

CHAPTER 8 A
Auxiliary Network (Underground)

TABLE OF CONTENTS

1. AUXILIARY NETWORK..... 5

1.1 GENERAL5

1.2 BROAD NETWORK DETAILS FOR DIFFERENT CORRIDORS5

1.3 GENERAL DESCRIPTION OF SCOPE OF WORK6

1.4 MANNING OF COMMISSIONED ASS'S7

2. Modification work at existing 33 kv network 8

2.1 Modification work at existing station Chand Pole ASS'S..... 8

3. AUXILIARY SUBSTATIONS IN UNDERGROUND SECTIONS..... 9

3.1 GENERAL9

3.2 LOCATIONS OF ASS.....9

3.3 GENERAL TECHNICAL REQUIREMENTS9

4. 33 KV / 415 V AUXILIARY TRANSFORMERS11

4.1 GENERAL11

4.2 CHARACTERISTICS11

4.3 ACCESSORIES12

4.4 TEMPERATURE PROTECTION13

4.5 TRANSFORMER VALUES13

5. 33 KV SWITCHGEAR 15

5.1 GENERAL15

5.2 SWITCH GEAR CUBICLES15

5.3 GENERAL REQUIREMENT16

5.4 MEDIUM VOLTAGE SWITCHGEAR INTERLOCKING24

6. 33 KV (MEDIUM VOLTAGE) CABLES (IN UNDERGROUND SECTIONS).....26

6.1 GENERAL26

6.2	GOVERNING SPECIFICATIONS.....	27
6.3	CONNECTING JUNCTIONS - MV ENDS	30
6.4	EXECUTION RULES.....	30
6.5	ATMOSPHERIC AND CLIMATIC CONDITIONS	30
6.6	CABLE TECHNICAL AND TEST SHEET	31
6.7	CABLE LAYING SPECIFICATION	31
7.	LOW VOLTAGE SWITCH BOARD (LVSB).....	37
8.	110 V DC POWER SUPPLY SYSTEM.....	38
8.1	GENERAL	38
8.2	SYSTEM DESCRIPTION.....	38
8.3	OTHER TECHNICAL REQUIREMENTS	39
8.4	EQUIPMENT SPECIFICATION.....	40
9.	110 V DC DISTRIBUTION BOARD	43
9.1	DESCRIPTION.....	43
9.2	EQUIPMENTS.....	43
9.3	OUTGOING FEEDERS	44
10.	EMERGENCY TRIPPING SYSTEM - FOR UNDERGROUND SECTION.....	44
11.	PROTECTIONS	45
11.1	GENERAL DEFINITION.....	45
11.2	PERFORMANCES REQUIRED	46
11.3	DESCRIPTION OF PROTECTION	47
11.4	33 kV CABLE PROTECTION.....	52
11.5	ASS EQUIPMENT PROTECTION.....	52
12.	LOW VOLTAGE CABLES AND WIRING	53
12.1	GENERAL	53
12.2	CABLE CROSS SECTION DETERMINATION	54

12.3 STANDARDS54

12.4 IDENTIFICATION55

12.5 CONNECTIONS55

12.6 CABLE LAYING.....56

13. INTERFACE WITH SCADA EQUIPMENTS58

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 Dry type transformers of suitable capacity installed in the ASS's. The Auxiliary power Network essentially consists of the following:

- A 33 kV cable Network, comprising of duplicate 33 kV insulated cables of suitable capacity, laid in the Viaduct, tunnel or at-grade, 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 ASS's at various passenger stations.

1.2 Broad Network Details for different Corridors

The Bid document covers the Underground Section of the Chand pole – Badi chaupar Corridor, The following are the Underground in the Line1 extension Chand pole to Badi chaupar) (The 33 kV Network of the entire Line -1 derives 33 kV power from 02 Auxiliary Main Substations (AMS) located at Sindhi camp, Mansarovar **(The Supply and Installation of Auxiliary Main Substations located in the premises of High Voltage Receiving Substations (RSS), is not within the scope of this Tender).**

Each AMS, under normal conditions, feeds 33 kV power to a specified number of ASS's located on either side of the AMS. The following **"Loop definition Table"** shows the details of ASS's fed from each AMS, via the particular Loop.

Power supply details of existing sections:-

Receiving Sub station	Location	Incoming Voltage	Power Source
RSS-1	Manasarovar	132 kV	Mansarovar GSS (220 / 132 kV)
RSS-2	Sindhi Camp	132 kV	GIS Substation, PWD Bungalow at Station Road (near RSRTC Bus Stand)

Loop Definition Table

AMS	Loop No.	Names of ASS fed by the Loop	
		Underground	Elevated
Mansarovar	1		Mansarovar Atish Market Vivek Vihar Shyam Nagar Ram nagar Civil line
Sindhi camp	2	Chand Pole Choti Chaupar Badi chaupar	Railway Station Sindhi Camp

1.3 General Description of Scope of Work

A general description of the broad Scope of Work, relating to 33 kV Auxiliary Network, covered in this Tender, is given below. **It shall, however, be clearly understood that the description is for the purpose of general guidance only and is not exclusive.** For complete appreciation of the Scope, the Specifications, Bills of Quantities along with their Explanatory Notes, Drawings and other relevant paragraphs of the Tender Documents shall be referred to.

1.3.1 In the Auxiliary Main Substations (AMS)

The Auxiliary Main Substation (AMS) is located in the RSS premises The JP/EW/1B/E2 Contractor will be required to supply and install the 33 kV cables from the outgoing 33 kV Switchgear at the Chand pole ASS upto the designated Choti chaupar and Badi cahupar ASS on the line.

1.3.2 In the Tunnel

The following works shall form part of this Tender:

- Supply, laying, jointing, termination, protection, testing and commissioning of all 33kV cables and line differential protection in Tunnels between ASS's and links to other Corridors, if any.

- The supply, laying, jointing and termination at either end, protection, testing and commissioning of 33 KV cables (LSOH) between, chandpole to choti choupar, choti choupar to badi choupar.

1.3.3 In the Auxiliary Substations (ASS)

The following works shall form part of this Tender:

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

- 33 kV / 415 V transformers
- 33 kV GIS Switchgear
- 33 kV Cables
- All measuring and protective devices
- Emergency Tripping System (For underground Section only) and interface with signaling contractor and with relevant contractor
- Batteries and battery chargers
- Cable paths and earthing
- Safety equipment and

Supply and erection of any other items required for successful and satisfactory working of the ASS, at all ASS's shall be within the scope of this Tender.

1.4 MANNING OF COMMISSIONED ASS'S

The Employer may call upon the Contractor to provide skilled supervisors / skilled workers / unskilled workers in the ASS's already commissioned and handed over to the Employer, for manning the installations, before commencement of the Revenue operation of the line.

The Contractor shall provide the necessary staff team for the purpose. The staff team deployed at the ASS's 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 the Employer, 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 the Employer. The Contractor shall be paid under the relevant BOQ item, for the services. It shall also be ensured by the Contractor that deployment of such staff team will not, in any way, affect the completion of other works within the specified Key Dates.

The Contractor shall follow/comply all labour laws irrespective of rates quoted.

2. MODIFICATION WORK AT EXISTING 33 KV NETWORK

2.1 Modification work at existing station Chand pole ASS's

The contractor should survey, access and conclude on the requirements of the modifications required at the existing ASS's of underground Chandpole station. 33 KV breakers for extension of power supply are provided at ASS-1 & ASS-2 of existing Chandpole station. The extension of existing 33 KV loop from Chandpole to all other stations shall be in the scope of the contract. The work includes, but not limited to the following:-

- (i) Control & Protection with Metering i/c all associated components such as pilot wire relays, over current relays, differential relays, directional relays as required as per protection scheme. The protection scheme as adopted for the contract shall be implemented & validated. Modification as required for SCADA i/c integration as required along with associated material if any.
- (ii) Providing 33 KV link feeders comprising of required numbers of single core 400 sqmm copper FRLSOH from Chandpole to the next station i.e Chhoti Chaupar i/c cable trays, supports brackets, hanging arrangement etc as required.
- (iii) Supply and installation of all types of C&M cables as required..
- (iv) All the materials required to carry out the work has to be included in this modification work.
- (v) Necessary civil work i/c shifting/rearrangement of the existing equipments at Chandpole shall be deemed as included in the contract.

For carrying out such modification works, the Contractor shall submit a specific programme i/c the sequence of work, time required, requirement of power block, man power plan etc, as required at least 15 days in advance.,

Upon approval of the employer the contractor shall carry out the work as per agreed program. The work shall be generally carried out during the non-operating hours of the Metro System. It shall be the contractor's responsibility to restore the existing installation to the original operable condition, so as to ensure resumption of metro services on the corridor. If, due to any reasons, the Contractor fails to restore the existing installations as above, a penalty of Rs 50,000/- per hour or part thereof, will be levied from the Contractor, without prejudice to any other claims of the Employer against the Contractor which may arise due to the Contractors inability to restore the installation to original operable condition.

It is recommended that the Bidder should inspect the site for understanding the scope of work before quoting the price and the price offered shall take into account all such contingencies. No claims other than the quoted price shall be acceptable in this regard.

3. AUXILIARY SUBSTATIONS IN UNDERGROUND SECTIONS

3.1 General

Auxiliary Substations (ASS), located in passenger stations is meant for transformation of power from 33 kV to 415 V through the 33 kV / 415 V distribution transformers and the 415 V protections.

In every Underground station, there are generally 02 Auxiliary Substations (ASS-1 and ASS-2) located near the ends of platform. In certain Underground Stations, there are 03 ASS's.

3.2 Locations of ASS

The following are the locations of ASS's in the Underground Stations, of the corridor.

Sr. No.	Name of Station	ASS Ref.	Tentative No. of transformer to be catered for at each ASS*	Location Level	Remarks
1	Chhoti chaupar	ASS-1	1X 3150kVA	Platform	
		ASS-2	1X 3150kVA	Platform	
2	Badi chaupar	ASS-1	1X 3150kVA	Platform	
		ASS-2	1X 3150kVA	Platform	

* The number and capacity of the transformers are tentative and is subject to confirmation.

3.3 General Technical Requirements

3.3.1 Location of ASS's

Each Underground Station will have normally 2 Nos. of ASS. In certain stations there may be more than 2 ASS's. The ASS's are normally located on the platform level at the ends. In certain cases they may be located on the concourse or ground level. For details of locations of ASS, refer para 2.2 above.

3.3.2 Electrical Switch Room (ESR)

3.3.2.1 Generally the ASS Room is combined with the Electrical Switch Room (ESR), which accommodates the LT equipments and panels. All equipments on the LT Panels, including 415 V Circuit Breakers (Incoming and Coupler) will be supplied and installed by the Station E&M Contractor. Connection between the 33 kV/415V Transformer Secondary and the LT Board, by means of cables or bus duct will also be done by the E&M Contractor. The Contractor shall maintain necessary interface with the E&M Contractor to ensure proper installation of LT Bus duct/cable. The Contractor shall

provide and ensure suitable interlocking arrangements between the above 415 V LT Incoming Breaker and the HT breaker and also the Auxiliary Transformer enclosure door.

The Contractor will provide the necessary protection relays for Transformer Protection eg. Differential relay and Restricted Earth fault relay. The Contractor shall also interface with E&M Contractor for matching the CT characteristics to ensure tripping of HT and LT breakers in case of Transformer fault within the zone of protection. In addition, Instantaneous and IDMT Overcurrent and Earthfault protection (50, 50N, 51, 51N) and Temperature protection 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.

3.3.3 Room size

The Room for accommodating the ASS (and ESR) equipments will be built by other Agencies. Room sizes and shapes may be different in different stations. Layout of ASS is enclosed in the tender drawing. However, contractor shall review and examine the ASS equipment layout of each ASS and based upon the dimension of equipment selected, develop the working drawing of each ASS in coordination with Civil and E&M Contractor.

3.3.4 Cable cutout

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 the JP/EW/1B/E2 Contractor will have to maintain an interface with the SBC. If due to the JP/EW/1B/E2 Contractor changing the Equipment layout or for any other reason, the location of cut-outs are required to be changed, the JP/EW/1B/E2 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.

3.3.5 Equipment handling

In the case of Underground ASS's located at Platform level, the movement of heavy equipments, like Transformers and HT Panels will be via the track and knock-down walls will be provided in the ASS Room for entry of heavy equipments. In the case of those ASS's located in the Concourse level, a suitable Cut-out (Hatch) of approximately 3.5mx3.5m will be provided to facilitate the heavy equipments being taken to the Concourse level. The Contractor will interface with Station building Contractor for proper size and position of cutout along with hooks for lifting the equipments.

3.3.6 Cable paths

Cable paths required for management of HT, LT and C&M cables, inside the ASS Rooms, shall be provided by the Contractor.

3.3.7 Equipment mounting

The Station Building Contractor will provide a finished floor. The Contractor may, if required, fix equipments on the floor with the help of anchor fasteners. In general, no additional concreting is considered necessary to be provided in the ASS Rooms. If any concrete pedestals/foundations are required to be provided to mount transformers/equipment, the same shall be provided by the Traction Contractor, after obtaining approval from Employer.

3.3.8 Earthing in the Underground ASS

The JP/EW/1B/E2 Contractor shall provide an earth bus inside the ASS, using 50X6 mm G I. flats. The design and layout of the earth bus shall be submitted by the JP/EW/1B/E2 Contractor for Employer's approval. The Main Earth Terminals (MET) will be provided by the System Vide Contractor (E&M), generally 4 to 6. The Contractor shall make connections of the Transformer Neutral; Metallic bodies of equipments etc to the earth bus/MET, as per approved drawing. The Contractor shall comply the standards and rules and regulations as applicable:-

- 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 Parctice of Earthing'

4. 33 KV / 415 V AUXILIARY TRANSFORMERS

4.1 General

This specification defines the main technical characteristics required for the 33000/415-240 V dry type transformers to be used in Auxiliary Substations (ASS).

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

Transformer shall satisfy the following requirements and shall also comply with standards in force when the transformers are manufactured, particularly IEC 60076, IEC 726 standards, BS 171 and IEC publication NO-1963 or latest and I E Rules and BEE Guidelines, applied in the manner altered, amended or supplemented by this specification, wherever applicable. In all cases, latest revision to these specifications referred to above shall apply.

The transformer shall be Cast resin type.

4.2 Characteristics

- | | |
|------------------------|------------------|
| - Climatic conditions: | indoor operation |
| - Operation: | continuous |
| - Windings: | Aluminium, |

- Primary line voltage (across phases): 33 kV
- Secondary voltage, off-load line voltage at 33 kV primary : 415 V
- Secondary voltage at full load and power factor 0.8: 396 V
- Insulation rated voltage: 36 kV
- Frequency: 50 Hz
- Withstand at industrial frequency: 70 kV
- Voltage surge withstand: 170 kV
- Coupling: delta-star, separate neutral
- Cooling: natural
- Off load tap changer: 0, $\pm 2.5\%$ and $\pm 5\%$
- Insulation Class F

The voltage shall be adjusted by a 5 positions switch which can be used "dead" and provides -5%, - 2.5%, 0, + 2.5%, and + 5% settings. Cover on the Tap changer and Delta link to be provided.

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

The primary and the secondary windings shall be capable of withstanding a symmetrical three-phases short-circuit regardless of the tapping selected. The short circuit level at secondary side for various ratings of transformers shall be as follows:

630 kVA	21.9kA
1000kVA	24.0 kA
1600 kVA	37.1 kA
2000 kVA	46.4 kA
2500 kVA	58.0 kA
3150 kVA	63 kA

The terminals shall be of the 36 kV type.

Conductors insulated at 36kV shall realize delta connection on primary side.

Secondary neutral of transformers shall be solidly earthed.

4.3 Accessories

- Installed on rollers
- Lifting rings
- Nameplate
- Grounding terminal.
- Base channel

4.4 Temperature protection

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

This shall consist of two sensors placed on each low-voltage winding, i.e. three alarm sensors and three trip out sensors.

An indicator shall be installed on the front door of the bay to indicate continuously the winding temperature. This shall be installed on the middle low voltage winding.

4.5 Transformer values

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

- Short-circuit voltage,
- No-load losses,
- Full-load copper losses

Efficiency at different load conditions:

- 1/4 - load: power factor = 1 (Minimum: 98.95%)
power factor = 0,8 (Minimum: 98.7)
- 1/2 - load: power factor = 1 (Minimum: 98.87%)
power factor = 0,8 (Minimum: 98.59%)
- 3/4 - load: power factor = 1 (Minimum: 98.67%)
power factor = 0,8 (Minimum: 98.34%)
- Full load: power factor = 1 (Minimum: 98.4%)
power factor = 0,8 (Minimum: 98%)

4.5.1 Transformer Cubicle

Transformers shall be installed in dismountable cubicle, wire-mesh type. Alternatively, the transformers may be supplied in a cubicle with enclosure and without any HV portions exposed minimum protection IP 2X. The door shall be provided with padlock arrangement & mechanical system interlock, 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. Transformer door shall be reverse interlocked, that is if any unauthorized person opens the Transformer door, Circuit breaker (HT & LT) on either side of Transformer shall trip automatically.

Temperature monitoring devices with two thresholds (alarm and tripping) must be provided and located on the upper part of the secondary windings.

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

4.5.2 Description

Two doors containing two windows to allow observation of the transformer accessories shall be provided in the front face & rear side.

These doors shall be closed and locked to prevent access to the transformer while either the MV or the LV side is live.

Consequently, ventilation louvers shall be installed at the bottom of the front doors and in the bay rear panel and roof. The metal sheet of roof of the Transformer enclosure shall be strengthened properly to carry the load of bus duct and to avoid any buckling due to weight of bus duct.

Cable arrangement shall facilitate the exchange of either of the two 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.

4.5.3 Terminal Arrangements

The terminal arrangement for high voltage side shall be suitable for required size of cables with FRLS/FRLSOH outer sheath. Suitable arrangements shall be available for cable terminations so that the cable weight doesn't come on the terminals. The terminal on HV & LV shall be suitable for receiving XLPE cable end termination with cable gland and anodized hard wire for the cable termination. The terminals on the primary side shall be of the 36 kV type. The connection with different terminal of transformer shall be through the L/ C type connector for sufficient clearances from transformer winding.

4.5.4 Painting

All steel surfaces shall be painted which shall be suitable for polluted atmosphere and has to comply with ICE-60072-2-5 standard. After baring of all metal surface an Intel two coat of rust proofing and anti corrosive paint shall be applied then they will be covered with three coats of glossy oil & weather resistance non fading paint.

4.5.5 Nuts & Bolts

The threads and hexagons of all nuts, bolts and stud shall conform to relevant IS or BS. No bolt or stud shall project through its nut(s) more than 6mm (or) four threads, except when otherwise approved for terminating stud/bolts. If bolts and nuts are so placed that they are inaccessible by means of ordinary spanners. All terminals should be provided with suitable cadmium plated and passivated high tensile steel hard wires facilitate cables termination.

5. 33 KV SWITCHGEAR

5.1 General

The switchgear shall be of the single busbar with 3-phase enclosure indoor metal-enclosed extendable type, which, when erected, shall form a complete switchboard.

The metal-enclosed switchgear shall be gas insulated and the circuit interrupting device shall be of vacuum type.

The switchgear offered shall have a basic insulation level (BIL) of not less than 170kV peak.

The switchgear shall be capable of operating in class B environment stipulated in clause 1.13 of General Specification.

The 33kV switchgear shall comply with the following IEC standards:

62271-103, 62271-200, 60376, 62271-1, 62271-100, 6, 66044-1 & 6, 61869 60028, 60044-2 and 62271-102, 60529.

5.2 Switch gear cubicles

5.2.1 General Description

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

5.2.2 Electrical characteristics

Rated voltage:	36 kV
Operation voltage:	33 kV
Frequency	50 Hz
Rated busbar current	1250A
Rated current of feeders:	630/1250 A
Rated current of transformer feeders:	630 A
Rated short time withstand current	25kA – 1 sec
Rated short circuit breaking current	25kA
Rated short circuit making current	62.5kA
Lightning impulse test (BIL) voltage:	170 kVp
Power frequency test voltage:	70 kVrms
Auxiliary Supply Voltage:	110V DC
Degree of Protection (HV Compartment):	IP65
Degree of Protection (LV Compartment):	IP3X

5.3 General Requirement

- i) GIS supplier should have minimum experience of 05 years for manufacturing of similar GIS substations. The type of GIS offered should have been in satisfactory operation for atleast three years. Contractor should submit performance certificate from the employer.
- ii) The 33kV equipment shall be built according to the SF6 gas insulation technology.
- iii) 33kV GIS as offered should be fully type tested as per latest IEC standards at the time of submitting the bid.
- iv) The equipment installed shall offer all necessary facilities for equipping and connecting the equipments sections to follow, without entailing any shut down of equipment already in service.
- v) In the event of arching in a compartment, the arches should not extend to the neighbouring compartment/Panel. Any failure to the enclosure of the compartment shall not lead to damages in the neighbouring compartments.
- vi) Suitable means of expansions should be provided in the metal enclosure and pipelines to absorb the actual thermal expansion and contraction of the SF6 equipment and to facilitate the alignment of the switchgear assembly.
- vii) The metal enclosure for the SF6 gas insulated equipment modules shall be made from aluminium alloy/ stainless steel.
- viii) GIS should be of modular design, and it should be possible to add feeder panels if required.
- ix) Inter-panel auxiliary and control wiring shall have terminals in each relevant cubicle so placed for the bus wiring to be readily run from unit to unit. Auxiliary and control wiring to be connected to other equipment shall be wired to terminals at the rear of individual cubicles, suitably located for the wiring to be extended via multi-core cabling run in floor ducts. All auxiliary and control wiring shall be separated from high-voltage conductors, even though the latter are insulated by earthed metal enclosures.
- x) All auxiliary and control cables and wirings shall have suitable marking, such as ferrule markers, which shall clearly identify their function and shall match the control schematic drawings and wiring diagrams. The markers shall fit firmly over the outer diameter of individual cable and each wire core. Marks shall be printed and legible. For easy identification, colour coding shall be used to differentiate various functions of the cable and wires. All auxiliary and control wirings shall also be complete with cable lugs for termination.
- xi) A relay and instrument compartment shall be located at the front of each switchgear unit and shall be provided with a hinged door for access to the internal wiring and terminals. Gaskets shall be used to provide close sealing. The height of the instrument panel above floor level shall not exceed 2,000mm unless

otherwise reviewed without objection by the Engineer who may require the Contractor to provide, at its own cost, suitable means for easy access to the instrument panel.

- xii) Anti-condensation heaters with humidity control function shall be installed for each switchgear panel.
- xiii) The switchboard shall be designed to cater for future extension.

5.3.1 Detail Description –Equipment & Accessories

5.3.1.1 Circuit Breakers

5.3.1.1.1 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.

5.3.1.1.2 The circuit breakers shall have rated operating sequence (duty cycle) of: O – 0.3s-CO – 3' – CO as per IEC 62271

The endurance class of Electrical, Mechanical & restrike performance operations of all breakers, earth switch isolator etc needs to mentioned in the GIS equipment proposal

5.3.1.2 Operating Mechanisms

5.3.1.2.1 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.

5.3.1.2.2 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.

5.3.1.2.3 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 IEC60056.

5.3.1.2.4 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.

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

5.3.1.2.6 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.

5.3.1.2.7 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 120% of rated voltage
- Spring charging motor 85 to 120% of rated voltage
- Closing release coil 85 to 120% of rated voltage
- Shunt trip release coil 70 to 120% of rated voltage

5.3.1.2.8 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.

5.3.1.2.9 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.

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

5.3.1.2.11 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.

5.3.1.3 Busbars and Connections

5.3.1.3.1 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.

5.3.1.3.2 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.

5.3.1.4 Insulation Gas

- 5.3.1.4.1 All live conductors shall be inside SF6 gas insulating medium & in a chamber with no gas handling requirement at site (prefilled at works). The joints of the busbar/panels should be of 36 kv rated voltage and type tested in assembled condition, Type test report should be provided at the time of vendor approval. The Contractor shall submit details on quantity, quality and density of SF6 gas to be used in the switchgear in accordance with IEC 60376.
- 5.3.1.4.2 The GIS shall be grouped into suitable gas compartments with each compartment fitted with a monitoring pressure gauge/sensors and a pressure relief device.
- 5.3.1.4.3 The gas shall still insulate the 33kV power frequency voltage when the SF6 gas pressure drops to 1 bar and the gas leakage rate shall be guaranteed to be less than 0.1% by mass per year.
- 5.3.1.4.4 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.
- 5.3.1.4.5 Internal insulation level between live parts and earth when the pressure of the gas goes to the atmospheric pressure should not be less than $1.2 \cdot 33 / 1.722$ kV.
- 5.3.1.4.6 SF6 Gas apparatus warning sign shall be provided on the GIS.
- 5.3.1.4.7 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.

5.3.1.5 Switchgear Interlocking

- 5.3.1.5.1 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.
- 5.3.1.5.2 An electrical or a mechanical key interlocking system shall be provided whereby it is not possible to apply an earth to a section of the busbar until all circuit breakers which can feed that section are locked open.
- 5.3.1.5.3 The earthing devices shall be provided with interlocks to ensure correct operation in conjunction with the associated circuit breaker.
- 5.3.1.5.4 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.

5.3.1.5.5 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. It shall not be possible to return to the service position and close the circuit breaker until the electrical tripping is again operative.

5.3.1.5.6 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.

5.3.1.5.7 When there is provision for isolation of sections of cable between two "either-or" interlocked circuit breakers, a key-operated over-ride shall be provided to permit both circuit breakers to be closed at the same time provided that the circuit between them is broken. It shall not be possible to restore the connection without tripping one of the two circuit breakers and releasing the key.

5.3.1.5.8 The mechanical closing button of circuit breaker shall be interlocked with the closing conditions of the circuit breaker such that operation of the mechanical closing button shall be prohibited if the closing conditions of the circuit breaker are not fulfilled.

5.3.1.6 Locking Facilities

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

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

5.3.1.7 Earthing and Earthing Devices

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

5.3.1.7.2 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.

5.3.1.7.3 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.

5.3.1.7.4 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 of not less than 2.5mm² cross-sectional area.

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

The individual GIS panel should be with an PT isolation arrangement to conduct all the after installation test on H.T cabling system as per requirement of standards.

5.3.1.8 Control Facilities

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

5.3.1.8.2 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.

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

5.3.1.8.4 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

5.3.1.8.5 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.

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

5.3.1.8.7 Exposed LV 220V AC terminals inside each Control cubicle shall be adequately shrouded to avoid accidental human contact.

5.3.1.9 Auxiliary Switches

5.3.1.9.1 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.

5.3.1.9.2 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.

5.3.1.9.3 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.

5.3.1.10 Cable entry

Cable connection shall be bottom entry. Cable termination shall be inner/outer cone plug in type. Suitable cover should be provided at the cable entry 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.

Back side cover shall be required to be provided if no maintenance is recommended from the rear portion of GIS.

5.3.1.11 Testing Facilities

5.3.1.11.1 All fixed and moving portions of the switchgear shall be provided with facilities to enable high voltage tests to be carried out.

5.3.1.11.2 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.

5.3.1.12 Current transformers

5.3.1.12.1 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.

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

5.3.1.12.3 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.

5.3.1.12.4 All current transformers shall be installed with the P1 terminals adjacent to the busbars.

5.3.1.12.5 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.

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

5.3.1.12.7 Secondary connection wirings shall be provided with copper conductors FRLSOH Cables as per required size

5.3.1.12.8 The class of all protection CTs shall be as per GTP.

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

5.3.1.12.10 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.

5.3.1.13 Voltage transformers

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

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

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

5.3.1.13.4 For protection and measurement applications, the VTs shall be of dual Class 3P/0.5. 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.

5.3.1.14 Paint-work

5.3.1.14.1 Painting should be suitable for polluted atmosphere and has to comply with IEC 60 721-2-5 standard

5.3.1.14.2 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.

5.3.1.15 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.

5.3.1.16 Fitting & Accessories

As a minimum following fittings and accessories shall be provided

a) Mechanically operated tripping and closing device

- b) Local / Remote /off control switch and indication lamps
- c) Operation counter
- d) Supporting frame if needed
- e) Name plate
- f) Foundation bolts
- g) Semaphore indicators
- h) Meters
- i) CTs & PTs as required
- j) Protection as required

5.4 Medium voltage switchgear interlocking

The medium voltage switchgear interlocking has several purposes:

- To avoid any paralleling between the both transformers of the AMS in remote control mode
- To avoid any paralleling between the 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's 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. 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.

5.4.1 Interlocking in remote control mode

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

5.4.1.1 1st Case, both RCCB closed

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

5.4.1.2 2nd Case, only one RCCB is closed

In this case, there is no risk of paralleling between the both transformers. Consequently it shall be possible to close all CB and ITC. But it shall be impossible to close back the second RCCB until the correct configuration of the both loop, that is to say the opening

of one CB or one ITC on each loop, to reach to previous condition when the both RCCB are closed.

5.4.2 Interlocking in local control mode

In local control mode it shall be possible to operate any CB and ITC 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 authorise the closing of all CB and ITC 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).

5.4.3 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 (ie 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.

5.4.4 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.

5.4.5 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.

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

5.4.6 Response to a Fault

5.4.6.1 *Fault on a 33 kV Incoming cable*

A fault may occur between phases on the MV cables or on the bus bars in the boards. In either case, it shall trip circuit breakers on either side of the fault via a Pilot wire protection.

5.4.6.2 *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 trip the Medium Voltage circuit breaker (MVCB).

5.4.6.3 *Grounding Fault on ASS MV 33 kV cables*

This fault shall trip the circuit breakers on either side of the fault.

6. 33 KV (MEDIUM VOLTAGE) CABLES (IN UNDERGROUND SECTIONS)

6.1 General

33 kV Cables are required to be used in the Auxiliary Network, for Supply of power at 33 kV to various Auxiliary Substations located at Stations and in the Depot. The Auxiliary Network consists of duplicate 33 kV feeders, each feeder consisting of 3 Single core cables, assembled in twisted or cloverleaf pattern.

The cable shall be 19/33 kV (E), grade, shall be as follow,

- Single core 400 sq.mm stranded copper conductor, XLPE insulated, Tape armouring, FRLSOH (for Undergournd section) sheathed.
- Single core 95 sq.mm stranded copper conductor, XLPE insulated, Tape armouring, FRLSOH (for Undergournd section) sheathed.
- Single core 400 sq.mm stranded copper conductor, XLPE insulated, Tape armouring, FRLS (for Part of AMS to ASS connections) sheathed.

It shall conform to IEC 60502 Part 2 latest for construction and IEC 60840 for testing. The cable shall be manufactured by a company having ISO accreditation for quality. The manufacturing process of XLPE cable shall consist of conductor screen, insulation & insulation screen shall be extruded in a single process.(triple extrusion) and cross linked by VCV Process 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. The technical requiriements of these cables are described in the following paragraphs.

6.2 Governing Specifications

The 33 kV Cables shall conform to IEC 502/1 and shall be of 19/33 kV (36). The cables shall be of dry-insulated, radial-field cable, based on proven technology. They shall be constituted by assembly of three single core cables in twisted or cloverleaf pattern.

6.2.1 Technical Particulars

6.2.1.1 *Description*

The cables shall be insulated with chemically cross-linked polyethylene, with semi-conducting screen over a copper conducting core, and insulating envelope and polyvinyl chloride protective sheath.

- operating voltage : 33 kV rms between phases,
- specified voltage : 19 kV rms (according to IEC 502/1)

6.2.1.2 *Fire Retardant Low Smoke Zero Halogen*

All cables shall be non-fire propagating, non-toxic and low-smoke producing and shall conform IEC 502-1 or equivalent and shall be of Zero Halogen.

6.2.1.3 *Conducting Core*

The conducting core shall be formed from stranded copper conductor, according to Class 2 as per Publication IEC 60228. The conductor shall be compact circular stranded.

The following shall be the cross-section of the conducting Core for different applications,

- Single core 400 sq.mm stranded copper conductor, XLPE insulated, Tape armouring, FRLSOH for the 33kV distribution Network cables in tunnels and Viaduct and for connections from the Network to the 33kV switchgear panels inside the ASS.
- 95 sqmm stranded copper conductor, XLPE insulated, Tape armouring, FRLSOH for connections from Transformer Circuit Breaker to the 33kV/415V Auxiliary transformer in the ASS.

The 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 this 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.

6.2.1.4 *Conductor Screen:*

The conductor screen shall be provided over the conductor by extrusion of semi-conducting compound. A semi conducting tape (s) shall be provided below the extruded semi conducting conductor screen to prevent penetration of compound in to the under lying conductor. Nominal thickness of conductor screen shall be 0.7mm.

6.2.1.5 *Insulation:*

The conductor with screening shall be provided with cross linked polyethylene (XLPE) insulation applied by extrusion. The nominal thickness of insulation shall not be less than 9 mm 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.

6.2.1.6 *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).

6.2.1.7 *Water Barrier, Longitudinal*

The water barrier shall be semi-conducting water swellable 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.

6.2.1.8 *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 shall submit the calculations giving details of the area of copper wire screen/copper tape.

An annealed plain copper binder tape shall be applied in the form of an open helix, over the copper wire screen.

6.2.1.9 *Inner Sheath:*

An inner layer of FRLSOH tape shall be applied over metallic screen followed by PE laminated Aluminium tape.

6.2.1.10 *Armouring:*

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

6.2.1.11 *Outer sheath:*

The outer sheath shall be extruded Red, Yellow , Blue colour, halogen free flame retardant polyolefin compatible with specified ambient and operating temperature. **The sheath shall be treated with anti termite and corrosion resistant compound.,** confirming to requirement of IEC specifications and extruded continuously.

The protective sheath shall carry the indications listed below, in letters and digits:

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

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

1. IEC 332 Part 1 & 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. A Temperature index of 260°C as per ASTM D 2863.
4. Determination of the amount of halogen Acid Gases as per IEC 754 Part-II
5. 3 m cube smoke emission test, when tested in accordance to IEC 61034/BS 7622- Maximum smoke emission 30%
6. 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
7. For FRLS cable maximum smoke emission should be 50% as per ASTM D 2843

6.2.1.12 *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. However 3 phase short circuit capacity of 33 kV cable shall be minimum 7 kA for 3 sec.

6.3 Connecting Junctions - MV Ends

6.3.1 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 Shrinkable Type.

6.3.2 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. For Underground section for straight through joint/termination shall be made by using Halogen free Jointing kit.

6.4 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 Electrotechnical Commission relative to power supply cables (IEC 55-1, 55-2 and 502-1). 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 502 rules in force on the date of the order.

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

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

6.5 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.

6.6 Cable Technical and Test Sheet

The tests shall be performed according to the corresponding 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 $4.U$ or the test shall be carried out as per latest standard in force.

6.7 Cable Laying Specification

6.7.1 General

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

The cable laying shall be generally in accordance with IS-1255-1983 and manufacturer's recommendations.

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.

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).

6.7.2 Not Used.

6.7.2.1 *Laying in Tunnels*

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

Supports/Brackets will be provided by E&M Contractor. The traction Contractor is to interface with E&M Contractor for route and location. The supply and installation of trefoil clamps 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

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

6.7.2.2 *Cables Installation*

6.7.2.3 *Laying out*

The cables shall be supplied 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 aluminum-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 mechanical paying out not accepted, for whatever reason, the 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.

6.7.2.4 *Tagging*

All cables laid inside channels, or on cable-tray shall carry an 8 x 5 cm Aluminum tag placed every 10 m and in specific locations such as connection sleeves, entry into and exit from ducts, possible pulling chambers.

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 the 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.

- Sealing of cut- outs.
- Sealing of 33 KV cable and control cable cutouts in the station premises in the scope of work of traction contractor
- JP/EW/1B/E2 contractor shall interface with SBC for cable cutouts.
- JP/EW/1B/E2 contractor shall be responsible for sealing of unused cutouts, if any.

6.7.3 Sheath Voltage Limiter

The JP/EW/1B/E2 Contractor shall provide sheath voltage limiter.

6.7.3.1 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.

6.7.3.2 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.

$$E_s = 314. I. L \text{ volts/m}$$

E_s = Sheath Voltage.

I = Current in the conductor

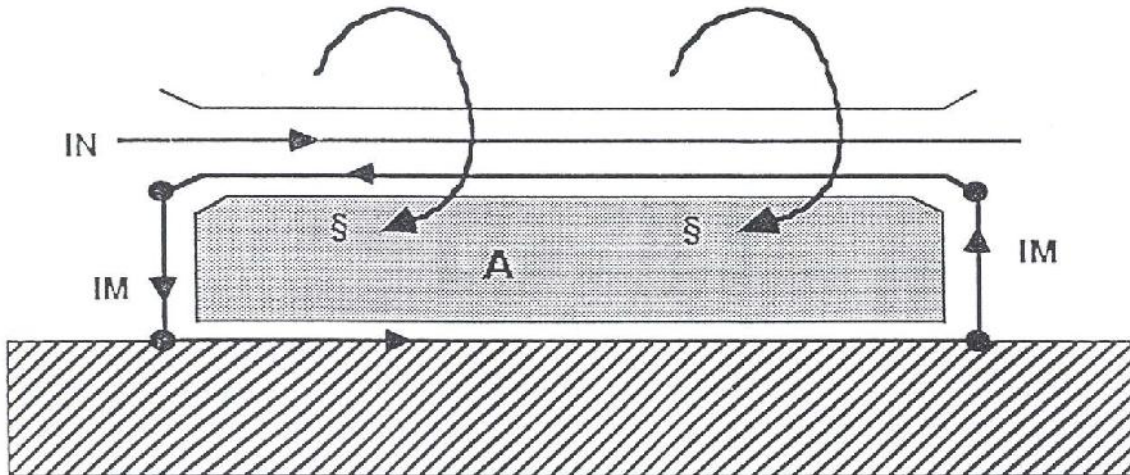
L = Mutual inductance between the sheaths of cables

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

6.7.3.3 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.

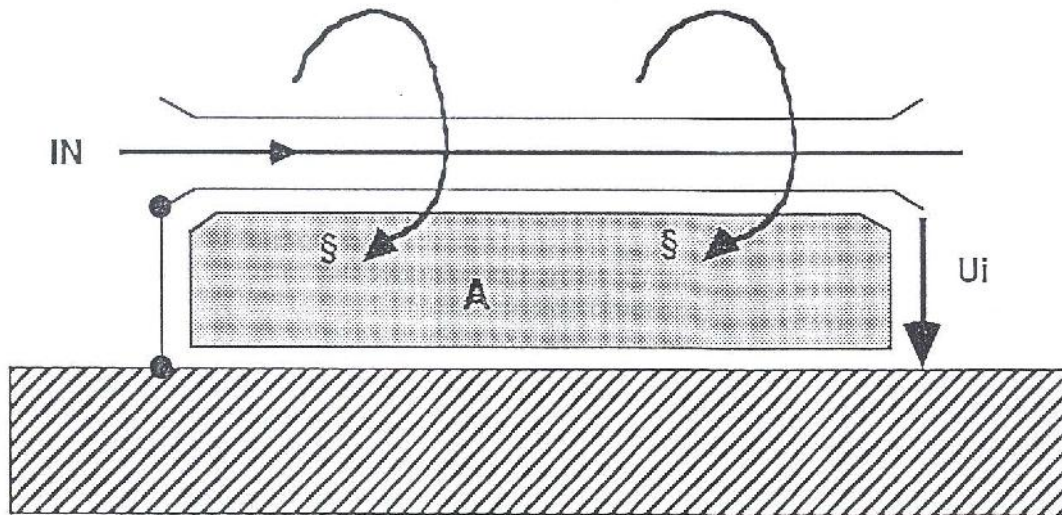
To utilize the full capacity of the cable, special bonding methods are employed.

Sheath Bonding methods:

- Single Point Bonding
- Mid Point Bonding
- Cross Bonding

6.7.3.3.1 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.

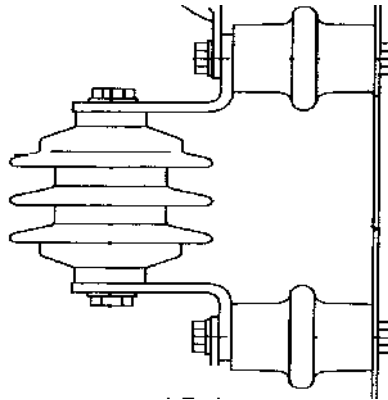


When the cable's Armour / sheath / concentric ground is floating at one end, a standing voltage will be generated on this metallic layer. The magnitude of this standing voltage is directly proportional to conductor current and to cable length. It's also proportional to the spacing between cables and 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.

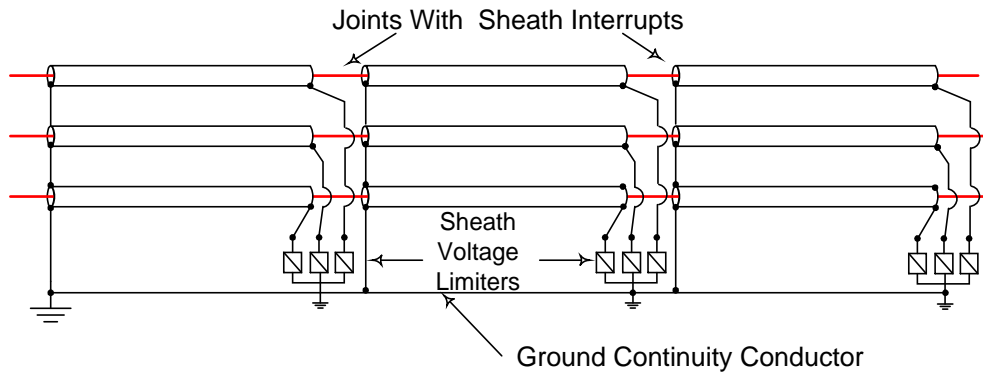
As per the earthing practices as laid down in IS 3043; Latest Version, this standing voltage should not exceed 65 Volts. Typically, Single point bonding is adopted for feeder lengths not exceeding 1km.

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 lengths, multiple single point bonding can be carried out with a ground continuity conductor.



6.7.3.3.2 Mid point Bonding:

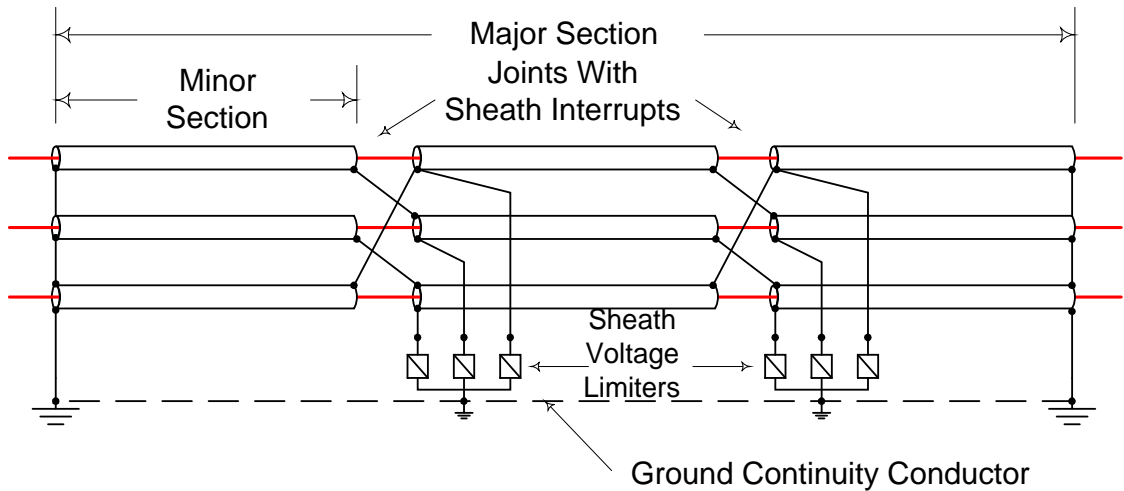
In this method, the bonding is carried out at the center of the cable feeder and the other two ends are grounded through SVL. This ensures that the sheath standing voltage is halved.

6.7.3.3.3 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 and shall be 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 JP/EW/1B/E2 Contractor shall prepare a design for 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 JP/EW/1B/E2 contractor will be required to submit and obtain approval from DMRC for the calculation that bonding method selected by him, single point bonding/ mid point 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 3 km.

7. LOW VOLTAGE SWITCH BOARD (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 underground stations (by means of cables or Bus duct) **will also be done by the station E & M Contractor.** The JP/EW/1B/E2 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

8. 110 V DC POWER SUPPLY SYSTEM

8.1 General

The 110 V DC Power required for the equipments at the ASS, shall be met from the 110 V DC Power Supply System provided at the ASS.

8.2 System Description

8.2.1 Type 1 System

The 110V DC Power Supply System shall consist of 1 Battery set and 2 battery chargers. The Battery set shall be designed to cater to the full requirement of 110 V DC power of all equipments in the ASS, with an 8-hours 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 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 not be less than 180 AH, in any case. Of the 2 Battery chargers, one shall be in service normally 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.

8.2.2 The automatic and manual change-over system from one source to the other, as provided shall operate as follows:

- 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 come back) 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 the 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 the 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 incidents which may occur during the change-over operation from one source to the other.

8.2.3 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. In the case of failure of the 'In Service' battery charger, the 'Standby' battery charger shall come into service through an 'Automatic Changeover' system.

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 VDC 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 device.

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

8.3 Other Technical Requirements

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 room
- No common main fuse for battery
- An installation, which is free from the risk of, short-circuits between the battery 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 so that short-circuit shall never occur, it must be provided with circuit protection, these shall provide absolute and safe selectivity, so that tripping is confined to the minimum. Only rapid protection characteristic may be used.

8.4 Equipment Specification

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

8.4.1 Battery

Batteries shall be of stationary compact, nickel-cadmium type consisting of 85 cells. They shall be maintenance free and if connection between batteries through the cables, cable shall be Fire Retardant Low smoke Type Zero Halogen. (FRLS OH) for Underground Section & fire retardant low smoke type (FRLS) for elevated section. The battery shall comply with IEC 60622/IEC 60623 & IEC 62259.

The battery protection shall be as close as possible to the battery and shall be contained in separate enclosure for negative and positive pole respectively. The enclosure shall be made of insulating material. The connection between the battery and its protection shall consist of single conductor and shall be run in such a manner so that they are protected from physical damage.

Each battery shall be connected through its own battery distribution board to the main board, and each battery section shall have its own supervisory equipment to indicate and alarm for the maximum and minimum voltage levels on float-charge and earth fault.

8.4.2 Battery Charger

AC Power Supply:

- Voltage : 230V/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 +0%, -15%
- Operating period after AC supply failure : 8 hours

- Constant power drain: shall be decided by the Contractor, to deliver the full duty. The minimum capacity of the Battery shall not be less than 180AH.

Battery charger shall have the provision of Alarm in case of low battery and also have the feature of battery reverse polarity Protection. Battery charger shall have potential free contacts to indicated the status of battery charger at ASS as well as OCC through SCADA. Also potential free contacts shall be providing for giving Alarm signal to SCADA System for failure of main battery charger and Switching of the Load on the other Hot standby battery chargers. Ripple content in the out voltage in any shall not be more than 3%.

External/Internal cabling of the battery charger shall be Fire Retardent Low smoke Zero Halogen type (FRLS OH), for Underground Section & fire retardant low smoke type (FRLS) for elevated section.

Charger:

The charger shall comprise of an inlet transformer and silicon diode/thyristor or thyristor bridge.

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.

8.4.2.1 Characteristics

Major characteristics are described in the annexed technical sheet.

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

8.4.2.2 *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 $+5\%$ of the frequency, whatever may be the output required.

The residual ripple ratio shall be as low as possible (less than 3,5%) so as not to disturb the various operating circuits.

Equalisation charge operation

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 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 in the OCC. However, if the ASS is unmanned, it shall be possible to nullify the audible alarm function at the unmanned AMS.

8.4.2.3 *Protections and monitoring*

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

- A device limiting the current out put 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.

8.4.2.4 *Miscellaneous*

The battery charger equipment shall also include:

- a 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,
- a signalling light denoting the opening of the make-break switch on the DC side through actuation of the magneto-thermal relay,
- a voltmeter indicating the voltage on the AC side
- a voltmeter indicating the voltage on the DC side
- A centre-zero ammeters which 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 charger and shall be operative when the 415 V supply is available to the charger.

9. **110 V DC DISTRIBUTION BOARD**

9.1 **Description**

Distribution of the 110 V DC sources shall be gathered inside two specific cabinets or two halves of a single cabinet, one for each half station, called DC auxiliary IP-43.

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.

9.2 **Equipments**

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

- Isolating switch/MCB
- Master power supply circuit breakers
- -

9.3 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 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 and 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.

9.3.1 AC Distribution Board

For providing AC 415 V supply, AC Distribution Board shall be provided in the ASS. Incoming feeders of ACDB shall be provided with earth leakage circuit Breakers along with MCCB/MCB. Bus Bar 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 and Fire retardant low smoke type (FRLS) for elevated section. Minimum Clearance between Phases and Earth/Neutral shall be 20 mm

Minimum IP rating of ACDB and DCDB shall be IP-43.

10. EMERGENCY TRIPPING SYSTEM - FOR UNDERGROUND SECTION

Every ETS Box consists of a unit which is fire protected and with a breakable glass, containing the emergency push button.

ETS Box will be cabled to the nearest PLC/RTU.

Emergency Trip System will house a blue location indicating light and a heavy duty telephone handset providing that any emergency conditions to push the button or for any other de-energising the request to call OCC. Telephone is a hot line telephone with heavy-duty handset. Each ETS box shall have 3-cable entrance for the following cable:

- Power supply Cable
- PLC/RTU Cable
- Telephone Cable

Some Technical specifications of ETS station are as follows :-

- Fire Protected Cover.
- Heavy duty telephone hand set
- Blue locations – indicating light and emergency push button
- Wall mounted ETS Box of approximate dimension 500 x 350 x 225 mm (Height x Width & depth)

- There will be no infringement of ETS Boxes with the moving dimensions of the Rolling Stock.
- Blue indication light shall be projected for easy visibility from a distance along track.
- Dual Lamp

NFPA – 130 (Fire Protection Standards for fixed guide wall transit system requirement will be considered for emergency trip system.)

Telephone line (hot line) for heavy-duty telephone hand set will be provided by S&T Contractor.

ETS Boxes will be placed at the following locations: -

- End of Platforms
- Station Control Room (SCR)
- Cross passage in each tunnel

Each ETS Station Boxes will be cabled to the nearest PLC/RTU. It means that each button on the ETS station will be digital input (DI) signal for the PLC/RTU. The ETS thus will be termed as addressable. The distance of the breakers to be tripped will be taken by the SCADA software centrally. This solution provides the quickest mechanism to transmit commands to a certain number of breakers simultaneously via different PLC/RTUs. Supply and erection of PLC/RTU will be in the Scope of JP/EW/1B/E2 Contractor.

The SCADA shall proceed through a predetermined programme of operation of circuit breakers and interruption to de-energize the OCS section where ETS plunger is activated and one section behind in the direction of train travel (in some cases). The work of SCADA from RTU on wards will be in scope of JP/EW/1B/E2 Contractor. The supply and erection of cables, ETS and any other material to complete the work is in Scope of JP/EW/1B/E2 contractor. Any equipment interface, device required for making operational the ETS system should be provided by JP/EW/1B/E2 contractor.

ETS cable system being an item of vital nature shall be protected from physical damage and shall be capable of withstanding temperature upto 950° C for 3 hour and in that condition not support combustion (category C - BS 6387).

11. PROTECTIONS

11.1 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 based on modular sets must comply with a high performance standard.

- 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

11.2 Performances required

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

11.2.1 Reliability

This criterion defines the mean time between failures (MTBF) which has to be calculated for about 10 years.

11.2.2 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.

11.2.3 Availability

This is expressed in terms of ratio using the formula:

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

And has to represent a level of 99.95 %.

11.2.4 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.

11.2.5 Electro magnetic compatibility

Due to the consequent interference levels in the premises, protection equipment has to present sufficient level of immunity defined by the following standards:

- IEC 61000.4-2 Class 3,
- IEC 61000.4-4 Class 4,

- IEC 61000.4-5 Class 3.

Such criteria shall be obtained by using either digital type relays or specific PLC cards.

11.3 Description of Protection

11.3.1 Relays

11.3.1.1 General Description

All relays shall conform to the requirements of IS:3231/IEC-60255/IEC61000 or other applicable standards. Relays shall be suitable for flush or semi-flush mounting on the front with connections from the rear. Protection facilities with fast discrimination and reliable operation, base on micro-processor technology, shall provide the protection scheme logic

11.3.1.2 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.

11.3.1.3 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.

11.3.1.4 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.

11.3.1.5 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 be 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. Similarly, separate operating indicator (auxiliary relays) shall also be provided in the trip circuits of protections located outside the board such as Buchholz relays, oil and winding temperature protection, sudden pressure devices, fire protection etc

11.3.1.6 Timers

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

11.3.1.7 Denergisation 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.

11.3.1.8 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

11.3.1.9 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 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).

11.3.1.10 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.

11.3.1.11 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.

11.3.1.12 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.

11.3.1.13 Phase Indications

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

11.3.1.14 Scope of Numerical Relays

For numerical relays, the scope shall include the following:

- a) Necessary software and hardware to up/down load 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.

11.3.1.15 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.

11.3.1.16 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 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.

11.3.2 Zones of Protection

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

11.3.2.2 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.

11.3.2.3 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 Representative for review and approval.

11.3.2.4 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.

11.3.2.5 To detect the location of the fault in the 33kV ring-main system, a detection relay shall be installed for all 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 Reenergize the healthy part of the network.

11.3.3 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 represents the start of the protection line.

11.3.4 Electrical protections

11.3.4.1 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.

11.3.4.2 Protections through lack of AC voltage

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.

11.3.4.3 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.

11.3.4.4 Over current protections

This function ensures the tripping of concerned circuit breaker when the current values 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 dependant time following a characteristic:
 - Inverse,
 - Very inverse,
 - Extremely inverse.

11.3.4.5 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.).

11.3.4.6 Differential protections

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

11.3.4.7 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 the both parts of the coupling apparatus.

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

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

11.3.5 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.

11.4 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. Line Differential protection with Pilot wires shall also be provided for the Section of 33 kV cables between ASS1/ASS2 and ASS3 at the Underground Station. In addition not limited to, Instantaneous and IDMT Overcurrent and Earthfault protection (50, 50N, 51, 51N) shall be provided, Over Current relay with Directional/Non Direction as required , to ensure that the network is fully protected against any faults on the 33kV Ring Main Network. Therefore, the functioning of these protections shall trip the either end of circuit breaker of 33kV power supply network.

11.5 ASS Equipment Protection

11.5.1 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)
- 87T Transformer Differential protection
- 51G Standby earth fault protection
- 64 : REF Protection (For UG and Depot ASS)

For Transformer differential protection, the JP/EW/1B/E2 Contractor shall provide the required Current Transformers in MV panels. In addition, the control cables between the MV breakers and LV Breakers shall also be provided by the JP/EW/1B/E2 Contractor. The necessary C&M cables for Transformer shall be supplied and installed by the JP/EW/1B/E2 Contractor. The E&M Contractor will provide the LT side CT. The E&M Contractor shall also interface with JP/EW/1B/E2 Contractor for matching

and Accuracy Class the CT characteristics to ensure tripping of HT and LT breakers in case of Transformer fault within the zone of protection.

The functioning of these protections shall trip the MVCB & corresponding LVCB.

Moreover, it shall be protected against heating by a two threshold temperature protection.

The first threshold shall transmit an alarm to the ECC as well as in the ASS.

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

11.5.2 Low voltage protection

The low voltage circuit breaker supply and installation by the E&M Contractor shall be equipped with magneto-thermal protection to protect the main circuit against short-circuit, over-current and earth fault. This protection shall be thermal compensated to take into account the ambient temperature. This protection shall be equipped on the LVCB1 and LVCB2. The tripping of 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 take into account the time delay and the current level of the downstream protections.

12. 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, SSP, AMS and ASS.

All LV cables, Control and Monitoring cables shall be Fire Retardant Low Smoke Zero Halogen Type (FRLSOH) for Underground section and Fire Retardant Low Smoke Type (FRLS) for Elevated section complying with BS 6724 for cables, BS 7211 for Wires.

12.1 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 voltage rating of distribution cables shall be 1100 as per IS 7078 part-1 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.

12.2 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:

- (i) Normal temperature rise
- (ii) Maximum voltage drop
 - 3% for main distribution lines (between primary and secondary cabinets)
 - 3% for lighting circuits
 - 5% for power circuits
 - 12% for motor circuits during start-up
- (iii) Overload and short-circuit
- (iv) Protection against indirect contact
- (v) If heavy currents are to be carried, the economic section must also be taken into account.

12.3 Standards

All cables shall comply with the IEC standards (IEC 288 and IEC 227) in force and shall, at least, have satisfied the following tests:

- Dielectric strength,
- Insulation resistance,
- Core resistance,
- Flash-over voltage,
- Insulation stability in a conductive environment,
- Capacitance and differential capacitance,
- Smoke opacity: NBS chamber test,
- Combustion gas analysis,
- Calculation of conventional pollution index,
- Calculation of the conventional toxicity index,
- Measurement of insulation and cladding thickness
- Measurement of diameters,
- Composition and dimensions of the conductive cores,
- Cable construction and identification of cores,

- Tensile properties of insulating and protective cladding mixtures,
- Thermal aging of insulation and protective cladding mixtures,
- Resistance of insulation and cladding materials to pressure at high temperature,
- Resistance of cladding to mineral oils,
- Resistance of cladding to acids and alkalis,
- Resistance of protective cladding to tearing,
- Core bending,
- Coiling at low temperature.

And for the corresponding cables:

- Category C 2 cables (non-flame propagating),
- Category C 1 cables (non-fire propagating),
- Category CR1 cables (Fire-resistant cables).

12.4 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 of 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,
- Non flammable,
- Permanence of the marking
- Easy reading.

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

12.5 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.

12.6 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 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.

12.6.1 Supports

12.6.1.1 *Cable-ways 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.

12.6.1.2 *Cable-way 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.

12.6.1.3 *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.

12.6.1.4 *Metal Tube*

Certain circuits may have to be protected by means of rigid steel tubes or flexible metal tube; 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.

12.6.2 **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.

12.6.3 **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, the 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 to damage 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.

13. INTERFACE WITH SCADA EQUIPMENTS

13.1 The various equipments provided in the ass shall be controlled and monitored by a Centralized Control Centre (OCC) installed at designated place. The necessary Supervisory Operation Control and Data Acquisition system (SCADA) including the Remote Terminal Units (RTU) at the ass will be provided by the JP/EW/1B/E2 contractor. The following works shall be in the scope of JP/EW/1B/E2 contractor

- Supply and installation of Interface Marshalling box in the Underground ASS's. The Marshaling Box shall provide for the input signal connections, including those from analog meters, from field equipments and the output signal connections to the field equipments. In addition, the Marshalling Box shall provide for the necessary connection from/to the RTU's. The Marshalling box shall provide facilities for interconnection between the signals to/from RTU and signals from/to the field units.
- The connection between the Marshalling box terminals and the field equipment terminals, via copper cables, shall be made by the JP/EW/1B/E2 Contractor. JP/EW/1B/E2 Contractor shall tag the either end/ of the cable with proper notification. All the connections between the Marshalling box terminals and the RTU and interconnection between the terminal blocks of the Marshalling Box, will be made by the JP/EW/1B/E2 Contractor.
- Details of SCADA specifications are provided in chapter 8 part D of this Technical specifications.
- The tentative I/O list for ASS (Underground) is shown below,

Sr. No.	Device	Event Description	Event Type			Alarm Class	Event Text	
			Digital Input	Digital Output	Analog Input		Normal State	Alarm State
1	Circuit Breaker (Incomer)	Local/Remote in Local	DI			P1	Remote	Local
2		Permission for Local Control	DI			P1	Banned	Permitted
3		110V DC Control Voltage Fail	DI			P2	Normal	Fail
4		Close Indication	DI			P0	Close	

Sr. No.	Device	Event Description	Event Type			Alarm Class	Event Text		
			Digital Input	Digital Output	Analog Input		Normal State	Alarm State	
5		Open Indication	DI			P0	Open		
6		CB in Test/Service	DI			P2	Service	Test	
7		CB Trip Circuit Unhealthy	DI			P3	Normal	Unhealthy	
8		Trip Relay Operated	DI			P2	Normal	Operated	
9		Spring Discharged	DI			P1	Charged	Discharged	
10		Open Command		DO					
11		Close Command		DO					
12		SCADA Permissive For Local Control		DO					
13		O/C & E/F Relay faulty	DI			P3	Normal	Faulty	
14		O/C Protection Operated	DI			P2	Normal	Operated	
15		E/F Protection Operated	DI			P2	Normal	Operated	
16		Reset of Master Trip Relay		DO					
16		PT	R-Y Voltage			AI			
17			Y-B Voltage			AI			
18			B-R Voltage			AI			
19	EIS	Close Indication	DI			P0			
20		Open Indication	DI			P0			

Sr. No.	Device	Event Description	Event Type			Alarm Class	Event Text	
			Digital Input	Digital Output	Analog Input		Normal State	Alarm State
21	Cable fault Detection	Pilot Wire Relay Communication Fail	DI			P3	Normal	Faulty
22		Pilot Wire Operated	DI			P2	Normal	Alarm
23	Circuit Breaker (Outgoing)	Local/Remote in Local	DI			P1	Remote	Local
24		Permission for Local Control	DI			P1	Banned	Permitted
25		110V DC Control Voltage Fail	DI			P2	Normal	Fail
26		Close Indication	DI			P0	Close	
27		Open Indication	DI			P0	Open	
28		CB in Test/Service	DI			P2	Service	Test
29		CB Trip Circuit Unhealthy	DI			P3	Normal	Unhealthy
30		Trip Relay Operated	DI			P2	Normal	Operated
31		Spring Discharged	DI			P1	Charged	Discharged
32		Open Command		DO				
33		Close Command		DO				
34		SCADA Permissive For Local Control		DO				
35		O/C & E/F Relay faulty	DI			P3	Normal	Faulty
36		O/C Protection Operated	DI			P2	Normal	Operated
37		E/F Protection	DI			P2	Normal	Operated

Sr. No.	Device	Event Description	Event Type			Alarm Class	Event Text	
			Digital Input	Digital Output	Analog Input		Normal State	Alarm State
		Operated						
38		Reset of Master Trip Relay		DO				
39	PT	R-Y Voltage			AI			
40		Y-B Voltage			AI			
41		B-R Voltage			AI			
42	EIS	Close Indication	DI			P0		
43		Open Indication	DI			P0		
44	Cable fault Detection	Pilot Wire Relay Communication Fail	DI			P3	Normal	Faulty
45		Pilot Wire Operated	DI			P2	Normal	Alarm
46	MVCB (Transformer Protection Breaker)	Local/Remote in Local	DI			P1	Remote	Local
47		Permission for Local Control	DI			P1	Banned	Permitted
48		110V DC Control Voltage Fail	DI			P2	Normal	Fail
49		Close Indication	DI			P0	Close	
50		Open Indication	DI			P0	Open	
51		CB in Test/Service	DI			P2	Service	Test
52		CB Trip Circuit Unhealthy	DI			P3	Normal	Unhealthy
53		Trip Relay Operated	DI			P2	Normal	Operated
54	Spring Discharged	DI			P1	Charged	Discharged	

Sr. No.	Device	Event Description	Event Type			Alarm Class	Event Text		
			Digital Input	Digital Output	Analog Input		Normal State	Alarm State	
55		Open Command		DO					
56		Close Command		DO					
57		SCADA Permissive For Local Control		DO					
58		O/C & E/F Relay faulty	DI			P3	Normal	Faulty	
59		O/C Protection Operated	DI			P2	Normal	Operated	
60		E/F Protection Operated	DI			P2	Normal	Operated	
61		Transformer differential Protection operated	DI			P2	Normal	Operated	
62		Reset of Master Trip Relay		DO					
63		Transformer differential relay faulty	DI			P3	Normal	Faulty	
64		REF Protection operated	DI			P2	Normal	Operated	
65		REF Relay Faulty	DI			P3	Normal	Faulty	
66		TEIS	Close Indication	DI			P0		
67			Open Indication	DI			P0		
68		Transformer	Winding Temp High Alarm	DI			P3	Normal	Alarm
69			Winding Temp High	DI			P3	Normal	Trip

Sr. No.	Device	Event Description	Event Type			Alarm Class	Event Text	
			Digital Input	Digital Output	Analog Input		Normal State	Alarm State
		Auto Trip Alarm						
70		Transformer Door Open	DI			P3	Normal	Open
71	Gas Compartments (individual signal for each compartment)	SF6 Gas pressure low Alarm – compartments 1, 2, 3, 4.....	DI			P2	Normal	Low
72		Not used						
73	Isolator of each bay.(Individual signal for each isolator)	Open command		DO				
74		Close command		DO				
75		Open indication	DI			P0		
76		Close indication	DI			P0		
83	Bus Voltage	R-Y Voltage			AI			
84		Y-B Voltage			AI			
85		B-R Voltage			AI			
86	AC DB	Lack of 415 Voltage	DI			P1	Normal	Alarm
87	DCCB	Lack of 110 Voltage	DI			P2	Normal	Alarm
88	Battery Charger	Charger Status	DI			P1	Normal	Standby
89		Float/Boost	DI			P2	Float	Boost
90		Input MCB Trip	DI			P2	Normal	Trip
91		AC Fail	DI			P2	Normal	Fail

Sr. No.	Device	Event Description	Event Type			Alarm Class	Event Text	
			Digital Input	Digital Output	Analog Input		Normal State	Alarm State
92		Charger Fail	DI			P2	Normal	Unhealthy
93		DC Under Voltage	DI			P2	Normal	Alarm
94		DC Over Voltage	DI			P2	Normal	Alarm
95		Output MCB Trip	DI			P2	Normal	Trip
96		Battery Output Voltage			AI			