of common bus voltage, indication for presence of 33 kV Supply shall be provided in cut — off Circuit Breaker only.
- End-boxes for 33kV three-phase cables of dry type aluminum or copper of appropriate cross-section, this box shall be supplied complete with all the necessary materials for installing the cable and completely making the end connection.
- The connection braids between the two sets of bus bar, the current transformers and the cable end-box, with sufficient gap so that when the braids are removed, the output terminals from the cable box be sufficiently distant from any earth, thus enabling the high voltage cable to undergo dielectric tests or any fault finding to be carried out by applying high voltage.
- A cable head earthing isolator, actuated manually, complete with the necessary interlock. Positions of the earthing isolator shall be visible through a glazed port.
- Voltage transformers as per SLD.
This compartment height shall be at least 800mm to ease cable connection and be equipped with an external cable support device. All CB panels shall have integral earth switch for cable side earthing.

3.4.2.5.3 Low voltage compartment:

- Voltage presence capacitor dividers, relay and facade LED indicator light. LED lamps shall indicate the presence of 33 kV voltage on incoming & outgoing side. In case of common bus voltage, indication for presence of 33 kV Supply shall be provided in cutting off Circuit Breaker only
- Open/closed and connect/disconnect position indicator LED lights and contacts.
- Facade measurement indicators (counter, Ammeter & Voltmeter when required) Facade mimic visual diagram
- Control and monitoring devices for the CB (programmable logic control)
- Control and monitoring, multi pin connector.

- Lockable access door
- LED lamp for illumination, heater controlled with thermostat, AC socket etc.

3.4.2.5.4 Withdrawal Trolley:

- Self-contained trolley fitted with rollers allowing 3 positions:
 - Plugged-in
 - Plugged-out (test position)
 - out of the cubicle
 - The Apparatus (see Circuit breaker here after chapter)
 - an apron panel of sheeting, on the front face, carrying the control button and the open and closed position annunciation via mechanical display,
 - a low voltage connector for all the control and annunciation (flexible multiple in connectors to the corresponding receptacle on the cubicle) with a device for securing the plug when handling the circuit-breaker, a grounding contact connecting the frame circuit of the circuit-breaker to the cubicle grounding busbar, all the interlocking mechanisms, a plugging actuator, if necessary, a manual actuating auxiliary system, provided with an interlocking device to avoid electrical control in this case,
 - Auxiliary annunciation contacts displaying whether the circuit-breaker is in open or closed position, connected to the terminal board of the low voltage circuits. Spare open and closed contacts shall be available in addition to those used for low voltage control and monitoring circuits.
 - An operating counter.
- The actuating system shall be of energy accumulation type, with low transient current consumption when arming the circuit breaker. It shall be equipped with an anti-hunting device.

3.4.2.5.5 Cubicles arrangement

- All cubicles, boxes or sheaths must be rigidly fastened to the floor.
- Cubicle level adjustment can be realized with special steel sections initially anchored in position.
- The assembly level thus executed will enable smooth pulling of the trolleys in the cubicles.

3.4.2.5.6 Cubicles grounding

- Each cubicle shall comprise a Copper grounding busbar of suitable cross section to which each of the metal masses of the component parts of the cubicle shall be connected, together with those of the instrument transformers.
- The grounding busbars of the various cubicles shall form a linkage interconnected together and a common single collector line shall be provided for connecting it to the earthing circuit of the station.
- The withdrawal trolley will be connected to this grounding bus-bar via a plug in/out contact.
- The cable end manual earthing isolator position shall be visible, through a glazed port.
- The bimetallic strips shall be provided by Traction contractor, wherever required

3.4.2.6 Paintwork

Painting should be suitable for polluted atmosphere and has to comply with IEC 60721-2-5 standard As a

minimum, an initial coat of rust-proofing and anti-corrosion paint will be applied after baring of all metal surfaces; then they will be covered with two coats of paint and one finishing coat, colour to be defined. Traction Contractor shall submit to the Employer, the complete details of the Switchgear Cubicles Metal work and Paintwork details, including details of the structure, process of finish and painting etc, for Employer's approval.

3.4.2.7 Protection level

The switchgear and control gear should have the minimum degree of protection (in accordance with IEC 60529)

- IP 4X for the enclosure for rated current up to 1250A (for complete panel)
- IP 2X or higher for the partition between compartments

3.4.2.8 Identification

The front of each cubicle shall carry a nameplate indicating its identification number and function. The text and type of nameplate shall be defined later.

3.4.2.8.1 Fault on a 33 kV Incoming cable

The fault may occur between phases on the MV cables or on the bus bars in the boards. In either case, it shall trip 33kV MVCB(s) of the ring or the main supply circuit breaker (RCCB/MCCB) on the 33 kV cable from the supplying AMS. To locate and isolate the fault, a pilot wire differential relay installed on each incoming/outgoing 33 kV boards of each ASS will send an indication that it detects & isolate a fault. This will be seen on the screen of the equipment and the fault could be located & also isolated by tripping of respective MVCB/RCCB/MCCB. In addition, the Over current & earth fault protection provided on the ring main MVBs shall work as a backup to pilot wire protection. Pilot wire differential relay will be a separate unit independent of OC & EF Relay unit.

3.4.2.8.2 Fault on a Transformer 33 kV Supply

A short-circuit inside the transformer, or in the transformer protection line or a short-circuit insufficiently isolated by the transformer downstream LV protection shall be detected with selection by the Medium Voltage circuit breaker (MVCB- Transformer Breaker) protection and it shall trip the respective MVCB.

3.4.2.8.3 Grounding Fault on ASS MV 33 kV cables

This fault shall trip the 33 kV cable main supply circuit breaker (RCCB/MCCB) in the AMS in addition to segregation of faulty section by pilot wire relay protection and OC & EF in cut-off / Ring main CBs.

3.4.2.8.4 Pilot wire differential Protection

Pilot wire differential protection will be installed in the elevated sections. PST contractor will supply & install pilot wire cable up to the adjoining elevated stations up to AMS (RSS).

3.4.2.9 APPARATUSES

3.4.2.9.1 Make-up & equipment

Each apparatus shall be tri-phases and Vacuum type. Each apparatus shall include

- Up & down stream plug-in connectors
- Life insulated poles
- Energy accumulation type actuation system (electromechanical springs)
- 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.

3.4.2.9.2 Current transformers

Each Current transformer will be installed in the cable end compartment between the downstream pole and the cable connector and at least one in current Transformer in busbar compartment.

Cable end compartment volume will allow current transformer easy access and removal.

Current transformers shall be cast resin type.

Current transformer performances shall be as per technical sheets included into the relevant Chapter.

Each Voltage transformer shall be installed in the cable end compartment, connected between the downstream pole and the cable connector through HRC fuses

Cable end compartment volume will allow voltage transformer easy access and removal.

Voltage transformers shall be cast resin type.

The Voltage transformer shall be provided with Surge arrester.

Voltage transformer performances shall be as per technical sheets included in the relevant Chapter.

3.4.2.9.3 Self-Interlock requirements

Apparatuses can be plugged-in or out, only if opened.

All access to the fixed plug-in parts is prevented when the apparatus is withdrawn. The interlock shall fulfil the following conditions:

- When unplugged and withdrawn from the cubicle, the apparatus shall inhibit opening of the flaps covering the receptacles and shall enable the key to be turned.
- By turning the lock and withdrawing the key, it shall not be possible to plug-in the circuit breaker.
- In addition, for the CB cubicles, it shall be possible to actuate the earth isolator only after first unplugging the CB and withdrawing the first key.
- Conversely, the earth isolator being closed, it shall not be possible to unlock the cubicle in order to plug a CB in.
- The type of lock shall be selected among equipment considered as being safety equipment.
- A general diagram of the key interlocks for the station, indicating all the locks provided for the present equipment shall be prepared.

NOTE: It shall invariably be possible to padlock the interlocks. There will be two kinds of apparatus:

A) Cut — off / Ring Main Circuit Breaker

The function of the Cut — off / Ring Main Circuit Breaker is to isolate a 33 kV cable, on load or fault.

Coupling circuit breaker will ensure the continuity of supply by creating a loop on the 33 kV cables.

They shall have the following characteristics

Voltage rating:	36 kV, 50 Hz
Current rating:	1250 A
Operating voltage:	33 kV
Breaking capacity:	25 kA
Closing capacity:	62.5 kA peak
Acceptable short duration current:	25 kA rms for 3 seconds

B) Circuit breakers

This cubicle is made to supply, protect and earth the ASS power transformer or any specified outgoing 33

kV feeder.

They shall have essentially the following characteristics

Voltage rating:	36 kV, 50 Hz
Current rating:	1250 A
Operating voltage:	33 kV
Breaking capacity:	25 kA
Closing capacity:	62.5 kA peak
Acceptable short duration current:	25 kA rms for 3 seconds

3.4.2.10 Medium voltage switchgear interlocking

The characteristics shall be adequate to cater to the transformer size they protect. The medium voltage switchgear interlocking has several purposes:

- To avoid any paralleling between both transformers of the AMS in remote control mode
- To avoid any paralleling between both transformers of the AMS in local control mode
 - To avoid the earthing of a cable under voltage presence For this purpose, the 33 kV network is divided into suitable loops.

Normally, the ASS connected to the various loops will derive power supply from the respective loop only. However, in an emergency situation, when one of the AMS's is totally out-of-service and consequently the loop connected to this AMS is in itself not able to derive power from the AMS, it would be necessary to resort to linking of the loops.

3.4.2.10.1 Interlocking in remote control mode

In remote control mode it shall be possible to operate any Ring Main CB and Coupling CB without any mechanical interlocking. That could be possible through the medium of the remote/local knob when in remote position.

1 case, both RCCB/MCCB closed

To avoid any paralleling between the both transformers of the AMS, the software shall authorize the closing of all Ring Main CB and Coupling CB of one loop except one (that is to say it shall be possible to close N-1 apparatuses on each loop).

2 case, only one RCCB/MCCB is closed

In this case, there is no risk of paralleling between both transformers. Consequently, it shall be possible to close all Ring Main CB and Coupling CB. But it shall be impossible to close back the second RCCB/MCCB until the correct configuration of both loop, that is to say the opening of one Ring Main CB or one Coupling CB on each loop, to reach to previous condition when the both RCCB / MCCB are closed.

3.4.2.10.2 Interlocking in local control mode

In local control mode it shall be possible to operate any Ring Main CB and Coupling CB with a mechanical interlocking. That could be possible through the medium of the remote/local knob when in local position.

To avoid any paralleling between both the transformers of the AMS, the mechanical interlocking shall authorize the closing of all Ring Main CB and Coupling CB except one on each loop, including the relevant RCCB/MCCB (that is to say it shall be possible to close N-1 apparatuses, including the RCCB, on each loop).

3.4.2.10.3 Loops coupling interlocking

Loops can be, if required, interconnected with the help of appropriate, apparatuses, with suitable interlocking to avoid any paralleling between transformers. The Loops are provided with an

interconnection arrangement between their respective feeders (i.e. Feeder cable 1 and cable 2). The loop coupling CB shall be provided with interlocking so as to ensure that it is not possible to couple two loops when both loops are live.

3.4.2.10.4 Earthing interlocking

A mechanical interlocking linkage shall be built in to prevent the grounding switch being closed if the main Ring Main CB is closed. Nonetheless, it shall be possible to operate the grounding switch with the compartment door open, but it shall be impossible to close the main Ring Main CB when the grounding switch is closed.

On the other hand, a lock interlocking shall forbid the earthing isolator closing until the Ring Main CB at the other extremity of the same cable of the nearest ASS is locked in open position.

3.4.2.10.5 Local Interlocking

- a) Each MV board shall include a non-return interlocking system, formed by security locks, to allow safe inspection of the transformer.

This interlocking system shall make it necessary to open a main LV circuit breaker (LVCB) and lock it open and unplugged before closing the protection bay ground isolating switch. Once this switch has closed, it shall be possible to open the door of the transformer bay. Distinct Castle keys to be ensured for transformer cubicle, MVCB, LVCB interlocking in the same and different ASS

- b) All 33 kV cable coupling bays shall include systems to interlock Ring Main CBs and grounding isolators to make it possible to work on a bay without cutting the main 33 kV cable.

- c) High-security locks shall form these interlocks.

- d) Ring of 33 kV system shall be (N-1) type.

The CB rack in/rack out Interlocking are tabulated below: -

Interlock	Function of interlock	Method of operation of interlock
Between the racking-in of the moving part and the installation of the low voltage plug.	The racking-in of the moving part is impossible if the low voltage is not connected.	The racking handle cannot be inserted to desired position
Between the racking-in of the moving part and the earthing switch "closed".	Racking-in of the moving part is impossible if the earthing switch is closed.	Earthing interlock lever Prohibits VCB movement
Between the closure of the earthing switch and the position of the moving part.	Closure of the earthing switch is impossible as soon as the moving part is in the course of being racked in or is "racked-in".	Earthing interlock lever prohibits "Om" movement.
Between the racking-in and the closed state of the moving part.	Racking-in of the moving part is impossible if the latter is closed.	Interlock lever prohibits insertion of the rack handle.
Between the closing of the moving part and racking-in	Closing of the moving part is impossible outside of the "Racked-in" or "Test" positions.	Electrical and manual command controls of the moving part are impossible.

The rear cover opening & earthing switch closure.	Opening of rear cover is impossible if the earthing switch is in "OFF" condition.	The interlock lever prohibits of rear cover movement
Cubicle front door opening & moving part in racked-in condition.	Opening of the front door is impossible if the moving part is racked-in.	The interlock lever prohibits the front cover movement.
Between Low voltage plug & position of moving part in racked-in condition.	Opening of the LV plug is impossible if the moving part is racked-in.	The interlock lever prohibits the LV plug opening.

3.4.2.11 Bar-Raising

3.4.2.11.1 Function

This cell shall enable linking between two cells when the parts to be connected are one at the bottom of the cell and the other at the top of the cell.

3.4.2.11.2 Description

This cell shall comprise a compartment, closed by bolted-on panel, access to which shall be prohibited in normal operation. Internal equipment shall mainly comprise one set of vertical bars of a rated current, mounted on insulator.

Employer's representative shall inspect the prototype of each type of 33 kV panel of approved vendors before commencement of bulk manufacturing by vendors. If any modification in prototype will be required by Employer, it shall be the responsibility of contractor/vendor to modify the product accordingly. After the successful inspection of prototype, formal approval shall be given by Engineer in-charge for bulk manufacturing of equipment.

The bill of material of equipment shall be approved by Employer's Engineer.

3.4.2.12 SAFETY FEATURES

The design shall incorporate / provide full perception for safety of all those working personal associated with maintenance of the switchgear. The following safety features shall be provided as a minimum.

- All HV compartments shall be tested for internal arc acc. to IEC 62271-200 of 25kA for 1 sec, confirming to Internal Arc Classification (IAC) AFLR as per IEC. The manufacturer shall produce type test report for the same.
- It shall not be possible to insert CB into the service when it is in the closed condition.
- It shall not be possible to withdraw the CB from service position unless it is in the open condition.
- It shall not be possible to close the CB in any position except when fully engaged in the service, test and isolated positions.
- All access to the fixed plug-in parts is prevented when the CB is withdrawn.
- A general diagram of the key interlocks for the station, indicating all the locks provided for the present equipment shall be prepared.
- It shall invariably be possible to padlock the interlocks through castle keys.

3.4.2.12.1 Fire Detection & Suppression System

The cubicles shall be protected against fire by means of automatic fire detector and extinguisher system with linear fire detection tube based clean agent direct gas flooding system.

33kV Switchgear Panels in the ASS shall be protected against fire by means of an 'automatic fire detector and extinguisher system', 'Fire trace' type or equivalent, complete with Extinguishing agent cylinder, approved by Chief Controller of Explosives, valve, flexible detection and delivery system in the form of a flexible tube, i.e. Linear Heat Sensing Tube (LHST), made of special non-conducting polymer, capable of withstanding a normal pressure of 12 bar and a maximum pressure of 20 bar, suitably routed inside the panel for detection of fire. The detection has to be done by the linear heat detection tube which will be routed inside the panel as per the design calculation. The Extinguishing agent cylinder shall be suitably mounted on the cubicles and shall be capable of flooding the cubicle with Extinguishing agent (Clean Agent Novec 1230), within the shortest response time, not more than 10 seconds after the fire is sensed by the Linear Heat Sensing Tube (LHST), i.e. flexible detector tube. Traction contractor shall submit the complete technical data of the system to the Employer's Representative, for approval.

The system shall monitor the weight of fire extinguishing agent cylinder with alarm. Potential free contacts for interface with fire detection & alarm system.

3.4.2.13 Detail Description — Equipment & Accessories

3.4.2.13.1 Circuit Breakers

Circuit breakers shall employ vacuum interrupters and shall have busbar side integral isolation facilities, i.e. a 3-position isolator with On-Off-Earth positions.

The circuit breakers shall have rated operating sequence (duty cycle) of: O — 0.3sec-CO — 3min - CO

3.4.2.13.2 Operating Mechanisms

The circuit-breaker and switch mechanisms shall be of spring-powered stored energy operation by means of a motor charged spring with manual and electrical released, or solenoid operated.

The mechanism shall be of the trip free type so that the circuit-breaker shall be free to open during the closing operation immediately after the operation of its tripping device. The circuit-breaker shall be capable of closing fully and latching, against its rated making current. The various parts shall be of substantial construction, carefully fitted to ensure free action, and designed to reduce mechanical shock during operation to a minimum.

In the event of a spring breaking, it shall still be possible to open the circuit-breaker safely and it shall be possible to close the circuit-breaker or switch adequately to carry its rated current in accordance with IEC62271-200.

Circuit-breaker Spring operated mechanisms shall have the following additional features:

- If the circuit-breaker is opened and the springs charged, it shall be possible to close, and then trip the circuit-breaker.
- If the circuit-breaker is closed and the springs charged, there shall be sufficient energy to trip, close, and then trip the circuit-breaker.
- Mechanical indication shall be provided to indicate the state of the spring; and
- Motor charged mechanisms shall be provided with means for charging the springs by hand. A shrouded push button for releasing the springs and an electrical release coil shall also be provided.

All circuit-breaker operating mechanisms shall be fitted with an electrical shunt trip release coil and a mechanical hand tripping device.

Tripping and closing circuits shall be provided with a fuse or miniature circuit breaker on each unit and shall be independent of each other and all other circuits. A trip circuit supervision scheme shall be incorporated for every circuit.

The electrical tripping and closing devices shall be operated satisfactorily, with a maximum temperature of 55 C inside the 33kV switchgear enclosure, over a DC voltage range as follows:

- | | |
|---------------------------|-----------------------------|
| • Closing solenoids | 85 to 110% of rated voltage |
| • Spring charging motor | 85 to 110% of rated voltage |
| • Closing release coil | 85 to 110% of rated voltage |
| • Shunt trip release coil | 70 to 110% of rated voltage |

All operating coils for use on the DC supply shall be connected in such a way that failure of insulation to earth does not cause the coil to become energised.

Auxiliary switches shall be provided in circuit breaker tripping circuits to interrupt the tripping supply as soon as the circuit breaker has completed the tripping operation. An auxiliary switch shall be provided in closing circuits to ensure that the closing circuit is open after a close has been made.

A proven positively driven mechanically operated indicating device shall be provided to show whether a circuit breaker is in the open or closed position.

Locking facilities shall be provided so that the circuit breaker, if required, can be prevented from being closed when it is open, and from being manually tripped when it is closed. It shall not be possible to gain access to the tripping toggle or any part of the mechanism which would defeat the locking of the manual trip.

3.4.2.13.3 Busbars and Connections

Busbars and connections between the pieces of apparatus forming the equipment of a cubicle shall be of high-conductivity copper. The conductivity shall not be less than 99.9% of that of a "Standard Annealed Copper", as defined in IEC Publication No. 60028.

Busbar connections and their supports shall be of an approved type, designed to withstand all normal and abnormal conditions arising in the System. They shall be capable of carrying the current equivalent to the breaking capacity of the switchgear for 3 seconds.

3.4.2.13.4 Insulation Gas

The Contractor shall submit details on quantity, quality and density of SF₆ gas to be used in the switchgear in accordance with IEC 60376.

The GIS shall be grouped into suitable gas compartments with each compartment fitted with a monitoring pressure gauge/sensor and a pressure relief device.

The gas leakage rate shall be guaranteed to be less than 0.1% by mass per year.

The GIS shall be so designed that an internal arc fault in a compartment will not affect other gas compartments, and compartments for operating mechanism and protection relays. The high-pressure gas or air from the GIS during an internal arc fault shall be directed or vented to a direction away from the operator. The Contractor shall provide type test reports for the internal arc test.

SF₆ Gas apparatus warning sign shall be provided on the GIS.

All special tools and equipment for installation, testing, commissioning, operation and maintenance of the GIS shall also be supplied by the Contractor. These include a suitable sized gas handling unit mounted on a trolley for purging, refilling and other gas works. The trolley shall be able to retain the SF₆ gas purged from any gas zones of the GIS.

3.4.2.13.5 Switchgear Interlocking

Where a circuit breaker or other switchgear is fitted with means for mechanical or electrical operation, interlocks shall be provided so that it is impossible for the electrical and mechanical devices to operate simultaneously.

The earthing devices shall be provided with interlocks to ensure correct operation in conjunction with the associated circuit breaker.

The isolators and the associated circuit breaker which are integral parts of the switchboard shall be equipped with mechanical interlocking to ensure that the isolators cannot be operated unless the associated CB is opened. For the same reason, motorised isolator shall be installed with electrical interlock to provide the same interlocking logic.

Means shall be provided whereby the electrical tripping of the circuit breaker is rendered inoperative during earthing operations both when closing and when closed in the earthed position.

Where interlocking over a distance is required, two independent criteria shall be used, e.g. absence of a voltage and remote feeding circuit breaker open. Indication of the remote condition shall be by single purpose circuit, care being taken that the conductors used are adequately screened and shielded to minimise both transverse and longitudinal voltages resulting e.g. from electromagnetic induction, differences in earth potential or other causes. The Contractor shall ensure that voltages dangerous to personnel or deleterious to correct operation shall not arise.

3.4.2.13.6 Locking Facilities

Padlocking facilities shall be provided for mechanical trip on circuit breakers to prevent manual tripping.

All cubicle access doors, other than those which are interlocked with a switching device, shall be provided with pad-lock type locking facility.

3.4.2.13.7 Earthing and Earthing Devices

All earth bars and terminals including those in the switchboard and inside the ASS shall be tinned copper.

All metal parts other than those forming part of an electrical circuit shall be directly connected to a high conductivity copper earth busbar which shall run the full length of and be bolted to the main frame of the switchboard.

At the position where joints or terminations occur, the earth busbar shall also be tinned. The earth busbar shall be rated to carry currents equal in magnitude and duration to that associated with the short circuit rating of the equipment.

The metallic cases of all instruments, relays or other associated components mounted on the switchgear shall be connected to the earth busbar by copper conductors or equivalent of not less than 2.5mm² cross-sectional area.

When components are provided for mounting separately, each shall be provided with an earthing terminal of not less than 30mm² cross-sectional area.

The above provisions are indicative unless otherwise reviewed without objection by the Engineer who may require the Contractor to reasonably explain and provide, at its own cost, suitable earthing connections.

3.4.2.13.8 Control Facilities

All circuit-breakers shall be capable of being operated electrically from the OCC via the SCADA system.

Proven, positively driven mechanical indicating devices shall be provided on all equipment to indicate whether the primary equipment is in the OPEN or CLOSED position. Care shall be exercised in the design and fitting of these indicators to ensure that the indicating device and associated apparatus does not interfere with the correct operation of the circuit-breaker or isolator.

Each circuit breaker shall be provided with the necessary auxiliary contacts and internal wiring to permit remote control and indication.

Separate switches for local electrical operation shall be installed for each circuit breaker and they shall be of a proven pistol-grip type. They shall have CLOSE and TRIP positions, with a spring return to a NEUTRAL position. The switches shall be lockable in the NEUTRAL position by means of a padlock.

A separate LOCAL / REMOTE CONTROL selector switch shall be provided for each circuit-breaker. In addition to the contacts in the control circuits, the switch shall have contacts closed in the LOCAL position for remote indication of switch positions. The switch shall have two positions and shall be lockable at both positions by means of a padlock.

Electrical tripping and closing devices shall be suitable for operation from 110V DC batteries.

Exposed LV 220V AC terminals inside each Control cubicle shall be adequately shrouded to avoid

accidental human contact.

3.4.2.13.9 Auxiliary Switches

Proven, positively direct-driven auxiliary switches shall be provided on all primary switching devices as required for indication, control and interlocking. Auxiliary switches shall be robust, shall have a positive wiping action when closing and shall be mounted in an accessible position clear of operating mechanisms. Three sets of spare switches comprising of normally open and normally closed contacts shall be provided on each unit.

Auxiliary switches shall be of the changeover type to be either normally open or normally closed and shall be positively lockable in the desired position.

Auxiliary switches shall be designed to make, break and carry, without undue heating, the current of their associated circuit or a current of three amperes DC, whichever is the higher.

3.4.2.13.10 Cable entry

Cable connection shall be bottom/top entry as per the locations of the ASS. Cable termination shall be outer cone plug in type. Suitable cover should be provided at the cable enter location of the GIS panel to avoid unintentional contact of the live parts by rodents etc. Contractor shall obtain approval from the employer for the above scheme.

3.4.2.13.11 Testing Facilities

All fixed and moving portions of the switchgear shall be provided with facilities to enable high voltage tests to be carried out. The PT shall be provided with isolation links/switches for enabling the high voltage / IR tests to be carried out. These facilities shall be such that wires, and connections need not be disconnected for the tests to be made.

When current transformers and protective relays are fitted, facilities including but not limited to isolation links, test blocks and test plugs shall be provided for primary and secondary injection tests to be performed. These facilities shall be such that wires and connections need not be disconnected for the tests to be made.

3.4.2.13.12 Current transformers

When CTs are used for protection and measurement purposes, they shall have the appropriate ratio, class and burden in line with the functions they are used for.

All current transformers shall have a 3-second short-time current rating of not less than the maximum System fault level.

Current transformers shall have an output rating adequate to cater for the burden connected to them and shall function satisfactorily under the maximum system fault condition.

All connections from secondary windings shall be brought out and taken by means of separate insulated leads to a terminal board mounted in an accessible position. Where multi-ratio secondary windings are required, a label shall be provided at the secondary terminal board clearly indicating the connections required for each ratio. The connections and ratios in use shall be shown on all diagrams of connections.

Current transformers shall have the appropriate ratio depending upon their application.

Secondary connection wirings shall have a minimum size of 4mm² copper conductors. The class of all protection CTs shall be as per GTP.

The Contractor shall prepare a schedule of CTs to be installed and submit the same for the Engineer's review.

The secondary windings of current transformers shall adopt single point earthing. The earth connection shall be made at a terminal block via a removable link.

3.4.2.13.13 Voltage transformers

Voltage transformers of the metal-enclosed encapsulated type are preferred. Other types may be submitted to the Employer's Representative for review and approval.

The secondary windings shall be connected to the secondary circuit through a LV fuse or a miniature circuit breaker (MCB).

The nominal VT ratio shall be 33kV/110V.

For protection and measurement applications, the VTs shall be of dual Class 3P/0.5 unless otherwise approved by the engineer. The burden of VTs shall be decided by the Contractor with a margin of 40% for future additions of instrumentations and submitted to the Employer's Representative for review and approval.

3.4.2.13.14 Paintwork

Painting should be suitable for polluted atmosphere and has to comply with the various parameters as specified as in the general specification.

As a minimum, an initial coat of rust-proofing and anti-corrosion paint will be applied after baring of all metal surfaces; then they will be covered with two coats of paint and one finishing coat, colour to be defined. The Contractor shall submit to the Employer, the complete details of the Switchgear Cubicles Metal work and Paintwork details, including details of the structure, process of finish and painting etc, for Employer's approval.

3.4.2.13.15 Identification

The front of each cubicle shall carry a nameplate indicating its identification number and function. The text and type of nameplate shall be defined.

3.4.2.13.16 Fitting & Accessories

As a minimum following fittings and accessories shall be provided

- Mechanically operated tripping and closing device
- Local / Remote /off control switch and indication lamps
- Operation counter
- Supporting frame if needed
- Name plate
- Foundation bolts
- Semaphore indicators
- Meters (All Meters should be Digital)
- CTs & PTs as required
- Protection as required

3.4.2.14 Medium voltage switchgear interlocking

The medium voltage switchgear interlocking has several purposes:

- To avoid any paralleling between both transformers of the AMS in remote control mode
- To avoid any paralleling between both transformers of the AMS in local control mode
- To avoid the earthing of a cable under voltage presence For this purpose, the 33 kV network is divided into suitable loops.

Normally, the ASS connected to the various loops will derive power supply from the respective loop only. However, in an emergency situation, when one of the AMS is totally out-of-service and consequently the loop connected to this AMS is in itself not able to derive power from the AMS, it would be necessary to resort to linking of the loops. When this is required to be done, the linking circuit breakers which are provided for this purpose are closed in a sequence so as to ensure that the two loops are not linked when

both loops are live. Suitable interlocking is provided for this purpose.
Refer to Auxiliary Power Supply Diagram for the corridor.

3.4.2.14.1 Interlocking in remote control mode

In remote control mode it shall be possible to operate any CB and CCB without any mechanical interlocking. That could be possible through the medium of the remote/local knob when in remote position.

A. 1st Case, both RCCB closed

To avoid any paralleling between the both transformers of the AMS, the software shall authorize the closing of all CB and CCB of one loop except one (that is to say it shall be possible to close N-1 apparatuses on each loop)

B. 2nd Case, only one RCCB is closed

In this case, there is no risk of paralleling between both transformers. Consequently, it shall be possible to close all CB and CCB. But it shall be impossible to close back the second RCCB until the correct configuration of both loop, that is to say the opening of one CB or one CCB on each loop, to reach to previous condition when the both RCCB are closed.

3.4.2.14.2 Interlocking in local control mode

In local control mode it shall be possible to operate any CB and CCB with a mechanical interlocking. That could be possible through the medium of the remote/local knob when in local position.

To avoid any paralleling between both the transformers of the AMS, the mechanical interlocking shall authorize the closing of all CB and CCB except one on each loop, including the relevant RCCB (that is to say it shall be possible to close N-1 apparatuses, including the RCCB, on each loop).

3.4.2.14.3 Loops coupling interlocking

Loops can be, if required, interconnected with the help of appropriate, apparatuses, with suitable interlocking to avoid any paralleling between transformers. The Loops are provided with an interconnection arrangement between their respective feeders (i.e. Feeder cable 1 and cable 2). The loop coupling interrupters shall be provided with interlocking so as to ensure that it is not possible to couple two loops when both loops are live.

3.4.2.14.4 Earthing interlocking

A mechanical interlocking linkage shall be built in to prevent the grounding switch being closed if the main circuit breaker is closed. Nonetheless, it shall be possible to operate the grounding switch with the compartment door open, but it shall be impossible to close the main circuit breaker when the grounding switch is closed.

On the other hand, a lock interlocking shall forbid the earthing isolator closing until the circuit breaker at the other extremity of the same cable of the nearest ASS is locked in open position.

3.4.2.14.5 Local Interlocking

- Each MV board shall include a non-return interlocking system, formed by security locks, to allow safe inspection of the transformer.
- This interlocking system shall make it necessary to open a main LV circuit breaker (LVCB) and lock it open and unplugged before closing the protection bay ground isolating switch. Once this switch has closed, it shall be possible to open the door of the transformer bay.
- All 33 kV cable coupling bays shall include systems to interlock interrupters and grounding isolators to make it possible to work on a bay without cutting the main 33 kV cable.

- High-security locks shall form these interlocks.

3.4.2.14.6 Protection Scheme

Pilot wire protection and backup overcurrent protection shall be provided on the ring feeder breakers of both UG and Elevated sections whose salient features should be implemented as discussed below:

The Primary Protection for the cable faults between two stations shall be pilot wire differential protection (87L) which will trip the respective MVCB on either end of the faulty section of the cable.

Advantages of keeping the pilot wire protection is that it does not require any current or time grading as it works on the difference of current in the zone between the two pilot wire relays. Traction contractor will supply & install armored pilot wire cable.

Overcurrent/earth fault protection shall be provided as a backup to pilot wire relay in the ring feeder breakers. They should be set with the direction towards bus bar inside an ASS. issued only when the relay senses the overcurrent fault in the forward direction.

The Transformers feeder breakers (i.e. MVCB-1/2) should be provided with the following protections:

- Transformer differential protection (87T) (For UG Only and 33/27.5 kV transformer feeder)
- Restricted Earth Fault protection(64NP) (For UG Only and 33/27.5 kV transformer feeder)
- Over Current Protection and Earth Fault Protection (50/51/50N/51N)
- Mechanical Door Limit Switch (Castle Key Arrangement) (33)
- Winding Temperature Indicator (49T). Following has to be ensured: -
- The ASS relay timings should be synchronized with the RTUs of the concerned ASS.

3.4.3 110 V DC Power Supply System

The 110V DC Power required for the equipment at the ASS, as well as for the equipment at the Traction Switching Station located, if any, adjacent to the station, shall be met from the 110V DC Power Supply System provided at the ASS. This DC system provided at the ASS to be designed to cater the DC power requirement of all equipment at ASS and adjacent Switching Station.

3.4.3.1 Battery System

Battery system shall consist of 1 Battery bank set and 2 battery chargers. The Battery bank shall be designed to cater the full requirement of 110 V DC power of all equipment in the ASS and adjacent switching station, with an 8-hour backup.

The capacity of the battery shall be designed by the Contractor taking into account the permitted voltage tolerance of the individual loads, the power consumption of various loads, the length of time they are in operation and the manner in which they draw power. The precise capacity of battery shall be determined to ensure total autonomy of the station and switching post (wherever available) for 8 hours as required to retain the power supply of the standby lighting and of the control/monitoring auxiliaries in case of total failure of the AC sources.

The battery capacity selected shall be according to load requirement and shall not be less than 180AH, in any case.

Out of 2 Battery chargers, one shall be in Service and the other as Standby. In the case of failure of the 'In Service' battery charger, the 'Standby' battery charger shall come into service through an 'Automatic Changeover' system.

- Automatic mode:
When a circuit breaker trips by lack/absence of voltage, the system switches automatically to the other source, if this one is under voltage, by closing the coupling circuit breaker.
When the voltage comes back to the normal source then after a delay (delay is to ensure that the voltage has well comeback) the system switches back automatically to the normal source by closing first the normal circuit-breaker, then by opening the coupling circuit-breaker. The parallel between both sources

shall be as short as possible.

- Manual mode with break:

In this mode, only two of the three circuit breakers should be closed simultaneously. It shall be necessary to open one circuit breaker before closing another one.

- Manual mode without break:

In this mode, it shall be necessary to choose between which apparatuses, the transfer shall be made:

- First source and coupling.
- Second source and coupling.

It shall never be possible to make a transfer directly between the first and the second sources.

The transfer shall be obtained by closing the circuit breaker which shall remain closed at the end of the operation. The opening of the other one shall be obtained automatically. The parallel between both sources shall be as short as possible, but enough to ensure a good transfer.

The equipment supplied shall be highly safe and reliable; it shall be described in detail when submitting the relevant drawings (equipment characteristics, layout plan, protections, monitoring) and it shall be guaranteed to eliminate all risks of incident which may occur during the change-over operation from one source to the other.

The batteries shall be of insulated pole type and wired in floating voltage mode.

In normal situation and for each normal battery-charger set, the charger shall supply the control and monitoring circuits and shall deliver the battery trickle charge. The second battery-charger set being in stand-by mode.

In case of fade-out of the AC voltage, the battery shall immediately and without break replace the charger to ensure permanent power supply of the circuits and controls.

The entire 110 V DC distribution and the batteries shall be isolated from the earth satisfactorily. The overall condition of this isolation shall be monitored permanently by a specific and highly reliable devices.

Each battery shall also ensure supply of safety lighting as soon as appears simultaneous fade-out of the half station AC sources.

The fundamental demand on a DC system is that it must be robust, simple and clearly arranged.

The DC system shall be based on the following principles:

- High selectivity
- Main distribution board located adjacent to the battery charger
- No common main fuse for battery
- An installation, which is free from the risk of short-circuit between the batteries and the main distribution board.

The DC system shall be earthed across a high resistance resistor, so that simple earth fault shall not cause tripping of the system.

The DC system shall be designed to allow unloading tests, boost charging and maintenance of each to be carried out during normal operation. This implies that provision shall be made for isolating the battery and the associated rectifier from the load.

Since the entire system cannot be designed such that short-circuit shall never occur, it must be provided with short circuit protection, this shall provide absolute and safe selectivity, so that tripping is confined to the minimum. Only rapid protection characteristic may be used.

Equipment Specification

The following 110V DC Source equipment shall be provided in the ASS Room.

3.4.3.2 Battery

- The Batteries shall be of stationary compact, nickel-cadmium type consisting of minimum 85 cells. Batteries shall be maintenance free and comply with IEC 60622/IEC 60623. The minimum capacity of the Battery shall not be less than 180 AH. The batteries shall be design for ambient temperature of 50-degree C.
- The cells shall be housed in high-strength impact resistant& alkali- resistant containers and should be transparent/translucent to facilitate checking of electrolyte level.
- Vent plugs shall be provided. Construction of cells shall be to ensure proper air circulation between the cells for heat dissipation/ ventilation. The vent plug shall be of robust design.
- Battery shall have provision for electrolyte top up to ensure electrolyte level does not fall below recommended level.
- The containers shall be strong enough, so that excessive bulging of container does not occur during service. Cells shall be supplied in filled charged state or otherwise electrolyte dry form & battery water separately or in liquid form shall be shipped as desired by the owner.
- Nickel plated copper inter-cell connectors shall only be used for connecting up adjacent cells. Inter-row connectors shall be of flexible PVC insulated copper cable. Bolts, nuts and washers shall be of stainless steel. All fasteners shall be tightened with torque wrench with specific torque.
- All terminals and cell inter-connectors shall be fully insulated or have insulation shrouds.
- Separate terminals shall be provided on the end cell for connecting load through DCDB and for connecting charger leads. All terminals shall be of suitably sized nickel-plated steel.
- Suitable corrosion resistant steel battery racks and cable supports shall be provided. Metallic racks shall be properly earthed. The bottom tier of stand shall have a ground clearance of 150 mm minimum above the floor. Racks shall be made of alkali resistant powder coated mildsteel to ensure corrosion resistance.
- The Traction Contractor shall submit the battery sizing calculations as per IEEE-1115 to Engineer in-charge for approval.
- The polarity and battery cell number marking of the terminals shall be marked for identification and marking shall be permanent and non- deteriorating.
- Battery shall be connected through its own battery distribution board to the main board and shall have its own supervisory equipment to indicate and alarm for the maximum and minimum voltage levels on float-charge and earth fault.

3.4.3.3 Battery Charger

It shall comply with IEC 60146 AC Power Supply:

- Voltage: 415V $\pm$ 10%
- Frequency: 50 Hz $\pm$ 3%
- Maximum short-circuit current: 4000 A rms.
- Recharge to 80% of the battery capacity: 8 hours

DC Output:

- Power supply voltage: 110 V + 10%, -15%
- Operating period after AC supply failure: 8 hours
- Constant power drain shall be decided by the Contractor, to deliver the full duty.

A typical block diagram of Battery charger is shown below: -

- Battery charger shall have the provision of Alarm in case of battery low and also have the feature of battery reverse polarity Protection. Battery charger shall have potential free contacts to indicate the status of battery charger at ASS as well as OCC through SCADA. Also, Potential free contacts shall be provided for giving Alarm signal to SCADA system for failure of Main battery charger and Switching of the Load on the Other Hot standby battery charger.
- Ripple content in the output voltage in any case shall not be more than 3%.
- Internal cabling of the Battery charger shall be Fire Retardant Low Smoke Zero Halogen Type. (FRLSOH) for underground section, and Fire-Retardant Low Smoke Type. (FRLS) for elevated section,
- Contractor shall ensure compatibility of battery charger with batteries. The contractor shall submit the undertaking for compatibility from both vendors i.e. battery and battery charger.
- The Working philosophy and sequence of events for battery chargers shall be submitted by traction contractor for approval.

Charger:

The charger shall comprise of an inlet transformer and silicon diode/thyristor or thyristor bridge for converting 3 phase AC supply to DC voltage.

The regulation system shall consist of plug-in modules fitted with polarization devices.

The charger shall include the following monitoring and measuring devices:

- Maximum and minimum DC voltages (threshold values to be defined)
- Charger shut-down due to an internal fault.
- General alarm for remote monitoring

The charger shall include the following control devices:

- A Main On/Off Switch,
- A Normal/Boost Selector Switch,
- A Control Deliberate Discharge.

The AC and DC terminal strips shall be separated from each other. Each battery charger shall be:

- designed to ensure operation according to the battery ratings as described below,
- installed in a sheet cabinet with feet, closed by panels.
- Ventilation shall be natural.

Characteristics

Major characteristics are described in the annexed technical sheet.

The chargers shall be diode and thyristors regulated type, wired as Graetzbridge.

Operating and Floating Rates

The voltage at the charger current output terminals shall be automatically kept within $\pm 1\%$ for variations of $+10\%$ / -15% of the AC voltage and of $\pm 5\%$ of the frequency, whatever may be the output required.

The residual ripple ratio shall be as low as possible (less than 3%) so as not to disturb the various operating circuits.

Equalisation charge Operations

This charge shall be able to take place up to the floating voltage within $+1\%$ under the same conditions as above.

Automatic change-over from floating to equalisation charge and conversely

Following any failure of more than five minutes of the AC supply network, the charger shall automatically revert to the charge position right upon return of the voltage and shall remain on this position throughout the time set by an adjustable timer (from 1 hour to 20 hours). After this time, the charger shall return to floating operation. The charger shall remain in floating operation if the network failure is shorter than five minutes.

Direct operation

The charger shall be capable of operating directly, without the battery, under the same conditions of accuracy as for the floating and charge modes.

Manually controlled operation

Operation in manual control shall be possible, i.e. it shall be possible to execute manual adjustment of the voltage in case of malfunction of the regulator.

Alarms

The status of all battery chargers shall be indicated at the ASS, as well as at the OCC (through SCADA), as per the following convention:

- Green — Healthy and in-service, Yellow — Healthy and standby, Red — Defective.
- The change of status from "Healthy" to "Defective" shall be accompanied by an audible alarm/hooter, both at the ASS and OCC in the OCC.

Protections and Monitoring

The charger shall be fitted with the following protections installed at its rear:

- The battery chargers shall be provided with surge protection devices of suitable type and ratings as approved by Engineer in charge..
- A device limiting the current output by the rectifier to its rated current value with sufficient capabilities of adjustment and possible pick-up of the set point value.
- Switching diodes.
- Breakers with fuse elements for overall protection on the transformer primary,
- Breakers with fuse elements in series with each rectifier component (diodes and thyristors).

- Breakers for the various auxiliary circuits,
- An on/off switch controlling a three pole make-break switch with magneto-thermal protection on the AC circuit and a two pole make- break switch with magneto-thermal protection on the DC circuit.
- The specific protection to ensure satisfactory operation and protection of the set.
- The control card circuit and capacitor shall be placed away from transformer to protect them from heat produced by transformer/heater.
- The capacitor used in battery charger shall only be of industrial grade only and of aluminium can with stud construction type which is having the minimum allowable temperature range of 85°C or higher with better cooling feature.
- All Electronic components/sub-parts of equipment shall only be of Industrial grade.
- It may also be noted that temperature inside the metal enclosed equipment go up to 70 Deg.C inside enclosure. This aspect shall be taken care while designing/manufacturing of the equipment and its electronics
- The Terminal Board shall only be factory fitted.
All the electronic cards supplied shall have following minimum requirements-
- Conformal coating not less than 3C2 category against protection from all harmful gases and 3C3 category for H₂S, N₂O, SO₂ and Mixed gases as per IEC60721-3-3 on all electronic cards used in IEDs, Relays, Breakers/BMs, Invertors, Battery Chargers/DCDB, PLC,,UPS and AVR's to provide protection against failure of cards due to environment conditions.
- Damp heat run test as per IEC 60068-2-78 standards.
- Dry heat run test as per IEC 60068-2-2 standards
- In addition, the details of configuration in the card, block diagram of the card and waveform signature of each test points for each card shall be submitted by Traction contractor.
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 Engineer In-charge.

Miscellaneous

The battery charger equipment shall also include:

- Signalling light denoting the opening of the make-break switch on the AC side, controlled by the tripping of one of the Miniature Circuit Breaker protecting the various circuits of the apparatuses
- Signalling light denoting the opening of the make-break switch on the DC side through actuation of the magneto-thermal relay
- Digital voltmeter indicating the voltage on the AC side
- Digital voltmeter indicating the voltage on the DC side
- A centre-zero ammeter switch shall indicate whether the battery is under charge, or the battery is only delivering the load.
- the position of the various circuit-breakers and of the protection and fault relays shall be monitored through two flip-flop stages.

An inspection light shall be fixed inside the charger compartment, which will automatically come "on" when the charger compartment is opened for inspection. This shall be independent of the "on/off" position of Battery changer and shall be operative when the 415 V supply is available to the charger.

Employer's engineer shall inspect the prototype of battery charger of approved vendors before commencement of bulk manufacturing by vendors. If any modification in prototype will be required by Employer's engineer, it shall be the responsibility of contractor/vendor to modify the product accordingly. After the successful inspection of prototype, formal approval shall be given by Engineer in-charge for bulk manufacturing of equipment.

The bill of material of equipment shall be approved by Engineer in-charge.

3.4.3.4 110 V DC Distribution Board

3.4.3.4.1 Description

Distribution of the 110 V DC sources shall be gathered inside cabinets, called as DC auxiliary Load Distribution Board.

These cabinets shall be equipped with doors, fitted with flexible seals, close via lock- bars and on which shall be installed a mimic diagram with signalling lights denoting the position of the main apparatuses.

All indication lamps shall be LED type.

Minimum IP rating of DCDB shall be IP —43. All metallic parts of the panel shall be connected to the main earth ring. Suitable earth terminals for this purpose shall be provided. Panel shall be dust and vermin proof complying to IEC 61439 and panel shall be fabricated min. 2mm thick CRCA Sheet.

Panel shall be processed with 9 tank chemical process and shall be epoxy powder coated with RAL 7032.

3.4.3.4.2 Equipments

Each cabinet shall include the following (list not restrictive):

- -Isolating switch
- -Master power supply circuit breakers
- -Non return diodes and set of normal/stand by supply bars
- -The current and voltage protection relays
- -The isolation monitoring
- -The automatic and manual device for change-over from one source to the other,
- with selector switches for automatic and manual, with or without break
- -The coupling circuit-breaker for both 110 V DC sources
- - The suitable surge protection device conforming to relevant standard shall be provided as per the requirement and approval of Engineer In- charge.

3.4.3.4.3 Outgoing Feeders

The outputs, protected by circuit breaker, whose rating shall be, selected according to the power of the installation services, corresponding to the distribution circuits intended to be supplied.

An interlocking device prohibiting paralleling and position limit switches of the main apparatuses shall also be provided.

Bus bar of DCDB shall be Electrolytic copper with heat shrinking sleeves. Internal cabling/wiring of DCDB shall be Fire Retardant Low Smoke Zero Halogen type (FRLSOH) for underground section & Fire-retardant low smoke type (FRLS) for elevated section. Wiring of suitable sizing shall be selected to carry the full load current. MCB shall be selected for providing discrimination between incoming and outgoing feeders.

3.4.3.5 AC Distribution Board

For Providing AC 415 v Supply, AC Distribution Board shall be provided in the ASS. Incoming Feeder of ACDB shall be Provided with Earth Leakage Circuit Breakers along with MCCB/MCB. Bus Bar and MCB for all the Feeders shall be sufficiently rated to provide the overloading and short circuit Protection. Bus bar of ACDB shall be Electrolytic copper with heat shrinking sleeves. Internal cabling/wiring of ACDB shall be Fire Retardant Low Smoke Zero Halogen type (FRLSOH) for underground section & Fire-retardant low smoke type (FRLS) for elevated section. Minimum Clearance between Phases and Phase & Earth/Neutral shall be 20 mm.

All indication lamps shall be LED type.

Minimum IP rating of ACDB shall be IP —43. All metallic parts of the panel shall be connected to the main earth ring. Suitable earth terminals for this purpose shall be provided.

The various items constituting the distribution board shall be neat and secured on a channel from framework designed for wall mounting.

The indicating lamps shall be of the low watt consumption, which shall be interchangeable and replaceable on front of the panel.

Suitable markings for identification of circuits shall be provided on the distribution panels. Suitable name plates shall also be provided on the ACDBs.

ACDB supply shall be taken from the essential power panel of E&M. The ASS contractor will interface with the E&M contractor in this regard.

The type-2 surge protection device conforming to relevant standard shall be provided as per the requirement and approval of Engineer In-charge.

3.4.3.6 LT Bus Duct (Sandwiched Type)/415V Cables

LT Bus Duct (sandwiched type)/415V Cables shall be provided between LV terminals of Transformer and LT Main Incomer panel by E&M contractor.

4. PROTECTIONS**4.1 GENERAL DEFINITION**

The purpose of the protection equipment is to ensure insulation or de-energising of equipment whose operating conditions have become abnormal to avoid:

- -any major repercussions on the traffic
- -any damages or dangerous effects on person and equipment.

The Contractor shall supply and install the protection system as stipulated in this TS. The protection system must comply with a high-performance standard.

4.2 PERFORMANCES REQUIRED

The protection system shall deploy numerical relays and shall comply with a high- performance standard regarding:

4.2.1 Reliability

This criterion defines the mean time between failures (MTBF), which has to be greater than 20 years.

4.2.2 Maintainability

This criterion represents the mean time for repairing (MTTR) and has to be considered only by replacement of faulty function or sub assembly.

The MTTR does not exceed 2 hours not including the dead time to reach the site.

Availability

This is expressed in terms of ratio using the formula:

$$\frac{MTBF}{MTBF + MTTR} \%$$

and has to represent a level of 99.95 %

4.2.3 Safety of operation

Safety is ensured by the means of:

- Cyclic self-test ensuring general supervision on software of equipment.
In case of fault, a watchdog is activated.
- All of inputs are insulated in galvanic and capacitive view and complemented.

4.3 PROTECTION DESCRIPTIONS

Relays

All relays shall conform to the requirements of IS:3231/IEC-60255/IEC 61000 or other applicable standards. Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear. The relay shall have a front panel back lit LCD display to display the parameters.

All the instantaneous relays should be capable of operating the circuit breaker within a duration of 120 ms from the occurrence of the fault. This time duration should include the dead time of the relays and this feature should be demonstrated during testing of the relays.

All main protective relays shall be of fully numerical type and shall comply as per IEC 61850 standard. Further, the test levels of EMI as indicated in IEC 61850 shall be applicable to these. All the relays shall be directly connected to the inter bay bus using Electrical/fiber optic cables and shall support peer to peer communication. The relays shall generate GOOSE messages as per IEC 61850 standards for interlocking and also to ensure interoperability with third party relays. Each relay should also generate an ICD file in XML format for engineering/ integration to an independent SCADA system. All the relays shall have suitable rear and front ports for connectivity to SCADA and PC/LAPTOP.

All protective relays shall be in draw out or plug-in type/modular cases with proper testing facilities.

The relays shall be designed for satisfactory operation between 70% and 110% of rated D.C. voltage of the Auxiliary sub-station.

The supply of relay should be inclusive of necessary software and hardware for interfacing with a PC, to be supplied by the Traction contractor.

The relay shall have inbuilt auto reclosure, disturbance recorder, fault locator, event logger facility and additional features required by Engineer in charge

The certificate for IEC 61850 Compliance from KEMA/CPRI, type test certificate from any Govt. Recognized Test House and performance certificate shall require to be submitted.

The Relay shall also have following facilities:

- The Relay shall have adjustable type of settings (instantaneous type, Delayed type, protection zones, stage settings etc.) as per the requirement of KRIDE.
- The same relay shall be provided with both 1A and 5A CT inputs and shall be selectable at site.
- The relay shall have facility to store and display all the parameters necessary for post fault analysis (Pre and Post fault recording minimum 500ms).
- Relay shall have facility to display all the operational and faults parameters and events including status of DI/DO signal on HMI.
- The relay shall be capable of measuring and storing values of a wide range of events, faults and disturbances. The relay shall have facility to record at least 200

- Events (including DI status) and 05 Fault records with time stamping (oscillography record).
- The CT terminals on the relay shall be suitable for ring-type lugs to avoid any hazard due to loose connection leading to CT open-circuit.
- The relay shall be suitable to accept both AC and DC supplies. The rated DC voltage shall be 110V.
- The numerical relay shall provide with supervisory functions such as trip circuit supervision, CB monitoring, CT supervision, DC supervision etc.
- The front panel of Relay shall have ingress protection rating of IP-52.
- The details of configuration in the card, block diagram of the card and waveform signature of each test point for each card shall be submitted by Traction contractor.
- The Relay shall also be used to authorize the operation of the incoming isolators and earthing isolators on no load

4.3.1 Communication of Relay

- The Relay shall have IEC 60870-5- 103, IEC 61850, Modbus, DNP3 communication protocol for system communication and USB / RS232/RS485 / RJ45 (Ethernet) port
- for uploading/downloading settings and records locally through PC or laptop.
- Relay shall have dual ports for RSTP and PRP redundancy for SCADA connectivity IEC 61850, IEC-60870-103, DNP3, Modbus protocols.
- The relay shall have time synchronization functionality on SNTP/NTP ± 1.0 ms typically.

4.3.2 Applicable Standard

All numerical relays must comply relevant IEC standards as follows: -

Sr. No.	Tests	Standards
	Emission tests	
1	Radiated emission	IEC 60255-26
2	Conducted emission	IEC 60255-26
	Immunity tests - Radiated disturbances	
3	Immunity to radiated fields	IEC 61000-4-3
4	Electrostatic discharge	IEC 61000-4-2
5	Immunity to magnetic fields at network frequency	IEC 61000-4-8
6	Pulse Magnetic field immunity	IEC 61000-4-9
	Immunity tests — Conducted disturbances	
7	Immunity to conducted RF disturbances	IEC 61000-4-6
8	Electrical fast transients (EFT)	IEC 61000-4-4
9	Surges	IEC 61000-4-5
10	Damped oscillatory wave (1 MHz)	IEC 61000-4-18
11	Voltage alternating component (ripple)	IEC 61000-4-17
12	AC voltage dips and interruptions	IEC 61000-4-11
13	DC voltage dips and interruptions	IEC 61000-4-29
	Mechanical robustness	
14	Vibrations	IEC 60255-21-1
15	Shocks	IEC 60255-21-2
16	Seismic	IEC 60255-21-3
	Climatic withstand	

17	Cold	IEC 60068-2-1
18	Dry Heat	IEC 60068-2-2
19	Change of temperature	IEC 60068-2-14
20	Damp heat cyclic	IEC 60068-2-30
21	Damp heat steady state	IEC 60068-2-78
22	Flowing mixed gas corrosion test	IEC 60068-2-60
	Safety	
23	Enclosure safety test	IEC 60529
24	1.2/50 ps impulse voltage withstand	IEC 60255-27
25	Dielectric voltage withstand	IEC 60255-27
26	Insulation resistance	IEC 60255-27
	Communication	
27	Communication	IEC-61850, IEC-60870-103, Modbus, DNP3

4.3.3 Environmental performance of Relays

The Auxiliary sub-stations shall not have provision of air-conditioning plant. Therefore, the relays shall be designed for operating satisfactorily under the climatic conditions of ambient temperature and relative humidity variation from 0°C to 55°C and 50% to 95% respectively.

The temperature during storage and transit may reach up to 70 Deg.C.

It also include the study of level of harmful gases and to provide conformal coating not less than 3C2 category against protection from all harmful gases and 3C3 category for H₂S, N₂O, SO₂ and Mixed gases as per IEC60721-3-3 on all electronic cards used in IEDs, Relays, Breakers/BMs, Invertors, Battery Chargers/DCDB, PLC, UPS and AVR's to provide protection against failure of cards due to environment conditions.

All relay shall be type tested as per method-4 of IEC-60068-2-60 for Acidic and heavy pollution environment, H₂S, SO₂, mixed gas tests

The conformal coating shall be done as per IEC 61086-1.

Table 1. Quick-Reference Guide to Conformal Coatings

Characteristic	Acrylic (AR)	Polyurethane (UR)	Epoxy (ER)	Silicone (SR)
Humidity Resistance	Excellent	Excellent	Good	Excellent
Humidity Resistance (Extended Periods)	Good	Excellent	Fair	Good
Abrasion Resistance	Fair	Good	Excellent	Good
Mechanical Strength	Fair	Excellent	Excellent	Good
Stress on Coated Components Resulting from Temperature Variation	High	High	High	Low
Temperature Resistance	Good	Fair	Fair	Excellent
Acid Resistance	Good	Excellent	Excellent	Good
Alkali Resistance	Fair	Excellent	Excellent	Good
Organic Solvent Resistance	Poor	Excellent	Excellent	Good
Dielectric Constant @ 23°C, 1 MHz	2.2–3.2	4.2–5.2	3.3–4.0	2.6–2.7
Repairability	Difficult	Difficult	Difficult	Easy

61086-1 © IEC:2004

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The first number of the code shall indicate the classification of the material:

- Class 1 General purpose
- Class 2 High reliability
- Class 3 Aerospace applications

The code letters for the different resin types and the methods of application are indicated in the Table 1.

Table 1 – Basic resins

Resin type	Code	Method of application
Acrylic	A	Dip, brush and spray
Epoxy	EP	Dip, brush and spray
Silicone	SI	Dip, brush and spray
Polyurethane	PUR	Dip, brush and spray
Oligomeric blend material	OL	Dip, brush and spray, UV curable
Paraxylilene	XY	Vacuum deposition
NOTE Additional resin types may be incorporated later, for example, polyester or phenolic resin.		

The suffix number is inserted after the code letters for each resin type and is interpreted as follows:

- Suffix 1: indicates that the conformal coating is water based.
- Suffix 2: indicates that the conformal coating is capable of being removed from the printed wire board by means of an appropriate solvent.

NOTE Suffixes 3, 4, 5, etc. may be introduced later to cover other variants of each resin type.

EXAMPLE Conformal coatings of type IEC 61086-1-PUR-1,2 denotes a general purpose material based on polyurethane which is water-based and removable with a suitable solvent.

Environmental parameter	Unit ¹⁾	Class ²⁾									
		3C1R	3C1L	3C1	3C2		3C3 ³⁾		3C4 ³⁾		
		Maximum value	Maximum value	Maximum value	Mean value	Maximum value	Mean value	Maximum value	Mean value	Maximum value	
a) Sea salts	None	No	No	No ⁴⁾	Salt mist		Salt mist		Salt mist		
b) Sulphur dioxide	mg/m ³	0,01	0,1	0,1	0,3	1,0	5,0	10	13	40	
	cm ³ /m ³	0,0037	0,037	0,037	0,11	0,37	1,85	3,7	4,8	14,8	
c) Hydrogen sulphide	mg/m ³	0,0015	0,01	0,01	0,1	0,5	3,0	10	14	70	
	cm ³ /m ³	0,001	0,0071	0,0071	0,071	0,36	2,1	7,1	9,9	49,7	
d) Chlorine	mg/m ³	0,001	0,01	0,1	0,1	0,3	0,3	1,0	0,6	3,0	
	cm ³ /m ³	0,00034	0,0034	0,034	0,034	0,1	0,1	0,34	0,2	1,0	
e) Hydrogen chloride	mg/m ³	0,001	0,01	0,1	0,1	0,5	1,0	5,0	1,0	5,0	
	cm ³ /m ³	0,00066	0,0066	0,066	0,066	0,33	0,66	3,3	0,66	3,3	
f) Hydrogen fluoride	mg/m ³	0,001	0,003	0,003	0,01	0,03	0,1	2,0	0,1	2,0	
	cm ³ /m ³	0,0012	0,0036	0,0036	0,012	0,036	0,12	2,4	0,12	2,4	
g) Ammonia	mg/m ³	0,03	0,3	0,3	1,0	3,0	10	35	35	175	
	cm ³ /m ³	0,042	0,42	0,42	1,4	4,2	14	49	49	247	
h) Ozone	mg/m ³	0,004	0,01	0,01	0,05	0,1	0,1	0,3	0,2	2,0	
	cm ³ /m ³	0,002	0,005	0,005	0,025	0,05	0,05	0,15	0,1	1,0	
i) Nitrogen oxides (expressed in the equivalent values of nitrogen dioxide)	mg/m ³	0,01	0,1	0,1	0,5	1,0	3,0	9,0	10	20	
	cm ³ /m ³	0,005	0,052	0,052	0,26	0,52	1,56	4,68	5,2	10,4	

4.3.4 Synchro-coupler relay

This relay shall ensure the authorization of closing a coupling apparatus. Its own functioning shall be into service only in the case of voltage presence on both parts of the coupling apparatus. When into service, it shall compare the phase, the frequency and the voltage of both sources to be coupled.

Phase difference, frequency difference and voltage difference shall be settable.

Protection Relay Setting

The Traction contractor shall be responsible for protection relay settings for all relays to be provided under PST contract. The Relay setting be calculated as per the fault level at each and every node in the network. The Traction contractor shall do necessary interface with RSS and E&M contractor for preparation of relay setting with proper coordination/grading of fault clearing time of all upstream and downstream breakers. The Traction contractor shall submit the relay setting for the approval of Engineer In-charge.

4.3.5 Staging of the protections

Selectivity of the protection arrangements shall be provided so as to avoid all unwanted tripping. The time delay shall be set so as to ensure chronological selectivity of the tripping. The manufacturer shall precisely define the minimum intervals between the various protection stages, accounting for the timings and for the actuation times of each one of the apparatuses involved.

4.3.6 Installations

The Relay used must provide full reliability and operating safety and not represent a weak spot for the tightness of equipment. The Relays shall never indicate any wrong data, not lose their accuracy regardless of ambient temperature or of the operating incident concerned.

4.3.7 Testing and Commissioning

The Traction contractor shall submit the detailed testing and commissioning scheme in consultation with OEM for all type of protection relay for the approval of Engineer In-charge.

All protection schemes/logics etc. shall be tested from primary side using primary injection kit. Also, all configurations, LED indication, tripping time, relay times shall be tested at site as per approved scheme.

Draw-out / Plug-in Type

All protective relays shall be in draw out or plug-in-type/modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied loose and shall be included in contractor's scope of supply.

4.3.8 Operation Voltage / Current

All AC operated relays shall be suitable for operation at 50 Hz. AC Voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for 1 amp CT secondary. All DC operated relays and times shall be designed for the DC voltage specified and shall operate satisfactorily between 80% and 110% of rated voltage. Voltage operated relays shall have adequate thermal capacity for continuous operation.

4.3.9 Auxiliary Relays / Contacts

The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of protective relays and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. also required for the complete protection schemes described in the specification shall be provided. All protective relays shall be provided with at least two pairs of potential free isolated output contacts. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme. Contacts shall be silver faced with spring action. Relay case shall have adequate number of terminals for making potential free external connections to the relay coils and contacts, including spare contacts.

4.3.10 Reset

All protective relays, auxiliary relays and timers except the lock out relays and interlocking relays specified shall be provided with self-reset type contacts. All protective relays and timers shall provide with externally hand reset positive action

operation indicators with inscription. All protective relays which do not have built-in hand-reset operation indicators shall have additional auxiliary relays with operation indicators (Flag relays) for this purpose.

4.3.11 Timers

Timers shall be of solid-state type. Time delay in terms of milli-seconds obtained by the external capacitor resistor combination is not preferred and shall be avoided.

4.3.12 De-energisation of Control Relays

No control relay which shall trip the power circuit breaker when the relay is de- energised shall be employed in the circuits.

4.3.13 Isolation of Trip Circuit for Testing

Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and

maintenance.

4.3.14 Shunt / Series relays

Auxiliary seal-in-units provided on the protective relays shall preferably be of shunt reinforcement type. If series relays are used the following shall be strictly ensured:

- a) The operating time of the series seal-in-unit shall be sufficiently shorter than that of the trip coil or trip relay in series with which it operates to ensure definite operation of the flag indicator of the relay.
 - b) Seal-in-unit obtain adequate current for operation when one or two relays operate simultaneously.
 - c) Impedance of the seal-in-unit shall be small enough to permit satisfactory operation of the trip coil on trip relays when the D.C. Supply voltage is minimum.
 - d) Trip circuit seal-in required for all trip outputs, irrespective of the magnitude of the interrupted current. The trip-circuit seal-in logic shall be only seal-in the trip output(s), but also the relevant initiation signals to other scheme function, (e.g. initiate signals to the circuit breaker failure function, etc.) and the alarm output signals.
 - e) Two methods of seal-in are required, one based on the measurement of AC current, catering for those circumstances for which the interrupted current is above a set threshold, and one based on a fixed time duration, catering for those circumstances for which the interrupted current is small (below the set threshold).
 - f) For the current seal-in method, the seal-in shall be maintained until the circuit breaker opens at which time the seal-in shall be reset and the seal-in method shall not now revert to the fixed time duration method. For this seal- in method, the sealing shall be maintained for the set time duration. For the line protection schemes, this time duration shall be independently settable for single and three-pole tripping.
 - g) Seal-in by way of current or by way of the fixed duration timer shall occur irrespective of whether the trip command originates from within the main protection device itself (from any of the internal protection functions), or from an external device with its trip output routed through the main protection device for tripping.
- Trip-circuit seal-in shall not take place under sub-harmonic conditions. (e.g. reactor ring down)

4.3.15 Spare Pair of Contacts

All protective relays and alarm relays shall be provided with one extra isolated pair of contacts wired to terminals exclusively for future use.

4.3.16 Setting Ranges

The setting ranges of the relays offered, if different from the ones specified shall also be acceptable if they meet the functional requirements.

4.3.17 List of installations using the types of Relays

The bidder shall include in his bid a list of installations where the relays quoted have been in satisfactory operation.

4.3.18 Phase Indications

All relays and their drawings shall have phase indications as R-red, Y-yellow and B- blue.

4.3.19 Scope of Numerical Relays

For numerical relays, the scope shall include the following:

- a) Necessary software and hardware to up/download the data to/from the relay from/to the personal computer installed in the substation. However, the supply of PC is not covered under this clause.
- b) The relay shall have suitable communication facility for connectivity to SCADA over IEC 61850 protocol.

4.3.20 Communication Ports

The relays should have communication ports for local communication for relay settings, modifications, extraction and analysis of fault/event/disturbance records from a laptop and for communication.

4.3.21 Facilities for fault analysis

The relays shall have the following tools for fault diagnostics

- a) Fault Record**
The relay shall have the facility to store fault records with the information on cause of trip, date, time, trip values of electrical parameters.
- b) Event Record**
The relay shall have the facility to store time stamped event records with 1 ms resolution.
- c) Disturbance records**
At least 5 secs of disturbance records shall be provided in the offered Numerical relays. Each record shall store data from at least 5 analogue channels and 16 digital channels. The data from DR function shall be available in IEEE/COMTRADE format and shall be compatible with the relay test kit being supplied under this contract.

The relay shall also be capable for sending Event Records, Fault Records and DR file over the communication link from relay to SCADA for Disturbance Recording functionality (in DR Workstation) shall be provided at OCC and BCC by Traction Contractor.

4.3.22 Zones of Protection

The zones of protection shall overlap providing back-up protections. The scheme of protection shall be fully coordinated with the infeed network.

The Contractor shall ensure proper coordination among different level of protection being applied in the design such that equipment failures will cause minimum disruption to the Railway System operation.

An interlocking and protection scheme that prevents inadvertent operation of switchgear resulting in electrical accident by inadvertent or spurious re-energisation of the supply shall be submitted to the Engineer's approval. Any 33kV cable or switchgear faults in the 33kV ring-main system will be cleared first by incoming feeder panel circuit breaker and backup by the outgoing 33kV feeder circuit breaker at RSS side.

To detect the location of the fault in the 33kV ring-main system; a detection relay shall be installed for at 33kV feeder panels at each ASS which will send to the OCC an indication that it detects a fault. This will be seen on the screen of the OCC Equipment and the fault could be located between the last relay detecting the fault and the first relay not detecting the fault. With these indications, the operator will be able to take the necessary measure to isolate the faulty section and to re-energize the healthy part of the network.

4.3.23 Hydraulic or thermal protections

These protections, such as lack of pressure or abnormal temperature, shall include measuring elements situated on the protected apparatus, actuating a contact (mandatory of flip-flop type) which represent the start of the protection line.

4.3.24 Protections through lack of monitoring voltage

Each cut-out apparatus shall include a device controlling its opening and preventing it from any re-closing in case of lack of monitoring voltage.

4.3.25 Protections through lack of AC voltage**4.3.26 Ensured by means of phase - phase voltage measurements with adjustable threshold, possibly associated to time delay, adjustable as well. The measurement shall be supplied from the secondary of the voltage transformers.****4.3.27 Protection against phase-phase short-circuits Ensured by means of current relays (primary current measurement relays with adjustable threshold, associated to time delay also with adjustable threshold). The current relay shall be supplied from the secondary of the current transformers.**

4.3.28 Over current protections

This function ensures the tripping of concerned circuit breaker when the current value reach the highest allowable load on the network in instantaneous or delayed time conditions.

Following the network configuration, pre-set tripping thresholds could be commuted via automatic interlocking or voluntary action.

Tripping curves characteristics could be:

- At constant time,
- At dependent time following a characteristic:
- Inverse,
- Very inverse
- Extremely inverse.

4.3.29 Protection against zero sequence faults

At the output level, these shall be ensured by means of zero sequence current measuring relays (obtained through associating of the currents from the current transformers). These relays shall not be affected by the capacitive currents in the cables during unbalanced operating times which occur on the power supply (such as earthing fault of the other cables,etc.).

4.3.30 Differential protections

Based on the instantaneous comparison, for each phase between the bar set or transformer incoming current and outgoing current, through current transformers.

4.3.31 Synchro-coupler relay

This relay shall ensure the authorisation of closing a coupling apparatus. Its own functioning shall be into service only in the case of voltage presence on both parts of the coupling apparatus.

When into service, it shall compare the phase, the frequency and the voltage of both sources to be coupled.

Phase difference, frequency difference and voltage difference shall be settable.

4.3.32 Initial alarm threshold

Performance of the CB is unaffected, in particular breaking capabilities remain intact.

Immediate intervention by specialist is not necessary.

4.3.33 Second alarm threshold

CB tripping and locked until SF6 refilling Isolating capabilities of the CB remain intact.

Immediate intervention by specialist is necessary. Control orders are inactive.

4.3.34 Devices

The devices used must provide full reliability and operating safety and not represent a weak spot for the tightness of equipment.

At no time shall these devices indicate any wrong data, not lose their accuracy regardless of ambient temperature or of the operating incident concerned.

This is why monitoring devices with temperature compensation are specified.

Each gas compartment should have its own SF6 pressure monitoring facilities as well as its static filters.

Pressure relief devices should be designed to limit maximum pressure rise below the bursting level of the enclosure and barrier insulation but not designed to retain the fragment of bursting disk.

All gas compartments shall be equipped with rupture diaphragms to prevent the enclosure from uncontrolled bursting.

4.3.35 Testing and inspection devices

Each compartment will be equipped with valves and connections enabling gas to be added or direct readout pressure measuring equipment to be fitted while the equipment is energised.

The various joints and gaskets shall ensure full tightness and be protected so as to withstand the effects of the various corrosive agents present in the atmosphere (pollution, temperature, humidity, etc.). The corresponding flanges shall be fitted with an effective system for Sealing all leaks even very slight ones that may occur around or because of these joints.

The apparatuses shall be fitted with pressure release valves with deflectors to ensure protection against overpressure. Test certificates of this device shall be supplied.

4.3.36 Presence of voltage

Voltage relay shall be used to authorise the operation of the incoming isolators and earthing isolators on no load.

4.3.37 Staging of the protections

Selectivity of the protection arrangements shall be provided so as to avoid all unwanted tripping.

The time delay of the various circuit breakers shall be set so as to ensure chronological selectivity of the tripping.

The supplier shall define precisely the minimum intervals between the various protection stages, accounting for the timings and for the actuation times of each one of the apparatus involved.

To avoid unwanted tripping, it shall be necessary, in particular, to account for transient phenomenon such as energising of transformers and engagement of cables.

4.4 33 KV CABLE PROTECTION

The entire 33 kV Cables Network shall be protected by means of Line Differential protection with Pilot wires, which will automatically trip the 33 kV Circuit Breakers on

either end of the faulty Section of the Cable. Pilot wire-based relay / differential protection shall also be provided for all 33 kV cables running in underground & elevated section

between any two ASS. In case of fault in a section protected by pilot wire based differential relay, the CBs at both ends of the section shall be tripped to isolate the faulty

section. In addition, not limited to, Instantaneous and IDMT Overcurrent and Earth fault protection (50, 50N, 51, 51N) shall be provided. Over current & earth fault protections

shall also be provided in each cut- off / ring main CB as backup protection. All protection including CTs as required will be provided by Traction Contractor.

Therefore, the

functioning of these protections shall trip the either end of circuit breaker of 33kV power supply network.

4.5 ASS EQUIPMENT PROTECTION**4.5.1 Medium voltage network protection**

The medium voltage network will be protected by RCCB/MCCB's located at ASS/AMS.

Nevertheless, Pilot wire relay protection shall be provided as explained above.

4.5.2 Transformer protection

The transformer is protected against fault by the followings:

- F 50: Instantaneous over current protection
- F 51: Time delayed over current protection

- F50 N: Instantaneous earth fault protection (zero sequence)
- F51 N: Time delayed earth fault protection (zero sequence)

Moreover, the transformer shall be protected against heating by a two-threshold temperature protection. The first threshold shall transmit an alarm to the OCC as well as in the ASS.

The second threshold shall trip the respective MVCB and corresponding downstream LVCB and transmit an alarm to the OCC.

4.5.3 Low Voltage Protection

The low voltage circuit breaker supply and installation will be done by the E&M Contractor shall be equipped with protection to protect the main circuit against short-circuit, over-current and earth fault. The tripping of low voltage circuit breaker (LVCB1 or LVCB2) shall also ensure tripping of the corresponding HV side breaker of the transformer (MVCB1 or MVCB2), by inter-tripping. The selectivity shall consider the time delay and the current level of the downstream protections

5 MEDIUM VOLTAGE CABLE

5.1 33 KV CABLE REQUIREMENTS (FOR ELEVATED SECTION)

This chapter deals with the specifications applicable to:

- a) all cables in elevated section and Depot, constituting the 33 kV distribution network.
- b) all cables in other than underground sections.
- c) Medium Voltage Cables in Elevated Section

The different cables shall be supplied as per the GTP of Cables shall be approved by Engineer In-Charge.

These specifications applicable to all cables in the adjoining elevated sections of various corridors, constituting the 33 kV distribution network. Further all types of Cables to be used in Underground Sections shall be Fire Retardant Low Smoke Zero Halogen Type (FRLSOH) and cables to be used in elevated sections shall be FRLS Type. Cables from AMS to ASS shall also be FRLS type excluding portion laid in underground section (station and tunnel) which shall be FRLSOH type. The interconnections between the elevated and underground section shall be dealt accordingly with minimum number of joints.

5.1.1 33 kV Distribution Cables

The elevated corridor ASS shall be supplied from a 33 KV cables Network, which shall consist of two cables (cable 1 and cable 2) normally independent from one another. The network is divided into loops, as necessary, as shown in the relevant 'Auxiliary Power Supply drawings'.

The three-phase short-circuit current to be considered, is 8 kA. Current frequency is 50 Hz.

The 33 kV distribution cables shall be laid inside cable path/channels provided on the viaduct along the tracks.

5.1.2 General Requirements

Traction Contractor shall confirm the section of these cables as regard to:

- the route installation,
- the thermal conditions in service,
- the climatic conditions,
- the energy and currents flowing through these cables, taking into account the worst electrical conditions:
- operation under permissible overload conditions,
- operation when all 33 kV distribution are supplied by only one transformer, and on only one 33 kV cable.

5.1.3 Dimensional and Electrical Characteristics

The type of 33 kV cable selected is dry-insulated, radial-field cable, which is based on proven technology.

5.1.4 33 kV cables specifications

They shall be constituted by assembly of three single core cables in twisted or cloverleaf pattern, insulated with chemically cross-linked polyethylene, with semi- conducting screen over a conducting core, insulating envelope Al Tape armouring and polyvinyl chloride protective sheath.

All 33kV Cable end in drums shall be sealed with Heat Shrinkable Type tape to avoid water ingress during transporting and storage.

- operating voltage: 33 kV rms between phases,
- conductors: As specified.

Traction Contractor shall verify cross-sectional area of these 33 kV cables, according to the latest arrangement of the ASS along each 33 kV cable.

5.1.5 Fire retarding properties

All cables shall be Fire Retardant Low Smoke (FRLS) and conform with IEC 60502-2 or equivalent (The cables to be used in the Underground Sections shall, in addition, be of Low Smoke Zero Halogen (LSOH) type). The cables, in addition, shall be non- fire propagating, non-toxic and low smoke producing type.

5.1.6 Standards

The 33 kV Cables shall satisfy the following requirements and shall also comply with standards in force when the cables are manufactured, particularly which are in the following table (Unless otherwise stipulated in the specifications, the latest version of the following Standards shall be applicable:

Standard	Description
IEC 60502	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) — Part 2: Cables for rated voltages from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV)"
IEC 60288	Conductors of insulated cables
IEC 60332	Part 1: Test on electric and optical fibre cables under fire conditions Part 2: Test on electric cables under fire condition
IEC 60811	Electric and optical fibre cables — Test methods for non-metallic materials
IEC 60754	Test on gases evolved during combustion of materials from cables — Part 1: Determination of the halogen acid gas content Part 2: Determination of acidity (by pH measurement) and conductivity
ASTM D 2843	Standard Test Method for Density of smoke from the Burning or Decomposition of Plastics
ASTM D 2863	Test Method for measuring of Minimum Oxygen Concentration to support candle- Like Combustion of Plastic (Oxygen Index)
IS 7098 Part 2	Cross linked polyethylene insulated thermoplastic sheathed cables, Part 2: for working voltages from 3.3 kV up to & including 33 kV.
IEC61034 BS 7622	Measuring of smoke density of cables burning under defined conditions
ASTM D 2843	

5.1.7 Specification & Construction features of 33 KV, FRLS Power Cable**5.1.7.1 Conducting Core**

The conducting core shall be made of bare annealed aluminium, according to class 2 as per publication IEC 60228, Latest Version.

The Cross Section of the conducting core shall be as follows for various connections.

Description	Conducting Core
From AMS/RSS to Station ASS	120 <u>sq. mm</u> Aluminium
From ASS to ASS (elevated section)	120 <u>sq. mm</u> Aluminium
For 33 kV CB to Transformer (33kV/415 V) (for less than 1MVA)	120 <u>sq. mm</u> Aluminium

5.1.8 Specification.

The cable shall be 19/33 kV, grade, single core, 120sq.mm stranded Aluminium conductor, XLPE insulated, PVC sheathed. It shall confirm to IEC 60502 Part 2 latest for construction and IEC 60840 for testing.

5.1.9 Constructional Features

5.1.9.1 Conductor:

The conductor shall be formed from annealed circular stranded Aluminium conductor complied with IEC latest publications 60228. The conductor shall be compact circular stranded.

5.1.9.2 Conductor Screen:

The conductor screen shall be provided as per clause 7.1 IEC 60502-2:2005 or equivalent clause in latest version of IEC 60502-2. The conductor screen shall consist of suitable thickness and volume resistivity. It shall be easily removable from conductor during jointing. Nominal thickness of conductor screen shall be 0.7mm.

5.1.9.3 Insulation:

The conductor with screening shall be provided with cross linked polyethylene (XLPE) insulation applied by extrusion. The nominal thickness of insulation shall be not be less than 9mm and subject to tolerance as per IEC — 60840, clause 10.6.2.

The insulation compound shall be of high quality, heat, moisture, ozone and corona resistant. XLPE compound should be from Borealis, Sweden or NUC Japan or any other equivalent reputed manufacturer. 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.

The Insulation shall be applied by extrusion and vulcanized using dry curing process to form a compact homogenous body free from micro voids and contaminants.

5.1.9.4 Insulation Screen

The Insulation screening 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. Semiconducting compound should be from Borealis Sweden or NUC Japan or any other equivalent reputed manufacturer. Nominal thickness of insulation screen shall be 0.7mm.

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

5.1.9.5 Water Barrier

The water barrier shall be semi-conducting water swell-able tape to be applied over the extruded insulation screening 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.

5.1.9.6 Metallic Screen:

The metallic screen shall be plain copper round wires /copper tape applied helically over the semi-

conductor bedding tape(s). The area of the copper wire /copper tape shall be should be able to withstand specified earth fault current. Bidder to submit the calculations giving details of the area of copper wire screen/copper tape.

5.1.9.7 Inner Sheath:

A polypropylene tape shall be applied over the metallic screen.

5.1.9.8 Armouring:

Double Tape Aluminium armouring should be applied over the inner sheath and the thickness of the same should be as per IEC 60502.

5.1.9.9 Outer sheath:

Cables laid in elevated sections shall be exposed to sun. The outer sheath shall be extruded in black colour with UV Protection and Anti Termite Anti Rodent Treatment, FRLS PVC confirming of requirement of IEC specifications and extruded continuously. Such cables shall have phase identification after interval of 10 meters. Colour coding shall be done at manufacturer's works / at site.

5.1.9.10 SHORT CIRCUIT RATING OF METALLIC SHEATH/SCREEN

The area of copper wires/copper tape shall be designed to meet the requirement of the system short circuit rating of 1 KA for 3 Seconds.

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/CCV Process dry curing technology to ensure homogeneity and absence of micro voids. The cables shall be manufactured by "Dry Curing" Process.

The Employer may decide to visit the works of cable manufacturer to confirm the manufacturing process mentioned.

Traction Contractor shall provide trefoil clamps of non — metallic sturdy type at every 5 meters with cable ties at every meter. For cable tags refer clause No. 5.6.3.2.

The protective sheath shall carry the indications listed below, in letters and digits at least 6 mm high:

- designation of ownership,
- nature and cross-sectional area of conductors,
- specified cable voltage,
- phase numbering,
- manufacturer's name.

33 kV cable for use in elevated section shall comply with following Test Standards in addition to IEC 60502.

1. IEC 332 Part 1 and 3, category A, test on single and bunched cables under fire condition.
2. Limiting Oxygen Index of at least 30 as per ASTM D 2863.
3. Temperature index of 260 ° C as per ASTM D 2863.
4. 3 m cube smoke emission test, when Tested in accordance to ASTM D2843/IEC 61034/BS 7622- Maximum smoke emission shall be 40% & Minimum light transmission shall be 60% (FRLS)
5. All Insulation is to be moisture and heat resistant, with temperature rating appropriate to the application conditions and in no case lower than 90° C.

5.2 CONNECTING JUNCTIONS - MV ENDS

5.2.1 Connecting Junctions

Connecting junctions shall reconstitute perfectly all elements of the MV cables, so as to obtain electrical and mechanical characteristics at least equal to those of the cable.

The Contractor shall submit to the client, for approval, a detailed description of the technique foreseen for execution of connections in MV lines.

However, maintenance and repair being able to be carried out only during a short period of time, at night, due consideration shall be given to connection processes having the following characteristics, quality being otherwise equal:

- quickness of execution,
- possibility of replacement without having to disturb the cable,
- Small bulk.

All. 33kV straight through joints shall be of Heat Shrink 'Raychem' Type.

5.2.2 Cable Heads

MV cable heads shall be connected to cable junction boxes with the MV apparatus. All 33kV Cable terminations shall be Heat Shrinkable Type 'Raychem' or equivalent.

For underground section straight through joint / termination shall be made by using Halogen free jointing kit.

5.2.3 Execution Rules

The entire supply shall be executed according to all Rules of the Art pertaining to professional-grade equipment, and in compliance with the technical specifications and specifications of the International Electro technical Commission relative to power supply cables (IEC 60055-1, 60055-2 and 60502-1). The supply shall be delivered, upon request by the client, only after execution of in-plant inspection operations and satisfactory testing according to the technical requirements imposed.

The cables shall pass all the tests stipulated in the IEC 60502 rules in force on the date of the order.

The sleeves and the insulating materials used shall meet the guaranteed requirements imposed.

The equipment shall be capable of withstanding intensive use without alteration, and of performing its duty even after extended idle period.

5.3 Atmospheric and climatic conditions

The entire equipment shall be designed for operation in hot weather, according to the climatic conditions.

The equipment shall be sturdy and properly treated against corrosion. This protection shall be suited to the various environmental conditions encountered in the various parts of the network.

It must be noted that environmental conditions shall be very severe during construction; these conditions shall not be the cause of any alteration of equipment or material whether already installed or simply stored.

5.4 Cable technical and test sheet

The tests shall be performed according to the corresponding IS/IEC standard.

After completion of laying of the cable and its accessories, a dielectric test is carried out through application, for 15 minutes, of an alternating voltage equal to square root $3.U$ or a direct voltage equal to $4.U$.

5.5 Cable laying specification

5.5.1 General

MV cables shall be laid all along the line on viaduct, in tunnel and in ground wherever required.

The cables shall be laid as per the international and national standards practice followed in metro system.

The heat elongation/contraction of the cables has to be taken into consideration for cable laying. Cable

shall be laid in a slightly waved line, similarly to sine curve in order to allow controlled movement.

Suitable Cable Cleats (material: SS-316) and intermediate restraint (metallic/non-metallic/composite) according to the size and short circuit current carrying capability of the cable shall be used for securing cable in electrical installation relying on the mounting surfaces as per latest edition of IEC 61914.

The GTP and make of cable cleat shall be approved by Engineer in-charge.

They shall be supplied on reels, the standard of which shall be determined according to the laying conditions.

This specification defines all types of work related to installation of cable routings, paying out and laying of the cables, at grade, on viaduct, in tunnels etc.

The Contractor shall produce a stake-out plan at 1:500 scale, which shall indicate the precise laying position and the type of routing (in channel or inside duct), accounting for all specific location of the line (Track crossings and entry into electrical stations).

Apart from the cable cleats, the cable dressing shall be proper, and cables shall be tied on each bracket with heavy duty nylon cable tie (UL listed Nylon 6.6 material). The cable tie shall be UV resistant, and Flammability shall be of UL94 V2 rating. The GTP and arrangement of cable Ties shall be approved by the Engineer In-charge.

5.6 Cable Routing

5.6.1 Laying between the AMS and the designated ASS

Routing of the MV cables between the AMS and the line shall be made according to the following principle:

- From 33 kV outgoing Circuit Breaker in AMS to RSS boundary in existing path provided by RSS Contractor (cable ducts with brackets, pipes etc.). The laying of 33kV cables in these cable paths shall be within the scope of the traction contractor
- From 33 kV outgoing Circuit Breaker (RCCB/MCCB at AMS) downstream to the designated entry point of elevated station, beyond which the cable path shall be provided by Traction Contractor.
- From the point of exit of the RSS-cum-AMS premises upto the entry point in the Underground stations, cables shall be laid generally buried in ground as per approved plans and specifications, below ground, below road or below footpath, as the case may be. In special circumstances, if required, the cables may be required to be laid in trenchless piping, in concrete cable trenches, in HDPE/GI pipes, under rail track crossings, or in air supported on piers/walls.
- Inside station/ASS, a cable path for cables from ground to elevated section (in station/in building) & up to ASS shall be provided by Traction Contractor. From the point of entry in the Underground station upto the-point of entry into the ASS Room and in undercroft, the cable path will be provided by the E&M Contractor.
- Communication cables for control & monitoring (SCADA) from RSS gateway to the station Telecom Equipment room in UG/Elevated station shall be laid by traction contractor in HDPE pipes. HDPE pipes shall also be supplied by traction contractor. These cables will have a route common with 25kV cables from RSS to the station as far as possible.

From RSS Boundary to the underground/Elevated station ASS through ground entry, across nallah & under railway tracks if any, road/street crossing wherever required, providing cable tranches as per specifications, complete with HDPE pipes wherever required (such as rail/road/street/nallah/crossing, etc.) protective covers, RCC cable route markers, trenchless cable path with HDPE pipes wherever required. G.I. Framework for cable supporting (such as across nallah etc.), restoration of road/ground/footpath/street etc, making test pits, route survey, identification of other utilities, interface with local authorities for permission and fee applicable etc. Taking due care for protection /handling/diversion of all the utilities or historical structures /obstructions coming in the way of cable route and will change the cable route (up, down or by side of utility) etc.as per the requirement of site.

2 nos. 100mm dia. HDPE Pipes for telecommunication cable of telecom contractor shall be supplied and laid by traction contractor.

Fee deposited by the contractor to Government Agencies for obtaining permission for Laying of Cables shall be reimbursed by KRIDE on submission of documentary evidence of payment. Road restoration charges paid by the contractor to the civic agencies will be reimbursed by KRIDE on submission of documentary evidence of payment. If for some stretch, road restoration is to be done by contractor, the price quoted in the BOQ shall be payable.

Depot ASS will be at grade and cable trenches will be provided by depot civil contractor; cable supports inside ASS shall be provided by traction contractor. Necessary interface to be carried out by traction contractor. Cable path from ASS to Station or AMS (outside depot boundary) will be in scope of Traction contractor.

Traction Contractor shall provide suitable means for secured cable laying with the approval of KRIDE.

5.6.2 Laying in Viaduct

Cables shall be laid in cable brackets/trenches along the walkway. The brackets / trenches in viaducts are in the scope of viaduct contractor in elevated/at grade sections and in the underground section it is the scope of E & M Contractor. Traction Contractor shall provide suitable means for secured cable laying on hangers/trays etc. with approval of KRIDE. The supply and installation of trefoil clamps of Non — metallic sturdy material at every 5 meters with cable ties every meter in the intervening space is under the scope of this contract. 33 kV danger boards will be provided at every 100 m shall be provided and also at locations wherever cables have to cross under tracks (near sidings etc.). Wherever trefoil clamps are not feasible cable ties shall be provided as approved by KRIDE.

Inside UG station, cables shall be laid inside ASS room, in under croft/cellar, in HDPE pipes, along/across track, in cable galleries, shaft etc.

Locations of joints shall be marked by suitable boards in tunnels, viaduct, under croft, shaft etc.

5.6.3 Laying in Tunnels

Cables shall be laid in the cable supports on the tunnel wall.

Support/Brackets will be provided by E&M Contractor. The Traction Contractor is to interface with E&M Contractor for route and location.

5.6.4 Laying in between Tunnels and Viaduct

The Traction Contractor shall interface with Station building contractor for cable cut- out for entry of 33kV cable to the Auxiliary substation. The cable path inside the Elevated station building will be provided by the Traction Contractor

5.7 Cables Installation

5.7.1 Laying out

The cables shall be delivered to the laying work site in suitable unit lengths, coiled on reels whose average weight shall not exceed about 8000 kg for copper-cored cables, as well as for aluminium-cored cable.

If cables are laid after the track is in position, then these reels shall be delivered by train as close as possible to the point of utilization, accounting for the constraints generated by the actual traffic on the existing line.

Paying out of the cables can be made manually or mechanically. The mechanical devices (electric or pneumatic) used for paying out the cables shall be so constructed that they would prevent damaging the cables. These devices shall be submitted to the client's representative for approval.

Should mechanically paying out not accepted, for whatever reason, traction contractor shall execute paying out of the cables with the number of personnel deemed necessary by the client's representative.

The laying team shall be under the authority of a supervisor qualified for this type of work.

To execute paying out, this supervisor shall comply with the instructions given by the client's representative in charge of technical supervision of cable laying.

All necessary precautions shall be implemented during operation to prevent any deterioration of the cable; the cable shall not be subjected to any twisting around its axis, and not be bent to a radius smaller than the minimum bending radius specified by the cable manufacturer. It shall be subjected only to the traction efforts strictly required to pay it out. In no event may the cable bear against the ground or against fixed stops; it shall rest onto rollers, situated sufficiently close to one another.

The ends of two successive reel lengths shall overlap by about two meters to enable cropping the cable ends before execution of the connection sleeves.

When the client's representative estimates that paying out of cables in a single length 200 to 500 m risks generating abnormal strains in the cable, one or several looping may have to be made. A cable looping is defined as being any operation that requires previous paying out of the cable outside the channel or cableways.

When two cable courses are superimposed inside channels, each course shall be separated by means of isolating plates every 3 m.

5.7.2 Tagging

All cables laid inside channels, or on cable-tray shall carry an 8 x 5 cm PVC tag placed every 50 m and in specific locations such as connection sleeves, entry into and exit from ducts, possible pulling chambers.

The R Y B colour illumination with reflective tapes to be provided on cable after 100 meter to identify the phase of the 3 run of 3 phase circuit of 33kV power supply network.

These tags, fastened via two clamps, shall bear the labels approved by the Employer.

Tagging of cables plays a part in safety as regard identification of the cables in case of incident and shall be made very carefully and Traction Contractor shall be

responsible for any error or for any incident subsequent to such an error. The tags shall be fastened right after the paying out of each reel.

5.8 Laying in Ground

5.8.1 Laying in Ground

On all the road crossings and at other appropriate locations, cable laying shall be through trenchless drilling and cable passing through high density polyethylene (HDPE) pipes in concrete pipes of appropriate diameter and thickness.

The 33kV cable between AMS and ASS of nearby station shall be laid in ground at depth of 1.2 meter duly protection by RCC slabs.

The cable laying shall be generally in accordance with IS1255; Latest Version or latest version and manufacturer's recommendations. The laying standards for cables laid in ground shall not be less than the following:

- The trenches for carrying the cables shall be at least 1.3 m deep and 1.0 m wide.
- Cables shall be laid at 1.2 m depth below the ground level and over a 100 mm bed of coarse sand.
- Trench is to be filled with sand up to a depth of 0.8 m below ground level.
- Warning concrete RCC slabs each approx. 0.8mx0.25mx0.05m (Thick) shall be laid above the sand.
- Trench shall be filled with earth up to 200 mm below the ground level.
- A warning net/tape printed with details of cables & KRIDE name shall be laid above the earth (at 200 mm depth below ground level).
- The top space of 200 mm shall be filled suitably and given a final finish matching the surrounding.
- The route shall be marked by suitable RCC cable markers at the suitable intervals and the positions of straight through joints shall be indicated by suitable RCC route markers.
- Route and joint bay markers shall contain details of KRIDE cables, contact nos. of BSTP Metro (Control centre) etc.
- On all the road crossings and at other appropriate locations, cable laying shall be through trenchless drilling and cable passing through high density polyethylene (HDPE) pipes in concrete

of appropriate diameter and thickness.

5.8.2 Conduits (HDPE)

Whenever the cables have to be laid below roads, they shall be laid in multi-conduit made of HDPE pipes embedded in concrete. The arrangement shall be generally as follow:

- Each circuit of the Incoming feeder shall consist of three cables, each cable laid in a conduit (so 6 cables laid in 6 conduits).
- Conduit for each cable shall be not less than 150 mm in diameter.
- In addition to the 2 circuits (6 cables) in conduits as above one spare conduit, without cable, shall be provided.
- in addition to the conduits for power cables, two additional conduits, each of not less than 100 mm dia, shall be provided to carry control and monitoring cables, one operational and one spare.
- The horizontal distance between two adjacent conduits shall not be less than 75mm.
- The route shall be marked by suitable retro-reflective/RCC cable markers at suitable intervals and the positions of straight through joints shall be indicated by suitable boards.
- The route shall be marked by suitable RCC cable markers at suitable intervals and the positions of straight through joints shall be indicated by suitable boards.
- The pulling chambers of required size will be provided by Traction Contractor.
- The top of the concrete shall be at least 1m below the road level.
- The cable path for laying of 33 kV cables including C & M cables from RSS to nearby ASS is covered in the scope of the work of Traction Contractor.

5.8.3 Sealing of cut-outs

Sealing of 33 kV cable and control cable cut outs is in the scope of work of SBC. Traction Contractor shall interface with SBC. Unused cut-outs made at the request of Traction Contractor shall be sealed by Traction Contractor.

5.8.4 Sheath Voltage Limiter

The Traction Contractor shall provide sheath voltage limiter as per calculations and requirement per site conditions.

5.8.5 General

In Medium Voltage power lines, three single core cables are used in place of three core cables. In the single core power transmission, the cables are usually covered with a metallic sheath to prevent ingress of moisture, protect the core from possible mechanical damage and create an earthed shield.

Unlike the three core cables, the Single core cable behaves like a transformer. The current carrying conductor of the cable acts as the primary winding and the metallic sheath as the secondary. The field of the current carrying conductor induces a voltage in the metallic sheath of the cable.

Sheath Induced voltage:

The magnitude of the EMF induced in the cable sheath is directly proportional to the magnitude of the load current carried by the conductor, the mutual inductance between sheaths of the cables, the spacing between the cables and the cable length.

$E_s = 314 \cdot I \cdot L$ volts/m E_s = Sheath Voltage.

I = Current in the conductor

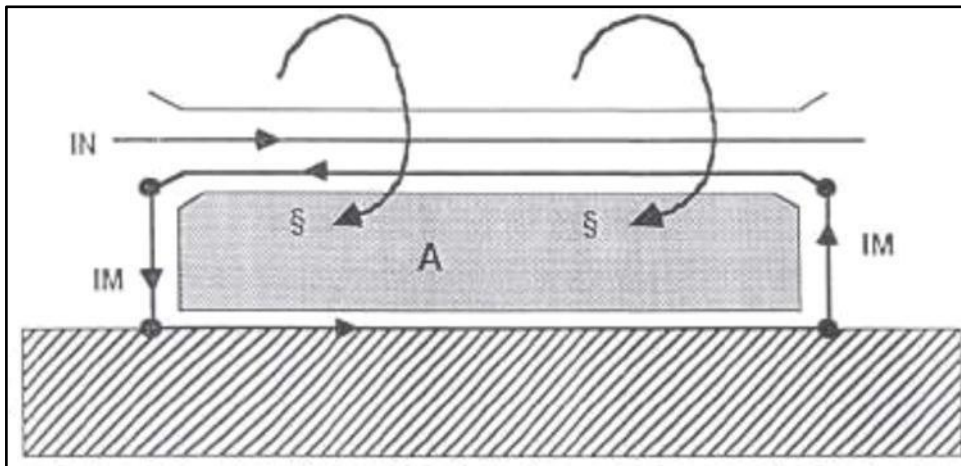
L = Mutual inductance between the sheaths of cables

This induced EMF causes a circulating current to flow in the sheath when both ends of the metallic sheath are bonded to the ground.

Circulating Currents:

Circulating currents are generated in the metallic sheaths of the cables when the cable's insulated conductor is carrying alternating current, and its metallic sheath is bonded to ground at both ends. It doesn't matter what metal the layer is. If it's metal and grounded at both ends there will be a current

induced into it. The magnitude of this circulating current depends on the current in the conductor and the impedance of the loop formed by this layer and the ground path.



This sheath circulating current causes sheath-circulating losses and causes heating. In such cases, the cables must be de-rated to 70% of their normal conductor current.

To utilize the full capacity of the cable, special bonding methods are employed. Sheath Bonding methods:

- Single Point Bonding
- Mid-Point Bonding
- Cross

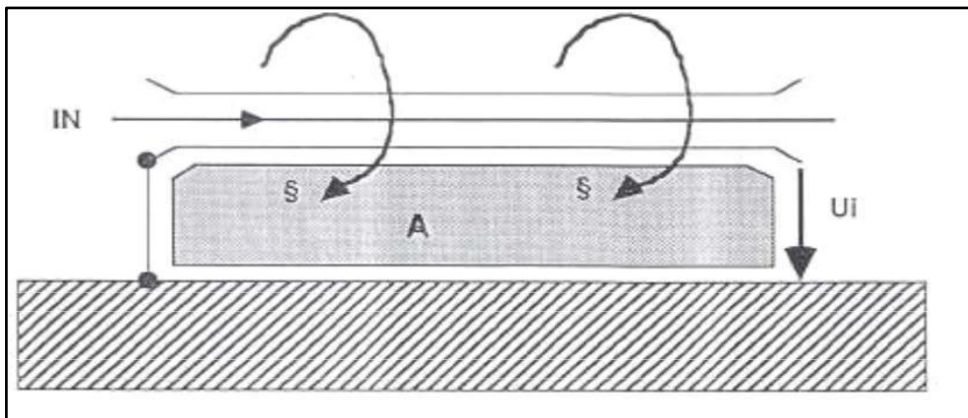
Single Point Bonding

In single point bonding, one end of the sheath is grounded, and the other end is kept floating. Usually, the supply end is grounded. Provision shall be made to provide continuity conductor of adequate size to connect both the earthed ends.

When the cable's Armour / sheath / concentric ground is floating at one end, a standing voltage will be generated on this metallic layer. The magnitude of this standing voltage is directly proportional to conductor current and to cable length. It's also proportional to the spacing between cables and how they're laid out (i.e. flat or trefoil), but current and length are the big factors. Generally standing voltage is not of concern except if the runs are long and / or conductor current is high.

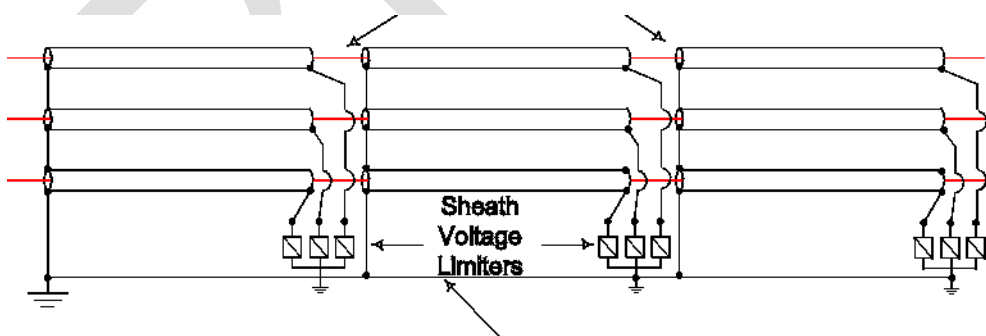
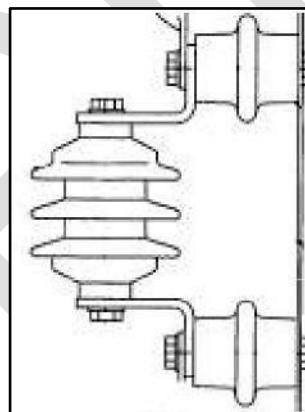
As per the earthing practices as laid down in IS 3043; Latest Version, this standing voltage should not exceed 65 Volts. Typically, Single point bonding is adopted for feeder lengths not exceeding 1 km.

During installation care must be taken to ensure that cable jackets are not damaged. If they are damaged the Armour or sheath could make contact with ground along the run. This forms ground loops, which would, allow circulating currents to flow and this causes cables to overheat. Sparking and cable failures have also been observed at points where cable jackets have been damaged and these circulating currents are allowed to flow to ground.



The floating end should be insulated from the ground. A Sheath Voltage Limiter is installed at the floating end so as to ensure that sheath does not see very high voltages at the time of fault. If the sheath is damaged, moisture ingress & flow of circulating current shall happen.

For longer feeder length bonding can be carried out with a ground continuity conductor.



Midpoint Bonding:

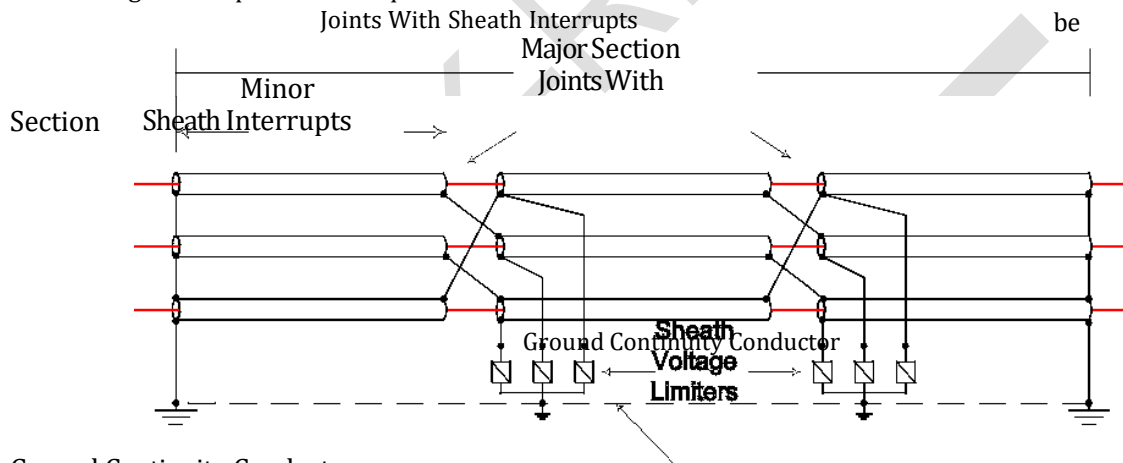
In this method, the bonding is carried out at the center of the cable feeder and the other two ends are grounded through SVL. This ensures that the sheath standing voltage is halved.

Cross-bonding:

For longer feeder lengths wherein, the Sheath induced voltages are high, cross bonding of sheaths is to be carried out.

The sheaths are electrically transposed at every splice, reducing both currents and voltages. SVL's are needed at 2 out of 3 joint locations, and a ground continuity conductor is often installed (but not mandatory).

The sheath bonding Copper cables (3.3 kV) of appropriate size, link boxes, sheath voltage limiters and other accessories are to be provided. The link boxes should be suitable for underground burial conforming to IP 68 protection requirement and shall



Ground Continuity Conductor

housed in a common bay near the jointing bay. The length of sheath bonding cables should not exceed 10 m.

Depending upon the route finally chosen, the PST Contractor shall prepare shop drawing of Bonding, and shall establish that with the Bonding method adopted, the sheath voltages do not exceed the max permissible limit.

In case Cross Bonding becomes necessary, the sheaths have to be electrically transposed at every 'straight though joint' location and Sheath Voltage Limiters (SVL) may require to be provided at 2 out of 3 Joint locations. This shall be decided during the design of the Bonding method.

The Traction contractor will be required to submit and obtain approval from KRIDE for the calculation that bonding method selected by him, single point bonding/ midpoint bonding/ cross bonding, ensures that the sheath voltage is limited to less than 65 V in case of ultimate full loading of cable i.e. considering short time overloading also. Generally, cross bonding is to be used if feeder length is more than 2km.

6 LOW VOLTAGE SWITCHBOARD (LVSB)

The Low Voltage Switch Board (LVSB) is meant to provide and protect the 415 V / 240 AC Supply of the Station Building. The LVSB will be supplied and erected by the E&M Contractor for the Stations. The connection between the Secondary of the Auxiliary Transformers and the LVSB, in the elevated/underground stations (by means of cables or Bus duct) will also be done by the station E&M Contractor. The Traction Contractor shall interface with the respective E&M Contractor to ensure that.

- Adequate facilities are available at the Auxiliary Transformer Secondary side to receive cable / Bus-duct connection.
- The Transformer Cubicle doors are provided with the necessary mechanical system interlock between the door, the LV Breakers and HV Breakers.
- LT CTs for differential protection.

7 LOW VOLTAGE CABLES AND WIRING

This specification is made to define the characteristics of low voltage cables used for distribution, control and monitoring. They shall be supplied either in A.C. or in D.C. They shall be used for electrical connection between apparatuses of RSS, TSS, 25 kV switching stations, AMS and ASS.

All LV cables, Control and Monitoring cables shall be armoured Fire-Retardant Low Smoke Type (FRLS) for Elevated section & Fire-Retardant Low Smoke Zero Halogen Type (FRLSOH) for Underground section Complying with BS 6724; Latest Version for cables, BS 7211; Latest Version for Wires and BS 7846; Latest Version for Cables used for Emergency services.

7.1 GENERAL

Conductors supplied for low voltage or remote-control lines shall have a bare or tinned copper core.

Semi flexible conductors shall be used; rigid conductors shall be prohibited.

The conductors' cross-section shall be a standard value and shall never exceed 240mm²; above this value, the appropriate number of conductors shall be connected in parallel.

The minimum cross-section of conductors shall not be less than 1.5 mm².

The minimum cross-section of current transformers secondary circuits shall not be less than 6 mm².

The minimum cross-section of voltage transformers secondary circuits shall not be less than 4 mm².

The voltage rating of distribution cables shall be 1100 Volts. Grounding conductors shall have green/yellow-stripped insulation. Neutral conductors are to be deemed as being active conductors. Cables and wires shall be treated to withstand flames propagation.

All LV cables and wiring shall be FRLS Type in elevated & FRLSOH in UG Sections.

7.2 CABLE CROSS SECTION DETERMINATION

Determining the technical core section of a cable implies determining the smallest standard cross-section in the type of cable selected which, under the applicable environmental conditions, could satisfy the following criteria:

1. Normal temperature rise

2. Maximum voltage drops
 - a) 3% for main distribution lines (between primary and secondary cabinets)
 - b) 3% for lighting circuits
 - c) 5% for power circuits
 - d) 12% for motor circuits during start-up
3. Overload and short-circuit
4. Protection against indirect contact
5. If heavy currents are to be carried, the economic section must also be taken into account.

7.3 STANDARDS

All LV cables shall be as per IS7098 Pt.1 and IEC60502 Pt.1 in force and shall satisfy the tests given in relevant applicable standards. The cable used for LV system shall comply with BS 6724 for cables, BS 7211 for wires and BS 7846 for cables used for emergency services and for the safety system like ETS. Further these cables should have reduced flame propagation properties to BS EN 50268 /61034. The specifications shall be applied in the manner altered, amended or supplemented by the latest version of these specifications and also the relevant provisions of the latest Indian Electricity Rules wherever applicable.

7.4 IDENTIFICATION

All conductors, cables, wiring, terminals and apparatuses shall be identified according to the indications of the diagrams.

This identification shall be placed so as to be easily read from the accessible face of the cable or wiring.

In all structures, cables shall be marked both at their ends and approximately every 20 meters over their full length, particularly when they change direction, enter conduits, etc.

Along the track, cables shall be identified in the pulling chambers and at their ends. The identification shall be realized with Tag-Holder providing the following guarantees:

- Easy fastening,
- Nonflammable,
- Permanence of the marking
- Easy reading.

The tag-holder and its bi-directional marking type shall be submitted to the employer's approval.

7.5 CONNECTIONS

All connections, whether made by end-fittings, sleeves or terminals, shall comply with good trade practice.

The connection terminal blocks supplied by the contractor shall be identified and includes space enabling precise referencing of all terminals, also possessing all guarantees of permanence and fastening.

The crimped section of cables shall be insulated by heat-retractable sleeve.

The screen of screened cables shall be connected to ground and continuity shall be ensured.

7.6 CABLE LAYING

In general, the cable laying shall comply with the principle of separation between the control and monitoring circuits and the auxiliary circuits of the building (lighting, power, and miscellaneous auxiliaries). The cable laying procedures shall conform to IS:1255-1983 (Latest Version).

The routings and supports of the two circuit networks shall be wholly separated.

Depending on the room gone through and the runs used by the equipment wiring and links, their purpose (supply or distribution of the auxiliary circuit cabinets) or the nature of

the specific element concerned (wiring, frame), several different arrangements may be selected to carry the cables and wires, however, in all cases, good care has to be taken to avoid contact between conductors and sharp edges of sheets, iron, etc.

Systematically, for control and monitoring cables, all the links of a section shall include 15% spare conductors with at least one spare conductor per cable.

7.6.1 Supports

7.6.1.1 Cableways of Perforated Sheet

This shall be the normal laying mode of the link conductors.

It shall be used systematically along wiring runs necessitating special mechanical protection, precaution or when it is necessary to carry several cable-way levels inside limited space.

Their width shall be defined to enable addition of at least 15% of the number of the cables initially foreseen.

In general, when sheets shall be superimposed, the clear heights between one another shall be defined so as to provide perfect accessibility to the cable layers they carry.

All necessary arrangements shall be taken to enable addition or possible replacement of a conductor in a layer and, consequently, to enable its pulling. Several superimposed layers of cables may use the same support sheet but superimposition shall be limited to cables of the same section. If crossings are required between cables or layers coming from different sections, a metal element shall be placed between the layers in way of the crossing. The extent and number of the fastening fittings shall be determined so as to avoid all distortions between rests. The anchoring process of the fittings shall be suited to the supporting element concerned.

7.6.2 Cableway on Fittings or Bridges

This arrangement shall be used only for small layers, not justifying the use of slabs.

The fittings or bridges shall be sized accounting for possible addition of 15% additional cables.

One independent fitting shall be provided per set of conductors coming from a same section; in no event may conductors coming from different sections be fastened to a common fitting or bridge. The number of fittings or bridges shall be determined so as to avoid all cable scalloping between fastenings.

7.6.3 Insulating tubes

When conductors are gathered in strands, they may be laid inside an insulating tube. This solution may be used only for short runs.

7.6.4 Metal Tube

Certain circuits may have to be protected by means of rigid steel tubes or flexible metal tubes; all the necessary precautions shall be taken to insulate the fastening so as not to cause contacts between masses of different categories. These metallic tubes shall be properly earthed.

7.6.5 Fastening of Cables and Conductors to their Supports

Fastening of the cables to their supports, whether perforated steel, fittings or bridges, shall be made by means of loosening-proof clamps made of flexible insulating material and by mean of mechanical tightening.

If several cables of the same section use a common horizontal run, they shall be able to be gathered and clamped by the same fastening clamp.

Fastening of conductors shall always be provided immediately next to their connection ends. In no event may connection to a terminal block be deemed as being fastening and permanent strain may be exerted on the terminals.

7.6.6 Mechanical Protection of Cables and Conductors

In all cases when the layout of the conductors of bar set of the earthing circuits could render them vulnerable (floor crossings, vertical layers or horizontal crossings through service passages), the necessary mechanical protection for the cables and conductors shall be ensured.

These protections shall show sufficient strength to prevent any damage to the cables and conductors following impacts, which may occur during equipment handling operations; they shall also possess good resistance against corrosion.

For vertical layers, Traction contractor shall ensure supply and installation of sheet casing ensuring efficient protection up to a height of 2 meters above ground. In case of single or limited number of conductors a spare tube shall always be laid.

Whenever LV cables or conductors are placed along a run adjacent to or crossing MV cables, full steel protection on the LV cables shall be provided.

It shall enable possible pulling of the MV cables without risking damaging the insulating material of MV cable.

This metal protection shall be connected to the nearest LV earthing collector and shall ensure electrical protection in the event.

All cable trays and supports shall be suitably connected to Earthing system at two distinct and separate points. Wherever cutting / welding process required at site, Traction Contractor shall ensure that cold galvanizing zinc paint should be applied after doing the process.

7.6.7 Sealing of cut-outs

Cut-outs of the Low Voltage cables will be sealed by SBC. Traction Contractor shall interface for the cable sealing with SBC. Wherever trefoil clamps are not feasible cable ties shall be provided as approved by KRIDE.

8 EARTHING

E&M Contractor will provide an Earth bus (MET) inside the ASS. Various metallic objects in ASS will be connected through suitable G.I. flats to the Earth bus (MET— Main Earth Terminal) by Traction Contractor. The bimetallic strips required for connection in any case shall be provided by Traction Contractor.

Connection from a main earth terminal (MET) for transformer neutrals to the earthing stations in the ground will be provided by E&M Contractor. Connection from the transformer neutral to this Earth bus (MET) for transformer neutrals will be provided by Traction Contractor. Interconnection between the ASS Main Earth Terminal and Station earth mat will be provided by E&M Contractor.

The Auxiliary transformer neutral is required to be connected to the ASS earth by means of 2 independent connections. In addition, the Traction Contractor will have to run an earth bus inside the ASS room, and all non-current-carrying metallic parts of the various equipments will require to be connected to this earth bus. The earth bus will ultimately have to be connected to the ASS earth, which may be an earth- mesh or a series of interconnected earth electrodes,

The Contractor shall comply the standards and rules and regulations as applicable:

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- a) IEEE -80 'IEEE Guide for Safety in AC Substation Grounding'
- b) IS 3043 'Indian Standard Code of Practice of Earthing'
- c) BS 7430 'Code of Practice of Earthing'

9 SAFETY REQUIREMENTS

Safety of equipments in the ASS shall be provided as per CEA regulations 2010. The indicative list of safety equipments shall be not limited to the following

The 33kV switchgear panels and Transformers in the ASS shall be protected against fire by means of an 'automatic fire detector and extinguisher system', 'Fire trace' type or equivalent, complete with

Extinguishing agent cylinder, approved by Chief Controller of Explosives, valve, flexible detection and delivery system in the form of a flexible tube, i.e. Linear Heat Sensing Tube (LHST), made of special non-conducting polymer, capable of withstanding a normal pressure of 12 bar and a maximum pressure of 20 bar, suitably routed inside the panel for detection of fire. The detection has to be done by the linear heat detection tube which will be routed inside the panel as per the design calculation. The Extinguishing agent cylinder shall be suitably mounted on the panel and shall be capable of flooding the cubicle/enclosure with Extinguishing agent (Clean Agent Novec 1230), within the shortest response time, not more than 10 seconds after the fire is sensed by the Linear Heat Sensing Tube (LHST), i.e. flexible detector tube. Traction contractor shall submit the complete technical data of the system to the Employer's Representative, for approval. The system shall monitor the weight of fire extinguishing agent cylinder with alarm. Potential free contacts for interface with fire detection & alarm system.

The system shall monitor the weight of fire extinguishing agent cylinder with alarm. Potential free contacts for interface with fire detection & alarm system.

- Tool Board.

- a) Safety tools: first-aid kit, first-aid and electric dangers drawings, insulated gloves, stool and insulated mat as per latest IS / IEC for 33 kV, panels, transformers, ACDB, DCDB, chargers, stretcher, Caution & warning notices.
- b) Fire protection equipment, such as fire buckets, sand buckets, portable fire extinguishers, wall-mounted or wheel-type fire extinguishers etc.
- c) Keyboard.
- d) Gas Resuscitation Kit.
- e) Any other requirement for safety as per CEA Regulation, 2010.

10 ELECTRO-MAGNETIC COMPATIBILITY: GENERAL

- a) An EMC Control Plan shall be submitted by the contractor as specified in the Employer's Requirements: General Specification for review by the Employer.
- b) The EMC control plan shall include measures to reduce conducted, induced and radiated emissions to acceptable levels as specified by EN50121:2006. The plan shall specify measures to increase immunity of the system and all its subsystems.
- c) The Plan shall specify basic' protective measures proposed for all electrical and electronic subsystem and components and specify measures to be adopted for selected subsystems and components.
- d) The Plan shall analyze EMI and EMC impacts on the design of the system, all other train-borne equipment and track-side equipment as well as the general environment. Particular attention should also be paid to additional requirements in grounding, bonding, and shielding, filtering and cabling arrangements.
- e) The Contractor is required to conducted full EMI tests at locations adjacent to television and radio transmission stations airport, and other transmitting commercial stations to be agreed with the Employer. These tests shall include simulated fault conditions.
- f) The radiated emissions shall not exceed the levels permitted by the relevant standards.
- g) Conductive emissions shall be below the levels deemed by the signaling equipment to the satisfaction of the Employer. This condition shall be met by each individual piece of equipment.
- h) Power cables and data cables shall be physically separated from each other. A power cable shall be located and arranged such as to minimize electrical induction or interference to train control and communication circuits as a result of traction, auxiliary or other currents, both static' transient or flowing.

11 INTER-SYSTEM EMI

The Contractor shall ensure that all equipment are designed and constructed in accordance with the latest issues or version of internationally recognized EMC standards, including but not limited to CISPR, EN50082, EN50121(1-5), EN 50123, EN 50155, IEC 60571-1, IEC61000, or equivalents, to ensure proper functioning.

12 SAFETY-RELATED SYSTEM INTERFERENCE

- a) Special attention must be given to the interface with safety-related operations and equipment such as the signalling and telecommunication systems. Special tests must be designed to ensure that the full range of emissions, whether conducted, induced, or radiated, individually or in combination with one another conform to the specific requirements of these safety related systems. Adequate safety margin must be ensured between the immunity levels of these safety-relate systems and the emission levels of the system specified by prevailing international standards.
- b) The subsystems and components which could possibly give rise to the level of emissions under both normal and fault conditions (conducted, induced or radiated) that may, affect the safety —related systems must be identified. The quantified risk assessment must be carried out as part of Hazard Analysis to determine the probabilities and effects of such interference. Measures must be taken to reduce emissions. The reliability of subsystems as well as the additional measures, e.g. filter, must be investigated.
- c) The probabilities of various conditions which could lead to an unsafe operation must be determined. An appropriate technical construction file suitable for safety audit must be developed to demonstrate EMC compliance to the Employer. The contractor shall note that the signalling contractor shall be responsible for determining the limits of interference for both the trackside and train-borne Signalling equipment, to ensure safe operation of the trains, high frequency radiated coupling through common mode, differential-mode, or ground loop mechanisms.

13 ENVIRONMENTAL EMC

- a) The equipment shall not produce significant interference with aeronautic equipment, radars, global positioning system, tracking systems, radio, television, tape recorders or players, heart pacemakers, radar, computer systems, magnetic media, portable and cellular telephones pagers, etc.; in the train or external audible systems as per International Standard EN50121(1-5). This includes action by static electricity, magnetic fields and electric fields.
- b) Effect of emission on explosive or volatile/flammable material must be considered. BS6656:2002 (Assessment of inadvertent ignition of flammable atmospheres by radio-frequency radiation-guide) and other related standards shall be adhered to.
- c) Effect of low frequency magnetic field produced by traction currents on BSTP Metro MRTS grounding system as well as electrolytic weakening of structures shall be taken care of.

14 GUIDELINES

IEC 61000-5 installation and Mitigation Guidelines must be observed wherever applicable.

15 POWER SOCKETS ALONG THE VIADUCT (FOR ELEVATED SECTION)

Power sockets shall be installed along the elevated viaduct by Traction Contractor. From each station 2 cables have to be laid, one on each direction.

Sockets shall be placed every 50 meters or near points & crossings. These power sockets shall be laid on the same side of cable brackets where 33 kV cable runs along track. They shall be 16 A rated current with

5 pins/ 3 phases plus neutral plus earth. They shall ensure a protection of IP 65. Not more than 2 sockets will be operated at any time. That is to say, the cable should be designed for carrying a continuous rated current of 32A, after considering the derating factors as applicable.

The cable along the via duct should be of the same cross section (min. 25 sq. mm.) throughout.

The 5 wires cables shall be laid along the line on the parapet, under the sockets with space enough between them to install the connection box.

The viaduct power socket cable will be laid on bracket at Viaduct / At-Grade. They shall be fixed, at least, every two meters.

The tube shall enter into the connecting box to ensure proper sealing of the system. One PVC conduit shall ensure the cabling between the connecting box and the socket

The connecting box shall ensure the connection of the socket by means of 5 wires cable. Due to the difference in size between the main cables and the socket cable, connecting plates will ensure this reduction.

The connecting box, PVC made, shall include five connecting plates, mounted on insulators. Each connecting plate, copper made, shall ensure the connection of three cables, one for the socket, the two others for the incoming and the outgoing cable.

The fixing of the cables will be done by bolt and nuts or bolt directly screwed in the connecting plate.

The cable termination shall not be open but shall only permit the screwing in order the cable do not fall and touch any other parts in case of bad tightening of the bolt.

The connecting box shall be fixed on the parapet, under the socket. The provision of viaduct socket is considered with Aluminium cable.

The connecting box shall be waterproof and dust-proof, with PVC tubes placed in position with a protection level of IP 65.

All armoured cables should meet the design criteria specified for 415 V cables.

The Supply for the power sockets at viaduct shall be provided from Main Lighting Panel in ASS/ESR Room. Traction Contractor shall do necessary interfacing with E&M Contractor.

16 VIADUCT LIGHTING ALONG THE VIADUCT (FOR ELEVATED SECTION)

Viaduct luminaire consisting of an extruded anodised aluminium alloy body sealed onto an extruded polycarbonate prismatic protector with high impact resistance IK10; a removable sliding plate equipped with control gear on one side and lamp(s) on the other; one or two frames made out of injection moulded on the other; one or two frames made out of injection moulded two polycarbonate covers closed with two stainless steel screws. This system ensures tightness of IP-67 for the whole luminaire. The fixture suitable for minimum 25-28W LED lamp with light output of 2600 lumens with all mounting accessories. However, contractor shall propose and install the viaduct lighting system of adequate lux as per standards.

Supply, installation, testing & commissioning of LED light fittings including all accessories e.g. lamps, holders, surface/recess mounting arrangement etc. including necessary supports, accessories and hardware as per specifications & as required at site and as below:

LED Standards

- a. Latest revision of all codes and standards are to be followed wherever specified otherwise for installation and requirements, Indian standards codes of practice or the relevant British Standard code of practice is to be followed, in absence of any standards.

- b. The luminaries shall have conformation standard of luminaries as per IEC 60598 / IS 10322 and shall have electrical safety as per IEC 61000, 61547, 61347, 62471, 60958, 62560, 60838-2-2, IEC 62262.
- c. **IEC 62471 or IS 16108**-Standard for Photobiological Safety of lamps and lamp systems.
- d. **IEC 62031**-Safety Standard for LED Module for general lighting-safety specifications.
- e. **IEC 61347-2-13 or IS 15885 (Part 2/Sec 13)** Standard for particular requirements for DC or AC supplied electronic control gear for Led Drivers.
- f. **IEC 60838-2-2**-Standard for Particular Requirements- Connectors for LED-modules.
- g. **IEC 62384 or IS 16104**-DC or AC supplied electronic control gear for LED modules - Performance requirements
- h. **EC DIRECTIVE 2002 / 95 / EC** and Related Commission-Restriction of the use of certain hazardous substances (RoHS) in electrical and electronic equipment including lighting.
- i. **IEC 61000-3-2 or IS 14700-3-2** "Electromagnetic compatibility (EMC)
- part 32: limits - limits for harmonic current emissions (equipment input currents 16A per phase)"
- j. **IEC 61000-3-3-(EMC)** for limits on voltage changes, voltage fluctuations and flicker.
- k. **IEC 61547** Standard for Equipment for general lighting purposes-EMC immunity requirements.
- l. CISPR 15. Limits and Methods of Measurement of Radio Disturbance Characteristics of Electrical Lighting and Similar Equipment. (applicable on type A luminaire specified in Table A below and all fixtures having wattage greater than 50 watts).
- m. **IEC 61000-4-11** Electromagnetic compaitability, Testing and measurement techniques- voltage dips, short interruptions and voltage variation immunity tests.
- n. **LED Characteristics standards- LM-80, TM-21.**
- o. **Luminaire Standard -LM 79, LM 70 and B50.**
- p. **IEC 60068/2/78 or IS 9000 / Part IV** : for damp heat test.
- q. **IEC 61086** : for conformal coating
- r. **IS 1239: Part 1: 2004** Steel Tubes, Tubulars and Other Wrought Steel Fittings - Specification - Part 1: Steel Tubes.
- s. **IS 1239: Part 2: 1992** Mild steel tubes, tubulars and other wrought steel fittings, Part 2 Mild steel tubulars and other wrought steel pipe fittings

A. Luminaire minimum specifications and requirements

- i. Luminaires should operate at +/- 6% voltage fluctuation for continuous use to comply to IEC. PF > 0.95; for EM circuits PF > 0.85.
- ii. All the components including the internal wiring of the luminaries to be used shall be manufactured of material, which are of FR type. All luminaires shall be manufactured to relevant sections of IEC or other approved international standards and the type tests for all luminaries shall be provided.
- iii. All internal wiring within the lighting fixtures shall be heat-resisting cables. The cable for viaduct lighting shall be of Aluminium.
- iv. All equipment shall confirm with the objective of the European Directives on EMC
- v. It shall comply with Input volt shall be 240V, 50Hz, Voltage tolerance: 180 - 270V, With Tolerance of Performance: +6% to 8% --- 202 to 254 V, With Tolerance of Safety: +/-10% --- 198 to 264 V.
- vi. Light output regulation: shall maintain constant light output of all LED lamps over operating ranges of 170Volts to 265 Volts. Luminous flux should not change more than +/-2%.
- vii. Relative Light Output: (percentage of light emitted compared with reference tube and ballast) shall not be less than 95% and more than 100%.
- viii. Input total harmonic content shall not exceed 10%.
- ix. Manufacturer has to submit the LM-79, LM 70 and B50 test report along with relevant documents and IES file of all luminaires.
- x. The housing & diffuser shall be robust and conforming to relevant standards and shall have UV and

corrosion resistance protection.

- xi. The luminaries shall have a high quality clear toughened glass or non- yellowish polycarbonate or PMMA diffuser with diffused reflection having a maximum transmissivity of 85% with fire retardant feature.
- xii. The fixture shall be suitable to work in diverse atmospheric condition like humidity, dust, corrosive etc.
- xiii. Manufacturer shall have in-house laboratories for carrying out acceptance tests and shall have **NABL accreditation for in-house laboratories** to perform all applicable photometric tests.
- xiv. Provision shall be made in the fixture for incoming power supply termination, preferably directly at the back of housing.
- xv. All screws should be SS 304 or higher grade.
- xvi. Each fixture shall be provided with 1-meter-long Aluminium conductor with suitable gland and terminations.
- xvii. Extruded aluminium housing shall be robust, heavy duty & anodized and shall have minimum thickness of 1.1 mm (preferably ribbed).
- xviii. Luminaire shall be embossed, or screen printed with manufacturer Name and logo. Also, the following information shall be marked on durable adhesive sticker as per IS code: Type of fitting/Manufacturer name/ Manufacturing year and month /wattage /Lumen/ Efficacy/ R number/IP/IK/ambient temp/CCT/CRI. The following general LED lamp parameters shall be applicable unless otherwise specified in specific design data;

B. LED DRIVER AND CONTROL CIRCUIT SPECIFICATIONS

1. LED driver shall be marked as per latest Standards.
2. The LED driver shall be constant current type.
3. Potted driver with silicon-based compound shall be provided for Type A-Suspended/ Surface mounted LED trunk fixture and all outdoor luminaries (refer Table A). The potting material should have atleast thermal conductivity of 0.8 W/mK. It should be moisture resistance and should be fire retardant. An unpotted sample of the driver also needs to be submitted at time of inspection. MSDS of potting material to be submitted.
4. For the balance type of luminaries, which do not have potted drivers, the PCB should have conformal coating complying to IEC 61086.
5. Over temperature protection / Thermal fold back should be provided in all luminaries' drivers.
6. Industrial grade or higher-grade components should be used for manufacturing of driver.
7. The driver shall be able to withstand surge (EFT+ESD interference) of minimum 4KV of 1.2 / 50 microseconds voltage waveform (IEC 61000-4-5) for all indoor luminaries. Outdoor Luminaires shall have surge protection of minimum 10 KV in common as well as differential mode.
8. The driver shall have under voltage, over voltage and short circuit protection and auto recovery mode.
9. Output current ripple content shall be less than or equal to 10% on load.
10. Output current regulation shall be +/- 5% of the rated current.
11. Output voltage ripple shall be within 3%.
12. Total harmonic distortion shall be less than or equal to 10%.
13. The LED driver of Type A-Suspended/ Surface mounted LED trunk fixture , and all outdoor fittings (wattage > 50 W, refer Table A) should comply to CISPR 15 for limits and method of measurement of Radio Interference Characteristics.
14. The control gear shall be compliant to IEC 61347-2-13 or IS 15885- Part 2/Sec 13.
15. The driver shall have an efficiency > 85% at rated nominal voltage and at full Load.
16. It shall have a power factor > 0.95. at rated nominal voltage and full load

17. It should give consistent performance in the input voltage range of 165V-270V at 50 Hz . The driver should have nominal voltage of 240
- V. The output voltage of the driver shall be designed to meet the power requirement for the system.
18. The driver shall be able to withstand 440 V for 8 hrs for all luminaries. After the application of high voltage, the performance parameters namely THD, PF, regulation and efficiency should not deteriorate.
19. The OEM shall submit damp heat test report confirming to IEC 60068/2/78 or IS 9000 / Part (IV).
20. The driver should have facility for cut off at over voltage.
21. The driver shall have inbuilt inverse polarity protection.
22. The Current Waveform Shall be Compliant to EN 61000-3-2.
23. The equipments shall comply with IEC 61547 for EMC immunity requirements.
24. The driver should be designed for ambient temperature, $T_a = 40$ degree celcius and the life of the driver shall be 50000 hrs (at full load and failure rate of less than 10%). Accordingly, T_c (case temperature) is to be decided by OEM. Measurement of T_c to be recorded during inspection after placing luminaire in ON condition in thermal chamber at $T_a=40$ OC, after temperature has stabilization. T_c should not be more than specified value.
25. Driver should be paired with luminaire that uses 20% less wattage than the maximum rated wattage of the driver.

C. LED lamp

- i. Type: High output, minimum 2600 lumen output nominal, 25-28 W
- ii. Color Rendering Index Ra: 80
- iii. Color Temperature: 4000 K
- iv. Life: More than 50000 hours

LED shall have an SDCM (standard deviation in colour maintenance) of less than or equal to 5.

The LED efficacy shall be more than 85% at a junction temperature of 85°C

Manufacturer has to submit the TM 21, LM-80 report along with relevant documents.

The Lighting distribution board at platform for viaduct lighting shall be provided by E&M Contractor. The Contractor shall interface with E&M Contractor for the same. For Lux level refer NFPA 130, Latest Version.

For fixing arrangement shall be made on handrail or on parapet. Viaduct lighting should not hinder the so that during movement of passengers during emergency evacuation.

The viaduct lighting shall be placed at interval such that adequate lux as per standards is achieved.

Note:

The bidder shall make necessary arrangements in the viaduct to provide viaduct lighting. No inserts / provisions will be provided.

ANNEXURE-A3 33/0.415KV DRY TYPE TRANSFORMER
33 KV / 415 V, 3 PHASE AUXILIARY TRANSFORMERS

The Auxiliary Transformers, also referred to as Auxiliary Station Transformers are required to supply the power requirement at 415 / 230 V of various electrical equipments, systems and appliances. Mainly these comprise of power required for lighting, fans, air- conditioning, Lifts, Escalators, Pumps, Signage boards, control and monitoring circuits, battery chargers, space heaters in the switchgear / panels etc.

This specification defines the main technical characteristics required for the 33000 / 415 V dry type transformers to be used in auxiliary substations (ASS), auxiliary main substations (AMS) or as required. This specification is applicable for the transformers of power rating of following capacity which are generally used in BSTP. This specification may be used for any other capacity in this range:

Transformer Capacity	
AN (Air Natural)	AF (Air Forced)
200 kVA	N/A
315 kVA	N/A
400 kVA	N/A
500 kVA	N/A
630 kVA	N/A
800 kVA	N/A
1000 kVA	N/A
1600 kVA	N/A
1600 kVA	2000 kVA
2000 kVA	N/A
2000 kVA	2500 kVA
2500 kVA	N/A
2500 kVA	3000 kVA
3150 kVA	N/A
3150 kVA	4000 kVA

The transformer offered shall be complete in all respects with all parts and accessories necessary for their efficient operation in substations. All such parts & accessories shall be deemed to be within the scope of this specification whether specifically mentioned or not.

2. GOVERNING SPECIFICATIONS:

The dry type auxiliary transformer shall conform to IEC 60076-11 with specified voltage as 33kV/415V.

2.1 STANDARDS

The transformer shall satisfy the following requirements and shall also comply with standards in force when the transformers are manufactured, particularly which are in the following table (Unless otherwise stipulated in the specifications, the latest version of the following Standards shall be applicable):

Standard #	Description
IEC 60076-3	Power transformers - Insulation levels, dielectric tests and external clearances in air
IEC 60076-11	Dry-type power transformers
IEC 60076-1	General power transformers,
IEC 60076-5	Ability to withstand short-circuit,
IEC 60076-12	Loading guide for dry-type power transformers,
IS 2026 - 5	Ability to withstand short circuit

2.2 ABBREVIATIONS

- IEC – International Electro technical Council
- IS - Indian Standard
- BS – British Standard
- ASS – Auxiliary Sub Station
- RSS – Receiving Sub Station
- GI – Galvanized Iron

3. TECHNICAL REQUIREMENTS:

The details and specifications applicable to three phase 33 kV / 415 V auxiliary transformer are given below -

- The primary and the secondary windings shall be capable of withstanding a symmetrical three-phase short-circuit regardless of the tapping selected. The short circuit level at secondary side for various ratings of transformers shall be as specified in the data sheet.
- The terminals shall be of the 36 kV type. Conductors insulated at 36 kV realize delta connection on primary side by using rigid conductors with suitable insulation sleeves. The secondary neutral shall be solidly earthed.
- This equipment shall satisfy all the requirements for interchangeability, interlock ability and functional control applicable to this type of equipment. It shall use a technology and components identical to those of the equipment to be installed in the Auxiliary sub stations.
- The Transformer shall be "Enclosed Dry Type Transformer" as per clause 3.3 of IEC 60076-11:2004, or as per latest updated version.

Characteristics:

Climatic conditions	indoor operation
Ambient temperature for design	50°C
Operation	Continuous
Windings	Aluminium for more than 200 kVA rating and Copper for 200 kVA & less rating
Primary line voltage (across phases)	33 kV
Secondary voltage, off-load	415 V
Primary Insulation rated voltage	36 kV

Frequency	50 Hz
Rated short duration separate source AC withstand voltage (r.m.s.)	70 kV (for HV winding), 3 kV (for LV winding)
Rated lightning impulse withstand voltage (peak value) (for HV winding)	170kV
Connections	Dyn11
Cooling	Air natural
Off load tap link	0, +2.5%, +5%
Overload Conditions	At least 10% for 2 Hours
Class of insulation for all windings	F Class for HV and LV winding
Climatic/Environmental/Fire Class	C1/E2/F1 (IEC 60076-11)

The magnetic circuit shall be in low-loss oriented-grain silicon steel sheet.

3.1 ACCESSORIES

- Installed on rollers/ base channels
- Lifting rings / Lifting Eyes
- 2 Nameplates - (1) on transformer, (2) on transformer enclosure
- Grounding terminal of Transformer frame, enclosure and Core
- Limit switches for enclosure doors as required
- Danger plates as per safety rules
- off circuit tap links with protection covers
- Fans with wiring upto scanner box, if applicable
- All the wires, control cables used shall be of FRLSH type, except in underground stations where it shall be FRLSZH type

The connection with different terminals of transformer shall be through C type or suitable connector for sufficient clearances from transformer windings HV connections of transformer shall be connected through insulated cables. HV terminals shall have suitable arrangement to provide sufficient clearance to 33 kV class cables from transformer windings and transformer enclosure as per IEC 60076-3.

3.1.1 All hardware like nuts, bolts, studs used should be of stainless steel. 3.1.2

The core shall be connected to earth.

3.2 TEMPERATURE PROTECTION

3.2.1 Transformers shall be fitted with a temperature protection system that allows winding temperatures to be monitored.

This shall consist of two sets of sensors placed inside each low-voltage winding to provide signals of Alarm and Trip and for fan operation. These signals to be used for Alarm and Trip of upstream circuit breakers, for fan operation, and also for indication in SCADA.

Temperature Sensor Relay should be installed in front side of the enclosure instead of front door of enclosure. An indicator and relay with 6 inputs channel with RS 485 communication port as above shall be installed on the front side panel of the transformer enclosure, to

indicate continuously the winding temperature.

Temperature sensor to be so designed to prevent any mal-operation due to dust.

- 3.2.2** The Temperature monitoring unit (TMU) shall be fixed in a separate housing fixed on the enclosure, which should prevent heat of transformer to directly affect the electronic components / circuit of TMU.

3.3 TRANSFORMER VALUES

The PST contractor shall confirm the following characteristics for each power distribution transformer:

- Short Circuit impedance (at 95°C and at principal tap with +/- 10 % tolerance as per IEC / IS.)
- No-load losses (Maximum),
- Full-load losses at 95°C (Maximum)
- Efficiency at 95°C at different load conditions:
Full load: Power factor = 1 (Minimum efficiency: 98.4%) Power factor = 0.8 (Minimum efficiency: 98%) The efficiency of transformer at $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$, full load at unity and 0.8PF for these loads shall be more than 98%. Bidder in the offer shall meet the conditions of efficiency as above.

3.4 TRANSFORMER CUBICLE

- 3.4.1** Transformers shall be installed in dismountable cubicle, made up of sheet steel of minimum 2 mm thickness, Powder coated with provision of wire-mesh.

The transformer enclosure shall be provided with cut out openings. The transformers shall be supplied in a cubicle with enclosure and without any HV portions exposed.

These Ventilation openings shall be provided all around on the transformer enclosure with sufficient open area to dissipate the heat released by transformer.

The door shall be provided with a mechanical interlocking system, to ensure that it is possible to open the door only when the protection circuit breakers on the HV side as well as LV side of the transformer are in 'open' position and Earth switch on upstream 33 kV cable is closed. Also circuit breakers on the HV side as well as LV side of the transformer should trip if somebody tries to open the door without opening the HV & LV side breakers.

Minimum Clearance of any earthed part or enclosure from any live terminal of transformer should be as per IEC 60076-3. Apart from this 500 mm clearance shall be maintained between any part of the transformer and its enclosure for ease of movement during O&M.

The transformer should be tested with enclosure in temperature rise type test. Temperature rise test shall be done with enclosure designed and intended to be used for the particular type of transformer. The enclosure supplied shall be similar as used in the temperature rise test.

Enclosure shall have inspection windows of minimum size of 400 mm x 400 mm on both sides to view primary & secondary sides of the transformer. LED Lights (10 Watts) inside

transformer enclosure on both HV and LV sides shall be provided for visual inspection from outside. Switch should be provided on outer side of the enclosure to operate the lights.

The cubicle shall have space for installation of snubber circuit and / or Surge Arrester on HV side of transformer.

The cubicle shall provide protection against direct contact with the power transformer. It shall include connections for the HV lines from the protection bay and connections for the low voltage circuit.

The transformer enclosure shall be designed and provided by the transformer manufacturer along with the transformer.

- 3.4.2 Cable arrangements shall facilitate the exchange of either of the transformers without any difficulty, i.e. the cables shall be laid along each side and connected to the transformer in such a way that it will not block the passage for removal of any of the transformer during service. The PST contractor will provide suitable size stiffeners in enclosure for connection of bus duct and to ensure that the enclosure does not deform due to Bus duct connection. The panel shall not make any rattling sound and should be provided with a rubber gasket as required.

3.4.3 Automatic fire detector and extinguisher system:-

'Automatic fire detector and extinguisher system' shall be provided in line with integrated fire suppression system of substation, and the provisions required, if any, shall be done by Transformer manufacturer.

The cubicles shall be protected against fire by means of an 'automatic fire detector and extinguisher system', 'based on Aerosol' approved by Chief Controller of Explosives, valves, flexible detection and delivery system in the form of a flexible tube made of special polymer, capable of withstanding normal pressure and maximum pressure as per design of the system and applicable standards, suitably routed inside the transformer enclosure for detection of fire. The system shall be suitably mounted on the Transformer enclosure or on the floor near the transformer enclosure and shall be capable of flooding the cubicle within the shortest response time, not more than 10 seconds after the fire is sensed by the flexible detector tube. The PST contractor shall submit the complete technical data of the system and shall obtain the approval of Employer's engineer before ordering for manufacture of transformer enclosure.

- 3.4.4 The bimetallic strip required for connection in any case shall be provided by the PST contractor.
- 3.4.5 The Transformer enclosure shall be provided with earthing connections by routing and connecting earth strips (suitably sized as per LT side fault level, but minimum GI Strip of 50 X 5 mm), and connected to all the panel sheets of the enclosure.

Above Earthing strips should be provided on suitable support arrangement fixed horizontally & vertically running along the inside of enclosure.

- 3.4.6 Entry inside the transformer enclosure should be blocked and all the trenches/cable entry openings etc. on the transformer enclosures should be sealed to avoid any entry of rodents / lizards / insects etc.

3.5 TERMINAL ARRANGEMENTS

The terminal arrangements for high voltage side shall be suitable for required size of cables. The terminal arrangement for Low voltage side shall be suitable for required size of cables/Bus ducts. Suitable arrangements shall be available for cable terminations so that the cable/Bus duct weight doesn't come on the terminals.

The terminals on the primary side should be provided with proper protection against creepage suitable for 36 KV.

3.5.1 The clearances of transformer HV side terminals shall be **more than 500mm** as per IEC 60076-3. The manufacturer shall submit the transformer drawings showing all the clearances and dimensions.

3.5.2 The provisions shall be made for the earthing connection of cable sheath for both HT and LT sides.

3.5.3 LV side terminal clearance: -

For the LV (415 V) terminals or bars, the clearances and creepage distances in Air, shall not be less than as specified below: -

Minimum Clearance & creepage distances between Phase to Phase in Air*	Minimum Clearance & creepage distances between Phase to Neutral / core / core frame / earth in Air*
25 mm	20 mm

* However, for safety purpose, Fire retardant Insulation tape of 1.1 kV strength should be provided on the phase terminal bars of the transformer on LV (415 V) side, wherever gap in air between phases to neutral is less than 50mm.

The Neutral terminal bar shall be preferably towards core / core frame, and the Phase terminal bars shall preferably be away from core / core frame.

3.5.4 There should be "No exposed" conductors or exposed live parts. All HV and LV terminals shall be protected/covered suitably with shrouds/tapes of corresponding voltage rating. Painted bus bars are preferred, which should be suitable for transformer design and service conditions.

3.5.5 **33 kV Cable connections:-** The 33 kV cable used for connection from 33kV CB to HV(33 kV) terminals of Transformer inside ASS shall be of at least 300 sq.mm or higher size, similar to 33 kV cable used in main line between ASS to ASS.

3.6 PAINTING

All steel surfaces shall be powder coated with average 120 micron thickness, which shall be suitable for heavily polluted atmosphere and shall be of color RAL 7032.

3.7 INSULATION OF WINDINGS

- > HV windings should be cast resin moulded type, and
 - > LV winding shall be of pre impregnated with top and bottom properly sealed by resin to protect from dust and moisture ingress/ or it may be cast resin moulded type.
- Insulation barrier sheet between LV and HV windings with appropriate clearance shall be provided for full height of windings. The insulation barrier must be fire proof, and fire retardent.

3.7.1 Identification of winding coils:- Each of the 33kV windings coils shall have identification name plate (sticker or engraved) with details of coil number, Transformer Sl. no., voltage, capacity, date of casting, manufacturer, etc. for traceability.

3.8 NAME PLATE DETAILS**3.8.1 Rating Plate fitted to the transformer**

Each transformer shall be provided with a rating plate of weatherproof material, fitted in a visible position, showing the items indicated below. The entries on the plate shall be indelibly marked (i.e. by engraving, stamping or by a photo chemical process).

- a) Dry type transformer
- b) Standard, Number & year of latest IEC 60076
- c) Manufacturer's name
- d) Manufacturer's serial number
- e) Year of manufacture
- f) Insulation system temperature for each winding. The first letter shall refer to high voltage winding, the second letter shall refer to low voltage winding.
When more than two windings are present, the letters shall be placed in the order of windings from the high voltage to low voltage
- g) No. of phases
- h) Rated power for each kind of cooling
- i) Rated frequency
- j) Rated voltages, including tapping voltages, if any
- k) Rated currents for each kind of cooling
- l) Connection symbol
- m) Short circuit impedance at rated current, rated voltage and at the appropriate referenced temperature (it shall be the measured value during FAT)
- n) Type of cooling
- o) Total mass
- p) Insulation levels
- q) Degree of protection
- r) Environmental class
- s) Climatic class

t) Fire behaviour class

The rated withstand voltages for all windings shall appear on the rating plate. The principles of the standard notation are illustrated in clause 5 of IEC 600763.

3.8.2 Rating Plate fitted to the transformer enclosure

Each transformer enclosure shall be provided with a rating plate of weatherproof material, fitted in a visible position, showing the items shown in 3.8.1 The entries on the plate shall be indelibly marked (i.e. etching, engraving, stamping or by a photochemical process).

3.9 CAPITALIZATION AND PENALTY

The transformers shall be designed for minimum losses. When comparing between different tenders the present value of the capitalized cost of losses in the transformers shall be added to their financial bid by the following formula $PW = K \cdot 365 \cdot 24 \cdot C (W_{ir} + b^2 W_{cu}) / 1000$

Where

- PW is the present worth (in INR) of annual capitalized cost of losses at 8% rate of interest over 25 years
- K is the present worth factor (8% interest, 25 years) = $\{(1+0.08)^{25} - 1\} / \{0.08 \cdot (1+0.08)^{25}\} = 10.675$
- **C is the cost of the kWh (in Indian Rupees) = Rs. 6.60 (or actual present tariff rate)**
- W_{ir} is the iron losses in Watts at normal voltage and main tapping
- W_{cu} is the full load losses in Watts at normal voltage and main tapping at 95°C
- b is the load factor of transformer = 50 %

Thus $PW = 10.675 \cdot 365 \cdot 24 \cdot 6.15 (W_{ir} + b^2 W_{cu}) / 1000$

$$PW = 617.18 (W_{ir} + 0.25 W_{cu})$$

In case the transformer losses during tests are found greater than the values guaranteed in the offer, a consolidated penalty shall be paid by the PST contractor, according to the following formula (any tolerance from the declared value on upper side will not be considered):

$$PW = 617.18 (W_{ir} + 0.25 W_{cu})$$

Where, dW_{ir} and dW_{cu} are the differences between the test values of iron losses at full voltage and and full load losses at full load on one transformer at main tapping and the values guaranteed in the offer.

3.10 TRANSIENT OVERVOLTAGE PROTECTIONS: -

PST contractor to carry out System study using EMTP, simulation and measurements, for ascertaining the over voltages due to transients at the terminals of Transformer. Suitable measures and protection for Transient over voltages should be worked out **for different length and size of cable** and provided for the Transformer protection, with the approval of Employer's engineer.

3.10.1 Surge Arresters/Snubber circuit:- Surge Arresters/ RC Snubber circuit shall be provided between Phase - Phase, and Phase - Earth, on all three phases, of suitable rated values on 33 kV side of Transformers. The surge counters for each Surge arrester should be provided. PST contractor to design and verify the rating of surge arrester for suitability ***based on the study in Para 3.10 above*** and obtain approval of Employer's engineer.

3.10.2 Snubber circuit and / or surge arrestors of suitable ratings at the HV terminal of Transformer to be provided. Design for the same to be submitted to engineer for approval.

3.10.3 Transformer Insulation:- The insulation of Transformer should be so designed and provided to be able to sustain the Transient over voltages in the 33 kV system.

The PST contractor should study the Transient over voltages expected in the system, and the insulation of Transformer should be designed accordingly.

3.10.4 The Transformer may be proposed to be provided with any other alternate protection measures against transient over-voltages subject to a proven solution and its approval by Employer's engineer.

3.10.5 Any damage due to fast switching events shall be covered under the manufacturer's standard warranties.

3.11 TRANSPORTATION AND PACKAGING: -

3.11.1 The transformer to be supplied in weather proof sea worthy proper packing to prevent any dust, moisture or any physical damage.

4. MAINTENANCE & LIFE

The transformer should be designed for best service life in the industry (Approx. 40 years) for all types of installation & under prescribed environmental conditions.

4.1. The Transformer to be kept clean.

The installation of transformer should be carried out in clean environment i.e. free from dust, debris etc. It should be ensured that the transformer should be kept clean in all conditions during the storage, installation, after charging, before hand over and during DLP. During Project phase till handover, regular cleaning of the transformer is the responsibility of PST contractor.

5. DATA SHEET - AUXILIARY TRANSFORMERS**5.1 AUXILIARY TRANSFORMER 200 KVA, 500 KVA AND 630 KVA**

Sr.no	INDICATIONS	U	VALUES Required		
			200 KVA	500 KVA	630 kVA
1	Manufacturer				
2	Place of manufacture				
3	Port of embarkation				
4	Manufacturer drawing reference				
5	Standards		IEC 60076	IEC 60076	IEC 60076
6	Rated power	kVA	200	50	630
6	Cooling mode		AN	A	AN
7	Primary rated insulation voltage	kV	36	36	36
8	Primary operating voltage	kV	33	33	33
9	Secondary rated operating voltage	V	415/240	415/240	415/240
10	Rated short duration power frequency withstand voltage for primary winding	kV	70	70	70
11	Rated lightning impulse withstand voltage for primary	kV	200	200	200
12	Short-circuit impedance (Cl. 3.3)	%	4	4	4
13	Short circuit current on secondary side	kA	6.9	17.4	21.9
14	tage setting (Offload tap links)	%	+5.0, +2.5, 0, -2.5, -5.0	+5.0, +2.5, 0, -2.5, -5.0	+5.0, +2.5, 0, -2.5, -5.0
15	Vector Group		Dyn11	Dyn11	Dyn11
16	Maximum noise level	dBA	65 dB at 1.5 metres	65 dB at 1.5	65 dB at 1.5 metres
17	Class of Insulation		F	F	F
18	Maximum iron losses	W	1050	1700	1950
19	Maximum load losses	W	2500	4800	5100
20	Dimensions (maximum)* Length Width Height	mm	-2000 -1500 -2250	-2000 -2000 -2250	-2000 -2000 -2250
30	Weight (maximum)* *Dimensions and weight shown are indicative only		1700	2600	3000

5.2 AUXILIARY TRANSFORMER 2500/3000 kVA

S.no.	INDICATIONS	U	
			2500/3000 kVA
1	Manufacturer		
2	Place of manufacture		
3	Port of embarkation		
4	Manufacturer drawing reference		
5	Standards		IEC 60076
6	Rated power	AN	2500
		AF	3000
7	Cooling mode		AN
			AF
8	Primary rated insulation voltage	kV	36
9	Primary operating voltage	kV	33
10	Secondary rated operating voltage	V	415/240
11	Rated short duration power frequency withstand voltage for primary winding	kV	70
12	Rated lightning impulse withstand voltage for primary winding	kV	200
13	Short-circuit impedance(Cl. 3.3)	%	6
14	Short circuit current on secondary side	kA	58
15	Voltage setting (Off load Tap Links)	%	+5.0, +2.5, 0, -2.5, -5.0
16	Vector Group		Dyn11
17	Maximum noise level	dBA	65 dB at 1.5 metres 75 dB at 1.5 m for AF
18	Class of Insulation		F
19	Maximum iron losses	kW	As per Manufacturer (Efficiency required is defined in Specifications)
20	Maximum load losses	kW	As per Manufacturer (Efficiency required is defined in Specifications)
	Dimensions (maximum)*		
	Length	mm	2100
	Width		2900
	Height		2
22	Weight (maximum)*	kg	7000
Dimensions and weight shown are indicative only			

6. TEST SHEET

6.1 AUXILIARY TRANSFORMERS

All Tests shall be performed on a completely assembled transformer including relevant accessories supplied.

All routine tests as per IEC 60076-11 are to be conducted including Partial Discharge during Manufacturer's Internal test & Factory Acceptance Test on all completely assembled transformer.

All type tests as per IEC 60076-11 shall be conducted on one transformer for each rating and make before supply to BSTP.

All the type tests shall be conducted on each rating of the transformer separately.

Central Electricity Authority (technical standard for construction of Electrical Plants and Electric Lines) regulations 2010, has made the short circuit testing mandatory. Short circuit withstand test shall be conducted on one of each type, rating and make of transformer to validate the design and quality unless such test has been conducted. The test shall be conducted before making any supply to BSTP.

The relevant regulations No. are 10(3)(g), 37(4)(k), 43(2)(a)(vi), which are available on CEA's website www.cea.nic.in.

In view of above the supplier shall subject the transformer to a short circuit test as per relevant IEC/IS standard meeting the requirement of above mentioned regulations of CEA.

6.2 PARTIAL DISCHARGE TEST

Partial Discharge Test shall be conducted on all the transformers in fully assembled condition during the routine tests. The maximum level of Partial Discharges shall be 10 pC as per IEC 60076-11 (2004) or updated as per latest IEC.

6.3 ENVIRONMENT, CLIMATE & FIRE BEHAVIOUR CLASS

To establish above classes, Transformer should to be tested As per IEC 60076-11, and reports should be submitted along with the vendor approval. The dry type transformer shall be rated for following classes –Environment Class E2, Climatic Class C1/C2 and Fire behaviour Class F1 -

Transformer only from the proposed manufacturing unit to be type tested, and confirmation certificate by Design head and unit head, for similar material and design used in other transformers to be submitted. *This certificate shall be treated as corporate warranty for any damages on this account.*

Class E2: Frequent condensation or heavy pollution or combination of both.

Class C1: The transformer is suitable for operation at ambient temperature not below – 5°C but may be exposed during transport and storage to ambient temperatures down to – 25°C.

Class F1: Transformers subject to a fire hazard. Restricted flammability is required. The emission of toxic substances and opaque smokes shall be minimised.

6.4 MEASUREMENT OF SOUND LEVEL (SPECIAL TEST)

Measurement of Sound Level test (special tests as per IEC 60076-11) shall be conducted during Manufacturer's Internal test & Factory Acceptance Test on all transformer using sound pressure level technique. The testing shall be conducted on a completely assembled transformer including relevant accessories supplied.

6.5 TEMPERATURE RISE TEST:-

The transformer should be tested with enclosure in temperature rise type test. Temperature rise test shall be done with enclosure designed and intended to be used for the particular type of transformer. The enclosure supplied shall be similar as used in the temperature rise test.

The temperature rise limits shall be as per IEC 60076-11, for example, for class F insulation, Temperature Rise shall be limited to 90 Deg C above ambient temperature of 50 Deg C.

The Temperature rise test of Transformer shall be conducted considering the transformer as "Enclosed Dry Type Transformer" as per clause 3.3 of IEC 60076-11:2004.

6.6 CHOPPED WAVE LIGHTNING IMPULSE TEST FOR LINE TERMINALS (LIC) (SPECIAL TEST): -

Chopped wave Lightning Impulse test for Line terminals (LIC) (Special test) shall be conducted as per IEC 60076-3 on all the windings, for one transformer of each type of kVA rating, being supplied in the contract.

The test voltage for LIC test shall be 220 kV for 33 kV ($U_m=36$ kV) windings.

The test report of previously conducted LIC test on exactly similar transformer shall be valid if not older than 5 years.

Test should be conducted with transformer enclosure assembly installed