PART 2 - EMPLOYER’S REQUIREMENTS

SUBSTATIONS (SUB)

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Abbreviations and Acronyms

%	Percentage
R	Resistivity
°C	Degrees Celsius
°F	Degrees Fahrenheit
A	Amperes
AC	Alternating Current
ACSR	Aluminum Conductor Steel Reinforced
AIS	Air-Insulated Substations
ANSI	American National Standards Institute
AWG	American Wire Gage
BIL	Basic Impulse Insulation Level
BSL	Basic Switching Impulse Insulation Level
CB	Circuit Breaker
Cm	Centimeter
CPU	Central Processing Unit
CT	Current Transformer
Cu	Copper
CVT	Capacitor Voltage Transformer
dB	Decibels
DC	Direct Current
F	Frequency
Ft	Feet
GIS	Gas-Insulated Substations
HMI	Human–Machine Interface
HSE	Health and Safety Executive
HV	High Voltage
HVAC	Heating, Ventilating, and Air Conditioning
Hz	Hertz (cycles per second)
IEC	International Electrotechnical Association
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronics Engineers
in.	Inch

kA	Kiloamperes (1,000 amperes)
kcmil	Kilocircular mils (1,000 circular mils)
kg	Kilogram (1,000 grams)
kHz	Kilohertz (1,000 hertz or cycles per second)
km	Kilometers (1,000 meters or 1,608 feet)
kN	Kilonewtons
kNm	Kilonewton meters
kPa	Kilopascals (1,000 Pascals)
ksi	KIP (1000lbs) per square inch
kV	Kilovolt (1,000 volts)
kVA	Kilovolt-amperes (1,000 volt-amperes)
kVAR	Kilovolt-amperes reactive (1,000 volt-amperes reactive)
kWh	Kilowatt-hour
LAN	Local Area Network
OLTC	On-Load Tap Changer
LV	Low voltage
M	Meter(s)
m^2	Square meter
mA	Milliamperes (0.001 ampere)
Mbps	megabits per second (1,000,000 bits per second)
mm	Millimeter (0.001 meter)
mV	Millivolt
MV	Medium Voltage
MVA	Megavolt-amperes (1,000,000 volt-amperes)
MVAR	Megavolt-amperes reactive (1,000,000 volt-amperes)
MW	Megawatt (1,000,000 watts)
N	Newton
N/m	Newtons per meter
NI-CAD	Nickel Cadmium
NLTC	No-Load Tap Change
O&M	Operations and Maintenance
ONAN	Oil Natural Air Natural
ONAF	Oil Natural Air Forced
OPGW	Optical Ground Wire

PC	Personal computer
PE	Polyethylene
PF	Power Factor
PT	Potential Transformer
PVC	Polyvinyl Chloride
PP	Power Plant
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SF6	Sulfur Hexaflouride
Std.	Standard
TCP/IP	Transport Control Protocol/Internet Protocol
UTP	Unshielded Twisted Pair
V	Volts
VA	Volt-amperes
VAC	Volts Alternating Current
VAR	Volt-amperes reactive
VDC	Volts Direct Current
VT	Voltage Transformer
WAN	Wide Area Network
XLPE	Cross-Linked Polyethylene

1. Scope of Design, Supply and Installation for Substations

One existing Hydro power station in Laudat - 11 kV, and three new electrical substations will be built and interconnected as part of this project:

- Hydroelectric power station of Trafalgar – 2.2/33 kV
- Hydroelectric power station of Padu – 33/11 kV
- Diesel power station of Fond Cole – 69/33/11 kV

Figure 1: Scope of work – substations

2. Summary of Contractors obligations for Substations

The works related to the project will be executed on a turnkey basis, design, supply and installation. Therefore, the works shall include, among others, calculations, design, manufacture, assembly and acceptance testing in the Contractor's workshop (manufacturer's facility) as well as the supply, customs clearance, delivery, unloading, storage, installation, adjusting, painting, identification, commissioning, acceptance and testing of new equipment to be installed, complete in every respect and suitable for satisfactory operation.

This section details the main items of plant to be supplied and installation works to be carried out under this contract. However, the Contractor is required to ascertain himself whether any additional plant or installation works are necessary so as to make the facility in working order on completion and in accordance with the requirements of the contract. Any additional equipment, plant or works, not specified but intrinsically required for the proper operation of the facility, are deemed to be included in the bid. Any quantities which may be set out in the price schedules, shall be considered as indicative quantities.

From the commencement date up to the signing of the completion of the facilities, the Contractor shall - at his own costs – store and secure the equipment and materials as well as protect them against damages, weathering, removal or destruction. It shall be the Contractor's obligation to construct fences and shelters, lighting, security services and all relevant measures to fulfil these duties.

The scope of this contract described in below sections and elsewhere in the bid documents shall cover all supplies and services required to meet the purpose of the plant, safe, reliable and contractual intended use of the facilities, even if these are not expressly mentioned in detail in the subsequent sections.

All works not expressly called for in this Employer Requirements/Specification, but necessary for the complete and proper installation and operation of the facility/equipment and accessories at the discretion of the Engineer shall be supplied and installed by the Contractor at no additional cost to the Employer.

Any terminal points which are not specified / included in the Employer Requirements/Specification but required for safe and reliable operation of the facility shall be deemed to be included in the scope of works and the Contractor shall carry out such terminal connection works at no extra cost to the Employer.

All preparatory works for terminal point connections, such as drawings, shall be under the directives of the Employer/ Engineer. Supply of necessary equipment, clean up etc. will be the Contractor's responsibility. The Employer should not be required to utilize its resources for such work.

The requirements detailed in the following paragraphs shall be read in conjunction with the detailed technical specifications and technical schedules. The final quantities shall be determined from the final design.

All temporary works and equipment, necessary to keep the substation in operation during the execution of the works, are included in the scope of supply and services. The Contractor who will be wholly responsible for ensuring that all materials used in the work and temporary works comply with the approved standards, and that all processes of workmanship are carried out with a high degree of efficiency, in accordance with an approved program an in compliance with the contract requirements.

In case discrepancies occur between the items of scope of supply and services stated hereby and the ones derived from the respective drawings and in case certain items of scope of supply are identified hereby but not in the respective drawings or vice versa, the Contractor is requested to interpret the project requirements by considering this document and all its parts in conjunction and collectively. The same principle applies with the price schedules. The contract is Lumpsum type. The most stringent requirements shall apply in case of deviations other than which qualifies under GCC 39 – Change in the Facilities

The itemized relevant unit prices in the price schedules shall include all costs of all supply and services, which are required for the function of the facility, but not exclusively mentioned elsewhere in the specification.

Coordination issues:

- Network operation:
    - The switch-off of lines and transformers has to be coordinated together with Employer

General operational restrictions of the substations caused by the project measures must be coordinated together with Employer

- Line bays:
    - The coordination of the measures at the start and end of the lines of connecting substation has to be coordinated by the contractor

- The coordination of the measures at substations must be coordinated with the measures of other projects. The coordination will be carried out by the Consultant/Employer. The Contractor must support the coordination of the Consultant/Employer.

The switch-off of transformer, lines, and busbars for a longer time during the construction phase is operational difficult. The contractor shall be flexible regarding timing of works to react quickly if a switch-off is possible or not possible. No standby time will be paid additionally.

Coordination during implementation and especially commissioning between the other ongoing projects will be the responsibility of Consultant/Employer.

The Contractors are encouraged to visit the substation and to familiarize themselves with the conditions and constraints which are present at the substation sites.

3. Specific works information for Substations

3.1 Specific Works Information for Hydroelectric Power Station Trafalgar 2.2/33kV

3.1.1 Localization

Substation	Geographical Coordinates	
	N	W
2.2/33 kV Trafalgar substation	15°19'35.41"N	61°20'18.05"W

Table 1: Localization of the Trafalgar substation 2.2 / 33kV

3.1.2 Scope of supply

The Contract scope of works for the new 2.2/33kV Trafalgar substation is the design, construction, supply, installation, connection, testing, pre-commissioning and final commissioning of all civil and electrical works, as well as the provision of drawings and documentation and any other requirements as defined in this specification.

The overall deliverables, at site, for this substation are:

Primary plant systems

- Two (02) 33/2.2kV 4MVA power transformers
- Two (02) 33/0.4kV 100kVA auxiliary transformer
- 33kV Metal-clad Switchgear:
    - One (01) 33 kV single busbar in one circuit breaker arrangement,
    - One (01) 33 kV busbar coupling cabinet,
    - Two (02) 33 kV measurement cabinets,
    - Two (02) 33 kV outgoing feeders to Geothermal SS and Padu SS,

  - Two (02) 33 kV incoming transformer feeders,
  - Two (02) 33/0.4 kV auxiliary transformer feeder: auxiliary power supply for substation

- 2.2kV Switchgear :
  - Adaptation of the existing 2.2kV cabinets to be used to transit power between 33kV and 2.2kV busbars through transformers.

- All 33kV and 2.2kV underground power cables inside the substation with their cables terminations (both extremities) and all necessary accessories. The 2.2kV MV cells already exists in the Trafalgar power plant side, However the substation contractor will be responsible for supplying, installing, testing and commissioning of all necessary cables with terminations and accessories to make the connection from power transformers till these existing 2.2kV cells.

  33kV UGC coming from Geothermal and Padu SS will be pulled and connected to 33kV switchgear (Geothermal and Padu Feeders) providing cable terminations. The contractor will provide the necessary cable trays for cable rising until 33kV cabinets.

  All requested technical requirements including cross section (defined as per energy to be transmitted) for MV cables are detailed in Guaranteed Technical Data tables in annexes of this document. A calculation note for 33kV and 2.2kV must be elaborated to confirm the choice of cross section and ability to transit the requested energy while applying all derating factors (ground temperature, ground thermal resistivity, depth of laying, buried,…).

- Earthing system including buried earth grid with earth connection and lightning protection system for switchyard (lightning mast and overhead ground wire) and control building lightning protection equipment.
- All rails for transformers, cable supports inside cable trenches,
- All site structures including concrete works, support structures, fencing, gates, exterior lighting
- All equipment needed inside control building: air conditioning equipment, fire detection system, lighting and sockets, camera supervision system, office room equipment, operators desks, sanitary equipment, kitchen equipment,…

Secondary systems within the control building

- Protection and control cubicles including IED/protection relays for each bay (with all necessary software installation setup and licenses),
- Common alarm panel including RTU,
- SCADA system with local HMI and remote control (with all necessary software installation setup and licenses),
- Telecommunication equipment in a dedicated cubicle and establish communication with adjacent sites (with all necessary software installation setup and licenses). Extension of FO cable, coming with 33KV feeders from Geothermal and Padu, from the entry of the substation until Telecom room. A FO connection must be established to Trafalgar power plant also.
- Metering equipment in a dedicated cubicle (with all necessary software installation setup and licenses),
- DC supplies including one 110VDC supply system (one 110VDC distribution board, one 110VDC battery bank, two 110VDC battery chargers) and one 48VDC supply system (one 48VDC distribution board, one 48VDC battery bank, two 48VDC battery chargers),

- AC 400/230V supplies including one 400VAC main LV switchboard (with three main input sources: source1, source2 and diesel generator with manual/automatic permutation between different sources, one LV switchboard from each station services transformer, one AC control building LV sub-board and LV outlets in the transformers area,
- Indoor and outdoor lighting and sockets,
- Diesel Generator of 100kVA
- Secondary wiring including LV and control cabling, inter-panel wiring, cable racks, trays and support brackets,
- Miscellaneous
  - Outdoor junction or marshalling boxes,
  - Nameplates,
  - Operational advisory signs, equipment labels, and equipment danger labels,
  - Any equipment needed to interface with the Trafalgar power plant electrical equipment and SCADA system,
  - Offices at site with air conditioner, electricity and water supplies and sanitary room during construction phase.
  - Any other essential equipment not mentioned above.

3.1.3 Scope of construction works

The construction scope of work to be performed by the Contractor consist of:

Electrical construction works

- Installation of buried earth grid with earthing pits and earth connections of all equipment,
- Installation of lightning protection equipment for outdoor switchyard and control building,
- Installation and connection of two new transformers 2.2/33KV, 4MVA connected to the new 33kV switchgear and to the existing 2.2KV switchgear,
- Installation and connection of two 33/0.4kV 100kVA auxiliary transformer,
- Installation and connection of Diesel Generator,
- Installation and connection of 33kV metal-clad switchgear,
- Pulling and connection of all 33kV and 2.2kV power cables, LV power and control cables inside substation,
- 33kV UGC coming from Geothermal and Padu SS will be pulled and connected to 33kV switchgear (Geothermal and Padu Feeders) providing cable terminations. The contractor will provide the necessary cable trays for cable rising until 33kV cabinets.
- Pulling and connection, from both sides, of all interface power and control cables to Trafalgar power plant equipment,
- Pulling and splicing (on ODFs) of FO cable from substation to power plant telecom room,

- Installation and connection of all protection and control cabinets, AC and DC switchboards, Batteries, Chargers, Inverter and SCADA system,
- Installation and connection of all indoor and outdoor lighting and sockets,
- Connection of substation and power plant earthing grid,
- Testing and commissioning of the whole substation equipment (locally and remotely from remote engineering workstation at Fond Cole).

Civil construction works

- Soil investigations
- All earthworks including cutting and filling. Cut and fill volume calculation according to the results contractor’s investigations,
- Construction of all outdoor equipment foundations and transformers foundations with oil collecting pits,
- The access to the substation must be segregated from the power plant by a fence and a door locking.
- The construction of fire walls at the north side of the substation building and all around 3 sides of the transformer with a minimal thickness of 0.3 m as shown in the architectural plan of the annex A3-1 of this document,
- Construction of heavy railed road for the transformer transportation operations,
- Construction of duct banks / cable trench with covers for all the 33 KV and 2.2 kV power cables and LV power and control cables. Different voltage level cables should never be placed in the same duct. The contractor must provide a detailed calculation note and a relative ducts layout for approval. Ducts for 33kV power cables for outgoing GTI and TPI feeders must be extended from 33kV switchgear to one meter outside the substation (with manholes for cable pulling). A new LV power and control covered cable trench must be constructed from new control building till the existing LV cable trench in the Trafalgar power plant.
- Construction of transformer tanks below the transformers that will have a capacity to contain 1.5*total oil volume of the transformer minimum.
- Construction of Control building with minimum surface of 130m², including a control and protection room, MV cells room, Batteries room, AC/DC auxiliary room, Telecom room, warehouse, office room, sanitary room, kitchen and outdoor location for station auxiliary transformer. This building must be connected to electricity and water supplies and connected to sewage system if exists otherwise provide other alternative. Details are in annex A3-1 of this document. In addition, the finishing work must be also considered as Plastering, painting, tiling, waterproofing, etc…
- Construction of a basement under MV room for MV cables entry
- Construction of roads, pavement, drainage system, fences, gravels surfacing of the substation area, landscaping and levelling.
- Ensuring a drainage system and all the necessary access roads for the substation
- Ensuring a water supply system, exterior and interior lighting, drainage system, and all the necessary access roads for the Trafalgar substation

- The concrete in contact with backfilling must be protected according to a detailed procedure submitted by the contractor and approved by the Project Owner.
- The Contractor is responsible for the construction of a security fence all around the substation with all the relative necessary gates, (minimum 1 vehicles' entry door, 1 personals' entry door, and 1 personal's exit door to ensure their safety and security during the execution phase)
- Construction of heavy railed road for the transformer transportation operations
- Construction of duct banks / cable trench for the 33kV and 2.2 kV cables that must be totally separated. The contractor must provide a detailed calculation note and a relative layout for approval.

For all the ducts/trench that link the substation to its outside limit, the responsible contractor for carrying out the work at Trafalgar substation must ensure the arrival of these duct banks/ trenches, (with all the necessary equipment, accessories, and ducts, + adequate closure), up to 1 m outside the boundary of the fence-to ensure that the ducts and the built structures are well secured and closed until the time of connection.

N.B.: In case of passage by cable trench, the cables will not be placed directly on concrete bases, cable trays must be used where each one should not contain > 3 cables beds, and 30 % of the cable trench must be free for future extension.

N.B.: The existing poles of the 11 kV transmission network on the front of the power plant entrance will be removed by Employer before any commencement of work.

3.1.4 Scope of design works

The Contractor must also provide supporting documentation, calculations, system studies, drawings, descriptions, manuals, quality control systems, progress reports and meetings with the project owner representative as set out in this Specification. Required supporting documentations may include but is not limited to the following:

- Earth Grid Study Report detailing Step and Touch Potentials for the site,
- Insulation Co-ordination Study,
- Protection relays settings and selectivity study,
- MV Cable Rating Study,
- Soil Resistivity Test Results,
- Soil Thermal Resistivity Test Results,
- Lightning Protection Study,
- DC Systems Requirement Study,
- AC Systems Requirement Study,
- Lighting Study Report (Indoor & Outdoor),
- Geotech Survey,
- All Site Surveying work,

- All needed drawings and calculation notes for electrical equipment and civil works dimensioning:
    - General arrangements (plan and elevation), layouts and sections drawings
    - Metallic structures and footings drawings and calculation notes
    - MV and LV equipment installation and connection drawings
    - Earthing grid layout, calculation notes and detailed connection drawings
    - Single line diagrams (protection and metering, SCADA, plant and Operations)
    - Switchgear panel general arrangements and schematics
    - AC and DC supply general arrangements and schematics
    - Measurement and Protection relays systems SLD and detailed drawings
    - Developed schematics for all MV feeders and LV switchboards.
    - SCADA system drawings and Telecom equipment schematics.
    - All MV and LV cables and busbars sections calculation notes and fittings.
    - Cable schedules
    - All drawings of any extension of the existing equipment,
    - Civil works detailed drawings and calculation notes: Foundation drawings, Cable duct/trench and conduit arrangement and elevation, Drainage plan,
    - Earthworks/pad design
    - Control Building Design including Building Services Design
    - Primary Plant Schedule for Procurement (8 weeks from date of Contract award)

The Contractor must perform a site visit prior to undertaking detailed design to determine site-specific conditions. He should visit the project area and then starts the surveys, soil investigations, geotechnical studies, etc…

NB: The design should consider a future extension of the MV switchgear by two feeders minimum.

3.1.4.1 Civil works design

As shown in the general layout annex A3-1, the building will be divided respectively into 2 major zones, defined by the following:

- The control building
- The transformer zone.

N.B.:

All the provided plans are indicatives, and the mentioned surfaces represent the minimum required areas.

Hence, the Contractor is responsible for making his own topographical, geotechnical, and magneto studies again, and then proposing his own substation layout for approval.

Control Building:

General:

The control building will have an area of 130 m2 minimum.

The building's level will be minimum at 0.65 m above the natural ground level.

A raised floor and a false ceiling will be placed all over the building surface except in the battery room.

A clear distance between the false ceiling and the false floor will be a minimum of 3.5 m.

Above the false ceiling and under the raised floor, a 50 cm minimum will take place, where the slab under the raised floor must be at a higher level than the level of the roadway.

N.B.: No detail design of the control building will be provided to the contractor, all the provided dimensions represent the minimum dimensions.

All the provided plans are indicative and should be considered as reference only. The contractor must conduct their own thorough investigations and studies from the beginning to design and construct the control building appropriately. Relying solely on the provided plans may not be sufficient, and it is essential for the contractor to take full responsibility for ensuring a comprehensive and accurate design that meets all project requirements.

Building dimensions:

This building will include minimum the following rooms:

- Batteries Room → 3.2*2.5 m2 minimum
- AC/DC & Charger room →3.7*2.7 m2 minimum
- Telecom room → 2.1*3.2 m2 minimum
- Control and protection room → 3.5*5 m2 minimum
- MV Room → 9.1*5.9 m2 minimum + basement with minimal depth of 2.1 m
- In addition, a zone must be reserved to the installation of Station Services Transformer 33/0.4kV → 3.2*2.5 m2 minimum

Foundations:

The foundations of the control building can be isolated, strap, or raft foundations, and must be founded in the natural ground.

The contractor is responsible to choose the types of foundations and their relative bottom level, according to the results of his geotechnical investigations, and he should submit a detailed calculation note for approval.

These foundations will be placed on a lean concrete surface with a minimum thickness of 0.1 m.

Backfilling is carried out with maximum thickness layers of 15 cm, which will be compacted and tested in accordance with specifications. The required compaction is 98% OPM.

For more details, please refer to the relative plans in the annex A3-1 of this document

Transformer zone:

For the transformer foundation, a raft foundation is recommended, but the contractor is responsible to choose the best type according to the results of his geotechnical investigations and should submit a detailed relative calculation note to the Employer for approval

These foundations will be based on natural ground level and on a surface of lean concrete with a minimum thickness of 10 cm.

A concrete screed will take place above this foundation with a slope of 1cm/m.

A grating will be placed above this screed to facilitate circulation.

The used grating could be either fire resistant or hot deep galvanized.

The rails will be placed on two concrete beams below the transformer. These rails will be extended to the heavy road.

The concrete must be protected from the inside of the transformer oil pit (where the oil will accumulate) with epoxy paint or equivalent. This paint must resist hot oil to be waterproof, and in order to block oil infiltration

The capacity of the transformer oil pit will be at least 1.5 * the total volume of the transformer.

The walls that surround the transformer oil pit must have a fire resistance of **4 hours minimum** with a minimal thickness of 0.3 m.

For more details, please refer to the relative plans in the annex A3-1 of this document

Finishing and other complementary works:

The Contractor must be responsible for the following complementary activities (but not limited to):

- Ensure the adequacy of the drainage system to avoid any risk of water infiltration inside the building.
- Separate the wastewater discharge pipe and direct it outside of the building to avoid any risk of infiltration inside the building.
- Supply and connection of sanitary equipment
- Supply and connection of indoor and outdoor lighting socket box
- Supply and connection of the lightning protection system
- Supply and connection of the air conditioning system
- False Ceiling in control room, protection room, telecom room, MV room, AC/DC charger room will be installed
- Raised Floor in control room, protection room, telecom room, MV room, AC/DC charger room will be installed
- Super caoutchouc smooth plastering and painting should be used on all walls and roof surfaces except of the battery room, where **anti-acid** plastering, painting, and tiling must be used. The masonry blockwork must be plastered and covered by Super caoutchouc smooth plastering (2 layers) with elasticity which is crucial to ensure the building's durability. Plastering thickness must be 2 cm minimum.
- Epoxy painting must be used for the floors of the MV cells room
- For all remaining floors, anti-slip tiling must be used
- Installation of a septic tank after having all necessary approvals and authorizations, and it should respect the country's norms and standards. It must comply with regulations with a capacity up to 15 people.
- The walls and the floors of WCs must be of ceramic tiling
- A gallon of hot water 50 L must be provided on site with all the relative mechanical and electrical protections, with respect to the norms and standards.
- Regarding the stairs' tiling, if it exists it must cover a minimum of 1.5 m of the height of the adjacent wall.

Roof:

The Contractor's services must include:

- The construction of a concrete slab with a slope for the recovery of rainwater
- Waterproofing
- The realization of the parapets all around the roof's edges
- The rainwater drainage pipes must be placed outside the building to avoid any risk of water infiltration inside the substation

  The contractor must submit for approval a detailed calculation notes for the quantification and the sizing of these ducts.
- The roof drainage should be integrated with manholes, featuring an overflow positioned 20 cm above the roof slab. (Manholes are to be strategically placed at each drain change of direction)
- The roof access must be provided for maintenance operations by crinoline ladders.

Carpentry

Services will include minimum the following items that may change in terms of size and quantities according to the client request and the new substation layout that must be provided by the contractor for approval:

- The supply, and installation of the following fire doors:
  - SIMPLE LEAF 90*240 → (Quantity = 2)
  - DOUBLE LEAF 2.1*2.4 → (Quantity = 1)
  - DOUBLE LEAF 1.5*2.4 → (Quantity = 4)

- The supply, and installation of the following windows:
  - Glaze window 1.2*0.4 → (Quantity = 9)
  - Glaze window 0.6*0.6 → (Quantity = 2)

Drainage system:

The Contractor must submit for approval a detailed calculation notes that concerns the necessary rainwater drainage pipes for the new substation, considering the water flow during the heaviest rains over a return period of 10 years.

The contractor is responsible to choose the substation's level that avoids any future possible risk of flooding.

Thus, he should install a drainage system all around and inside the substations that must be connected to the nearest existing rainwater drainage system to avoid all these possible risks.

The road drainage will be oriented from one side with a suitable slope.

The proposed solution must take into account the cleaning and maintenance needs.

Surfaces management and access roads:

The access to the substation must be segregated from the power plant by a fence and a door locking.

From the north side of the substation, a fire wall will be erected with a **minimal thickness of 0.3 m**,

Heavy railed road must be designed to support a minimum capacity of (**16t/axle**).

For the other free surfaces, they will be in accordance with the plans provided in the annex A3-1 of this document.

The Contractor is responsible for creating all the necessary access for the working zone.

In addition, the contractor must submit a detailed calculation note showing the Cut and Fill quantities according to his own topographical survey.

Please refer to the relative plans provided in the annex A3-1 of this document.

Fences and gates:

We can define two different types for fences:

1. Prefabricated concrete columns every 2 meters + isolated reinforced concrete foundation + mesh fencing 5x5 + semi-buried pallet-board + barbed wire (the height must be no less than 2.5 meters): This type of fence will be used to demarcate the substation from the DOMELEC site.

2. Reinforced concrete columns every 2.5 meters + isolated reinforced concrete foundations + masonry blocks + plastering + barbed wire (the height must also be no less than 2.5 meters): This type of fence will be used to separate the substation from neighboring areas or roads.

Please refer to the sections of the annex A3-1 for more details.

Exterior and interior lighting

The Contractor is responsible for the supply and installation of a sufficient exterior and interior lighting system.

He should use the latest lighting technology which saves energy and protects the environment, (LED technology or equivalent)

In addition, he should provide for approval a detailed calculation notes showing the minimum degree of illuminance that must be provided in each room of the buildings and at the level of the exterior area.

He is responsible for the following activities:

- Supply and connection of exterior and interior lighting and socket box
- Supply and connection of the lightning protection system.

Water supply

The contractor should provide a detailed calculation note that concerns an adequate and sufficient water supply system for the Trafalgar substation 2.2/33 kV.

The Contractor is responsible to install a water distribution system to supply the control building facilities such as:

- The sanitary facilities
- The eyewash in the battery rooms
- Etc…

An overhead water tank with a minimum capacity of 1000L will be installed.

Duct banks:

The Contractor is responsible for the construction of all the necessary duct bank and cable trench for the (33kV and 2.2kV) cables that must be separated in terms of voltage level.

A detailed inventory of the existing gutters shall be made before and after the work's execution, and in case of any noticed deterioration, the contractor will be responsible for all necessary restoration at his own expense.

All the duct bank / cable trenches are clearly represented on the relative plan of the Trafalgar substation, in the annex A3-1 of this document, that should be considered as an indicative layout and the contractor must provide his own layout for approval.

N.B.:

In case of passage by cable trench, the cables will not be placed directly on concrete bases, cable trays must be used where each one should not contain > 3 cables beds, and 30 % of the cable trench must be free for future extension.

3.1.4.2 Electrical design

SLD

The new Trafalgar substation under this contract will consist of the 33/2.2kV switchgear as described (see also the respective SLD on annex A3-2)

The substation consists of a new 33KV switchgear which will be installed inside MV room keeping space for two future MV cubicles minimum. Two power transformers will be installed in the switchyard in addition to the station services auxiliary transformer near the control building.

The design shall be prepared considering the possibility to allow an easy extension in the future without any relocation of any equipment. Thus, cable ducts, openings, civil works, building works, arrangement of all secondary equipment, etc shall be designed and prepared for the final stage. Single line, layout, section, building and other relevant drawings shall show the final extension of the substation.

Outdoor Medium voltage equipment

The contractor will supply and install:

- Two 33/2.2kV power transformers 4MVA YNd11 ONAN cooling, two winding transformer, with off-load tap-changer, including two current transformers on the HV side and one on the neutral grounding of the 33 kV winding.
- Two 33/0.4kV service auxiliary transformer 100KVA with current transformers for neutral grounding of 0.4 kV windings

MV switchgear

The complete 33 kV switchgear shall comprise a floor mounted, air-insulated metal-clad switchgear suitable for indoor use and shall be constructed in accordance with IEC 62271-1 and 62271-200.

The contractor will supply a complete 33kV Metal-clad Switchgear, indoor arrangement and single busbar system with Rated Current Busbar 1600 A and Rated Short Circuit Withstand Current common for all equipment 25 kA (3 sec).

The switchgear will include:

- Two (02) 33 kV measurement cabinets,
- One (01) 33kV busbar coupling cabinet,
- Two (02) 33 kV outgoing feeder to Geothermal and Padu,
- Two (02) 33 kV incoming transformers feeders,
- Two (02) 33/0.4 kV Service auxiliary transformer feeder: auxiliary power supply for substation

Incoming feeder will include:

- One voltage transformer 33/√3 **/** 0,11/√3 **/** 0,11/√3 kV
- One earthing switch 1250A
- One current transformer with two ratios and three secondaries 200-100/1-1-1A
- One withdrawable SF6 CB 1250A
- One busbar disconnector with earthing switch 1250A
- Voltage presence indicator for each cell
- Low voltage compartment with IED control and protection equipment in the front panel

Outgoing feeder will include:

- One voltage transformer 33/√3 **/** 0,11/√3 **/** 0,11/√3 kV
- One earthing switch 1250A
- One current transformer with two ratios and three secondaries 800-400/1-1-1A
- One withdrawable SF6 CB 1250A
- One busbar disconnector with earthing switch 1250A
- Voltage presence indicator for each cell
- Low voltage compartment with IED control and protection equipment in the front panel

Busbar Coupling will include:

- Two earthing switch 1250A
- One current transformer with two ratios and two secondaries 800-400/1-1A
- One withdrawable SF6 CB 1250A
- Two busbars’ disconnectors with earthing switch 1250A
- Low voltage compartments with IED control and protection equipment in the front panel

Measurement cubicle will include:

- One voltage transformer 33/√3 **/** 0,11/√3 **/** 0,11/√3 kV
- One earthing switch 1250A
- One fuse
- One busbar disconnector with earthing switch 1250A

Station service auxiliary transformer feeder will include:

- One earthing switch 630A
- One Fuse switch
- One busbar disconnector with earthing switch 630A
- Voltage presence indicator for each cell
- Low voltage compartment protection equipment in the front panel

MV room should be designed to allow future extension. The contractor should forecast all (actual need and future) MV cables entries to the 33kV switchgear and conduits for all LV cables and communication cables between MV room and other rooms inside control building.

Auxiliary AC and DC system

The 110VDC system supply should include:

- One 110VDC distribution board with two incoming sources,
- One 110VDC battery bank with minimum capacity of 250Ah,
- Two 400/230V redundant rectifiers/ 110VDC battery chargers,
- One 110VDC/ 230VAC dual inverter,

The 48VDC system supply should include:

- One 48VDC distribution board with two incoming sources,
- One 48VDC battery bank with minimum capacity of 100Ah,
- Two 400/230V redundant rectifiers/ 48VDC battery chargers,

The 400/230V AC system supply should include:

- One 400V AC main LV switchboard with three main input sources: source1, source2 and diesel generator with manual/automatic permutation between different sources
- One LV switchboard from each station services transformer,
- One AC control building LV sub-board
- LV outlets in the 33kV switchyard near each transformer

An emergency lighting system (110 VDC) shall be installed in the control building (control room, MV-room, LV-room, and telecommunication room).

A diesel generator set,100 kVA minimum shall be installed and connected to the 400V busbar feeding the essential services.

Protection system

For 33 kV feeders:

- One outgoing feeder with UGC 33 kV link to Padu
- One outgoing feeder with UGC 33 kV link to Geothermal
- Two transformers' feeders 33/2.2 kV 4 MVA
- One Busbar coupling feeder
- Two auxiliary transformer 33/0.4 kV 100 kVA feeders.

Types of feeders	ANSI functions 33 kV Trafalgar		
	main	Back up	common
Line feeder (UGC link 33)	Fn 87L: line differential	Fn 50/51 50N 51N 49	Events recorder power metering
33/2.2kV Transformer feeder	Fn 87T: Transformer differential Fn 49: current overload.	Buchholz relay wiring heating probe. Fn 67/ 67N: directional over current (to the busbar protection)	Events recorder
Auxiliary feeder (Transformer 33/0.4 kV link)	Fn 49: current overload.		Events recorder
Busbar coupling	Fn 50/51		Events recorder

Table 2: ANSI Functions for 33kV level protection Trafalgar SS

Metering

Energy metering devices should be installed on each MV feeders and each auxiliary sources for AC switchboard.

All revenue meters shall be of programmable microprocessor based digital type, offering outstanding measurement accuracy and reliability, communication capability, event storage, suitable for operating in harsh environment.

Cables

The contractor should provide and connect complete cabling including mainly:

- 33kV XLPE single core cables from the 33kV switchgear up to the 33/2.2kV transformers and 33/0.4kV auxiliary transformers;
- 2.2kV XLPE single core cables from the existing 2.2kV switchgear up to the 33/2.2kV transformers.
- Low voltage cables for AC/DC control, signaling, lighting, LV power consumers etc. including all accessories as required for the project.

All requested technical requirements including cross section (defined as per energy to be transmitted) for MV cables are detailed in Guaranteed Technical Data tables in annexes of this document. A calculation note for 33kV and 2.2kV cables must be elaborated to confirm the choice of cross section and ability to transit the requested energy while applying all derating factors (ground temperature, ground thermal resistivity, depth of laying, buried,…)

Substation Control and Monitoring system (SCMS)

A Control and Monitoring System (SCMS) shall be installed in the new building. This control system will take into account the new installations:

- Transformers
- Incoming feeders
- Outgoing feeders
- Bus Bars
- Measurements
- Service auxiliary transformers
- Auxiliaries section and substation alarms.

The composition of each SCMS unit will be in accordance with the technical specifications in section “Substation Control and Monitoring System (SCMS)” below. The communication protocol between the relays shall be in accordance with the IEC 61850 standard. The Ethernet network shall be 100/1000 Mbps and shall use manageable Ethernet switches equipped with electrical and optical ports to interconnect all the equipment in the system.

The system will also ensure the dialogue with the protections of the new 33 kV lines, 2.2/33 kV transformer and 33 kV feeders.

The architecture drawing of Trafalgar substation SCMS is provided in Annex A3-3.

Telecom System

The telecommunication equipment for the Trafalgar substation shall include:

- Supply and installation of Fiber Optic Access Cables (FOAC) including all trenching, protection pipes, civil works, cable trays etc for the safe and proper installation of the cables from the FO joint boxes at the entry of the feeder to the ODF at the substation communication room. FO connection must be established to Trafalgar power plant also.
- Supply and installation of suitable Optical Distribution Frames (ODF) / patch panel with single mode pig tail terminations at the control building
- SDH Broadgate terminal and multiplex equipment, Redundant Power Supply Module, Redundant control board, PCM access multiplexer, digital comfort telephone set, any other necessary equipment to establish communication between all substation networks.

The Bidder shall supply all cabling, accessories and services required for proper operation of the telecommunication equipment at the substation as well as the integration into the overall telecommunication system.

3.2 Specific Works information for Hydroelectric power station of Padu – 33/11 kV

3.2.1 Localization

Substation	Geographical Coordinates	
	N	W
33/11 kV Padu substation	15°19'14.54"N	61°21'5.58"W

Table 3: Localization of the Padu substation 33/11 kV

3.2.2 Scope of supply

The Contract scope of works for the new 33/11kV Padu substation is the design, construction, supply, installation, connection, testing, pre-commissioning and final commissioning of all civil and electrical works, as well as the provision of drawings and documentation and any other requirements as defined in this specification.

The overall deliverables, at site, for this substation are:

Primary plant systems

- Two (02) 33/11kV 3,5MVA power transformers
- Two (02) 11kV earthing transformers connected directly to secondaries of power transformers 33/11kV,
- Two (02) 33/0.4kV 100kVA auxiliary transformers,
- 33kV Metal-clad Switchgear:
    - One (01) 33 kV single busbar in one circuit breaker arrangement,
    - One (01) 33 kV busbar coupling cabinet,
    - Two (02) 33 kV measurement cabinets,
    - Two (02) 33 kV outgoing feeders to Fond Cole SS and Trafalgar SS,
    - Two (02) 33 kV incoming transformer feeders,
    - Two (02) 33/0.4 kV auxiliary transformers feeders: auxiliary power supply for substation
- Existing 11kV Switchgear:
    - Repurposing of two existing outgoing feeders PFI and TPI to be able to transit power between 33kV and 11kV busbars.
- All 33kV and 11kV underground power cables inside the substation with their cables terminations (both extremities) and all necessary accessories. The 11kV MV cells already exists in the Padu power plant side, However the substation contractor will be responsible for supplying, installing, testing and commissioning of all necessary cables with terminations and accessories to make the connection from power transformers till these existing 11kV cells.

  33kV UGC coming from Fond Cole and Trafalgar SS will be pulled and connected to 33kV switchgear (Fond Cole and Trafalgar Feeders) providing cable terminations. The contractor will provide the necessary cable trays for cable rising until 33kV cabinets.

  All requested technical requirements including cross section (defined as per energy to be transmitted) for MV cables are detailed in Guaranteed Technical Data tables in annexes of this document. A calculation note for 33kV and 11kV must be elaborated to confirm the choice of cross section and ability to transit the requested energy while applying all derating factors (ground temperature, ground thermal resistivity, depth of laying, buried,…)
- Earthing system including buried earth grid with earth connection and lightning protection system for switchyard (lightning mast and overhead ground wire) and control building lightning protection equipment.
- All rails for transformers, cable supports inside cable trenches,

- All site structures including concrete works, support structures, fencing, gates, exterior lighting
- All equipment needed inside control building: air conditioning equipment, fire detection system, lighting and sockets, camera supervision system, office room equipment, operators' desks, sanitary equipment, kitchen equipment,…

Secondary systems within the control building

- Protection and control cubicles including IED/protection relays for each bay (with all necessary software installation setup and licenses),
- Common alarm panel including RTU,
- SCADA system with local HMI and remote control (with all necessary software installation setup and licenses),
- Telecommunication equipment in a dedicated cubicle and establish communication with adjacent sites (with all necessary software installation setup and licenses). A FO connection must be established to Trafalgar power plant.
- Metering equipment in a dedicated cubicle (with all necessary software installation setup and licenses),
- DC supplies including one 110VDC supply system (one 110VDC distribution board, one 110VDC battery bank, two 110VDC battery chargers) and one 48VDC supply system (one 48VDC distribution board, one 48VDC battery bank, two 48VDC battery chargers),
- AC 400/230V supplies including one 400VAC main LV switchboard (with three main input sources: source1, source2 and diesel generator with manual/automatic permutation between different sources, one LV switchboard from each station services transformer, one AC control building LV sub-board and LV outlets in the transformers area,
- Indoor and outdoor lighting and sockets,
- Diesel Generator of 100kVA
- Secondary wiring including LV and control cabling, inter-panel wiring, cable racks, trays and support brackets,
- Miscellaneous
    - Outdoor junction or marshalling boxes,
    - Nameplates,
    - Operational advisory signs, equipment labels, and equipment danger labels,
    - Any equipment needed to interface with the Padu power plant electrical equipment and SCADA system,
    - Offices at site with air conditioner, electricity and water supplies and sanitary room during construction phase.
    - Any other essential equipment not mentioned above.

3.2.3 Scope of construction works

The construction scope of work to be performed by the Contractor consist of:

Electrical construction works

- Installation of buried earth grid with earthing pits and earth connections of all equipment,
- Installation and connection of lightning protection equipment for outdoor switchyard and control building,
- Repurposing of two feeders TPI and FPI in the existing 11kV switchgear to allow their use as incoming feeders for the two new transformers 33/11kV (Current transformers, LV adaptation including protection relay, cabling, interlocks,…)
- Installation and connection of two new transformers 33/11KV, 3,5MVA connected to the new 33kV switchgear and to the existing 11KV switchgear,
- Installation and connection of Two 33/0.4kV 100kVA auxiliary transformers,
- Installation and connection of two earthing 11kV transformers
- Installation and connection of 100kVA Diesel Generator,
- Installation and connection of 33kV metal-clad switchgear,
- Pulling and connection of all 33kV and 11kV power cables, LV power and control cables inside substation,

  33kV UGC coming from Fond Cole and Trafalgar SS will be pulled and connected to 33kV switchgear (Fond Cole and Trafalgar Feeders) providing cable terminations. The contractor will provide the necessary cable trays for cable rising until 33kV cabinets.
- Pulling and connection, from both sides, of all interface power and control cables to Padu power plant equipment,
- Pulling and splicing (on ODFs) of FO cable from substation to power plant telecom room,
- Installation and connection of all protection and control cabinets, AC and DC switchboards, Batteries, Chargers, Inverter and SCADA system,
- Installation and connection of all indoor and outdoor lighting and sockets,
- Connection of substation and power plant earthing grid,
- Testing and commissioning of the whole substation equipment (locally and remotely from remote engineering workstation at Fond Cole).

Civil construction works

- Soil investigations
- All earthworks including cutting and filling. Cut and fill volume calculation according to the results contractor’s investigations,
- Construction of all outdoor equipment foundations and transformers foundations with oil collecting pits,
- Build firewalls that surround the two transformers from 3 sides with a minimal thickness of 0.3m
- Construction of heavy railed road for the transformer transportation operations,
- Construction of duct banks / cable trench with covers for all the 33kV and 11kV power cables and LV power and control cables. Different voltage level cables should never be placed in the same duct. The contractor must provide a detailed calculation note and a relative ducts layout for approval. Ducts for

33kV power cables for outgoing TPI and PFI feeders must be extended from 33kV switchgear to one meter outside the substation (with manholes for cable pulling). A new LV power and control covered cable trench must be constructed from new control building till the existing LV cable trench in the Padu power plant.

- Construction of transformer tanks below the transformer that will have a capacity to contain 1.5*total oil volume of the transformer minimum,
- Construction of Control building with a minimal surface of 155m², including a control and protection room, MV cells room, Batteries room, AC/DC auxiliary room, Telecom room, warehouse, office room, sanitary room, kitchen and outdoor location for station auxiliary transformer. This building must be connected to electricity and water supplies and connected to sewage system if exists otherwise provide other alternative. Details are in annex A3-4 of this document. In addition, the finishing work must be also considered as Plastering, painting, tiling, waterproofing, etc…
- Construction of a basement under MV room for MV cables entry
- Construction of roads, pavement, drainage system, fences, gravels surfacing of the substation area, landscaping and levelling.
- Ensuring a drainage system and all the necessary access roads for the substation
- The concrete in contact with backfilling must be protected according to a detailed procedure submitted by the contractor and approved by the Project Owner.
- Access to the substation must be segregated from the power plant by fence, door locking.
- Construction of duct banks / cable trench for the 33, 11 kV cables that must be totally separated. The contractor must provide a detailed calculation note and a relative layout for approval.
- Ensuring a water supply system, exterior and interior lighting, drainage system, and all the necessary access roads for the Padu substation

For all the ducts/trench that link the substation to its outside limit, the responsible contractor for carrying out the work at Padu substation must ensure the arrival of these duct banks/ trenches, (with all the necessary equipment, accessories, and ducts, + adequate closure), up to 1 m outside the boundary of the fence, to ensure that the ducts and the built structures are well secured and closed until the time of connection.

N.B.: In case of passage by cable trench, the cables will not be placed directly on concrete bases, cable trays must be used where each one should not contain > 3 cables beds, and 30 % of the cable trench must be free for future extension.

3.2.4 Scope of design works

The Contractor must also provide supporting documentation, calculations, system studies, drawings, descriptions, manuals, quality control systems, progress reports and meetings with the project owner representative as set out in this Specification. Required supporting documentations may include but is not limited to the following:

- Earth Grid Study Report detailing Step and Touch Potentials for the site,
- Insulation Co-ordination Study,
- Protection relays settings and selectivity study,

- MV Cable Rating Study,
- Soil Resistivity Test Results,
- Soil Thermal Resistivity Test Results,
- Lightning Protection Study,
- DC Systems Requirement Study,
- AC Systems Requirement Study,
- Lighting Study Report (Indoor & Outdoor),
- Geotech Survey,
- All Site Surveying work,
- All needed drawings and calculation notes for electrical equipment and civil works dimensioning:
  - General arrangements (plan and elevation), layouts and sections drawings,
  - Metallic structures and footings drawings and calculation notes,
  - MV and LV equipment installation and connection drawings,
  - Earthing grid layout, calculation notes and detailed connection drawings,
  - Single line diagrams (protection and metering, SCADA, plant and Operations),
  - Switchgear panel general arrangements and schematics,
  - AC and DC supply general arrangements and schematics,
  - Measurement and Protection relays systems SLD and detailed drawings,
  - Developed schematics for all MV feeders and LV switchboards,
  - SCADA system drawings and Telecom equipment schematics,
  - All MV and LV cables and busbars sections calculation notes and fittings,
  - Cable schedules,
  - All drawings of any extension of the existing equipment,
  - Civil works detailed drawings and calculation notes: Foundation drawings, Cable duct/trench and conduit arrangement and elevation, Drainage plan,
  - Earthworks/pad design,
  - Control Building Design including Building Services Design,
  - Primary Plant Schedule for Procurement (8 weeks from date of Contract award).

The Contractor must perform a site visit prior to undertaking detailed design in order to determine site-specific conditions. He should visit the project area and then starts the surveys, soil investigations, geotechnical studies, etc…

NB: The design should take into account a future extension of the MV switchgear by two feeders minimum.

3.2.4.1 Civil works design

The building will be divided respectively into 2 major zones, defined by the following:

- The control building

- The transformer zone.

For more details, please refer to the general layout in annex A3-4.

N.B.:

All the provided plans are indicatives, and the mentioned surfaces represent the minimum required areas.

Hence, the Contractor is responsible for making his own topographical, geotechnical, and magneto studies again, and then proposing his own substation layout for approval.

Control Building:

General:

The control building will have an area of 155 m2 minimum.

The building's level will be minimum at 0.6 m above the natural ground level.

A raised floor and a false ceiling will be placed all over the building surface except in the battery room.

A clear distance between the false ceiling and the false floor will be a minimum of 3.5 m.

Above the false ceiling and under the raised floor, a 50 cm minimum will take place, where the slab under the raised floor must be at a higher level than the level of the roadway.

N.B.: No detail design of the control building will be provided to the contractor, all the provided dimensions represent the minimum dimensions.

All the provided plans are indicative and should be considered as reference only. The contractor must conduct their own thorough investigations and studies from the beginning to design and construct the control building appropriately. Relying solely on the provided plans may not be sufficient, and it is essential for the contractor to take full responsibility for ensuring a comprehensive and accurate design that meets all project requirements.

Building dimensions:

The ground floor story, (h clear min=3.5 m between false ceiling and raised floor), will include the following:

- Batteries Room → 3.7*3 m2 minimum
- AC/DC & Charger room →3.7*3 m2 minimum
- Telecom room → 4.8*1.8 m2 minimum
- Control and protection room → 3.5*4.8 m2 minimum
- Kitchenette + Rest room→ 2*5.5 m2 minimum
- MV Room → 9.7*6 m2 minimum + Basement with a minimum clear height = 2.1 m.
- In addition, a surface will be reserved for the installation of a Station Services Transformer 33/0.4 KV → 3.3*2.5 m2 minimum

Foundations:

The foundations of the control building can be isolated, strap, or raft foundations, and must be founded in the natural ground.

The contractor is responsible to choose the types of foundations and their relative bottom level, according to the results of his geotechnical investigations, and he should submit a detailed calculation note for approval.

These foundations will be placed on a lean concrete surface with a minimum thickness of 0.1 m.

Backfilling is carried out with maximum thickness layers of 15 cm, which will be compacted and tested in accordance with specifications. The required compaction is 98% OPM.

for more details, please refer to the relative plans in the Annex A3-4of this document

Transformer zone:

For the transformer foundation, a raft foundation is recommended, but the contractor is responsible to choose the best type according to the results of his geotechnical investigations and should submit a detailed relative calculation note to the Employer for approval.

These foundations will be based on natural ground level and on a surface of lean concrete with a minimum thickness of 10 cm.

A concrete screed will take place above this foundation with a slope of 1cm/m.

A grating will be placed above this screed to facilitate circulation.

The used grating could be either fire resistant or hot deep galvanized as mentioned in the general technical specifications section of this document.

The rails will be placed on two concrete beams below the transformer. These rails will be extended to the heavy road.

The concrete must be protected from the inside of the transformer oil pits (where the oil will accumulate) with epoxy paint or equivalent. This paint must resist hot oil in order to be waterproof, and in order to block oil infiltration

The capacity of the transformer oil pit will be at least 1.5 * the total volume of the transformer.

The walls that surround the transformer oil pit must have a fire resistance of 4 hours minimum.

For more details, please refer to the relative plans in the appendix of this document

Finishing and other complementary works:

<u>The Contractor must be responsible for the following complementary activities without being limited to:</u>

- Ensure the adequacy of the drainage system in order to avoid any risk of water infiltration inside the building.
- Separate the wastewater discharge pipe and direct it outside of the building to avoid any risk of infiltration inside the building.
- Supply and connection of sanitary equipment
- Supply and connection of interior and exterior lighting and outdoor socket box
- Supply and connection of the lightning protection system
- Supply and connection of the air conditioning system
- False Ceiling in control room, protection room, telecom room, MV room, AC/DC charger room will be installed
- Raised Floor in control room, protection room, telecom room, MV room, AC/DC charger room will be installed
- Super caoutchouc smooth plastering and painting should be used on all walls and roof surfaces except of the battery room, where **anti-acid** plastering, painting and tiling must be used. The masonry blockwork must be plastered and covered by Super caoutchouc smooth plastering (2 layers) with elasticity which is crucial to ensure the building's durability. Plastering thickness must be 2 cm minimum.
- Epoxy painting must be used for the floors of the MV cells room
- For all remaining floors, anti-slip tiling must be used
- Installation of a septic tank after having all necessary approvals and authorizations, and it should respect the country's norms and standards. It must comply with regulations with a capacity up to 15 people.
- The walls and the floors of WCs must be of ceramic tiling
- A gallon of hot water 50 L must be provided on site with all the relative mechanical and electrical protections, with respect to the norms and standards.
- Regarding the stairs' tiling, if it exists it must cover a minimum of 1.5 m of the height of the adjacent wall.

Roof:

The Contractor's services must include:

- The construction of a concrete slab with a slope for the recovery of rainwater
- Waterproofing
- The realization of the parapets all around the roof's edges
- The rainwater drainage pipes must be placed outside the building to avoid any risk of water infiltration inside the substation

  The contractor must submit for approval a detailed calculation notes for the quantification and the sizing of these ducts.
- The roof drainage should be integrated with manholes, featuring an overflow positioned 20 cm above the roof slab. (Manholes are to be strategically placed at each drain change of direction)
- The roof access must be provided for maintenance operations by crinoline ladders.

Carpentry

Services will include at minimum the following items that may change in terms of size and quantities according to the client request and the new substation layout that must be provided by the contractor for approval:

- The supply, and installation of the following fire doors:
  - SIMPLE LEAF 90*240 minimum → (Quantity = 3 minimum)
  - DOUBLE LEAF 1.5*2.4 minimum → (Quantity = 5 minimum)
- The supply, and installation of the following wooden door:

  wooden door (2.4*0.7 minimum) → (Quantity = 2 minimum)
- The supply, and installation of the following windows:
  - Glaze window 1*0.8 minimum → (Quantity = 2 minimum)
  - Glaze window 2*2 minimum → (Quantity = 1)
  - Glaze window 0.6*0.6 minimum → (Quantity = 3 minimum)

Drainage system:

The Contractor must submit for approval a detailed calculation notes that concerns the necessary rainwater drainage pipes for the new substation, considering the water flow during the heaviest rains over a return period of 10 years.

The contractor is responsible to choose the substation’s level that avoids any future possible risk of flooding.

Thus, he should install a drainage system all around and inside the substations that must be connected to the nearest existing rainwater drainage system to avoid all these possible risks.

The road drainage will be oriented from one side with a suitable slope.

The proposed solution must take into account the cleaning and maintenance needs.

Surfaces management and access roads:

Access to the substation must be segregated from the power plant by fence, door locking.

From the north side of the substation, a retaining wall will be erected just at the limit of the heavy railed road with a minimal thickness of 0.3 m,

Heavy railed road must be designed to support a minimum capacity of (16t/axle).

For the other free surfaces, they will be in accordance with the plans provided in the Annex A3-4of this document.

The Contractor is responsible for creating all the necessary access for the working zone.

In addition, the contractor must submit a detailed calculation note showing the Cut and Fill quantities according to his own topographical survey.

Please refer to the relative plans provided in the Annex A3-4 of this document.

Fences and gates:

We can define two different types for fences:

1. Prefabricated concrete columns every 2 meters + isolated reinforced concrete foundation + mesh fencing 5x5 + semi-buried pallet-board + barbed wire (the height must be no less than 2.5 meters): This type of fence will be used to demarcate the substation from the DOMELEC site.

2. Reinforced concrete columns every 2.5 meters + isolated reinforced concrete foundations + masonry blocks + plastering + barbed wire (the height must also be no less than 2.5 meters): This type of fence will be used to separate the substation from neighboring areas or roads.

Please refer to the Annex A3-4 *for more details.*

Exterior and interior lighting

The Contractor is responsible for the supply and installation of a sufficient exterior and interior lighting system.

He should use the latest lighting technology which saves energy and protects the environment, (LED technology or equivalent)

In addition, he should provide for approval a detailed calculation notes showing the minimum degree of illuminance that must be provided in each room of the buildings and at the level of the exterior area.

He is responsible for the following activities:

- Supply and connection of exterior and interior lighting and socket box
- Supply and connection of the lightning protection system.

Water supply

The contractor should provide a detailed calculation note that concerns an adequate and sufficient water supply system for the Padu substation 33/11 kV.

The Contractor is responsible to install a water distribution system to supply the control building facilities such as:

- The sanitary facilities
- The eyewash in the battery rooms
- Etc…

An overhead water tank with a minimum capacity of 1000L will be installed.

Duct banks:

The Contractor is responsible for the construction of all the necessary duct bank and cable trench for the cables (33kV and 11kV) that must be placed separately.

A detailed inventory of the existing gutters shall be made before and after the work's execution, and in case of any noticed deterioration, the contractor will be responsible for all necessary restoration at his own expense.

All the duct bank / cable trenches are clearly represented on the relative plan of the Padu substation, in the Annex A3-4 of this document, that should be considered as an indicative layout and the contractor must provide his own layout for approval.

3.2.4.2 Electrical design

SLD

The new Padu substation under this contract will consist of the 33/11kV switchgear as described (see also the respective SLD on Annex A3-5)

The substation consists of a new 33KV switchgear which will be installed inside MV room keeping space for one future MV cubicles minimum. Two power transformers will be installed in the switchyard in addition to the station services auxiliary transformers near the control building. Two earthing 11kV transformers should be connected to 33/11kV transformers.

The design shall be prepared considering the possibility to allow an easy extension in the future without any relocation of any equipment. Thus, cable ducts, openings, civil works, building works, arrangement of all secondary equipment, etc shall be designed and prepared for the final stage. Single line, layout, section, building and other relevant drawings shall show the final extension of the substation.

Outdoor Medium voltage equipment

The contractor will supply and install:

- Two 33/11kV power transformers 3,5MVA YNd11 ONAN cooling, two winding transformers, with off-load tap-changer, including two current transformers on the primary side and one on the neutral grounding of the 33 kV winding,
- Two 33/0.4kV service auxiliary transformers 100kVA with current transformers for neutral grounding of 0.4 kV windings,
- Two 11kV earthing transformers zigzag winding, connected to 33/11kV transformers including one current transformer on the neutral grounding.

MV switchgear

The contractor will supply a complete 33kV Metal-clad Switchgear, indoor arrangement, and single busbar system with Rated Current Busbar 1600 A and Rated Short Circuit Withstand Current common for all equipment 25 kA (3 sec).

The switchgear will include:

- Two (02) 33 kV measurement cabinets,
- One (01) 33kV busbar coupling cabinet,
- Two (02) 33 kV outgoing feeder to Fond Cole and Trafalgar,
- Two (02) 33 kV incoming transformers feeders,
- Two (02) 33/0.4 kV Service auxiliary transformer feeders: auxiliary power supply for substation

Incoming feeder will include:

- One voltage transformer 33/√3 **/** 0,11/√3 **/** 0,11/√3 kV
- One earthing switch 1250A
- One current transformer with two ratios and three secondaries 200-100/1-1-1A
- One withdrawable SF6 CB 1250A
- One busbar disconnector with earthing switch 1250A
- Voltage presence indicator for each cell
- Low voltage compartment with IED control and protection equipment in the front panel

Outgoing feeder will include:

- One voltage transformer 33/√3 **/** 0,11/√3 **/** 0,11/√3 kV
- One earthing switch 1250A

- One current transformer with two ratios and three secondaries 800-400/1-1-1A
- One withdrawable SF6 CB 1250A
- One busbar disconnector with earthing switch 1250A
- Voltage presence indicator for each cell
- Low voltage compartment with IED control and protection equipment in the front panel

Busbar Coupling will include:

- Two earthing switch 1250A
- One current transformer with two ratios and two secondaries 800-400/1-1A
- One withdrawable SF6 CB 1250A
- Two busbar disconnectors with earthing switch 1250A
- Low voltage compartment with IED control and protection equipment in the front panel

Measurement cubicle will include:

- One voltage transformer 33/√3 **/** 0,11/√3 **/** 0,11/√3 kV
- One earthing switch 1250A
- One fuse
- One busbar disconnector with earthing switch 1250A

Station service auxiliary transformer feeder will include:

- One earthing switch 630A
- One Fuse switch
- One busbar disconnector with earthing switch 630A
- Voltage presence indicator for each cell
- Low voltage compartment protection equipment in the front panel

MV room should be designed to allow future extension. The contractor should forecast all (actual need and future) MV cables entries to the 33kV switchgear and conduits for all LV cables and communication cables between MV room and other rooms inside control building.

Repurposing of two existing 11kV outgoing feeders to be suitable for evacuating energy coming from new 33/11kV transformers (CT, protection relays, etc…)

Auxiliary AC and DC system

The 110VDC system supply should include:

- One 110VDC distribution board with two incoming sources,
- One 110VDC battery bank with minimum capacity of 250Ah,
- Two 400/230V redundant rectifiers/ 110VDC battery chargers,
- One 110VDC/ 230VAC dual inverter,

The 48VDC system supply should include:

- One 48VDC distribution board with two incoming sources,

- One 48VDC battery bank with minimum capacity of 100Ah,
- Two 400/230V redundant rectifiers/ 48VDC battery chargers,

The 400/230V AC system supply should include:

- One 400V AC main LV switchboard with three main input sources: source1, source2 and diesel generator with manual/automatic permutation between different sources
- One LV switchboard from each station services transformer,
- One AC control building LV sub-board
- LV outlets in the 33kV switchyard near each transformer

An emergency lighting system (110 VDC) shall be installed in the control building (control room, MV-room, LV-room and telecommunication room).

A diesel generator set,100 kVA minimum shall be installed and connected to the 400V busbar feeding the essential services.

Protection system

For 33 kV feeders.

There are:

- One outgoing feeder with UGC 33 kV link to Trafalgar
- One outgoing feeder with UGC 33 kV link to Fond Cole
- Two transformers feeders 33/11 kV 3.5 MVA
- One Busbar coupling feeder
- Two auxiliary transformers feeder 33/0.4 kV 100 kVA

Types of feeders	ANSI functions 33 kV Padu		
	main	Back up	common
Line feeder (ugc link 33kV)	Fn 87L: line differential	Fn 50/51 50N 51N 49	Event recorder power metering
33/11kV Transformer feeder	Fn 87T: Transformer differential Fn 49: current overload.	Buchholz relay wiring heating probe. Fn 67/ 67N: directional over current (to the busbar protection)	Event recorder
Auxiliary feeder (transformer 33/0.4 kV link)	Fn 49: current overload.		Event recorder
Busbar coupling feeder	Fn 50/51		Event recorder

Table 4: ANSI Functions for 33kV level protection Padu SS

Metering

Energy metering devices should be installed on each MV feeders and each auxiliary sources for AC switchboard.

All revenue meters shall be of programmable microprocessor based digital type, offering outstanding measurement accuracy and reliability, communication capability, event storage, suitable for operating in harsh environment.

Cables

The contractor should provide and connect complete cabling including mainly:

- 33kV XLPE single core cables from the 33kV switchgear up to the 33/11 kV transformers and 33/0.4kV auxiliary transformers;
- 11kV XLPE single core cables from the existing 11kV switchgear up to the 33/11kV transformers;
- 11kV XLPE single core cables from the 11 kV earthing transformers up to the 33/11kV transformers;
- Low voltage cables for AC/DC control, signaling, lighting, LV power consumers etc. including all accessories as required for the project.

All requested technical requirements including cross section (defined as per energy to be transmitted) for MV cables are detailed in Guaranteed Technical Data tables in annexes of this document. A calculation note for 33kV and 11kV must be elaborated to confirm the choice of cross section and ability to transit the requested energy while applying all derating factors (ground temperature, ground thermal resistivity, depth of laying, buried,…)

Substation Control and Monitoring system (SCMS)

A Control and Monitoring System (SCMS) shall be installed in the new building. This control system will take into account the new installations:

- Transformers
- Earthing transformers
- Incoming feeders
- Outgoing feeders
- Bus Bars
- Measurements
- Service auxiliary transformers
- Auxiliaries section and substation alarms.

The composition of each SCMS unit will be in accordance with the technical specifications in section “Substation Control and Monitoring System (SCMS)” below. The communication protocol between the relays shall be in accordance with the IEC 61850 standard. The Ethernet network shall be 100/1000 Mbps and shall use manageable Ethernet switches equipped with electrical and optical ports to interconnect all the equipment in the system.

The system will also ensure the dialogue with the protections of the new 33 kV lines, 33/11 kV transformers and 33 kV feeders.

The architecture drawing of Padu substation SCMS is provided in Annex A3-6.

Telecom System

The telecommunication equipment for the Trafalgar substation shall include:

Supply and installation of Fibre Optic Access Cables (FOAC) including all trenching, protection pipes, civil works, cable trays, etc, for the safe and proper installation of the cables from the FO joint boxes at the entry of the feeder to the ODF at the substation communication room. FO connection must be established to Trafalgar power plant also.

Supply and installation of suitable Optical Distribution Frames (ODF) / patch panel with single mode pig tail terminations at the control building

SDH Broadgate terminal and multiplex equipment, Redundant Power Supply Module, Redundant control board, PCM access multiplexer, digital comfort telephone set, any other necessary equipment to establish communication between all substation network.

The Bidder shall supply all cabling, accessories and services required for proper operation of the telecommunication equipment at the substation as well the integration into the overall telecommunication system.

3.3 Specific Works Information for Diesel power station of Fond Cole – 69/33/11 kV

3.3.1 Localization

Substation	Geographical Coordinates	
	N	W
69/33/11 kV Fond Cole substation	15°18'51.50"N	61°23'7.67"W

Table 5: Localization of the Fond Cole substation 69/33/11 kV

3.3.2 Scope of supply

The Contract scope of works for the new 69/33/11kV Fond Cole substation located in the premise of the Fond Cole power plant, is the design, construction, supply, installation, connection, testing, pre-commissioning and final commissioning of all civil and electrical works, as well as the provision of drawings and documentation and any other requirements as defined in this specification.

The overall deliverables, at site, for this substation are:

Primary plant systems

- GIS switchgear, composed of:
    - Double busbars 69kV switchgear in one circuit breaker arrangement,
    - One (01) Line bay to Geothermal SS
    - One (01) Line bay Spare (Future West Coast SS),
    - One (01) 69/11kV Transformer bay,
    - One (01) busbar coupler bay,
    - Two (02) busbar measurement,
    - One LCC for each bay,
    - Overhead crane for GIS compartments shifting inside GIS room,
- One (01) 69/11 kV 15 MVA power transformer

- Three 69kV (03) cables terminations with integrated three (03) surge arresters and their corresponding metallic supports on the 69kV side of the power transformer.
- One (01) 33/11 kV 20 MVA power transformer
- Two (02) 11/0.4kV 160 kVA auxiliary transformers
- Two (02) 11kV earthing transformers connected directly to the secondary of respectively to 69/11kV and 33/11kV power transformers.
- 33kV metal-clad Switchgear :
    - One (01) 33 kV single busbar in one circuit breaker arrangement,
    - One (01) 33 kV measurement cabinet,
    - One (01) 33 kV outgoing feeder to Padu,
    - One (01) 33 kV incoming transformer feeder,
- 11kV metal-clad Switchgear :
    - One (01) 11 kV single busbar in one circuit breaker arrangement,
    - One (01) 11kV busbar coupling cabinet,
    - Two (02) 11 kV measurement cabinets,
    - Four (04) 11 kV outgoing feeders,
    - Two (02) 11 kV incoming transformer feeders,
    - Two (02) 11 kV incoming High speed generators feeders,
    - One (01) 11 kV incoming feeder to connect existing 11kV switchgear busbar,
    - Two (02) 11/0.4 kV auxiliary transformers feeders: auxiliary power supply for substation.
- Repurposing of one cabinet of the existing 11kV Switchgear :
    - Repurposing of an existing 11 kV cell to connect existing 11kV busbar to the new 11kV switchgear busbar including all necessary protection relay, accessories, LV wiring adaptation and any other necessary equipment.
- All 69kV, 33kV and 11kV underground power cables inside the substation with their cable's terminations (both extremities) and all necessary accessories. The substation contractor will be responsible for supplying, installing, testing and commissioning of all necessary cables with terminations and accessories to make the connection from:
    - Primary and secondary sides of 69/11kV and 33/11kV power transformers to GIS and MV rooms,
    - Earthing transformers to the secondary side of each power transformer,
    - Station services transformer to 11kV switchgear,
    - Existing 11kV switchgear in the power plant to new 11kV switchgear,
    - Outgoing feeders cabinets, from 11kV switchgear, to the first pole/ or 1m outside the substation.

69kV and 33kV UGC coming from Geothermal and Padu SS will be pulled and connected respectively to 69kV GIS (Geothermal bay) and 33kV switchgear (Padu Feeder) providing cable terminations. The contractor will provide the necessary cable trays for cable rising until 69kV GIS and 33kV cabinet.

All requested technical requirements including cross section (defined as per energy to be transmitted) for HV and MV cables are detailed in Guaranteed Technical Data tables in annexes of this document. A calculation note for 69kV, 33kV and 11kV must be elaborated to confirm the choice of cross section and ability to transit the requested energy while applying all derating factors (ground temperature, ground thermal resistivity, depth of laying, buried,…)

- Earthing system including buried earth grid with earth connection and lightning protection sytem for switchyard (lightning mast and overhead ground wire) and control building lightning protection equipment.
- All anchor bolts for equipment foundations, rails for transformers, cable supports inside cable trenches,
- All site structures including concrete works, support structures, fencing, gates, exterior lighting
- All equipment needed inside control building: air conditioning equipment, fire detection system, lighting and sockets, camera supervision system, office room equipment, operators desks, sanitary equipment, kitchen equipment,…

Secondary systems within the control building

- Protection and control cubicles including BCU and protection relays for each bay (with all necessary software installation setup and licenses),
- Common alarm panel including RTU,
- SCADA system with local HMI and remote control (with all necessary software installation setup and licenses),
- Telecommunication equipment in a dedicated cubicle and establish communication with adjacent sites (with all necessary software installation setup and licenses). A FO connection must be established to Fond Cole power plant and to location of remote-control workstation for substations,
- Metering equipment in a dedicated cubicle (with all necessary software installation setup and licenses),
- DC supplies including one 110VDC supply system (one 110VDC distribution board, one 110VDC battery bank, two 110VDC battery chargers) and one 48VDC supply system (one 48VDC distribution board, one 48VDC battery bank, two 48VDC battery chargers),
- AC 400/230V supplies including one 400VAC main LV switchboard (with three main input sources: source1, source2 and diesel generator with manual/automatic permutation between different sources, one LV switchboard from each station services transformer, one AC control building LV sub-board and LV outlets in the 69kV switchyard,
- Indoor and outdoor lighting and sockets,
- Diesel Generator of 100kVA
- Secondary wiring including LV and control cabling, inter-panel wiring, cable racks, trays and support brackets,
- Miscellaneous:
  - Outdoor junction or marshalling boxes,
  - Nameplates,
  - Operational advisory signs, equipment labels, and equipment danger labels,
  - Any equipment needed to interface with the Sugar Loaf power plant electrical equipment and SCADA system,

- Offices at site with air conditioner, electricity and water supplies and sanitary room during construction phase.
- Any other essential equipment not mentioned above.

3.3.3 Scope of construction works

The construction scope of work to be performed by the Contractor consist of:

Electrical construction works

- Installation of double busbar 69kV GIS switchgear: Two Line bays to Geothermal and Future West Coast substations, One 69/11kV Transformer bay, One busbar coupler bay, Two busbar measurement
- Installation of all metallic structures anchored to their concrete foundations,
- Installation of buried earth grid with earthing pits and earth connections of all equipment,
- Installation and connection of lightning protection equipment for outdoor switchyard and control building,
- Installation and connection of a new transformer 69/11KV, 15MVA connected to the new 11kV switchgear,
- Installation and connection of three 69kV (03) cables terminations with integrated three (03) surge arresters and their corresponding metallic supports on the 69kV side of the power transformer.
- Installation and connection of a new transformer 33/11KV, 20MVA connected to new 33kV and 11KV switchgears,
- Installation and connection of two new 11kV earthing transformers connected directly to the secondaries of 69/11kV and 33/11kV power transformers,
- Installation and connection of two 11/0.4kV 160kVA auxiliary transformers connected to the new 11KV switchgear,
- Installation and connection of 100kVA Diesel Generator,
- Repurposing of an existing cabinet in the existing 11kV switchgear to allow connection to the new 11kV switchgear,
- Pulling and connection of all 69kV, 33kV and 11kV power cables, ground wire and LV power and control cables inside substation and till existing Fond Cole power plant. 69kV cable should be connected from GIS (with Plug-In SF6 gas sealing end) to power transformers (outdoor cold shrinkable cable termination).

  69kV and 33kV UGC coming from Geothermal and Padu SS will be pulled and connected respectively to 69kV GIS (Geothermal bay) and 33kV switchgear (Padu Feeder) providing cable terminations. The contractor will provide the necessary cable trays for cable rising until 69kV GIS and 33kV cabinet.
- Pulling and connection, from both sides, of all interface power and control cables to Fond Cole power plant equipment,
- Pulling and splicing (on ODFs) of FO cable from substation to power plant telecom room and to remote control workstation at Fond Cole,

- Installation of all protection and control cabinets, AC and DC switchboards, Batteries, Chargers, Inverter and SCADA system,
- Installation and connection of all indoor and outdoor lighting and sockets,
- Connection of substation and power plant earthing grid,
- Testing and commissioning of the whole substation equipment including the extension of the existing 11kV switchgear (localy and remotely from remote engineering workstation at Fond Cole).

Civil construction works

- All earthworks including cutting and filling. Cut and fill volume calculation according to the results contractor's investigations,
- The construction of retaining walls at the north (with piles or any other retaining method), and another one at the south side of the substation with a minimal thickness of 0.3 m
- The realization of all the necessary openings for the cable passages in the basement
- Construction of all outdoor equipment foundations and transformers foundations with oil collecting pits,
- Build firewalls that surround the two transformers from 3 sides with a minimal thickness of 0.3m
- Construction of heavy railed road for the transformer transportation operations,
- Construction of duct banks / cable trench with covers for all the 69kV, 33kV and 11 kV power cables and LV power and control cables. Different voltage level cables should never be placed in the same duct. The contractor must provide a detailed calculation note and a relative ducts layout for approval. Duct for the 69kV GFI and 33kV PFI underground cables must be extended from the cable's termination of Fond Cole substation till 1m outside the relative fencing limit (with manholes for cable pulling). Duct for 11kV outgoing feeders must be extended from the 11kV switchgear till 1m/or first pole outside the relative fencing limit (with manholes for cable pulling). New Ducts for 11kV underground cables must be done from new 11kV switchgear till the existing 11kV switchgear (in power plant). A new LV power and control covered cable trench must be constructed from new control building till the entry of an existing LV cable trench in the Fond Cole power plant.
- Construction of transformer tanks below each of the installed transformers with an oil separator system
- The construction of a new building that will include 3 sub-buildings separated in between by construction joints, represented in yellow on the plans of the Annex A3-7 of this document. These sub-buildings are respectively the GIS building, the Transformers zone, and the control building. The Control building includes a control and protection room, MV cells room, Batteries room, AC/DC auxiliary room, Telecom room, warehouse, office room, sanitary room, kitchen and outdoor location for station auxiliary transformer. This building must be connected to electricity and water supplies and connected to sewage system if exists otherwise provide other alternative.
- Construction of a basement under MV room for MV cables entry
- Construction of roads, pavement, drainage system, fences, gravels surfacing of the substation area,
- Ensuring a drainage system and all the necessary access roads for the substation
- Ensuring a water supply system, exterior and interior lighting, drainage system, and all the necessary access roads for the substation

- The existing 11 kV switchgear must be extended to be interconnected with the new 11 kV switchgear located in the new building part of this new project.
- **The access** to the substation must be segregated from the power plant by a fence and a door locking.
- The concrete in contact with backfilling must be protected according to a detailed procedure submitted by the contractor and approved by the Project Owner.

For all the ducts/trench that link the substation to its outside limit, the responsible contractor for carrying out the work at the Fond Cole substation must ensure the arrival of these duct banks/ trenches, (with all the necessary equipment, accessories, and ducts, + adequate closure), up to 1 m outside the boundary of the fence, to ensure that the ducts and the built structures are well secured and closed until the time of connection.

N.B.: In case of passage by cable trench, the cables will not be placed directly on concrete bases, cable trays must be used where each one should not contain > 3 cables beds, and 30 % of the cable trench must be free for future extension.

N.B.: Some 11 kV poles and a fire hydrant will be displaced before starting the construction of the new building, (Employer Scope).

3.3.4 Scope of design works

The Contractor must also provide supporting documentation, calculations, system studies, drawings, descriptions, manuals, quality control systems, progress reports and meetings with the project owner representative as set out in this Specification. Required supporting documentations may include but is not limited to the following:

- Earth Grid Study Report detailing Step and Touch Potentials for the site,
- Insulation Co-ordination Study,
- HV and MV Cable Rating Study,
- Protection relays settings and selectivity study,
- Soil Resistivity Test Results,
- Soil Thermal Resistivity Test Results,
- Lightning Protection Study,
- DC Systems Requirement Study,
- AC Systems Requirement Study,
- Lighting Study Report (Indoor & Outdoor),
- Geotech Survey,
- All Site Surveying work,
- All needed drawings and calculation notes for electrical equipment and civil works dimensioning:
    - General arrangements (plan and elevation), layouts and sections drawings
    - Metallic structures and footings drawings and calculation notes
    - HV, MV and LV equipment installation and connection drawings

- Earthing grid layout, calculation notes and detailed connection drawings
- Single line diagrams (protection and metering, SCADA, plant and Operations)
- Switchgear panel general arrangements and schematics
- AC and DC supply general arrangements and schematics
- Measurement and Protection relays systems SLD and detailed drawings
- Developed schematics for all HV bays, MV feeders and LV switchboards.
- SCADA system drawings and Telecom equipment schematics.
- All HV, MV and LV cables and busbars sections calculation notes and fittings.
- Cable schedules
- All drawings of any extension of the existing equipment,
- Civil works detailed drawings and calculation notes: Foundation drawings, Cable duct/trench and conduit arrangement and elevation, Drainage plan,
- Earthworks/pad design
- Control Building Design including Building Services Design
- Primary Plant Schedule for Procurement (8 weeks from date of Contract award)

The Contractor must perform a site visit prior to undertaking detailed design in order to determine site-specific conditions. He should visit the project area and then starts the surveys, soil investigations, geotechnical studies, etc…

NB: The design should take into account a minimum future extension (without outage) of the 69 kV GIS switchgear by two more line bays and sufficient space for minimum future extension of 33kV switchgear (one busbar coupler, two feeders and one measurement cabinet) and 11kV switchgear (two feeders).

3.3.4.1 Civil works design

The building will be divided respectively into 3 major sub-building, defined by the following:

- The control building
- The GIS building
- The transformer zone.

These 3 zones will be separated in between by a construction joint as shown in the plans of the Annex A3-7 of this document

N.B.:

All the provided plans are indicatives, and the mentioned surfaces represent the minimum required areas.

Hence, the Contractor is responsible for making his own topographical, geotechnical, and magneto studies again, and then proposing his own substation layout for approval.

Control Building:

General:

The control building consists of a 2-story building, with an area of (9*14.5 m2) minimum.

The building’s level will be minimum at 0.6 m above the natural ground level.

A raised floor and a false ceiling will be placed all over the building surface except in the battery room.

A clear distance between the false ceiling and the false floor will be a minimum of 3.5 m.

Above the false ceiling and under the raised floor, a 50 cm minimum will take place, where the slab under the raised floor must be at a higher level than the level of the roadway.

N.B.: No detail design of the control building will be provided to the contractor, all the provided dimensions represent the minimum dimensions.

All the provided plans are indicative and should be considered as reference only. The contractor must conduct their own thorough investigations and studies from the beginning to design and construct the control building appropriately. Relying solely on the provided plans may not be sufficient, and it is essential for the contractor to take full responsibility for ensuring a comprehensive and accurate design that meets all project requirements.

Ground Floor:

The ground floor story, (h clear min=3.5 m), will include the following;

- MV Room 11 KV → 8*8.5 m2, minimum
- MV Room 33 KV → 6.6*6.6 m2, minimum
- Stairs with a base level of 0.6 m → 5 *1.5 m2, minimum
- In addition an outside zone must be reserved for the installation of the Station service Transformer 11/0.4 KV → 2.8*2.7 m2, minimum

First Floor:

The first floor (h min=4.1 m), will include the following:

- Telecom room → 3.5*2.8 m2, minimum
- AC/DC & Charger room →3.5*2.7 m2, minimum
- Batteries Room → 3.5*2.55 m2, minimum
- Control and protection room → 3.9*7.3 m2, minimum
- Office room → 3.35*3.9 m2, minimum
- Kitchenette → 3.35*2 m2, minimum
- Rest room → 3.35*2.2 m2, minimum
- Stairs with a base level of 4.7 m → 7 *1.5 m2, minimum

Foundations:

The foundations of the control building can be isolated, strap, or raft foundations, and must be founded in the natural ground.

The contractor is responsible to choose the types of foundations and their relative bottom level, according to the results of his geotechnical investigations, and he should submit a detailed calculation note for approval.

These foundations will be placed on a lean concrete surface with a minimum thickness of 0.1 m.

Backfilling is carried out with maximum thickness layers of 15 cm, which will be compacted and tested in accordance with specifications. The required compaction is 98% OPM.

For more details, please refer to the relative plans in the Annex A3-7 of this document

GIS Building:

<u>General:</u>

The GIS building consists of a basement with a minimum clear height of 2.1 m and a story above with a minimal clear height of 6.15 m to install the GIS switchgear at a level of 0.6 m minimum to avoid any risk of future flooding.

This building has an area of (9*16 m2) minimum.

<u>Foundations:</u>

The foundations of the GIS building can be a strap, or raft foundations, and must be founded in the natural ground.

The contractor is responsible to choose the types of foundations and their relative bottom level, according to the results of his geotechnical investigations, and he should submit a detailed calculation note for approval.

These foundations will be placed on a lean concrete surface with a minimum thickness of 0.1 m.

Backfilling is carried out with maximum thickness layers of 15 cm, which will be compacted and tested in accordance with specifications. The required compaction is 98% OPM.

for more details, please refer to the relative plans in the Annex A3-7 of this document

Transformer zone:

For the transformers foundation, a raft foundation is recommended, but the contractor is responsible to choose the best type according to the results of his geotechnical investigations, and should submit a detailed relative calculation note to the Employer for approval.

These foundations will be based on natural ground level and on a surface of lean concrete with a minimum thickness of 10 cm.

A concrete screed will take place above this foundation with a slope of 1cm/m.

A grating will be placed above this screed to facilitate circulation.

The used grating could be either fire resistant or hot deep galvanized.

The rails will be placed on two concrete beams below transformer. These rails will be extended to the heavy road.

The concrete must be protected from the inside of the transformer oil pit (where the oil will accumulate) with epoxy paint or equivalent. This paint must resist hot oil in order to be waterproof, and in order to block oil infiltration

An oil separator tank must be installed where the details are provided in the general requirement of the section ‘‘Detailed Requirements for Civil Works‘‘.

The walls that surround the transformer oil pit must have a fire resistance of 4 hours minimum.

For more details, please refer to the relative plans in the appendix of this document

Finishing and other complementary works:

The Contractor must be responsible for the following complementary activities without being limited to :

- Ensure the adequacy of the drainage system in order to avoid any risk of water infiltration inside the building.
- Separate the wastewater discharge pipe and direct it outside of the building to avoid any risk of infiltration inside the building.
- Install monorails at the control building, to transport the electrical equipment to the level of the other floors.
- Provide an overhead crane for the 69 kV GIS.
- Supply and connection of sanitary equipment
- Supply and connection of lighting and outdoor socket box
- Supply and connection of interior lighting and sockets
- Supply and connection of the lightning protection system
- Supply and connection of the air conditioning system
- False Ceiling in control room, protection room, telecom room, MV room, AC/DC charger room will be installed
- Raised Floor in control room, protection room, telecom room, MV room, AC/DC charger room will be installed
- Super caoutchouc smooth plastering and painting should be used on all walls and roof surfaces except of the battery room, where **anti-acid** plastering, painting and tiling must be used. The masonry blockwork must be plastered and covered by Super caoutchouc smooth plastering (2 layers) with elasticity which is crucial to ensure the building's durability. Plastering thickness must be 2 cm minimum.

- Epoxy painting must be used for the floors of the MV cells and GIS room
- For all remaining floors, anti-slip tiling must be used
- Installation of a septic tank after having all necessary approvals and authorizations, and it should respect the country's norms and standards. It must comply with regulations with a capacity up to 15 people.
- The walls and the floors of WCs must be of ceramic tiling
- A gallon of hot water 50 L must be provided on site with all the relative mechanical and electrical protections, with respect to the norms and standards.
- Regarding the stairs' tiling, it must cover a minimum of 1.5 m of the height of the adjacent wall.

Roof:

The Contractor's services must include:

- The construction of a concrete slab with a slope for the recovery of rainwater
- Waterproofing
- The realization of the parapets all around the roof's edges
- The rainwater drainage pipes must be placed outside the building to avoid any risk of water infiltration inside the substation

  The contractor must submit for approval a detailed calculation notes for the quantification and the sizing of these ducts.
- The roof drainage should be integrated with manholes, featuring an overflow positioned 20 cm above the roof slab. (Manholes are to be strategically placed at each drain change of direction)
- The roof access must be provided for maintenance operations by crinoline ladders.

Carpentry

Services will include minimum the following items that may change in terms of size and quantities according the client request and the new substation layout that must be provided by the contractor for approval:

- The supply, and installation of the following fire doors:
  - SIMPLE LEAF 90*240 minimum→ (Quantity = 7 minimum)
  - DOUBLE LEAF 2*2.4 minimum → (Quantity = 3 minimum)
  - DOUBLE LEAF 1.5*2.4 (0.4+1.1) minimum → (Quantity = 1 minimum)
  -
- The supply, and installation of the following sectional door:

  Sectional door (2.1*4.5 minimum) → (Quantity = 1 minimum)
- The supply, and installation of the following wooden door:

  wooden door (2.4*0.7 minimum) → (Quantity = 2 minimum)
- The supply, and installation of the following windows:
  - Glaze window 1*0.8 minimum → (Quantity = 10 minimum)
  - Glaze window 1.2*1.2 minimum → (Quantity = 2 minimum)
  - Glaze window 0.6*0.6 minimum → (Quantity = 2 minimum)

Drainage system:

The Contractor must submit for approval a detailed calculation notes that concerns the necessary rainwater drainage pipes for the new substation, taking into account the water flow during the heaviest rains over a return period of 10 years.

The contractor is responsible to choose the substation’s level that avoids any future possible risk of flooding.

Thus, he should install a drainage system all around and inside the substations that must be connected to the nearest existing rainwater drainage system to avoid all these possible risks.

The road drainage will be oriented from one side with a suitable slope.

The proposed solution must take into account the cleaning and maintenance needs.

Surfaces management and access roads:

The access to the substation must be segregated from the power plant by a fence and a door locking.

From the north and the south side of the substation, a retaining wall will be erected with a minimal thickness of 0.3 m, and backfilling operation will take place especially from the south side.

The contractor must submit a detailed calculation note showing the Cut and Fill quantities according to its own topographical survey.

In the south direction, a heavy railed road will take place designed with a minimum capacity of (16t/axle).

For the other free surfaces, they will be in accordance with the plans provided in the Annex A3-7 of this document.

The Contractor is responsible for creating all the necessary access for the working zone.

Please refer to the relative plans provided in the Annex A3-7 of this document.

Fences and gates:

We can define two different types for fences:

1. Prefabricated concrete columns every 2 meters + isolated reinforced concrete foundation + mesh fencing 5x5 + semi-buried pallet-board + barbed wire (the height must be no less than 2.5 meters): This type of fence will be used to demarcate the substation from the DOMELEC site.

2. Reinforced concrete columns every 2.5 meters + isolated reinforced concrete foundations + masonry blocks + plastering + barbed wire (the height must also be no less than 2.5 meters): This type of fence will be used to separate the substation from neighboring areas or roads.

Please refer to the sections of the Annex A3-7 *for more details.*

Exterior and interior lighting

The Contractor is responsible for the supply and installation of a sufficient exterior and interior lighting system.

He should use the latest lighting technology which saves energy and protects the environment, (LED technology or equivalent)

In addition, he should provide for approval a detailed calculation notes showing the minimum degree of illuminance that must be provided in each room of the buildings and at the level of the exterior area.

He is responsible for the following activities:

- Supply and connection of exterior and interior lighting and socket box
- Supply and connection of the lightning protection system.

Water supply

The contractor should provide a detailed calculation note that concerns an adequate and sufficient water supply system for the Fond Cole substation 69/33/11 kV.

The Contractor is responsible to install a water distribution system to supply the control building facilities such as:

- The sanitary facilities
- The eyewash in the battery rooms
- Etc…

An overhead water tank with a minimum capacity of 1000L will be installed.

Duct banks:

The Contractor is responsible for the construction of all the necessary duct bank and cable trench for the cables (69kV, 11kV and 33 kV) that must be placed separately.

A detailed inventory of the existing gutters shall be made before and after the work's execution, and in case of any noticed deterioration, the contractor will be responsible for all necessary restoration at his own expense.

All the duct bank / cable trenches are clearly represented on the relative plan of the Fond Cole substation, in the Annex A3-7 of this document, that should be considered as an indicative layout and the contractor must provide his own layout for approval.

3.3.4.2 Electrical design

SLD

The new Fond Cole substation under this contract will consist of the 69/33/11kV switchgear as described (see also the respective SLD on Annex A3-8)

The substation consists of a new 69kV GIS switchgear installed inside GIS room, 33kV switchgear in 33kV MV room and an 11kV switchgear in an 11kV MV room. Contractor should keep space for minimum two other 69kV GIS Line bays. One coupling, two feeders and one measurement cabinet as future extension of 33kV switchgear and two feeders for future extension of the 11kV switchgear. Two power transformers will be installed in the switchyard in addition to the station services auxiliary transformers near the control building. Two earthing 11kV transformers should be connected to 69/11kV and 33/11kV power transformers.

The design shall be prepared considering the possibility to allow an easy extension in the future without any relocation of any equipment. Thus, cable ducts, openings, civil works, building works, arrangement of all secondary equipment, etc shall be designed and prepared for the final stage. Single line, layout, section, building and other relevant drawings shall show the final extension of the substation.

Outdoor High voltage and Medium voltage equipment:

The contractor will supply and install:

- One 69/11kV power transformer 15MVA YNd11 ONAN/ONAF cooling, two winding transformers, with on-load tap-changer, automatic voltage regulator, including two current transformers on the primary side and one on the neutral grounding of the 69kV winding,
- One 33/11kV power transformer 20MVA YNd11 ONAN/ONAF cooling, two winding transformers, with on-load tap-changer, automatic voltage regulator, including two current transformers on the primary side and one on the neutral grounding of the 33kV winding,
- Two 11/0.4kV service auxiliary transformers 160kVA with current transformers for neutral grounding of 0.4 kV windings,
- Two 11kV earthing transformers zigzag winding, connected to 69/11kV and 33/11kV power transformers including current transformers on the neutral grounding.

HV switchgear

The contractor will supply a complete 69kV GIS Switchgear, indoor arrangement and double busbar system with Rated Current Busbar 1250 A and Rated Short Circuit Withstand Current common for all equipment 25 kA (3 sec).

The GIS switchgear will be composed of:

- One (01) Line bay to Geothermal SS
- One (01) Line bay Spare (Future West Coast SS),
- One (01) 69/11kV Transformer bay,

- One (01) busbar coupler bay,
- Two (02) busbar measurement,
- One LCC for each bay,

GIS 69kV Line bay module will be composed of:

- Two motorized busbar disconnectors (one for each busbar) 1250A
- One motorized maintenance earthing switch 1250A
- One motorized CB 1250A
- One current transformer with two ratios and four secondaries 400-200/1-1-1-1A
- One motorized maintenance earthing switch 1250A
- One motorized Line disconnector 1250A
- One motorized high speed earthing switch 1250A
- One voltage transformer 69/√3 **/** 0,11/√3 **/** 0,11/√3 kV
- Local control cabinet including BCU, switches, synoptic with TPL, test blocks, terminals, etc.

GIS 69kV Transformer bay module will be composed of:

- Two motorized busbar disconnectors (one for each busbar) 1250A
- One motorized maintenance earthing switch 1250A
- One motorized CB 1250A
- One current transformer with two ratios and four secondaries 400-200/1-1-1-1A
- One motorized maintenance earthing switch 1250A
- One motorized Line disconnector 1250A
- Local control cabinet including BCU, switches, synoptic with TPL, test blocks, terminals, etc.

GIS 69kV Busbar coupling bay module will be composed of:

- Two motorized busbar disconnectors (one for each busbar) 1250A
- Two motorized maintenance earthing switch 1250A
- One motorized CB 1250A
- Two current transformers with two ratios and two secondaries 800-400/1-1A
- Local control cabinet including BCU, switches, synoptic with TPL, test blocks, terminals, etc.

GIS 69kV Busbar measurement bay module will include:

- Two motorized maintenance earthing switch 1250A
- Two voltage transformers 69/√3 **/** 0,11/√3 **/** 0,11/√3 kV
- Local control cabinet including BCU, switches, synoptic with TPL, test blocks, terminals, etc.

MV switchgear

The contractor will supply a complete 33kV Metal-clad Switchgear, indoor arrangement and single busbar system with Rated Current Busbar 1600 A and Rated Short Circuit Withstand Current common for all equipment 25 kA (3 sec).

The 33kV switchgear will include:

- One (01) 33 kV measurement cabinet,
- One (01) 33 kV outgoing feeder to Padu,
- One (01) 33 kV incoming transformer feeder,

Incoming feeder will include:

  - One voltage transformer 33/√3 **/** 0,11/√3 **/** 0,11/√3 kV
  - One earthing switch 1250A
  - One current transformer with two ratios and three secondaries 800-400/1-1-1A
  - One withdrawable SF6 CB 1250A
  - One busbar disconnector with earthing switch 1250A
  - Voltage presence indicator for each cell
  - Low voltage compartment with IED control and protection equipment in the front panel

Outgoing feeder will include:

  - One voltage transformer 33/√3 **/** 0,11/√3 **/** 0,11/√3 kV
  - One earthing switch 1250A
  - One current transformer with two ratios and three secondaries 800-400/1-1-1A
  - One withdrawable SF6 CB 1250A
  - One busbar disconnector with earthing switch 1250A
  - Voltage presence indicator for each cell
  - Low voltage compartment with IED control and protection equipment in the front panel

Measurement cubicle will include:

  - One voltage transformer 33/√3 **/** 0,11/√3 **/** 0,11/√3 kV
  - One earthing switch 1250A
  - One fuse
  - One busbar disconnector with earthing switch 1250A

The contractor will supply a complete 11kV Metal-clad Switchgear, indoor arrangement and single busbar system with Rated Current Busbar 2000 A and Rated Short Circuit Withstand Current common for all equipment 25 kA (3 sec).

The 11kV switchgear will include:

  - One (01) 11 kV single busbar in one circuit breaker arrangement,
  - One (01) 11kV busbar coupling cabinet,
  - Two (02) 11 kV measurement cabinets,

- Four (04) 11 kV outgoing feeders,
- Two (02) 11 kV incoming transformer feeders,
- Two (02) 11 kV incoming high speed generators feeders,
- One (01) 11 kV incoming feeder to connect existing 11kV switchgear busbar,
- Two (02) 11/0.4 kV auxiliary transformer feeder: auxiliary power supply for substation.

Incoming transformers feeder will include:

- One voltage transformer 11/√3 **/** 0,11/√3 **/** 0,11/√3 kV
- One earthing switch 1250A
- One current transformer with two ratios and three secondaries 1200-600/1-1-1A
- One withdrawable SF6 CB 1250A
- One busbar disconnector with earthing switch 1250A
- Voltage presence indicator for each cell
- Low voltage compartment with IED control and protection equipment in the front panel

Incoming feeder to connect existing 11kV switchgear will include:

- One voltage transformer 11/√3 **/** 0,11/√3 **/** 0,11/√3 kV
- One earthing switch 1250A
- One current transformer with two ratios and three secondaries 400-200/1-1-1A
- One withdrawable SF6 CB 1250A
- One busbar disconnector with earthing switch 1250A
- Voltage presence indicator for each cell
- Low voltage compartment with IED control and protection equipment in the front panel

Incoming high speed generator feeder will include:

- One voltage transformer 11/√3 **/** 0,11/√3 **/** 0,11/√3 kV
- One earthing switch 1250A
- One current transformer with two ratios and three secondaries 200-100/1-1-1A
- One withdrawable SF6 CB 1250A
- One busbar disconnector with earthing switch 1250A
- Voltage presence indicator for each cell
- Low voltage compartment with IED control and protection equipment in the front panel

Outgoing feeder will be composed of:

- One voltage transformer 11/√3 **/** 0,11/√3 **/** 0,11/√3 kV
- One earthing switch 1250A
- One current transformer with two ratios and three secondaries 800-400/1-1-1A
- One withdrawable SF6 CB 1250A
- One busbar disconnector with earthing switch 1250A

- Voltage presence indicator for each cell
- Low voltage compartment with IED control and protection equipment in the front panel

Busbar Coupling will be composed of :

- Two earthing switch 2000A
- One current transformer with two ratios and two secondaries 2000-1000/1-1A
- One withdrawable SF6 CB 2000A
- Two busbar disconnectors with earthing switch 2000A
- Low voltage compartment with IED control and protection equipment in the front panel

Measurement cubicle will be composed of :

- One voltage transformer 11/√3 **/** 0,11/√3 **/** 0,11/√3 kV
- One earthing switch 1250A
- One fuse
- One busbar disconnector with earthing switch 1250A

Station service auxiliary transformer feeder will be composed of:

- One earthing switch 630A
- One Fuse switch
- One busbar disconnector with earthing switch 630A
- Voltage presence indicator for each cell
- Low voltage compartment protection equipment in the front panel

MV rooms should be designed to allow future extension. The contractor should forecast all (actual need and future) MV cables entries to the 33kV and 11kV switchgears and conduits for all LV cables and communication cables between MV rooms and other rooms inside control building.

Auxiliary AC and DC system

The 110VDC system supply should include:

- One 110VDC distribution board with two incoming sources,
- One 110VDC battery bank with minimum capacity of 400Ah,
- Two 400/230V redundant rectifiers/ 110VDC battery chargers,
- One 110VDC/ 230VAC dual inverter,

The 48VDC system supply should include:

- One 48VDC distribution board with two incoming sources,
- One 48VDC battery bank with minimum capacity of 100Ah,
- Two 400/230V redundant rectifiers/ 48VDC battery chargers,

The 400/230V AC system supply should include:

- One 400V AC main LV switchboard with three main input sources: source1, source2 and diesel generator with manual/automatic permutation between different sources
- One LV switchboard from each station services transformer,
- One AC control building LV sub-board
- LV outlets in the switchyard near each transformer

An emergency lighting system (110 VDC) shall be installed in the control building (control room, MV-room, LV-room and telecommunication room).

A diesel generator set,100 kVA minimum shall be installed and connected to the 400V busbar feeding the essential services.

Protection system

The 69 kV link is made with an UGC link of 2.5 kilometers long (Fond Cole SS side) followed by an OHL of around 4.8 kilometers and an UGC of 1.5 kilometers long (Geothermal SS side). A main differential relay will protect all the link from Fond Cole to Geothermal. The UGC link will be protected by a cable differential relay and an earthing over current relay.

The auto reclosing will be possible if the fault will occur only on the OHL part.

ANSI table functions

Types of feeders	ANSI functions required Fond Cole 69 kV SS		
	main	**Back up**	**common**
69kV Busbar	Fn 87B: busbar differential protection	SF6 Over pressure	Voltage measurement Events recorder, disturbance recorder;
69kV Line feeders	Fn 87L: line differential Fn 87C: cable diffrenetial for the UGC 2.5 kilometers. 50BF: breaker failure	Fn 32P: directional active power Fn 49: current overload.	Events recorder, disturbance recorder; faults locator (optional) Fn 79: auto reclose (depending on the fault ohl or ugc link) ; power metering
Transformer 69/11 kV feeder	Fn 87T: transformer differential Fn 49: current overload.	Buchholz relay wiring heating probe.	Events recorder.

Table 6: ANSI Functions for 69kV level protection Fond Cole SS

For 33 kV feeders:

- One line feeder with UGC 33 kV link to Padu
- Transformer feeder with UGC 33 /11 kV.

For 11kV feeders:

- Two incoming transformer feeders with UGC 11 kV link
- One incoming feeder for linking old 11kV switchgear
- Two incoming feeders for high-speed generators

- Four outgoing feeders
- Busbar Coupling feeder
- Auxiliary transformer feeders 11/0.4 kV 160 kVA.

Types of feeders	**ANSI functions 33 and 11 kV Fond Colé**		
	main	**Back up**	**common**
Line feeder (UGC link 33kV)	Fn 87L: line differential	Fn 50/51 50N 51N 49	Events recorder. power metering
33/11kV transformer feeder	Fn 87T:transformer differential Fn 49: current overload.	Buchholz relay wiring heating probe. Fn 67/ 67N: directional over current (to the busbar protection)	Events recorder.
11kV Outgoing feeder	Fn 50/51 50N 51N 49		Events recorder.
11kV link with old switchger	Fn 50/51 50N 51N 49		Events recorder.
11kV incoming generators feeders	Fn 67/ 67N: directional over current Fn 25*: Synchro check* *FN 27: Voltage control*	Fn *32P: directional active power*	*Events recorder.*
Auxiliary feeder (transformer 11/0.4 kV link)	Fn 49: current overload.		Events recorder.
Busbar Coupling feeder	Fn 50/51		Events recorder.

Table 7: ANSI Functions for 33kV and 11kV levels protection Fond Cole SS

Metering

Energy metering devices should be installed on each MV feeders and each auxiliary sources for AC switchboard.

All revenue meters shall be of programmable microprocessor based digital type, offering outstanding measurement accuracy and reliability, communication capability, event storage, suitable for operating in harsh environment.

Cables

The contractor should provide and connect complete cabling including mainly:

- 69kV XLPE single core cables from the 69kV GIS up to the 69/11 kV transformers;
- 33kV XLPE single core cables from the 33kV switchgear up to the 33/11 kV transformers;
- 11kV XLPE single core cables from the new 11kV switchgear up to the 69/11kV transformers;
- 11kV XLPE single core cables from the new 11kV switchgear up to the 33/11kV transformers;

- 11kV XLPE single core cables from the new 11 kV switchgear up to the 11/0.4kV auxiliary transformers;

- 11kV XLPE single core cables from the 11 kV earthing transformers up to the 69/11kV and 33/11kV transformers secondaries;

- 11kV XLPE single core cables from the new 11 kV switchgear up to the existing 11kV switchgear;

- Low voltage cables for AC/DC control, signaling, lighting, LV power consumers etc. including all accessories as required for the project.

All requested technical requirements including cross section (defined as per energy to be transmitted) for HV and MV cables are detailed in Guaranteed Technical Data tables in annexes of this document. A calculation note for 69kV, 33kV and 11kV must be elaborated to confirm the choice of cross section and ability to transit the requested energy while applying all derating factors (ground temperature, ground thermal resistivity, depth of laying, buried,…)

Substation Control and Monitoring system (SCMS)

A Control and Monitoring System (SCMS) shall be installed in the new building. This control system will take into account the new installations:

- 69kV equipment.
- Transformers
- Incoming feeders
- Outgoing feeders
- Bus Bars
- Measurements
- Service auxiliary transformers
- Auxiliaries section and substation alarms.

The composition of each SCMS unit will be in accordance with the technical specifications in section “Substation Control and Monitoring System (SCMS)” below. The communication protocol between the relays shall be in accordance with the IEC 61850 standard. The Ethernet network shall be 100/1000 Mbps and shall use manageable Ethernet switches equipped with electrical and optical ports to interconnect all the equipment in the system.

The system will also ensure the dialogue with the protections of the new 69 kV lines, 69/11kV transformers, 33/11kV transformers and 33kV and 11kV feeders.

The architecture drawing of Fond Cole substation SCMS is provided in Annex A3-9.

Telecom System

The telecommunication equipment for the Trafalgar substation shall include:

Supply and installation of Fiber Optic Access Cables (FOAC) including all trenching, protection pipes, civil works, cable trays, etc, for the safe and proper installation of the cables from the FO joint boxes at the entry of the feeder to the ODF at the substation communication room. FO connection must be established to Trafalgar power plant also.

Supply and installation of suitable Optical Distribution Frames (ODF) / patch panel with single mode pig tail terminations at the control building

SDH Broadgate terminal and multiplex equipment, Redundant Power Supply Module, Redundant control board, PCM access multiplexer, digital comfort telephone set, any other necessary equipment to establish communication between all substation network.

The Bidder shall supply all cabling, accessories and services required for proper operation of the telecommunication equipment at the substation as well the integration into the overall telecommunication system.

3.4 Specific Works Information for Laudat Power Station

3.4.1 Localization

Substation	Geographical Coordinates	
	N	W
Laudat Power station	15°19'56.50"N	61°19'44.20"W

Table 8: Localization of Laudat power station

3.4.2 Scope of supply

The Contract scope of works for the existing 11kV switchgear at Laudat power station is the design, construction, supply, installation, connection, testing, pre-commissioning and final commissioning of all civil and electrical works, as well as the provision of drawings and documentation and any other requirements as defined in this specification.

The overall deliverables, at site, for this substation are:

- Adaptation of the existing 11kV cell used as TLI feeder (PIX Areva switchgear):
  - New differential protection identical to the one in the other feeder end (at Geothermal 33kV switchgear: Laudat outgoing feeder),
  - Establishment of FO optical communication link between both protection relays,
  - New CTs since this feeder will transit a power of 5MVA from Geothermal substation,
  - Energy meter,
- Secondary wiring adaptation including LV and control cabling, inter-panel wiring, cable racks, trays and support brackets,
- Telecommunication equipment in a dedicated cubicle and establish communication with adjacent sites (with all necessary software installation setup and licenses).
- FO link between the new protection relay and the telecom cabinet ODF.
- Miscellaneous
  - Any other essential equipment not mentioned above.

3.4.3 Scope of construction works

The construction scope of work to be performed by the Contractor consist of:

- Repurposing of existing 11kV feeder TLI to allow the use as incoming feeder from new 33/11kV transformer at Geothermal SS (Current transformers, LV adaptation including protection relay, cabling, interlocks,…),
- Pulling and connection of all LV power and control cables inside Laudat power station,
- Pulling and connecting of the 11kV UGC coming from Geothermal SS until the existing 11kV cabinet.
- Pulling and connecting the FO cable coming from Geothermal SS until the new Telecom cabinet and splice it to the new ODF.
- Pulling and connection of FO link between the new protection relay and the Telecom cabinet (ODF) and communication establishment between differential protection in Laudat and Geothermal SS.
- Testing and commissioning of the whole adaptation: 11kV UGC, FO link, protection relay, energy meter, communication between both sides, telecom equipment. The whole 11kV power UGC and FO cable link between Laudat and Geothermal SS should be tested.

3.4.4 Scope of design works

The Contractor must also provide supporting documentation, calculations, system studies, drawings, descriptions, manuals, quality control systems, progress reports and meetings with the project owner representative as set out in this Specification. Required supporting documentations may include but is not limited to the following:

- Protection relays settings and selectivity study,
- All needed drawings and calculation notes for electrical equipment and civil works dimensioning:
  - General arrangements (plan and elevation), layouts and sections drawings,
  - MV and LV equipment installation and connection drawings,
  - Single line diagrams,
  - Switchgear panel general arrangements and schematics,
  - Measurement and Protection relays systems SLD and detailed drawings,
  - Developed schematics for new 11kV feeder,
  - Telecom equipment schematics,
  - All MV and LV cables and busbars sections calculation notes and fittings,
  - Cable schedules,
  - All drawings of any extension of the existing equipment,
  - Civil works detailed drawings and calculation notes: Cable duct/trench and conduit arrangement and elevation, Drainage plan, …
  - Primary Plant Schedule for Procurement (8 weeks from date of Contract award).

The Contractor must perform a site visit prior to undertaking detailed design to determine site-specific conditions.

The contractor will be responsible for the design, procurement, and installation of any necessary equipment, in Laudat substation, for the commissioning of the new 11 kV UGC link between Geothermal substation and Laudat power station.

The communication between both protection differential relays will be through new OF link.

3.5 Further Services to be provided

The Contractor must ensure the training of the Employer’s main personnel regarding maintenance and operation of the new primary and secondary equipment and automation devices in substations, including test equipment and tools. The following training must be provided:

3.5.1 Local/ On-Site Training

#	Subject	Description	Number of participants	Training venue	Objectives
1	GIS and AIS Outdoor equipment	Installations, commissioning, Operation & Maintenance	10	Project Site	Operational and maintenance
2	33kV and 11kV Metal Clad Switchgears	Installations, commissioning, Operation & Maintenance	10	Project Site	Operational and maintenance
3	Transformers Integral Maintenance	Transport of transformers and inspection upon arrival at the client Assembly, inspections upon completion of assembly Transformer oil Transformer life management incl. troubleshooting/maintenance/life extension and service works Commissioning and operation	10	Project Site	Capacity building to personnel working in operation and maintenance of power transformer
4	System protection and SCMS	Installation, configuration, programming and commissioning	10	Project Site	Knowledge transfer to client personnel in relation to specific equipment to be supplied under the project
5	Telecom Equipment	Installation, configuration, programming and commissioning	10	Project Site	Knowledge transfer to client personnel in relation to specific equipment to be supplied under the project
6	AC & DC Auxiliary System & ground system	Maintenance, Design, Troubleshoot	10	Project Site	Knowledge transfer to client personnel in relation to specific equipment to be supplied under the project

3.5.2 International training

For overseas training, all expenses in the overseas training shall be borne by the contractor including airfares, accommodation, international and local transportation and allowances of $200.

#	Subject	Description	Number of participants	Training venue	Objectives
1	AIS and GIS Switchgears	Design, Implementation and Commissioning of HV/MV Switchgear equipment	2 participants	Manufacture's premises	Capacity building to personnel working in

#	Subject	Description	Number of participants	Training venue	Objectives
		The course shall include the following: • Introduction to HV/MV substations • HV/MV substation configurations • HV/MV substation equipment o Power transformers o Circuit breakers o Disconnect switches o Surge arresters, insulators, bushings, etc. o Instrument transformers • HV/MV substation design and considerations o Insulation coordination o Lightning protection o Grounding design considerations • Substation auxiliary supplies (AC and DC) • Cabling	/ duration 1 week		operation and maintenance of power transformer
2	System protection and Control	The course shall cover: • Power system fundamentals • Short circuit theory, terminology and calculation for HV/MV systems • Design of protective systems for HV/MV networks • Protection relays selection and coordination • Application of protection system for cable and OHL lines • Application of protection systems to power transformers • Design of advanced control system for HV/MV systems	2 participants / duration 1 week	Manufacture's premises	Capacity building to personnel working in operation and maintenance of power transformer
3	SCMS and Telecommunication	The course shall cover: • Substation telecommunications and automation fundamentals • Telecommunication protocols, standards and architecture	2 participants / duration 1 week	Manufacture's premises	Capacity building to personnel working on SCADA system

#	Subject	Description	Number of participants	Training venue	Objectives
		• Telecommunication technologies • SCADA systems architecture, operation, maintenance and reporting • Cybersecurity • Protection of substation telecommunication equipment			
4	Power Transformer Lifecycle Management	Diagnostic possibilities: • Oil analysis • Standard electrical measurements • In-depth electrical measurements • Determining humidity in the winding insulation • On-site MV-testing Local maintenance processes: • Oil circulation vacuum process • Stationary drying process • Oil regeneration • Online monitoring • Modernization possibilities • Performance boosting	2 participants / duration 1 week	Manufacture’s premises	Capacity building to personnel working in operation and maintenance of power transformer

4. General Technical Requirements for the Substations

4.1 General

The electro-mechanical devices and equipment of this project shall be in compliance with the requirements and conditions of the specification. IEC-Recommendations/Publications standard has priority. The equipment shall be manufactured not more than one year prior to its delivery to the respective final destination.

The offer shall reflect the major requirements like largest possible uniformity of all major components, easy replacement and repair, highest degree of maintenance free equipment, service safety and availability.

The equipment and devices shall be factory-assembled and tested at the manufacturers' works. All equipment, accessory, measuring devices and materials which must be supplied must be new, not previously used and must be of the standard design of the Manufacturer. They shall be developed with respect to the latest requirements of the applicable standards and must be manufactured based on the use of the latest technologies.

Unless otherwise specified, current and voltage values and ratings shall include a 10 % safety margin. The supplier must submit all related data and documents like short-circuit calculations, reduction factors and maximum admissible service data, weather data, like maximum admissible temperature and relative air humidity, and other relevant factors.

In addition to the risks and liabilities in accordance to CIP delivery conditions, the Contractor will bear all costs and risks associated with off-loading at site, storage at site and transportation on site to the installation of plant and equipment.

4.2 Electrical Motors

Only IEC (or DIN) motors (squirrel-cage type) for direct start shall be used and comply in every respect with the aggregate to be driven (pump, compressor etc.) and its operating conditions. Further all existing voltage ratios, voltage dips or drops must be taken into account.

For motors insulation class F shall be considered, however, the motors shall not exceed, when being operated at operation the temperature of class B shall not be exceeded.

The type of construction shall be fully-enclosed, fan-cooled, protection class IP 44 in compliance with IEC. Outdoor installed motors shall be absolutely weather-proof and, if necessary, protected against extreme sun rays.

The bearings shall be self-lubricating or greased ball-type or roller-type bearings.

4.3 Low Voltage Switchgear

Low voltage switchgear for 400/230 V shall be supplied in approved standard, completely wired and tested.

Degree of protection shall be IP 44 for indoor installation and IP 55 for outdoor installation. The bottom openings shall be fire-proof sealed. All necessary accessories like: base frames, supporting racks, anchoring, and connections to adjacent plants, are to be included. The LV switchboards and their iron/metal elements shall be hot-galvanized against corrosion; Outdoor switchboards must be equipped with hydrostatic-controlled heating. Withdrawable or swiveling device groups shall be preferred.

4.4 Auxiliary Material

All auxiliary material required for operation and safety, even if not explicitly specified, shall be considered, and included: all types of auxiliary relays for control, protection, alarms, contact multiplication etc. as well as terminals, wiring material, sensors, measuring instruments, cable platforms, cable pipes, insulators, copper bars, insulating elements etc.

4.5 Earthing

All main electrical equipment shall be earthed on 2 different connection points each on the opposite site of the equipment. Each earthing connection shall be dimensioned for the minimum of 60% of the rated short circuit current at the respective substation for the respective voltage level.

Earthing shall be carried out by using tinned copper soft drawn concentric strands conductor.

For substations:

- It shall be earthed at the width of each bay as stated above
- A separate earthing conductor bar, dimensioned for the full short circuit current shall be placed in parallel under the busbars.

The earthing systems shall be designed in compliance with the latest applicable standards and regulations.

For disconnect switches and earthing switches an earthing mat shall be installed beneath the operator's possible standing place for the protection of the operators. This mat should consist of 50 mm^2 tinned copper wire arranged in a spiral of about 1 m diameter with maximum 0.2 m distance between spiral wires, and with one end connected to the operating mechanism. The mat shall be above the normal earthing/grounding system and shall be connected to the main earthing grid.

Scope of reconstruction of switchyard earthing systems is defined during the design stages on the basis of inspection results.

The earthing system to new buildings shall be closed loop meshed connected to existing earthing system.

The grounding conductors’ sizes shall be checked at the short circuit current withstand capability.

The earthing of the surge arresters shall be done using additional earth stripes.

The earthing conductor and cable lug connections shall be done using hydraulic crimping tools.

The connections / joints of different metals shall be done by suitable materials or by protective coating.

The rehabilitated grounding systems have to be tested by measurements, certified and proved to suitability.

4.6 Lightning Protection

The external lightning protection is always realized by means of lightning rods. The rods are to be installed on the gantries. Sufficient protection has to be proved by a corresponding calculation.

The lightning rods shall be supplied hot-galvanized and fixed to the corresponding support structures by means of the adequate constructional measures. The sufficient static dimensioning has to be proved. The scope of supply of the lightning protective posts also includes the supply of all necessary fastening material to install the rods on towers or poles.

The areas without existing gantries shall be provided with two towers or poles with lightning rods.

For the electrical service buildings, a separate lightning protection consisting of lightning Stainless-steel rods and arresters shall be provided and to be connected to the earthing system.

Overvoltage protection according to electromagnetic compatibility measures for sensitive de-vices shall be tested during detailed planning and, if necessary, included in the scope of supply.

All these services are included in the lump sum price.

4.7 Lighting Equipment

All lighting equipment shall be designed in accordance with DIN 5035 guideline or equivalent standard. Basis for all lighting fittings are the DIN/VDE standards and regulations or equivalent standard.

Lighting fittings shall include all necessary suspensions, wirings, luminous elements fitted to the respective areas and utilization. The lighting fittings must be selected by the Contractor according to their application.

Fittings with fluorescent lamps shall be supplied with low-loss ballast. The outdoor lighting including streetlamps shall be with gas discharge lamps.

Basis for the design are the min. illuminances according to DIN 5035 and the working place guideline-regulation ASR 7/3. The required illuminances are as follows: 300 Lux throughout the entire switchgear rooms, 300 Lux in front of protective measuring and metering devices, 500 Lux in the control room. The total area of the switchgear shall be provided with an illuminance level of minimum 20 Lux. Entrance areas shall have a minimum illumination level of 100 lx.

The cables shall be installed in HDPE pipes.

All switchboards shall be provided with internal lighting per each panel.

A switch for the external lighting shall be installed in the main control room including the necessary cables.

Additionally, the control of the outdoor lighting (photo sensor controlled and central circuit switching) shall be installed inside the lighting distribution board in the main control building.

The external lighting shall be supplied by a new external lighting sub-distribution board.

The cables shall be led at the gantry structures in HDPE conduits.

The Contractor has to provide, if required, sufficient lighting for his own working/erection.

4.8 Lubricants

All equipment which needs lubricants shall be lubricated according to the requirements of the manufacturer. The required lubricants and additional lubricant which shall be sufficient for the entire guarantee period shall be supplied by the General Contractor.

4.9 Designation Labels (Nameplates)

All new equipment/device/panel/cabinet/switchboards designation labels shall be in English language, weather-proof and fitted to the lifetime of the devices. Additionally, all new devices shall be equipped with designation number plates and plates with new operational names of the equipment.

All apparatus, plant and equipment shall be clearly and permanently labelled in English and to be approved of the Employer. Where labels are provided for making clear the method of operation of equipment they shall be concise and preferably diagrammatic in form. They shall be of suitable size as to be readable at normal operating positions.

Each item of plant or equipment covered by this Specification shall be supplied, complete with an identification nameplate, clearly engraved or stamped with the Manufacturer's name, plant number and date, together with any other such information that will assist future maintenance and the purchase of spare parts. The Contractor shall submit for approval to the Employer, details of the labels indicating the identification and the type of label being supplied prior to the labels being ordered.

All equipment shall be provided with permanently engraved labels and/or number plates secured by fixing screws, to facilitate replacement.

Nameplates, labels and their fixing screws shall be of stainless steel or other corrosion resistant material.

Where the use of vitreous enameled labels is approved, the whole surface including the back and edges shall be properly covered and protective washers shall be provided in front and at the back of the fixing screws.

Labels to match existing equipment shall be of uniform appearance and size. The use of double - sided tape will not be permitted to secure labels on indoor or outdoor equipment.

Danger labels shall have red lettering on a white background. All other labels shall have black lettering on a white background.

Before production of labels, the Contractor shall submit to the Employer full-scale drawings of the proposed labels for the necessary approval.

The labels and indications are very important for use during references in case there is any malfunctioning part, either during or after installation.

4.10 Warning Signs (moveable and fixed)

Supply of new warning signs (movable and fixed) weather-proof in English language according the EDM with pictogram. All warning signs shall be in a sufficient number for use during the rehabilitation measures and later the operation of the substation.

- Movable warnings signs should be supplied and positioned to mark and secure on-going work in the substation (by the Contractor and/or Employer). All moveable warning signs shall include all necessary stands/racks and/or re-attachable fixing material.

- Fixed warning signs shall be supplied and installed including durable fixing material.

4.11 Padlock System for Electric Switchboards

It has to be adapted to existing standard system. For the outdoor switchboards shall be provided with a padlock system of high-quality anti-corrosive. Sufficient numbers of spare keys shall be provided.

4.12 Explosion Hazardous Plants/Rooms

Electrical installations in battery rooms are to be designed ex-proof.

Work in neighborhood of explosion hazardous areas have to be designed with the necessary caution under strict observation of the applicable regulations (incl. factories).

4.13 Steel Structures, Bolts, Screws and Nuts

Blank, non anti-corrosive steel, screw and connection material are not allowed. All provided materials are:

- hot-dip galvanized steel structures
- hot-dip galvanized screw material for all outdoor devices and installations
- Non-ferrous screw material like brass, bronze etc. according to the suppliers' standard

The proposed metallic structures are to be provided by the Contractor for cable raising and equipment supports.

Any steel part presenting a punching crack will be directly evacuated from the site.

The Contractor is responsible to submit for the approval of the project owner all the calculation notes and manufacturing plans that concerns all the used metallic structures.

The contractor will be responsible to ensure their perfect insertion and all compatibility of the assembly.

These structures must be designed for a service life of 50 years minimum, relatively to the climate conditions and supposed loads.

Screwed connections at steel structures shall principally be fitted at both sides (screw and nut) with washers. For non-restressed screwed connections (tension without torque key) additionally a spring washer between nut and washer shall be provided.

Holes must be clean and free of all kinds of residues.

4.14 Sealing

Rubber sealing shall be of high-quality, non-aging material, which will not be affected by humidity, heat and temperature variations. The supplier has to proof the quality and lifetime by certificate.

Where synthetic sealing material is used, with or without flour carbon coating, the supplier has to submit the manufacturer's name and the relevant data for approval.

4.15 Degrees of Protection and Cabinet/Cubicles Sealing

The largest part of the devices is exposed to the common outdoor conditions like:

Sun, rain, wind, dust, heat, humidity etc. All these climatic elements shall not affect the operation safety and availability of the devices.

Degree of protection for outdoor cabinets/devices: IP 55

Degree of protection for indoor installations: IP 44

In areas where oil or acid effects occur, the respectively higher degree of protection, IP 55, must be provided.

The outdoor cubicles shall be double-walled (shields) to prevent from direct sun rays heating.

All bottom holes and cable openings shall be sealed fire-proof. Cables shall always enter via screwed cable glands made from corrosion free metal (stainless steel, no plastic etc.).

The doors of protection and control cubicles shall be equipped with windows which allow the visibility of all installed and installable components (over the entire width and length of the door).

The window in the doors of all cubicles must be safety glass.

4.16 Cable Installation

All secondary cables shall be double shielded. The screens must be screwed to the earthing point. **At both ends of the screens shall be earthed.**

All cables within the substations shall be laid in concrete cable channels or cable trays, plastic or metal pipes.

In the channels, the cables shall be laid on galvanized cable trays and fixed by plastic tapes. Correct bending radiuses must absolutely be ensured.

All cables that are laid at structures, gantries, or towers, are laid in cable trays or pipes.

All cable entries and are closed with fire-proof material.

Types and quantity of power cables, control cables, optic-fiber cables shall be defined by the Contractor at the design stage.

5. Detailed Technical Requirements for Primary Equipment of the Substations

5.1 General

All equipment and installations shall be constructed and designed for durability and continuous operation with high economic efficiency and low maintenance costs.

All workmanship must be throughout of the highest quality. The design, dimensions and materials of all equipment parts must be carried out in a way that the stress to which they will be exposed do not cause any distortion or damage under the most severe conditions during their entire service lifetime. Welding, filling, or plugging of damaged parts will not be permitted without the written approval of the Employer.

The design shall be carried out in a way that it shall facilitate inspection, cleaning, repairs, operation and maintenance. All equipment shall be designed in order to ensure reliable operation at the atmospheric conditions in the areas where the substations are located and under the variations of load and voltages as they may occur under the working conditions of the respective power system. The design of all substation equipment shall be carried out in a way that it minimizes the risk of damage due to deterioration, or damage within in operation of all parts of the substation. The design shall incorporate all reasonable precaution and provision for the safety of those involved in the maintenance of the contract works and all associated works supplied and executed within other contracts.

All corresponding parts shall be interchangeable wherever possible throughout the contract works, and they have to be carried out in a way, that it will facilitate the installation of replacement parts.

For design and construction strict attention shall be paid to satisfying the specified operational requirements which are indicated below.

The Contractor shall submit his proposal for approval by the Employer.

Even if not especially mentioned under the respective chapter, all delivered/installed material shall be suitable for unrestricted use in temperate climate.

The Contractor is bound to provide complete works, even if the equipment or services which must be provided are not specifically mentioned in the specification.

5.2 Voltage Levels and Characteristic Data

Frequency

Rated frequency of all equipment shall be 50 Hz.

Voltage Levels

The following voltage levels have to be considered in the project:

- HV/MV 3-phase 69/33/11 kV (Transmission and distribution voltage levels)
- LV AC 400/220 V (low voltage distribution voltage level)
- LV DC 110 V (battery voltage level)

- LV DC 48 V (Telecommunication equipment)

Electrical Characteristic Data for HV and MV Equipment IEC 62271-1

Nominal operating voltage	U_n [$kV_{r.m.s}$]	69	33	11
Rated voltage	U_m [$kV_{r.m.s}$]	72	36	12
Standard short time power-frequency withstand voltage	U_{pf} [$kV_{r.m.s}$]	140	70	28
Standard lightning impulse withstand voltage	U_{li} [kV_{peak}]	325	170	75
Rated frequency	[Hz]	50	50	50
Minimum insulator creepage distance: phase-to-phase phase-to-earth	[cm/$kV_{(r.m.s.)}$]	3,1 4,4	3,1 4,4	3,1 4,4
Rated short-time (3 sec. withstand current)	[$kA_{(r.m.s}$]	25	25	25
Starpoint		Solidely earthed	Solidely earthed	None. Through earthing transformer (ZigZag)

6. GIS

6.1 General

The SF6 gas insulated metal enclosed switchgear shall be totally safe against inadvertent touch of any of its live constituent parts. It should be designed for indoor/outdoor (as specified) application with meteorological conditions at site as per Section Project. All parts of the switchgear should be single phase/ three phase enclosed.

The arrangement of gas sections or compartments shall be such as to facilitate future extension of any make on either end without any drilling, cutting or welding on the existing equipment. To add equipment, it shall not be necessary to move or dislocate the existing switchgear bays.

The design should be such that all parts subjected to wear and tear are easily accessible for maintenance purposes. The equipment offered shall be protected against all types of voltage surges and any equipment necessary to satisfy this requirement shall be deemed to be included. The required overall parameters of GIS are as follows:

Technical particulars	69kV system
Rated Voltage	72.5 kV (rms)
Rated frequency	50 HZ
Grounding	Effectively earthed
Rated power frequency withstand Voltage (1 min) line to earth	140 kV (rms)
Impulse withstand BIL (1.2/50 µsec) Line to earth	325 kVp
Rated short time withstand current (3 sec)	25 kA (rms)
Rated peak withstand Current	80 kA (peak)
Guaranteed maximum gas losses for complete installation as well as for all individual sections in %.	As per IEC- 62271-203
Seismic Level	6 out of 12 (Medvedev–Sponheuer–Karnik scale)

The metal-enclosed gas insulated switchgear, including the operating devices, accessories and auxiliary equipment forming integral part thereof, shall be designed, manufactured, assembled and tested in accordance with the IEC-62271-203 & IEC-62271-200 publications including their parts and supplements as amended or revised to date.

6.2 General Requirements

6.3 Reference Standards

The metal-enclosed gas-insulated switchgear, including the operating devices, accessories and auxiliary equipment forming integral part thereof, shall be designed, manufactured, assembled and tested in accordance with the following International Electro-technical Commission (IEC) Publications including their parts and supplements as amended or revised

IEC 62271-203	Gas Insulated metal-enclosed switchgear for rated voltages above 52KV
IEC 62271- 100	High voltage alternating current Circuit breakers
IEC 60694	Common clauses for high voltage Switchgear and control-gear standards
IEC 62271- 200	Gas Insulated metal-enclosed switchgear for rated voltages above 11kV & upto and including 52kV
IEC 62271-102	Alternating current disconnectors (isolators) and earthing switches
IEC 61128	Alternating current disconnectors. Bus-transfer current switching by disconnectors
IEC 61129	Alternating current earthing switches. Induced current switching
IEC 66044-1	Current transformers
IEC 66044-2	Voltage transformers
IEC 60137	Bushings for alternating voltages above 1000 V
IEC 60859	Cable connections for gas-insulated switchgear
IEC 60480	Guide to checking of sulphur hexafluoride taken from electrical equipment
IEC 60099 -1/4	Non-linear resistor type arresters for AC systems
IEC 60439	Factory-built assemblies of low-voltage switchgear and control Gear.
IEEE 80 (2000)	IEEE Guide for Safety in AC Substation grounding Earthing of GIS- an application guide
IEC TS 60859	Cable connections for gas-insulated metal-enclosed switchgear for rated voltages of 72.5kV and above-Fluid-filled and extruded insulation cables-Fluid-filled and dry type cable-terminations
IEC 60034	Rotating Electrical Machines
IEC 60044-6	Requirements for Protective Current Transformers for Transient Performance
IEC 60096-1	Radio-Frequency Cables-General Requirements and Measuring Methods
IEC 60099-4	Metal-Oxide Surge Arresters without Gaps for AC Systems
IEC 60099-5	Surge Arresters-Part 5: Selection and Application Recommendations
IEC 60227-1	Polyvinyl Chloride Insulated Cables of Rated Voltages up to and including 450/750V-Part1: General Requirements
IEC 60255	Electrical Relays (Applicable Parts)
IEC 60265-2	High-Voltage Switches for rated voltage of 52kV and above
IEC 60376	Specification and Acceptance of New Sulfur Hexafluoride
IEC 60427	Report on Synthetic Testing of High-Voltage Alternating Current Circuit-Breaker
IEC 60439	Factory-built Assemblies of Low-Voltage Switchgear and Control gear
IEC 60445	Basic and safety principles for man-machine interface, marking and identification-Identification of equipment terminals and of terminations of certain designated conductors, including general rules for an alphanumeric system
IEC 62271-110	Inductive load switching
ANSI/IEEE C37.1	Standard Definition, Specification, and Analysis of Systems Used for Supervisory Control, Data Acquisition and Automatic Control
ANSI C37.12 AC	High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis Specification Guide
ANSI/IEEE C37.122	Standard for Gas Insulated Substations
IEEE C 37.122.1	Guide for Gas-Insulated Substations
ANSI/IEEE C37.123	Guide to Specifications for Gas Insulated Substations
IEEE C57.13	Standard Requirements for Instrument Transformers
IEEE 1291	Guide for Partial Discharge Measurements in Power Switchgear

IEEE 1300	Guide for Cable Connections for Gas-Insulated Substations
NEMA CC 1	Electric Power Connectors for Substations
NEMA CC 3	Connectors for Use between Aluminum or Aluminum-Copper Overhead Conductors
ICEA S-61-402	Thermoplastic-Insulated Wire and Cable for the
NEMA-WC5	Transmission and Distribution of Electrical Energy
ASTM B-8	Specification for Concentric-Lay Stranded Copper Conductors, Hard, Medium Hard, or Soft

The components and devices which are not covered by the above standards shall conform to, and comply with, the latest applicable standards, rules, codes and regulations of the internationally recognized standardizing bodies and professional societies as may be approved by the Employer. The manufacturer shall list all applicable standards; codes etc. and provide copies thereof for necessary approval.

In case the requirements laid down herein differ from those given in above standard in any aspect the switchgear shall comply with the requirements indicated herein in regard thereto.

6.4 Design Requirements

6.4.1 Definitions

Assembly: refers to the entire completed GIS equipment furnished under contract.

Bay: refers to the area occupied by one Circuit Breaker and associated equipment used to protect one feeders/line/bus coupler in double bus scheme.

Compartment: When used in conjunction with GIS equipment, compartment refers to a gas tight volume bounded by enclosure walls and gas tight isolating barriers.

Enclosure: When used in conjunction with GIS equipment, enclosure refers to the grounded metal housing or shell which contains and protects internal Power system equipment breaker, disconnecting switch, grounding switch, voltage transformer, current transformer, surge arresters, interconnecting bus etc.)

Manual Operations: means operation by hand without using any other source of Power.

Module: When used in conjunction with GIS equipment, module refers to a portion of that equipment. Each module includes its own enclosure. A module can contain more than one piece of equipment, for example, a module can contain a disconnecting switch and a grounding switch.

Reservoir: When used in conjunction with GIS equipment, reservoir refers to a larger gastight volume.

6.4.2 General Design and safety requirement

The GIS assembly shall consist of separate modular compartments e,g Circuit Breaker compartment, Bus bar compartment filled with SF6 Gas and separated by gas tight partitions so as to minimize risk to human life, allow ease of maintenance and limit the effects of gas leaks failures & internal arcs etc. These compartments shall be such that maintenance on one feeder may be performed without de- energizing the adjacent feeders. These compartments shall be designed to minimize the risk of damage to adjacent sections and protection of personnel in the event of a failure occurring within the compartments.
Rupture diaphragms with suitable deflectors shall be provided to prevent uncontrolled bursting of pressures developing within the enclosures under worst operating conditions.

The workmanship shall be of the highest quality and shall conform to the latest modern practices for the manufacture of high technology machinery and electrical switchgear.

The switchgear, which shall be of modular design, shall have complete phase isolation.
The conductors and the live parts shall be mounted on high graded epoxy resin insulators.
These insulators shall be designed to have high structural strength and electrical dielectric properties and shall be shaped so as to provide uniform field distribution and to minimize the effects of particle deposition either from migration of foreign particles within the enclosure or from the by-products of SF6 breakdown under arcing conditions.

Gas barrier insulators and support insulators shall have the same basis of design. The support insulators shall have holes on both sides for proper flow of gas.

Gas barrier insulators shall be provided so as to divide the GIS into separate compartments. They shall be suitably located in order to minimize disturbance in case of leakage or dismantling. They shall be designed to withstand any internal fault thereby keeping an internal arc inside the faulty compartment. Due to safety requirement for working on this pressurized equipment, whenever the pressure of the adjacent gas compartment is reduced, it should be ensured by the bidder that adjacent compartment would remain in service with reduced pressure. The gas tight barriers shall be clearly marked on the outside of the enclosures.

The material and thickness of the enclosures shall be such as to withstand an internal flash over without burn through as per IEC. The material shall be such that it has no effect of environment as well as from the by-products of SF6 breakdown under arcing condition.

Each section shall have plug- in or easily removable connection pieces to allow for easy replacement of any component with the minimum of disturbance to the remainder of the equipment. Inspection windows shall be provided for disconnector and earth switches.

The material used for manufacturing the switchgear equipment shall be of the type, composition and have physical properties best suited to their particular purposes and in accordance with the latest engineering practices. All the conductors shall be fabricated of aluminum/ copper tubes of cross-sectional area suitable to meet the normal and short circuit current rating requirements. The finish of the conductors shall be smooth so as to prevent any electrical discharge. The conductor ends shall be silver plated and fitted into finger contacts or tulip contacts. The contacts shall be of sliding type to allow the conductors to expand or contract axially due to temperature variation without imposing any mechanical stress on supporting insulators.

Each pressure filled enclosure shall be designed and fabricated to comply with the requirements of the applicable pressure vessel codes and based on the design temperature and design pressures as defined in IEC-62271-203/ IEC-62271-200.

The manufacturer shall guarantee that the pressure loss within each individual gas-filled compartment shall not be more than half percent (0.5%) per year.

Each gas-filled compartment shall be equipped with static filters, density switches, filling valve and safety diaphragm. The filters shall be capable of absorbing any water vapor which may penetrate into the enclosures as well as the by-products of SF6 during interruption. Each gas compartment shall be fitted with separate non-return valve connectors for evacuating & filling the gas and checking the gas pressure etc.

The switchgear line-up when installed and operating under the ambient conditions shall perform satisfactorily and safely under all normal and fault conditions. Even repeated operations up to the permissible servicing intervals under 100% rated and fault conditions shall not diminish the performance or significantly shorten the useful life of the switchgear. Any fault caused by external reasons shall be positively confined to the originating compartment and shall not spread to other parts of the switchgear. The internal components shall be maintenance free for at least 10 years. Routine replacements of insulating gas shall not be required in intervals of less than ten years.

The thermal rating of all current carrying parts shall be minimum for one sec. for the rated symmetrical short-circuit current.

The switchgear shall be of the free standing, self-supporting with easy accessibility to all the parts during installation & maintenance with all high-voltage equipment installed inside gas- insulated metallic and earthed enclosures, suitably sub-divided into individual arc and gas-proof compartments preferably for:
a) Bus bars
b) Intermediate compartment
c) Circuit breakers
d) Line disconnectors
e) Voltage Transformers
f) Gas Insulated bus duct section between GIS and XLPE cable
g) Gas Insulated bus section between GIS & Transformer/ Reactor (if applicable)

The bus enclosure should be sectionalized in a manner that maintenance work on any bus disconnector (when bus and bus disconnector are enclosed in a single enclosure) can be carried out by isolating and evacuating the small effected section and not the entire bus.

The arrangement of the individual switchgear bays shall be such so as to achieve optimum space-saving, neat and logical arrangement and adequate accessibility to all external components.

It is required that the three phases of each switchgear bay be arranged side by side. The arrangement of the equipment offered must provide adequate access for operation, testing and maintenance.

Local Control & Substation Automation System:
Separate control cubicle including gas monitoring kiosk shall be provided for each bay which shall be installed near the switchgear for local control & monitoring of respective switchgear bay.

Local control cubicle for GIS shall be equipped with suitable hardware & software for remote control operation and conform to the bay level controller as detailed in Section: Substation Control and Monitoring System

BCU/BPU can also be used as Local Control Cubicle (LCC) depending upon the design of the offered equipment, as such separate LCC need not be provided.

Relay & Protection panel’s room shall house this equipment and shall be located adjacent to GIS room. It shall be air-conditioned through split air conditioners. The capacity and quantity of air conditioners shall be finalized during detailed engineering.

All the elements shall be accessible without removing support structures for routine inspections and possible repairs. The removal of individual enclosure parts, or entire breaker bays shall be possible without disturbing the enclosures of neighboring bays.

It should be impossible to unwillingly touch live parts of the switchgear or to perform operations that lead to arcing faults without the use of tools or brute force.

In case of any repair or maintenance on one bus bar disconnectors, the other bus bar should be live and in service.

All interlocks that prevent potentially dangerous mal-operations shall be constructed such that they cannot be operated easily, i.e. the operator must use tools or brute force to override them.

In general, the contours of energized metal parts of the GIS and any other accessory necessary shall be such, so as to eliminate areas or points of high electrostatic flux concentrations. The surfaces shall be smooth with no projection or irregularities which may cause visible corona. No corona shall be visible in complete darkness which the equipment is subjected to specified test voltage. There shall be no radio interference from the energized switchgear at rated voltage.

The enclosure shall be of continuous design and shall meet the requirement as specified in clause no. 10 (special considerations for GIS) of IEEE- 80, Year- 2000.The enclosure shall be sized for carrying induced current equal to the rated current of the Bus. The conductor and the enclosure shall form the concentric pair with effective shielding of the field internal to the enclosure.

The fabricated metal enclosures shall be of Aluminums alloy having high resistance to corrosion, low electrical loses and negligible magnetic losses. All joint surfaces shall be machined, and all castings shall be spot faced for all bolt heads or nuts and washers. All screws, bolts, studs and nuts shall conform to metric system. The other type of non-magnetic enclosures may be considered.

The breaker enclosure shall have provision for easy withdrawal of the interrupter assemblies. The removed interrupter assembly must be easily and safely accessible for inspection and possible repairs.

The enclosure shall be designed to practically eliminate the external electromagnetic field and thereby electrodynamics stresses even under short circuit conditions.

The elbows, bends, cross and T-sections of interconnections shall include the insulators bearing the conductor when the direction changes take place in order to ensure that live parts remain perfectly centered and the electrical field is not increased at such points.

The Average Intensity of electromagnetic field shall not be more than 50 micro -Tesla.
The contractor shall furnish all calculations and documents in support of the above during detailed engineering.

The Bidder shall furnish the following information regarding the loosely distributed metallic particles within the GIS encapsulation.
a) Calculations of critical field strength for specific particles of defined mass & geometry
b) The methodology and all the equipment for electrical partial discharge (PD) detection and/or acoustic detection methods, including that mentioned in the specification elsewhere.

The switchgear shall have provision for connection with ground mat risers. This provision shall consist of grounding pads to be connected to the ground mat riser in the vicinity of the equipment.

The ladders and walkways shall be provided wherever necessary for access to the equipment. A portable ladder with adjustable height may also be supplied to access to the equipment.

Wherever required, the heaters shall be provided for the equipment to ensure the proper functioning of the switchgear at specified ambient temperatures. The heaters shall be rated for 240V AC supply and shall be complete with thermostat, control switches and fuses, connected as a balanced 3-phsase, 4-wire load. The possibility of using heaters without thermostats in order to achieve the higher reliability may be examined by the bidder and accordingly included in the offer but it shall be ensured by the bidder that the temperature rise of different enclosures where heating is provided should be within safe limits as per relevant standards. One copy of the relevant extract of standard to which the above arrangement conforms along with cost reduction in offer. If any, shall also be furnished along with the offer. The heaters shall be so arranged and protected as to create no hazard to adjacent equipment from the heat produced.

The enclosure & support structure shall be designed that a mechanic 1780 mm in height and 80 Kg in weight is able to climb on the equipment for maintenance.

The sealing provided between flanges of two modules / enclosures shall be such that long term tightness is achieved.

Alarm circuit shall not respond to faults for momentary conditions. The following indications including those required elsewhere in the specifications shall be generally provided in the alarm and indication circuits.

Gas Insulating System
a) Loss of Gas Density.
b) Loss of Heater power (if required)
c) Any other alarm necessary to indicate deterioration of the gas insulating system.

Operating System:
a) Low operating pressure
b) Loss of Heater power
c) Loss of operating power
d) Loss of control
e) Pole Discordance

The equipment will be operated under the following ambient conditions:
a) The ambient temperature varies between 0 degree-C and 50 degree-C.
b) The humidity will be about 95% (indoors)
c) The elevation is less than 1000 meters

Temperature rise of current carrying parts shall be limited to the values stipulated in IEC-694, under rated current and the climatic conditions at site. The temperature rise for accessible enclosure shall not exceed 20°C above the ambient temperature of 50°C. In the case of enclosures, which are accessible but need not be touched during normal operation, the temperature rise limit may be permitted up to 30°C above the ambient of 50°C.

In case of any internal arc fault regardless of whether it occurs in a bus bar section, a bus bar isolator or the circuit breaker, repair works should be possible without shutting down the substation; at least one busbar and the undisturbed feeder should remain in operation. It should be possible to remove and replace a fully assembled circuit breaker without interfering the operation of the adjacent feeder. All circuit breakers of same rating should be interchangeable.

The GIS equipment shall be arranged in such a manner that in case of maintenance work on any of the equipment, at least one bus bar should be available for operation.

The inter bay width shall be sufficient to allow access to all drive mechanisms and other termination boxes without the need of dismantling other apparatuses.

These conditions shall be taken into account by the supplier in the design of the equipment.

6.4.3 Bellows or Compensating Units

Adequate provision shall be made to allow for the thermal expansion of the conductors and of differential thermal expansion between the conductors and the enclosures. The bellows shall be metallic (preferably of stainless steel) of following types or other suitable equivalent arrangement shall be provided wherever necessary.

1. Lateral / Vertical mounting units: These shall be inserted, as required, between sections of busbars, on transformer, shunt reactor and XLPE cable etc. Lateral mounting shall be made possible by a sliding section of enclosure and tubular conductors.
2. Axial compensators: These shall be provided to accommodate changes in length of bus bars due to temperature variations.
3. Parallel compensators: These shall be provided to accommodate large linear expansions and angle tolerances.
4. Tolerance compensators: These shall be provided for taking up manufacturing, site assembly and foundation tolerances.
5. Vibration compensators: These bellow compensators shall be provided for absorbing vibrations caused by the transformers and shunt reactors when connected to SF6 switchgear by oil- SF6 bushings.

6.4.4 Indication and verification of switch positions

Indicators shall be provided on all circuit breakers, isolators and earth-switches, which shall clearly show whether the switches are open or closed. The indicators shall be mechanically coupled directly to the main contact operating drive rod or linkages and shall be mounted in a position where they are clearly visible through glass windows.

6.4.5 Pressure relief

Pressure relief devices shall be provided in the gas sections to protect the main gas enclosures from damage or distortion during the occurrence of abnormal pressure increase or shock waves generated by internal electrical fault arcs (preferably in downward direction).
Pressure relief shall be achieved either by means of diaphragms or plugs venting directly into the atmosphere in a controlled direction.
If the pressure relief devices vent directly into the atmosphere, suitable guards and deflectors shall be provided. Contractor shall submit to the owner the detailed criteria design regarding location of pressure relief devices/rupture diaphragms.

6.4.6 Pressure vessel requirements

The enclosure shall be designed for the mechanical and thermal loads to which it is subjected in service. The enclosure shall be manufactured and tested according to the pressure vessel code (ASME/CENELEC code for pressure Vessel.)

Each enclosure must be tested as a routine test at 1.5 time the design pressure for one minute. The bursting strength of Aluminum castings must be at least 5 times the design pressure. A bursting pressure test shall be carried out at 5 times the design pressure as a test on each type of enclosure.

6.4.7 Grounding

The grounding system shall be designed and provided as per IEEE-80-2000 and CIGRE44 to
Protect operating staff against any hazardous touch voltages and electro-magnetic interferences.

As the area involved is small, contractor has to take special measures for the same.
The GIS supplier shall define clearly what constitutes the main grounding bus of the GIS.
The GIS supplier must supply the entire material for grounding bus of GIS via conductor, clamps, joints, operating and safety platforms etc. The GIS supplier is also required to supply all the earthling conductors and associated hardware material for the following:

1. Connecting all GIS equipment, bus ducts, enclosures, control cabinets, supporting structure etc. to the ground bus of GIS.
2. Grounding of transformer, CVT, SA and other outdoor switchyard equipment/structures etc.

Enclosure of the GIS may be grounded at several points so that there shall be grounded cage around all the live parts. A minimum of two nos. of grounding connections should be provided for each of circuit breaker, transformer terminals, cable terminals, surge arrestors, earth switches and at each end of the bus bars. The grounding continuity between each enclosure shall be effectively interconnected with Cu/ Al bonds of suitable size to bridge the flanges. In case the bidder does not offer external bonding, the bidder shall demonstrate that the connectivity offered by them between each enclosure is effective and does not require external bonding**.** Further similar design should have been in service for offered voltage. Subassembly to subassembly bonding shall be provided to provide gap & safe voltage gradients between all intentionally grounded parts of the GIS assembly & between those parts and the main grounding bus of the GIS.

Each marshalling box, local control panel, power and control cable sheaths and other non current carrying metallic structures shall be connected to the grounding system of GIS via connections that are separated from GIS enclosures.

The grounding connector shall be of sufficient mechanical strength to withstand Electromagnetic forces as well as capable of carrying the anticipated maximum fault current without overheating. At least two grounding paths shall be provided to connect each point to the main grounding bus. Necessary precautions should be under taken to prevent excessive currents from being induced into adjacent frames, structures of reinforcing steel and to avoid establishment of current loops via other station equipment.

All flexible bonding leads shall be tinned copper. All connectors, for attaching flexible bonding leads to grounding conductors and grounding conductors to support structures shall tinned bronze with stainless steel or tinned bronze hardware.

The contractor shall provide suitable measure to mitigate transient enclosure voltage caused by high frequency currents caused by lightning strikes, operation of surge arrestor, ph./ earth fault and discharges between contacts during switching operation. The grounding system shall ensure safe touch & step voltages in all the enclosures. The contractor shall provide suitable barrier of non-linear resistor/ counter discontinued SF6/Air termination, SF6/ Transformer or Reactor termination, SF6/ HV cable bushing etc. to mitigate transient enclosure voltage.

The bidders shall provide lightening mast/GS shield wire at suitable place for protection of whole sub-station including transformers, GIS cum control room building etc. The bidder shall submit detailed proposal for grounding system of whole substation including indoor and outdoor equipment with Earth mat using 40mm. dia MS rod for approval of purchaser. The riser shall be GS flat of size 75X12mm for outdoor equipment and 50x6mm for indoor.

The bidder shall submit detailed proposal for grounding system for approval of purchaser.
Any provision to be made in the building design to take care of earthing requirement shall also be clearly spelt out.

6.4.8 Circuit breakers

SF6 gas insulated metal enclosed circuit breakers shall comply with the latest revisions of
IEC- 62271-100 & relevant IEC except to the extent explicitly modified in the specification and shall meet with requirements specified.

Circuit breakers shall be equipped with the operating mechanism. Circuit breakers shall be of single pressure (puffer) type. Complete circuit breaker with all necessary items for successful operation shall be supplied. The circuit breakers shall be designed for high-speed single and three phase reclosing with an operating sequence and timing as specified.

6.4.8.1 Duty Requirements

Circuit breaker shall be C2 – M2 class as per IEC 62271-100.
Circuit breaker shall meet the duty requirements for any type of fault or fault location also for line charging and dropping 69kV effectively grounded system and perform make and break operations as per the stipulated duty cycles satisfactorily.

6.4.8.2 The circuit breaker shall be capable of

i) Interrupting the steady and transient magnetizing current corresponding to 33/11kV and 69/11kV class transformers.
ii) Interrupting line/cable charging current as per IEC without re-strikes and without use of opening resistors.
iii) Clearing short line fault (Kilometric faults) with source impedance behind equivalent to symmetrical fault current specified.
iv) Breaking 25% the rated fault current at twice the rated voltage under phase opposition Condition.
v) Interrupting capacitor bank if applicable. The breaker shall satisfactorily withstand the high stresses imposed on them during fault clearing, load rejection and re-energization of capacitor bank & lines with trapped charges.

6.4.8.3 Total Break Time

The total break time shall not be exceeded under any of the following duties
i) Test duties T10,T30,T60,T100 (with TRV as per IEC- 62271-100)
ii) Short line fault L90, L75 (with TRV as per IEC-62271-100)
iii) The Bidder may please note that total break time of the breaker shall not be exceeded any duty conditions specified such as with the combined variation of the trip coil voltage (70-110%), pneumatic/hydraulic pressure and SF6 gas pressure etc.
While furnishing the proof for the total break time of complete circuit breaker, the bidder may bring out the effect of non-simultaneity between poles and show how it is covered in the total break time.

The values guaranteed shall be supported with the type test reports.

6.4.8.4 Constructional features

The features and constructional details of breakers shall be in accordance with requirements stated hereunder.

Contacts
All making and breaking contacts shall be sealed and free from atmospheric effects.
Contacts shall be designed to have adequate thermal and current carrying capacity for the duty specified and to have a life expectancy so that frequent replacement due to excessive burning will not be necessary.
Provision shall be made for rapid dissipation of heat generated by the arc on opening.

Any device provided for voltage grading to damp oscillations or, to prevent re-strike prior to the complete interruption of the circuit or to limit over voltage on closing, shall have a life expectancy comparable of that of the breaker as a whole.

Breakers shall be so designed that when operated within their specified rating, the temperature of each part will be limited to values consistent with a long life for the material used. The temperature rise shall not exceed that indicated in IEC-62271-100 under specified ambient conditions.

The gap between the open contacts shall be such that it can withstand at least the rated phase to ground voltage for eight hours at zero pressure above atmospheric level of SF6 gas due to its leakage. The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lockout pressure continuously (i.e. 2 pu. Power frequency voltage across the breaker continuously).

In the interrupter assembly, there shall be an adsorbing product box to minimize the effect of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be such as to be fully compatible with SF6 gas decomposition products.

Provisions shall be made for attaching an operational analyzer to record travel, speed and making measurement of operating timings etc. after installation at site.

6.4.8.5 Operating mechanism

General Requirements
a) Circuit breaker shall be operated by spring charged mechanism. The mechanism shall be housed in a dust proof cabinet and shall have IP: 42 degrees of protection.

b) The operating mechanism shall be strong, rigid, not subject to rebound or to critical adjustments at site and shall be readily accessible for maintenance.

c) The operating mechanism shall be suitable for high-speed reclosing and other duties specified. During reclosing the breaker contacts shall close fully and then open. The mechanism shall be antidumping and trip free (as per IEC definition) under every method of closing.

d) The mechanism shall be such that the failure of any auxiliary spring will not prevent tripping and will not cause trip or closing operation of the power operating devices.

e) A mechanical indicator shall be provided to show open and close position of the breaker. It shall be located in a position where it will be visible to a man standing on the ground level with the mechanism housing closed. An operation counter shall also be provided in the central control cabinet.

f) Working parts of the mechanism shall be of corrosion resisting material, bearings which require grease shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned or locked to prevent loosening or changing adjustment with repeated operation of the breaker.

g) The bidder shall furnish detailed operation and maintenance manual of the mechanism along with the operation manual for break the circuit.

Control
a) The close and trip circuits shall be designed to permit use of momentary- contact switches and push buttons.

b) Each Circuit breaker pole shall be provided with two (2) independent tripping circuits' valves, pressure switches, and coils each connected to a different set of protective relays.

c) The breaker shall normally be operated by remote electrical control. Electrical tripping shall be performed by shunt trip coils. However, provisions shall be made for local electrical control. For this purpose, a local/remote selector switch and close and trip control switch/push buttons shall be provided in the breaker central control cabinet.

d) The trip coil shall be suitable for trip circuit supervision during both open and close position of breaker.

e) Closing coil and associated circuits shall operate correctly at all values of voltage between 85% and 110% of the rated voltage. Shunt trip and associated circuits shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of rated voltage. If additional elements are introduced in the trip coil circuit their successful operation and reliability for similar applications on circuit breakers shall be clearly brought out in the additional information schedules. In the absence of adequate details, the offer is likely to be rejected.

f) Dosimeter contacts and pressure switch contacts shall be suitable for direct use as permissive in closing and tripping circuits. Separate contacts have to be used for each of tripping and closing circuits. If contacts are not suitably rated and multiplying relays are used then fail safe logic/schemes are to be employed. DC supplies for all auxiliary circuit shall be monitored and for remote annunciations and operation lockout in case of dc failures.

g) The auxiliary switch of the breaker shall be positively driven by the breaker operating rod.

Spring operated Mechanism

a) Spring operated mechanism shall be complete with motor. Opening spring and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit shall also be provided.

b) As long as power is available to the motor, a continuous sequence of the closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty.

c) After failure of power supply to the motor one close open operation shall be possible with the energy contained in the operating mechanism.

d) Breaker operation shall be independent of the motor which shall be used for compressing the closing spring. Facility for manual charging of the closing spring shall also be provided. The motor rating shall be such that it required preferably not more than 60 seconds for full charging of the closing spring.

e) Closing action of circuit breaker shall compress the opening spring ready for tripping.

f) When closing springs are discharged after closing a breaker, closing springs shall automatically be charged for the next operation and an indication of this shall be provided in the local and remote-control cabinet.

g) Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition.

h) Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is in the closed position.

i) The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.

6.4.8.6 Additional data to be furnished along with the offer

a) Drawing showing contacts in close, arc initiation, full arcing, arc extinction and open position.
b) Data on capabilities of circuit breakers in terms of time and number of operations at duties ranging from 100% fault currents to load currents of the lowest possible value without requiring any maintenance or checks.
c) Curves supported by test data indicating the opening time under close open operation with combined variation of trip coil voltage and hydraulic pressure.

6.4.8.7 Tests

In accordance with the requirements, the circuit breaker along with its operating mechanism shall conform to the type tests as per IEC-62271-100.

Routine Tests

Routine tests as per IEC: 62271-100 shall be performed on all circuit breakers. In addition to the mechanical and electrical tests specified by IEC, the following shall also be performed.
Speed curves for each breaker shall be obtained with the help of a suitable operation analyzer to determine the breaker contact movement during opening, closing, auto-reclosing (if applicable) and trip free operation under normal as well as limiting operating conditions (control voltage, pneumatic pressure etc.). The tests shall show the speed of contacts directly at various stages of operation, travel of contacts, opening time, closing time, shortest time between separation and meeting of contacts at break make operation etc. This test shall also be performed at site for which the necessary operation analyzer along with necessary transducers, cables, console etc. shall be furnished as mandatory maintenance equipment.

The test for getting signature of the dynamic contact resistance measurement shall also be carried out at factory. The test result shall be treated as reference signature for condition monitoring in future.

6.4.9 GIS Connection:

The connection between GIS and high voltage cable at GIS end is done through cable termination / cable sealing end. Plug in cable sealing ends for XLPE cables shall consist of gas tight plug-in sockets, and prefabricated plugs with grading elements of silicone rubber.
A separate cable basement is provided for cable entry, its distribution and installation.
The design of the cable end box shall fully comply with the IEC standard. The type and size of cable is specified.
All end cable modules shall be suitable for connecting single core, XLPE specified cable.
Necessary provision for termination of specified nos. of such power cables shall be made in GIS. GIS supplier shall either carry out the work of termination or coordinate with cable terminator for such connection as specified in schedule of requirement. Provision shall be suitable for terminating cable size and type approved by utility.

6.4.9.1 Technical Characteristics

The GIS CB to be supplied shall comply with guaranteed technical particulars as indicated in Annex A2-2.

6.4.10 Disconnectors (isolators)

Disconnectors shall be of the single-pole/three poles, group operated type, installed in the switchgear to provide electrical isolation of the circuit breakers, the transformers, shunt reactor, double bus and transmission lines/cables. The disconnectors shall conform to IEC-62271-102 and shall have the ratings as specified.

6.4.10.1 Technical Characteristics

The GIS Disconnectors and Earthing Switches to be supplied shall comply with guaranteed technical particulars as indicated in Annex A2-3.

6.4.10.2 Construction & Design

The three-pole group operated disconnectors shall be operated by electric motor suitable for use on 220 V DC system and shall be equipped with a manual operating mechanism for emergency use. The motor shall be protected against over current and short circuit.

Disconnectors shall be designed as per relevant IEC. These shall be suitable to make and break the charging currents during their opening and closing. They shall also be able to make and break loop current which appears during transfer between bus bars. The contact shielding shall also be designed to prevent restrikes and high local stresses caused by transient recovery voltages when these currents are interrupted.

The disconnecting switches shall be arranged in such a way that all the three phases operate simultaneously. All the parts of the operating mechanism shall be able to withstand starting torque of the motor mechanism without damage until the motor overload protection operates.

It shall be possible to operate the disconnecting switches manually by cranks or hand wheels. The contacts shall be both mechanically and electrically disconnected during the manual operation.

The operating mechanisms shall be complete with all necessary linkages, clamps, couplings, operating rods, support brackets and grounding devices. All the bearings shall be permanently lubricated or shall be of such a type that no lubrication or maintenance is required.

The opening and closing of the disconnectors shall be achieved by either local or remote control. The local operation shall be by means of a two-position control switch located in the bay module control cabinet.

Remote control of the disconnectors from the control room shall be made by means of remote/ local transfer switch.

The disconnector operations shall be inter-locked electrically with the associated circuit breakers in such a way that the disconnector control is inoperative if the circuit breaker is closed.

Each disconnector shall be supplied with auxiliary switch having six normally open and six normally closed contacts for future use over and above those required for switchgear interlocking and automation purposes. The auxiliary switch contacts are to be continuously adjustable such that, when required, they can be adjusted to make contact before the main switch contacts.

The signaling of the closed position of the disconnector shall not take place unless it is certain that the movable contacts will reach a position in which the rated normal current, peak withstand current and short time withstand current can be carried safely.

The signaling of the open position of the disconnector shall not take place unless the movable contacts have reached such a position that the clearance between the contacts is at least 80 percent of the rated isolating distance.

All auxiliary switches and auxiliary circuits shall be capable of carrying a current of at least 10 A DC continuously.

The auxiliary switches shall be capable of breaking at least 2 A in a 110 V DC circuit with a time constant of not less than 20 milliseconds.

The disconnectors and safety grounding switches shall have a mechanical key (pad locking key) and electrical inter-locks to prevent closing of the grounding switches when isolator switches are in the closed position and to prevent closing of the disconnectors when the grounding switch is in the closed position.

The local control of the Isolator and high-speed grounding switches from the bay module control panel should be achieved from the individual control switches with the remote/local transfer switch set to local.

All electrical sequence interlocks will apply in both remote and local control modes.

Each disconnector shall have a clearly identifiable local, positively driven mechanical position indicator, together with position indicator on the bay module control cabinet and provisions for taking the signals to the control room. The details of the inscriptions and coloring for the indicator are given as under:

	SIGN	**COLOR**
Open position	Open	Green
Closed position	Closed	Red

All the disconnecting switches shall have arrangement allowing easy visual inspection of the travel of the switch contacts in both open and close positions, from the outside of the enclosure.
The disconnecting switches shall be provided with rating plates and shall be accessible for inspection.

The disconnecting switches shall be capable of being padlocked in both the open and closed positions with the operating motor automatically disengaged. The padlocking device shall be suitable for a standard size lock with a 10 mm shank. The padlock must be visible and directly lock the final output shaft of the operating mechanism. Integrally mounted lock when provided shall be equipped with a unique key for such three-phase group. Master key is not permitted.

6.4.11 Safety grounding switches

Three-pole, group operated, safety grounding switches shall be operated by electric motor for use on 110 V DC ungrounded system and shall be equipped with a manual operating mechanism for emergency use. The motor shall be protected against over-current and short-circuit.
Each safety grounding switch shall be electrically interlocked with its associated disconnector and circuit breaker such that it can only be closed if both the current break and disconnector are in open position. Safety grounding switch shall also be mechanical key interlocked with its associated disconnector.

Each safety grounding switch shall have clearly identifiable local positive driven mechanical indicator together with position indicator on the bay module control cabinet and provision for taking the signal to Control room.

The details of the inscription and coloring for the indicator are given as under:

	SIGN	**COLOR**
Open position	Open	Green
Closed position	Closed	Red

Interlocks shall be provided so that manual operation of the switches or insertion of the manual operating device will disable the electrical control circuits.

Each ground switch shall be fitted with auxiliary switches having six normally open and six normally closed contacts for use by others over and above those required for local interlocking and position indication purposes.

Provision shall be made for padlocking the ground switches in either the open or closed position.

All portions of the grounding switch and operating mechanism required for grounding shall be connected together utilizing flexible copper conductors having a minimum cross sectional area of 50 sq.mm.

The main grounding connections on each grounding switch shall be rated to carry the full short circuit rating of the switch for 1 sec. and shall be equipped with a silver- plated terminal connector suitable for steel strap of adequate rating for connection to the grounding grid.

The safety grounding switches shall conform to the requirements of IEC- 62271-102.

Mechanical position indication shall be provided locally at each switch and remotely at each bay module control cabinet/ substation automation system.

The rated Induced Current and Voltage for earth switches for both electrostatic and electromagnetic coupling shall be as per IEC 62271-102.

6.4.12 High Speed Make Proof Grounding Switches

Grounding switches located at the beginning of the feeder bay modules shall be of the high speed, make proof type and will be used to discharge the respective charging currents, in addition to their safety grounding function. These grounding switches shall be capable of interrupting the inductive currents and to withstand the associated TRV.

Single phase switches shall be provided with operating mechanism suitable for operation from an 110V DC.

The switches shall be fitted with a stored energy closing system to provide fault making capacity.

The short circuit making current rating of each ground switch shall be at least equal to its peak withstand current rating of 100 kA. The switches shall have inductive/ capacitive current switching capacity as per IEC-62271-102.

Each high speed make proof grounding switch shall have clearly identifiable local positive driven mechanical indicator together with position indicator on the bay module control cabinet and provision for taking the signal Control Room.

The details of the inscription and coloring for the indicator shall be as under:

	SIGN	COLOR
Open position	Open	Green
Closed position	Closed	Red

High speed ground switch operation should be possible locally from the bay module control cabinet, or remotely from the control room in conjunction with opening of the associated disconnector.

These high speed grounding switches shall be electrically interlocked with their associated circuit breakers and disconnectors so that the grounding switches cannot be closed if the circuit breakers and disconnectors are closed.

Interlocks shall be provided so that the insertion of the manual operating devices will disable the electrical control circuits.

Each high-speed ground switch shall be fitted with auxiliary switches having six NO & six NC auxiliary contacts for use by others, over and above these required for local interlocking and position indication. All contacts shall be wired to terminal blocks in the local bay control cabinet. Provision shall be made for padlocking the ground switches in their open or closed position.

All portion of the grounding switches and operating mechanism required for connection to ground shall be connected together utilizing copper conductor having minimum cross-sectional area of 50 sq. mm.

The main grounding connection on each grounding switch shall be rated to carry the peak withstand current rating of the switch for 1 sec. and shall be equipped with a silver-plated terminal connector suitable for steel strap of adequate design for connection to the grounding grid.

The high speed make proof grounding switches shall confirm to the requirements of IEC62271-102.

The rated Induced Current and Voltage for earth switches for both electrostatic and electromagnetic coupling shall be as per IEC 62271-102.

6.4.13 Instrument transformers

6.4.13.1 Current Transformers.

The current transformers and accessories shall conform to IEC: 60044-1 and other relevant standards except to the extent explicitly modified in the specification.

The particulars of the various cores may change within reasonable limits as per the requirements of protection relay supplier. The manufacturer is required to have these values confirmed from the purchaser before proceeding with design of the cores. The other characteristics of CTs shall be as given in Current Transformer guarantee technical requirements.

Ratios and Characteristics
The number, rating, ratios, accuracy class, etc. for the individual current transformers secondary cores shall be in accordance with technical requirement table. Where multi-ratio current transformers are required, the various ratios shall be obtained by changing the effective number of turns on the secondary winding.

Rating and Diagram Plates.
Rating and diagram plates shall be as specified in the IEC specification incorporating the year of manufacture. The rated extended current rating voltage and rated thermal current shall also be marked on the name plate.

The diagram plates shall show the terminal markings and the relative physical arrangement of the current transformer cores with respect to the primary terminals (P1 & P2).

The position of each primary terminal in current transformer SF6 gas section shall be clearly marked by two plates fixed to the enclosure at each end of current transformer.
Constructional Details:
a) The current transformers incorporated into the GIS will be used for protective relaying and metering and shall be of metal- enclosed type. The secondary windings shall be air insulated and mounted inside the metal enclosure. All the current transformers shall have effective electromagnetic shields to protect against high frequency transients.
b) Each current transformer shall be equipped with a marshalling box with terminals for the secondary circuits, which are connected to the local control cubicle. The star/delta configuration and the inter connection to the line protection panels will be done at the CT terminal block located in the local control cubicle.
c) Current transformers guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.
d) The rated extended primary current shall be 150% at all ratios and 200% at ratios other than highest ratios.
e) The instrument security factor at all ratios shall be less than five (5) for metering core. ISF shall be verified without use of any auxiliary reactor.
f) The wiring diagram, for the interconnections of the three single phase CTs shall be provided inside the marshalling box.
g) The current transformers shall be suitable for high-speed auto-reclosing.
h) Provisions shall be made for primary injection testing either within CT or outside.
i) Electromagnetic shields to be provided against high frequency transients typically 1-30 MHz.
j) The bidder will take care for the compatibility of the CT vis-à-vis burden of relay and connecting leads, however for calculation purpose fault current may be taken as 31.5 kA for 69kV as well as 33kV and secondary current may be calculated accordingly.
k) The output burden of cores shall be as technical requirement. However, burden of each core shall be finalized during detailed engineering.

6.4.13.2 Voltage transformers

The voltage transformers shall conform to IEC- 60044-2 and other relevant standards except to the extent explicitly modified in the specification.
Voltage transformers shall be of the electromagnetic type with SF6 gas insulation.
The earth end of the high voltage winding and the ends of the secondary winding shall be brought out in the terminal box.

Ratios and Characteristics
The rating, ratio, accuracy class, connection etc. for the voltage transformers shall be in accordance with Annex A2-5.

Rating and diagram plates
Rating and diagram plate shall be provided complying with the requirements of the IEC specification incorporating the year of manufacture and including turns ratio, voltage ratio, burden, connection diagram etc.

Secondary Terminals, Earthing and Fuses

The beginning and end of each secondary winding shall be wired to suitable terminals accommodated in a terminal box mounted directly on the voltage transformer section of the SF6 switchgear.
All terminals shall be stamped or otherwise marked to correspond with the marking on the diagram plate. Provision shall be made for earthing of the secondary windings inside the terminal box.

The transformer shall be able to sustain full line to line voltage without saturation of transformer.
The accuracy class will be at maximum tap.

Constructional Details of Voltage Transformers.
a) The voltage transformers shall be located in a separate bay module on the bus and will be connected phase-to ground and shall be used for protection, metering and synchronization. The voltage transformers shall be located in a separate module.

b) The voltage transformers shall be of inductive type, nonresistant and shall be contained in their own-SF6 compartment, separated from other parts of installation. The voltage transformers shall be effectively shielded against high frequency electromagnetic transients. The voltage transformers shall have three secondary windings

c) Voltage transformers secondaries shall be protected by MCB for all the windings. In addition, Contacts shall be provided for MCB monitoring scheme. The secondary terminals of the VT's shall be terminated to the stud type non disconnecting terminal blocks in the secondary boxes via the fuse.

d) The voltage transformer should be thermally and dielectrically safe when the secondary terminals are loaded with the guaranteed thermal burdens.

e) The accuracy of 0.2 on secondary III should be maintained throughout the entire burden range as per Table IIA and IIB, without any adjustments during operation. However, the burden of each core shall be finalized during detailed engineering.

f) The diagram for the interconnection of the VTs shall be provided inside the marshalling box.

6.4.13.3 Tests

Current and voltage transformers shall conform to type tests and shall be subjected to routine test in accordance with IEC.

6.4.13.4 Technical Characteristics

See Annexes A2-4 and A2-5

6.4.14 Incomer and Outgoing Connections

There shall be provision to connect XLPE cables at incomer and outgoing feeders. The sizes of cable have been defined in the specifications. However, final size will be decided during detailed engineering. In addition, one set of each size of test bushing/plug shall also be provided for testing purpose.

6.4.15 Partial Discharge Monitoring System & Dew Point Meter

Static Contact Resistance Meter and Dynamic Contact Resistance Meter, CB operational
Analyzer, SF6 Gas Leak Detector Meter, Portable P.D meter & Dew point meter shall be offered as per relevant price schedule and shall be considered for evaluation of bid. The specifications are enclosed in section special equipment.

6.4.16 Quality of Sf6 Gas

a) The SF6 gas insulated metal-clad switchgear shall be designed for use with SF6 gas complying with the recommendations of IEC 376, 376A & 376B, at the time of the first charging with gas. All SF6 gas supplied as part of the contract shall comply with the requirements of IEC as above as a minimum & should be suitable in all respects for use in the switchgear under all operating conditions.
b) The high-pressure cylinders in which SF6 gas is supplied & stored at site shall comply with the requirements of following standards & regulations.
c) SF6 gas shall be tested for purity, dew point, air, hydrolysable fluorides and water contents as per IEC: 376, 376A & 376B and test certificates shall be furnished to the owner indicating all test results as per IEC standards for each lot of SF6 gas. Further site tests for moisture, air content, flash point and dielectric strength to be done during commissioning of GIS. Gas bottles should be tested for leakage during receipt at site.
d) The bidder shall indicate diagnostic test methods for checking the quality of gas in the various sections during service. The method proposed shall, as a minimum check the moisture content & the percentage of purity of the gas on annual basis.
e) The bidder shall also indicate clearly the precise procedure to be adopted by maintenance personnel for handling equipment that are exposed to the products of arcing in SF6 Gas so as to ensure that they are not affected by possible irritants of the skin and respiratory system. Recommendations shall be submitted for suitable protective clothing, method of disposal of cleaning utensils and other relevant matters.
f) The bidder shall also indicate the details and type of filters used in various gas sections and should also submit the operating experience with such filters.

6.4.17 SF6 Gas monitoring devices and alarm circuits

Dial type temperature compensated gas density or density monitoring devices with associated pressure gauge will be provided. The devices shall provide continuous & automatic monitoring of the state of the gas & a separate device shall be provided for each gas compartment so that each compartment can be monitored simultaneously as follows:

Compartments except circuit breaker
a) **Gas Refill level**
This will be used to annunciate the need for the gas refilling. The contractor shall provide a contact for remote indication.
b) **'Zone Trip' level**
This is the minimum level at which the manufacturer will guarantee the insulation rating of the assembly. Contacts shall be in accordance with requirement.

Circuit Breaker:
a) **'Gas Refill' level**
This will be used to annunciate the need for gas refilling. The contractor shall provide a contact for remote indication.
b) **'Breaker Block' level**
This is the minimum gas density at which the manufacturer will guarantee the rated fault interrupting capability of the breaker. At this level the breaker block contact shall operate & the tripping & closing circuit shall be blocked.
c) ‘**Zone Trip' level**
This is the minimum level at which the manufacturer will guarantee the insulation rating of the assembly. Contacts shall be in accordance with requirement.

The bidder should furnish temperature v/s pressure curves for each setting of density monitor along with details of the monitoring device.

It shall be possible to test all gas monitoring relays/devices without de-energizing the primary equipment & without reducing pressure in the main section. Plugs & sockets shall be used for test purposes. It shall also damp the pressure pulsation while filling the gas in service, so that flickering of the pressure switch contacts does not take place.

Gas Leakage

The maximum gas leakage shall not exceed 0.5% (half percent) per year for the whole equipment and for any individual gas compartment separately.

Gas Supply

The contractor shall include the supply of all SF6 gas necessary for filing & putting into operation the complete switchgear installation being supplied. In addition, 20% of total gas requirement shall be supplied in separate cylinders as spare requirement, over & above the requirement of gas for successful commissioning. Pl. refer list of mandatory spares in this connection.

6.4.18 Gas filling and evacuating plant

All the plant necessary for filling and evacuating the SF6 gas in the switchgear shall be supplied with the contract to enable any maintenance work to be carried out. This shall include all the necessary gas cylinders for temporarily storing the evacuated SF6 gas.
The capacity of the temporary storage facilities shall at least be sufficient for storing the maximum quantity of gas that could be removed when carrying out maintenance or repair work on the switchgear and associate equipment of at least one complete bay. Where any item of the filling and evacuating plant is of such a weight that it cannot easily be carried by maintenance personnel, it shall be provided with lifting hooks for lifting and moving with the overhead cranes.

The capacity of the plant should be such that it is capable of excavation/ filling of maximum quantity of gas contained in a compartment could be removed/ filled within 30 minutes while carrying out maintenance/ repair work.

The evacuation equipment shall be provided with all the necessary pipes couplings, flexible tubes and valves for coupling up to the switchgear for filling or evacuating all the gases.
The gas compartments shall preferably be fitted with permanent non-return valves through which the gas is pumped into or evacuated form the compartments.
Details of the filling and evacuating plant that will be supplied, as well as the description of the filling and evacuating procedures shall be provided along with the bid.

6.4.19 SF6 GIS to XLPE Cable Termination

The 69 kV underground cables are to be connected to 69 kV GIS by the interfacing of XLPE cable sealing end to GIS Cable termination enclosure for making connection 1C x 240 mm² XLPE cable.
However exact size shall be intimated at the time of detailed engineering. This interface section shall be designed in a manner which will allow ease of operation and maintenance.

The SF6 GIS to XLPE cable termination shall conform to IEC-859 (latest edition). The provision shall be made for a removable link. The gap created when the link is removed should have sufficient electric strength to withstand the switchgear high voltage site tests.
The bidder may suggest alternative arrangements to meet these requirements. The corona rings/stress shields for the control of electrical field in the vicinity of the isolation gap shall be provided by the GIS manufacturer.

All supporting structures for the SF6 bus duct connections between the XLPE cable sealing ends and the GIS shall be supplied by the supplier. The supplier may specify alternative connecting & supporting arrangements for approval of the purchaser.

The opening for access shall be provided in each phase terminal enclosures as necessary to permit removal of connectors to isolate the XLPE cables to allow carrying out the insulation tests. The typical arrangement drawing of interconnecting bus-duct/cables from GIS bay module to XLPE cable termination end shall be submitted along with offer.

6.4.20 Electric Overhead Crane

EOT Crane of suitable capacity shall be provided for erection & maintenance of largest GIS component/assembly. The crane shall consist of all special requirements for erection & maintenance of GIS equipment.

The crane shall be possible to be operated through the cable & through the pendant control, which shall be easily accessible from the floor of GIS building.

6.4.21 Painting of enclosure

All enclosures shall be painted externally as per manufacturer's painting procedure. The painting procedures as followed shall be enclosed with the bid.

6.4.22 Heaters

Wherever required, heaters shall be provided to prevent moisture condensation.
Heaters are not allowed inside the main circuit.

6.4.23 Identification & rating plate

i) Each bay shall have a nameplate showing
a) A listing of the basic equipment from air entrance bushing to air entrance bushing (such as a breaker, disconnectors grounding switches, current transformers, voltage transformers, and bushings).
b) A schematic diagram indicating their relative locations.
c) DTL Contract Number.

ii) Each module will have its own Identification & rating plate.

The rating plate marking for each individual equipment like circuit breaker, disconnectors, grounding switches, current transformer, voltage transformers, surge arrester etc shall be as per their relevant IEC.

7. 69kV Outdoor conductor and fittings

7.1 General Requirements

All current-carrying clamps shall be rated for a utilization period of min. 30 years.

The work material selected, and the shaping shall be such that a mechanical stability is ensured that will not be affected by the required screw tightening torque. The contact pressure to the conductors to be connected shall be - under consideration of the requested screw tightening torque - large enough that the contact pressure will not be inadmissibly further reduced due to the unavoidable sagging of the overhead conductors.

A current carrying connection shall transmit min. the same current as that of the conductor to be connected (studs, terminal). That means that at maximum admissible constant current, the steady-state temperature of the terminal should nowhere be higher than the temperature of the conductor outside the connection.

A current-carrying connection shall min. correspond to the rated short-time current IthN (1s) of the conductor.

All material to be used shall be corrosion-proof. Where connecting studs or terminals are of copper, Copper-plated aluminum terminals shall be used to protect against galvanic corrosion.

All fittings and accessories which may not have been specifically mentioned, but which are necessary and essential for the efficient working, shall be deemed to be included in the contract

7.2 Regulations and Standards

This technical specification covers minimum requirements for the nominal rating, kind of compound materials, design, construction and test of commonly used fittings in substations. Fittings of substations shall be designed, manufactured and tested in accordance with the requirements of the latest revision of the following standards and to this specification:

IEC 61284: Overhead lines- requirements and test for fittings.

IEC 60060-1: High voltage test techniques, part 1: General definitions and test requirement.

IEC 60120: Dimensions of ball and socket coupling of string insulator units.

IEC 60471: Dimensions of clevis and tongue coupling of string insulators units.

IEC 60372: Locking device for ball and socket coupling of string insulator units: Dimensions and tests.

IEC 60472: Measurement method for radio interference voltage (RIV)

IEC 60826: Loading and strength of overhead transmission lines.

IEC 61089: Round wire concentric lay overhead electrical stranded conductors.

IEC 61854: Overhead lines- requirements and tests for spacers.

CISPR 16-1: Specification for radio disturbance and immunity measuring apparatus and methods- part 1: Radio disturbance and immunity measuring apparatus.

CISPR 18-2: Radio interference characteristics of overhead power lines and high voltage equipment- part 2: Method of measurement and procedure for determining limits

ISO 1461: Hot dip galvanized coating on fabricated ferrous products- specifications

ISO 2859: Sampling procedures for inspection by attributes.

ISO 3951: Sampling procedures and charts for inspection by variables for percent non- conforming.

NEMA CC1: Electric power connection for substations

ASTM A123: Standard specification for zinc coating on iron and steel products

ASTM A153: Standard specification for zinc coating on iron and steel hardware

ASTM A239: Practice for locating the thinnest spot in zinc (galvanized) coating on iron or steel articles

ASTM A 370: Standard test methods and definitions for mechanical testing of steel products

7.3 Design requirements

All power clamps and connectors shall conform to IEC standard and shall be made of materials listed below:

- For connecting ACSR conductors: Aluminum alloy casting,
- For connecting Bimetallic connectors made of copper with ACSR Conductor: Bimetallic conductors made from aluminum alloy casting with 2mm thick bimetallic linear
- For connecting GSW: Galvanized mild steel shield
- Bolts, nuts & lain, washers : Electrogalvanized for sizes below M12, for others hot dip galvanized

The fittings shall be designed so as to:
- Avoid damaging the conductor under service conditions.
- Withstand the mechanical loads relevant to installation, maintenance and service, the designed service current including short circuit current, the service temperatures and environmental circumstances.
- Withstand against seismic forces.
- Ensure that individual components are secured against becoming loose in service.
- Have limited corona effects.
- Prevent from point or linear connection between connections.

Surfaces of compression fittings in contact with the conductor or earth wire shall be protected from becoming contaminated before installation.

Each equipment shall be supplied with the necessary terminals and connectors, as required by the ultimate design for the particular installation. The conductor terminations of equipment shall be either expansion, sliding or rigid type suitable for the selected conductor.
The requirement regarding external corona and RIV as specified for any equipment shall include its terminal fittings and the equipment shall be factory tested with the connectors in position. If corona rings are required to meet these requirements, they shall be considered as part of that equipment and included in the scope of work.

Where copper to aluminum connections are required, bi-metallic clamps shall be used, which shall be properly designed to ensure that any deterioration of the connection is kept to a minimum and restricted to parts which are not current carrying or subjected to stress. The design details of the joint shall be furnished to the Purchaser by the Contractor.

No current carrying part of any clamp shall be less than 10 mm thick. All ferrous parts shall be hot dip galvanized. Copper alloy liner of minimum 2 mm thickness shall be cast integral with aluminum body for Bi-metallic clamps.

All casting shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be blurred and rounded off.

Flexible connectors, braids or laminated straps made for the terminal clamps for bus posts shall be suitable for both expansion or through (fixed/sliding) type connection.

Clamp shall be designed to carry the same current as the conductor and the temperature rise shall be equal or less than that of the conductor at the specified ambient temperature. The rated current for which the clamp/connector is designed with respect to the specified reference ambient temperature, shall also be indelibly marked on each component of the clamp/connector, except on the hardware.

All current carrying parts shall be designed and manufactured to have minimum contact resistance.

Screwed Connections

Unless otherwise specified, steel screws of galvanized steel shall be provided. For fastening, strain washers are to be provided each between screw head and flat connection resp. between nut and flat connection. Spring washers or toothed washers are not allowed.

Mounting

The mounting instruction of the terminal manufacturers must be strictly observed. Special attention must be given to the indication about the torque to tighten the screws.

For the mounting of fixed connections with squeeze clamps and dead-end clamps, the mounting tools indicated in the mounting instructions have to be used.

8. 69kV Outdoor Surge Arresters

8.1 Regulations and Standards

The surge arrestors to be supplied shall be in compliance with the latest applicable IEC 60099-4, Metal-oxide Gapless Surge Arresters for AC Systems. Deviations hereto must be indicated in detail when submitting the offer and must be approved by the Employer.

Surge arrestors shall be of the nonlinearly metal oxide type. They must comply with IEC60099-4.

The min. characteristic data of the arrestors must comply with the indicated characteristic in the data sheet and have to be confirmed or corrected/verified by the bidder in his offer.

The surge arrestors shall be housed in composite (polymer) insulators.

Please refer to the technical data sheets of “Annex 1: Datasheets technical requirements” for all required values.

All apparatus shall be of latest design and shall fulfill all requirements stated in applicable standards, referred to for each apparatus.

Summary of Standards referred to in this specification

IEC 60099-4	Metal-oxide surge arresters without gaps for a.c. systems
ISO 9001	Quality management systems – Requirements
ISO 14001	Environmental management systems - Requirements with guidance for use

8.2 General requirements

The surge arresters will be installed in outdoor substations to protect substation equipment. The surge arresters shall be guaranteed suitable for the service conditions stated in this specification, without deterioration or degradation of the materials or performance characteristics over the anticipated service lifetime of the equipment (estimated at 30 years).

The surge arresters shall:

- Be of the gapless Metal oxide type.
- Comply with IEC 60099-4.
- Be suitable for outdoor operation under the specified service conditions.
- Fulfill the ratings and performance criteria detailed in this specification.
- Be new and preferably a standard model in current production. Modifications to the manufacturer’s standard model may be accepted if considered necessary to meet the requirements stated in this specification, provided full details are specified with the offer.
- Be of a single column construction.
- Be well sealed against the ingress of air and moisture.
- Be suitable for pedestal mounting or alternatively suspended mounting.
- Be supplied complete with line and earth terminals and specified accessories.
- Be marked in accordance with IEC 60099-4.

8.3 Design requirements

The design of the surge arrester shall consist of a single column of ZnO blocks, divided into appropriately sized series-connected unit housings. Multiple columns connected in parallel are not permitted, regardless of whether they are in the same or separate housings.

The surge arresters shall be housed in an insulator formed from silicone. The final polymer compound after the addition of functional fillers shall contain at least one third pure silicone rubber, but shall not contain any EVA (Ethyl Vinyl Acetate), EPR Ethyl Propylene Rubber), EPDM (Ethylene Propylene Diene Monomer) or other UV sensitive material. LSR (Liquid Silicone Rubber) is not preferred for HV applications. Details of the final polymer compound shall be provided with the offer.

To verify that the housing material used is suitable for long-term outdoor use, it is a specific requirement that the design shall have passed weather ageing tests specified in IEC 60099-4. Tests must be made on a complete arrester or arrester unit; tests on materials or sections will not be accepted.

The housing shall be completely sealed to prevent the ingress of air and moisture and shall have been proven safe in the event of an arrester overload. Details are to be provided with the offer.

The sealing method for the housing shall be well proven both in service and testing. Preference shall be given to designs in which the silicone housing is molded directly onto the internal components, without the use of separate insulators, sealing devices or sealing compounds.

The arresters must show evidence of their safe performance under short circuit conditions.
Arresters with enclosed gas volume are to be fitted with venting arrangements to release excessive internal pressure; however, preference shall be given to an open-cage design, which provides automatic and safe short-circuit behavior.

For the 69kV primary side of power transformer and due to the limited space, the contractor should propose a design for a 69kV cable connection to the transformer bushings using dry-insulated outdoor cable termination with integrated surge arresters as specified in the technical requirement in annexes.

8.4 Testing requirements

Type tests

The arrester design shall be subjected to the applicable type tests specified in
IEC 60099-4. The purchaser will accept certified test reports of previously performed tests in lieu of actually performing type tests on the arresters to be supplied provided that these tests have been made on ZnO-blocks/arresters/arrester units which are applicable to the design and type of arrester being offered.

Routine tests

Routine tests as described in IEC 60099-4 shall be performed.

Quality assurance

Evidence must be submitted that the development, design, manufacture sales and after sales service relating to the surge arresters are in accordance with
ISO 9001 and ISO 14001.

The manufacturer shall show evidence that the varistor blocks have never been exposed to moisture before being assembled in the arrester units.

Preference will be given to suppliers which design and manufacture at one and same location. Furthermore, the manufacturer must prove that they have at least 10 years experience of manufacturing surge arresters at the same location at which they will manufacture the offered equipment. Details shall be submitted with the tender.

Additional preference shall be given to arrester manufacturers that can provide evidence that they have complete quality control for the active elements (ZnO varistors). In the event that the ZnO varistors are not manufactured at the same location or by the same manufacturer of the arresters, details must be provided with the offer of how the quality and characteristic performance can be guaranteed.

8.5 Accessories

Arresters intended for pedestal mounting shall be delivered with an insulating base. The insulating base shall be of a proven design, consisting of minimal parts.

Each arrester shall be equipped with a surge counter to register the number of surges. The design shall be such that the voltage drop across the counter is negligible during operation so that the protection level is not increased from that for the arrester alone. The counter shall be completely sealed in a housing to prevent the ingress of air and moisture and shall have been proven safe in the event of an arrester overload.

The tenderer shall also propose special apparatus for verification of the status of the surge arresters. The preferred method is through third-order harmonic analysis of the leakage current with compensation for harmonics in the voltage. It is required that these verifications can be made with the arrester in service and connected to power. For this reason, preference shall be given to apparatus which does not require touching or coming near the arrester or its connections. It is considered a further advantage if the apparatus is able to be read remotely without the need for hard wiring. Details of the apparatus and its function shall be included with the offer.

The surge counter shall be equipped with a leakage current indicator

8.6 Technical data for 69 kV Surge Arrester

69 kV Surge Arresters to be supplied shall comply with guaranteed technical particulars as indicated in Annex A2-12.

8.7 Technical Documentation

Dimension drawings of the devices have to be supplied and submitted to the Employer for approval. Modifications at approved drawings are only admissible if agreed by the Employer.

The Contractor has to submit the operation and maintenance manual to the Employer 5-fold in English; consisting of the following documents:

- Data sheet
- Description and documents for construction and functioning
- Transport
- Commissioning
- Maintenance
- Storage
- Dimension drawing

9. XLPE Cables

9.1 69kV XLPE Cables and accessories

9.1.1 Regulations and Standards

The latest edition of the following Codes and Standards shall be applicable for the equipment/material covered in this section.

IEC 60228	Conductors of Insulated Cables
IEC 60840	Power Cables with Extruded Insulation and Their Accessories for Rated Voltages Above 30kV (Um=36kV) up to 150kV (Um=170kV) - Test Methods and Requirements.
IEC 60949	Calculation of Thermally Permissible Short-Circuit Currents, Taking into Account Non-Adiabatic Heating Effects
ICEA P-45-482	Short Circuit Performance of Metallic Shields and Sheaths of Insulated Cable
AEIC CS7	Specifications for Cross Linked Polyethylene Insulated Shielded Power Cables Rated 69 through 138kV
IEC 60229	Tests on cable over-sheaths which have a protective function and are applied by extrusion
IEC 60230	Impulse tests on cables and their accessories
IEC 60287-Parts 1&2	Electric cables – Calculation of the current rating – Part 1: Current rating equations and calculation of losses – Part 2: Thermal resistance
IEC 60684	Flexible insulating sleeving
IEC 60811-1-1	Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section1: Measurement of thickness and overall dimensions – Tests for determining the mechanical properties
IEC 60811-1-2	Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section 2: Thermal ageing methods
IEC 60811-1-3	Insulating and sheathing materials of electric cables – Common test methods - Part 1: General application – Section 3: Methods for determining the density - Water absorption tests – Shrinkage test
IEC 60811-1-4	Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section Four: Tests at low temperature
IEC 60811-2-1	Insulating and sheathing materials of electric and optical cables – Common test methods - Part 2-1: Methods specific to elastomeric compounds –Ozone resistance, hot set and mineral oil immersion tests
IEC 60811-4-1	Common test methods for insulating and sheathing materials of electric cables – Part 4: Methods specific to polyethylene and polypropylene compounds –Section One: Resistance to environmental stress cracking – Wrapping test after thermal ageing in air – Measurement of the melt flow index – Carbon black and/or mineral content measurement in PE
IEC 60885-3	Electrical test methods for electric cables – Part 3: Test methods for partial discharge measurements on lengths of extruded power cables
IEC 60287	Calculation of Continuous Current Rating of Cables (100% LF)
IEC 60793-2	Optical fibres – Part 2 – Product specification for multimode fibres
ISO 48	Rubber, vulcanised or thermoplastic – Determination of hardness (hardness between 10 IRHD and 100 IRHD)
ISO 9001	Quality systems - Model for quality assurance in production, installation and servicing

ISO 14644-1	Cleanrooms and associated controlled environments – Part 1 – Classification of air cleanliness

9.1.2 Service Conditions

General Operating Conditions
The conditions under which the cables will be required to operate are:

- Installed in a separate trefoil arrangement in a single way duct/phase comprised of HDPE conduit in concrete encasement
- at a nominal depth of around 1,500mm
- Cable ends rising up concrete, timber, or metal poles and exposed to direct sunlight;
- Ambient air temperature not exceeding 40°C summer day time and 15°C winter night time as determined by a shaded thermometer;
- Ambient soil temperature not exceeding 35°C;
- An altitude not exceeding 1,500m above sea level;
- A high humidity (90%) combined with a high temperature (40°C); followed by a sudden drop in temperature of up to 10°C;
- Soil thermal resistivity 1,5 K m/W
- An area in which the cables may be installed is home to subterranean termite, Mastotermes Darwiniesis and the coastal brown ant, Pheidole Megacephala.
- High Seismicity conditions: 6 out of 12 (Medvedev–Sponheuer–Karnik scale)
- Both end bonding

Operating Conditions – Exposed Cable
Exposed sections of cable will be subject to the following additional service conditions:

- Solar radiation intensity of 1,100W/m²;
- Tropical summer storms with high winds upto 288km/h and an annual rainfall in excess of 1,500mm;
- Areas of coastal salt spray and/or industrial pollution with equivalent salt deposits densities in the range of 2.0 - 3.0g/m².
- Maximum wind pressure 700 N/m2
- Level of pollution, very high

Regarding short-circuit rating adiabatic and non-adiabatic values shall be calculated using the Following conditions:

- Conductor initial temperature 90 °C
- Conductor operating temperature at emergency conditions 130 °C
- Conductor final temperature at short circuit conditions 250 °C
- Aluminum screen initial temperature 80 °C
- Aluminum screen final temperature 180 °C
- Short-circuit duration: 1 s

69kV Systems
The power cables required are for use on 69kV, three phase, 50Hz systems.
The neutral points of the 69kV transformers system are directly earthed.
The maximum system voltage (phase to phase) on the systems is 72 kV and the required impulse insulation level is 350 kVp.

The specified cables shall be designed to meet a 25kA (1s) earth fault duties for 69kV level.

9.1.3 Design and construction requirements

Unless otherwise specified, the cable shall be manufactured in accordance with AEIC CS7 and tested in accordance with AEIC CS7 or IEC 60840.

The power cable shall be designed for ambient temperature conditions.

The cable shall be designed to withstand a conductor temperature of 130°C without any detrimental effects on any of its components. However, the cable sizing shall be based on a maximum permissible continuous temperature of 90°C and emergency loading temperature of 105°C.

The construction of the cable shall be essentially as described below. The ratings and dimensions shall be as indicated in the Data Schedule.

The power cable shall meet or exceed the requirements of this Specification in all respects.

Manufacturer's drawings shall show the outline of the power cable, together with all pertinent dimensions. Any variations in these dimensions due to manufacturing tolerances shall be indicated.

The 69kV cables shall be designed and manufactured to comply with the test requirements set out in IEC standard.

During the contract period, the Tenderer shall not change the design, supplier, manufacturing process or compounding of the materials without the written approval of the Purchaser.

The conductor screen, insulation and insulation screen shall be manufactured using a 3 in 1 extruder head with all three layers applied in the same extruder head.

The conductor shield, cross-linked polyethylene insulation and insulation shield shall be extruded by the simultaneous triple extrusion method to assure homogeneity between the insulation and the semiconducting shields.

The insulation shield shall be bonded firmly and continuously to the insulation.

The cross-linking process shall be by the dry cure dry cooling or dry cure wet cooling method.

It is desirable that the process has facilities at the point of extrusion to monitor and control the thickness of the extruded screens and the insulation and the concentricity of the cable (this may be done by X-Ray scanning and control or similar techniques).

The Tenderer must state in the tender submission how they will control the concentricity of the cable and the thickness of the extruded cable screens and the cable insulation. This will be considered in assessing tenders.

The Tenderer must provide details of cable accessories that the manufacturer used for the compliance testing of tendered cables to requirements and is requested to advise of any other accessories used by the manufacturer with demonstrated compatibility with the tendered or similar cable construction.

Cables shall be capable of satisfactory operation under a power supply system frequency variation of ±5% voltage variation of ±10 % and combined frequency voltage variation shall be +10 % & - 15%.
Cable shall be suitable for laying in ducts underground.
Cable shall have heat and moisture resistance properties. These shall be of type and design with proven record on transmission network service.

The power cable shall be free of material and manufacturing defects which would prevent it from meeting the requirements of this Specification.

Conductors

The aluminum conductors shall be stranded compacted circular class 2, complying all the features specified herein and in standard IEC 60228. Conductor material shall be AAC-1350, i.e. 99.5% aluminum content.

The aluminum conductors’ cross-sectional areas for 69kV cable should be one core $240mm^2$.

Longitudinal water barriers must be applied to all conductors to avoid water penetration.

Electrical resistance in direct current at 20ºC for 69kV conductor, measured as indicated on IEC60228:2004 Annex A, shall be equal or smaller to 0.11Ω/KM.

The individual wires shall be of the same nominal diameter before stranding into the compacted circular formation. Successive layers of wires shall have opposite directions of lay.

Any lubricants used during compaction of the conductor shall be removed from the conductors prior to application of the core screen. Greasing of the conductors is not permitted.

Conductor Screen

It shall consist of a fully bonded layer of black semi-conductive cross-linked compound. It shall be extruded over the conductor to provide a smooth surface without causing any damage to the conductor or insulation and ensuring material compatibility.
The conductor screen nominal thickness shall be 1.5 mm.
The conductor screen minimum thickness measured and accepted at any point shall not be less than 1.2 mm. In addition, the average of all the measures shall not be less than the nominal thickness (1.5 mm).

The resistivity of extruded semi-conducting screens applied over the conductor shall not exceed 1.000W·m.

Insulation

The insulation shall be super clean grade cross-linked polyethylene complying with the requirements of IEC 60840, IEC 60811 Parts 1 to 4 inclusive and IEC 60885-3 applied by an extrusion process; simultaneously with the semi-conductive conductor and insulation screens within one crosshead.

The insulation shall be free from faults and imperfections larger than the resultant values given by the maximum extruder filter mesh size stated by the Tenderer.

All manufacturing rooms and areas where PE, additives and peroxides are handled and mixed shall be suitably sealed and provided with air-dryers and filtering systems corresponding to clean room conditions in accordance ISO 14644-1 Class 5 to Class 6 or the equivalent provisions in the USA Fed. Gov. Standard 209a (Class 1,000 to 10,000) as applicable.

The Tenderer is required to submit, with the tendering documentation, copies of manufacturing and purchasing specifications of raw materials and detailed quality procedures in relation to sampling and testing conditions and requirements. The Principal shall have access to inspect the manufacturers’ works should he elect to do so.

Insulation thickness and concentricity requirements shall be in accordance with the requirements.

The XLPE insulation must allow maximum conductor temperatures of 90 °C in normal operation and 250 °C under short circuit condition by at least 1 seconds.
The insulation minimum thickness measured and accepted at any point of the cable shall not be less than 90% of the nominal value: $t_{min} = 0.9\ t_n$

Nominal and minimum thickness for XLPE insulated cables are:

- Nominal (tn): 9mm
- Minimum (tmin): 8.1mm

Alternatively, the nominal insulation thickness may be based on a design stress as agreed between the supplier and the purchaser. For an agreement of this nature to be considered the Tenderer must provide evidence of accelerated testing carried out to demonstrate the expected life of the cable

The expected service life of the cable under the specified environmental conditions shall be stated.

De-gassing of the insulation shall be effected before the metallic sheath is applied to the cables. The cable cores shall be dry nitrogen cured and de-gassed to the manufacturer's recommendations, but in any case as a minimum, at ambient temperature for 1 day per millimeter of insulation thickness prior to the further laying up of the cable core.

The Tenderer shall provide details with the tender documentation of the de-gassing process, stating the temperatures and periods of time that manufactured core material of the cable is exposed to allow gasses to ventilate.

At the end of the de-gassing process the residual gases shall be identified and quantified by measuring the cross-linking by-product concentration in cable samples using the tests conducted in a thermo-gravimetric analyzer (TGA) in accordance with the procedure and meeting the requirements of Clause 2.4.15 of CENELEC Document HD 632 S2:2008 Part 2.

Insulation Screen

A black layer of cross-linked semi-conductive compound shall be applied over the insulation. Such layer shall be compatible with insulation temperatures in normal operation and during short circuit.
The insulation screen shall be adhered to the insulation.
Unless otherwise indicated in the Local Sections, the insulation screen minimum thickness measured and accepted at any point shall not be less than 1.2 mm. In addition, the average of all the measures shall not be less than the nominal thickness 1.5 mm.

The resistivity of extruded semi-conducting screen applied over the insulation shall not exceed 500W·m.

Water Blocking of the Insulation Screen

Non-biodegradable, water-swellable semi-conductive tape(s) shall be applied over the insulation screen.

Such tape shall be applied without harming the adjacent layers and could work as additional separator layer as well. The swelling tape shall be applied with a minimum overlap same as 10%.

The Tenderer shall submit with their tender submission the results of tests carried out demonstrating the effectiveness of water blocking method and materials proposed.

Corrugated Aluminum Sheath

The Aluminum sheath comprising the moisture barrier shall provide an impervious barrier.

Corrugated sheaths shall be extruded in a continuous process from rolls of sheet metal without joins in any one drum length.

Annular corrugations are requested to assist with the prevention of water permeation along the cable and to facilitate the cutting and removal of the metallic sheath without damage to the core of the cable.

The following instructions must be fulfilled for the corrugated aluminum earth screen:

- Material shall be aluminum of 99.6% minimum purity having an elongation of 16% minimum.
- The corrugated sheath shall be of uniform thickness, homogeneous construction, seamless, free from defects, porosity and intercrystalline fracture. A layer of bitumen or other suitable compound, incorporating corrosion inhibitors, shall be applied over the aluminum sheath for corrosion protection and to provide a moisture seal with the oversheath.
- Nominal thickness of aluminum sheath must be equal or greater than 2.0 mm.
- The minimum thickness of the corrugated aluminum sheath measured and accepted at any point of the cable shall not be less than 85% of the nominal value minus 0,1 mm:
  $t_{min}=0{,}85t_n-0{,}1$
  Where: t_{min}: minimum thickness in millimeters and t_n: nominal thickness in millimeters
- The maximum electric resistance at 20ºC shall be equal or less than 0,5Ω/KM

IEC 60949 or ICEA Publication P-45-482 shall be used by the manufacturer to determine the effective cross-sectional area of the metallic shield and its short circuit current carrying capability.

Protective Layers, Over-Sheaths and Outer-Sheaths

An extruded over-sheath shall be applied to the cable. The over-sheath shall be comprised of a layer of black LMDPE complying with the requirements of IEC 60840 and IEC 60229 and have the properties specified below.

The outer sheath shall be resistant to moisture, abrasion, and UV.

The compound shall have a minimum of 2% carbon black and shall be capable of operating continuously at 900C.

A graphite coating shall be applied on the over-sheath to allow for present and future testing of the integrity of the cable sheath. The Tenderer shall give details of the graphite coating being offered.

For the purposes of this specification the term LMDPE (linear medium density polyethylene) refers to an over sheath that shall have the following properties:

- Density: 0.930 – 0.950 g/cm3
- Hardness - Shore D 54 – 58

The Tenderer shall provide sample test results of shrinkage tests carried out on the LMDPE outer sheath insulation using the test procedure and meeting the requirements of IEC standard.

The minimum thickness of the outer sheath measured and accepted at any point of the cable shall not be less than 85% of the nominal value minus 0,1 mm: $t_{min}=0{,}85\ t_n-0{,}1$ (Where: t_{min}: minimum thickness in millimeters and t_n: nominal thickness in millimeters)

Minimum thickness at any point of the outer sheath is 3mm

A conductive layer shall be applied over the jacket to serve as an electrode for testing the integrity of the jacket.

The thickness of the conductive layer shall be sufficient so that the jacket integrity test can be done successfully

Marking

The marking must be indelible paint, easily legible and carried out by indenting or embossing above the surface of the outer sheath in a continuous way.
Durability shall be checked by the test given in sub-clause 4.4 of standard IEC 60794-1-21.

The jacket for all the cables shall be embossed marked in English at intervals not exceeding one meter with the following minimum information:

a. Electric Cable

b. Voltage designation, 69kV

c. Type of insulation, XLPE

d. Insulation thickness, mm

e. Conductor cross-sectional area, mm^2 and material

f. The manufacturer's name or trademark

g. Year of manufacture

h. Cumulative length at every one meter with the highest length mark on the outer end of the cable.

The print will be made every 0.5 meters and with a font size of not less than 10 mm

Marking by matrix print is not acceptable

Ampacity and Short-circuit rating

The ampacity and short-circuit rating **estimated** values shall be given for network design purposes and should comply with the requested values in annexes.
Unless otherwise indicated in local sections, such ampacity values shall be calculated in steady state condition, for single core laying, when installed in buried duct using the operational conditions listed above.

9.1.4 Testing

Acceptance tests

Acceptance tests (routine tests and sample tests) shall be carried out in the Supplier’s facilities.

Type tests

Type tests shall be performed before supplying a type of cable covered by this standard in order to demonstrate satisfactory performance characteristics to meet the intended application.
When type tests have been successfully performed on one type of cable covered herein with a specific cross-section, rated voltage and construction characteristics, the type approval could be accepted as valid for as long as the following conditions are met:

- The conductor cross-section is not larger than that of the tested cable.
- The cable has similar constructions as that of the tested cable, i.e. utilizes same materials, (conductor, screens, insulation, earth screen, outer sheath) and the same manufacturing process.
- The rated voltage does not exceed that of the tested cable.
- The calculated nominal electrical stress and the impulse voltage stress calculated using nominal dimensions at the cable conductor screen do not exceed the respective calculated stresses of the tested cable by more than 10 %.
- The calculated nominal electrical stress at the cable insulation screen and the impulse voltage stress calculated using nominal dimensions do not exceed the respective calculated stresses of the tested cable.

When the design or the materials of the cable are changed (which might affect the performance characteristics of the cable), the relevant type tests shall be repeated.

Cables shall undergo type tests after having passed all the acceptance tests gathered in routine and sample tests lists.

All samples needed for the type tests shall be taken from the same production length.

The type tests shall comprise the electrical tests on the complete cable system and the non-electrical test on cable components and complete cable as specified in 7.7.5 and 7.7.6. For cables with Umax = 170 kV, calculated nominal electrical stress at the conductor screen not higher than 8.0 kV/mm and calculated nominal electrical stress at the insulation screen not higher than 4,0 kV/mm the electrical tests should be performed on cables alone.

The type tests on cable components only need to be carried out on samples from cables of different voltage ratings and/or conductor cross-sectional areas if different materials and/or different manufacturing processes are used to produce them. However, repetition of the ageing tests on pieces of completed cable to check compatibility of materials may be required if the combination of materials applied over the screened core is different from that of the cable on which type tests have been carried out previously.

Electrical Type Test list

i) Bending test IEC 60840 sub-clause 12.4.3 and IEC 62067 sub-clause 12.4.4
ii) Tan d measurement: IEC 60840 clause 12.4.5
iii) Heating cycle voltage test: IEC 60840 clause 12.4.6
iv) Partial discharge test at ambient and high temperature: IEC 60840 clause 12.4.4
v) Lightning impulse voltage test followed by a power frequency voltage test: IEC 60840 clause 12.4.7
vi) Partial discharge test at ambient and high temperature: IEC 60840 clause 12.4.4
vii) Examination of cable: IEC 60840 clause 12.4.8
viii) Resistivity of cable semi-conducting screens: IEC 60840 clause 12.4.9

Non-Electrical Type Test list

i) Check of cable construction: IEC 60840 clause 12.5.1
ii) Mechanical properties of insulation before and after ageing: IEC 60811-501 and IEC 60811-401 and IEC 60840 clause 12.5.2
iii) Mechanical properties of oversheath before and after ageing: IEC 60840 clause 12.5.3, IEC 60811-501 and IEC 60811-401.
iv) Ageing tests on pieces of complete cable to check compatibility of materials: IEC 60840 clause 12.5.4, IEC 60811-501 and IEC 60811-401.
v) Pressure test at high temperature on oversheath: IEC 60811-508
vi) Test for LSHF oversheaths at low temperature: IEC 60811-505 and IEC 60811-506
vii) Hot set test for XLPE insulation: IEC 60811-507
viii) Measurement of carbon black content of black PE oversheaths: IEC 60811-605
ix) Test under fire conditions: IEC 60332-1-2
x) Water penetration: IEC 60840 Annex E
xi) Tests on components of cables with a longitudinally applied metal tape or foil, bonded to the oversheath: IEC 60840 clause 12.5.15
xii) Shrinkage test for XLPE insulation: IEC 60811-502
xiii) Shrinkage test for PE and LSHF oversheaths: IEC 60811-503
xiv) Oversheath halogen acid content: IEC 60754-1

Routine test list

Routine tests shall be performed at 100% of delivered spools to demonstrate product integrity as per standard IEC 60840.
i) Partial discharge test
ii) Voltage test
iii) Electrical test on oversheath of the cable
iv) Measurement of electrical resistance of conductor and metal screen

v) Measurement of capacitance

Sample Test list

Sample tests are carried out over samples taken from each batch (manufacturing series) in order to verify that the finished product meet the design specifications.

The sample tests shall be carried out on one length from each batch (manufacturing series) of the same type and cross-section of cable, but shall be limited to not more than 10 % of the number of lengths in any contract, rounded to the nearest whole number.

If the sample from any length selected for the tests fails in any of the tests, further samples shall be taken from two further lengths of the same batch and subjected to the same tests as those in which the original sample failed. If both additional samples pass the tests, the other cables in the batch from which they were taken shall be regarded as having complied with the requirements of this standard. If either fails, this batch of cables shall be regarded as having failed to comply.

Test are:

i) Cable examination

ii) Measurement of thickness of cable insulation and oversheath: IEC 60811-201, IEC 60811-202

iii) Measurement of thickness of metal sheath: IEC 608410

iv) Measurement of diameters: IEC 60811-203

v) Hot set test for XLPE insulation: IEC 60811-507

vi) Lightning impulse voltage test: IEC 62067 clause 10.12

vii) Water penetration test: IEC 60840 Annex E

viii) Tests on components of cables with a longitudinally applied metal tape or foil, bonded to the oversheath: IEC 60840 Annex F

ix) Measurement of thickness of conductor and insulation screens: IEC 60811-202

x) Mechanical properties of XLPE insulation: IEC 60811-507

vi) Lightning impulse voltage test: IEC 62067 clause 10.12

vii) Water penetration test: IEC 60840 Annex E

viii) Tests on components of cables with a longitudinally applied metal tape or foil, bonded to the oversheath: IEC 60840 Annex F

ix) Measurement of thickness of conductor and insulation screens: IEC 60811-202

x) Mechanical properties of XLPE insulation: IEC 60811-501

xi) Mechanical properties of sheath: IEC 60811-501

xii) Abrasion resistance of cable markings: IEC 60794-1-21 sub clause 4.4

Prequalification Test list

Prequalification tests shall be performed before supplying a type of cable covered by this standard in order to demonstrate satisfactory long-term performance of the complete cable system.

The prequalification test shall be performed on cable systems where the calculated nominal electrical stresses at the conductor screen will be higher than 8.0 kV/mm and/or at the insulation screen higher than 4,0 kV/mm.

The prequalification test shall be performed except if cable systems with the same construction and accessories of the same family have been prequalified for a higher rated voltage.

Prequalification test must be performed on a cable system, using a cable of a large conductor cross-section in order to cover thermo-mechanical aspects. General conditions for these tests and their extension are those indicated in IEC 62067 clause 13 for cables with U_0=127 kV and IEC 60840 clause 13 for cables with U_0<127 kV.

i) Heating cycle voltage test: IEC 60840 clause 13.2.4

ii) Lightning impulse voltage test: IEC 60840 clause 13.2.5

iii) Examination of the cable system after completion of the tests above: IEC 60840 clause 13.2.6

Development Test list

These are tests made during the development of a cable design and shall be performed before supplying a type of cable covered by this standard in order to demonstrate satisfactory performance of the complete cable system.

i) Impact test: IEC TR 61901 clause 4.1.1

ii) Sidewall loading test: IEC TR 61901 clause 4.1.3

iii) Long term ageing of adhesive bonds of components of laminated covering: IEC TR 61901 clause 4.1.4

iv) Mechanical properties of the welding: IEC TR 61901 clause 4.1.5

v) Short circuit test: IEC TR 61901 clause 4.1.5

9.1.5 Packing and shipping

The samples needed for tests shall be taken from additional lengths of the same batch included in the supply order. Thereby, the lengths in any contract could not be diminished in order to perform any test. The allowed tolerance of the cable length provided on each drum is -0%, +1% of the nominal length required.

In addition to the applicable items as per IEC standard, packing and shipping of the cable shall conform to the following:

- A pulling eye attached to the conductor shall be provided at the outside cable end of each cable shipping length.
- The cable ends shall be sealed with a waterproof, heat shrinkable plastic or elastomeric end cap with adhesive type sealing compound. Cable ends shall be properly secured to the reel.
- The cable shall be delivered without splices, on standard sized non-returnable steel drums of sturdy construction properly packed and lagged externally to prevent the cable from possible damage during transport. Wood lagging shall be used and have a minimum thickness of 50mm.

Cable reels/drums shall be marked in legible and indelible letters giving the following particulars:

a. Cable voltage and conductor size
b. Type of cable
c. Length and weight of cable on reel
d. Gross weight
e. Dimensions of reel
f. Manufacturer's name and country of origin
g. Purchase Order number
h. Contract number
i. Serial number of reel
j. TBU stock number in 10 cm high bold numerals.
k. Direction of rolling of reel

All markings shall appear on both sides of the reel
Cable reel identification shall include any additional information as required by shipping instructions.

9.1.6 69kV Cable Accessories

Indoor Dry plug-in SF6 termination for 69kV GIS connection

The dimensions of cable termination interfaces for SF6 Gas Insulated Switchgear (GIS) shall meet the requirements of IEC TS60859 or IEEE 1300. Any variations in these dimensions due to manufacturing tolerances shall be indicated.

The termination shall be Class 1 per IEEE 48 or equivalent. For apparatus terminations, the temperature of the medium in direct contact with the termination (ambient inside enclosure) shall not exceed 55ºC.

All terminations for GIS shall employ, as a minimum, a double sealing method per IEC 60859 to prevent leakage of SF6 gas. Details of the sealing method shall be submitted by the bidder for review and approval. The seals shall have a life expectancy of not less than 30 years.
Cable termination manufacturer shall provide and install the non-linear resistance/surge arresters, symmetrically between the GIS-side flange and ground, at the cable termination with GIS having shield break insulation to bypass very fast transients generated in GIS per IEC 60859 or IEEE 1300

The terminations required in this specification shall have the following characteristics:

a. The dry compact switchgear termination for rated voltage of 69 kV must be designed to be installed in gas-insulated switchgear (GIS). It complies with IEC 62271-209 standard, which essentially specifies the interfaces between the termination and the switchgear. Therefore, the termination will fit into all GIS that comply with IEC 62271-209.
b. Dry interfaces, no oil-filling
c. Dimensions comply with IEC 62271-209
d. Pressure-tight resin housing
e. Operates in SF6 and insulating liquids
f. Pre-fabricated and factory-tested silicone-rubber stress cone
g. Torque-controlled or wedge-type multi-contact conductor bolt
h. No special tools required to install the termination
i. Insulated cable gland for sectionalization
j. Type tested according to IEC 60840, IEC 62067 and IEC 62271-209 standards

A suitable nameplate shall be provided in the termination kit giving the following information:

a. Manufacturer's name
b. Type of termination
c. Designation no.
d. IEEE terminator class no.
e. Insulation class
f. Maximum design voltage to ground
g. Maximum and Minimum cable conductor size
h. Maximum and Minimum cable insulation diameter
i. BIL
k. Rated internal pressure, kPa
l. Date of Manufacture

Cable termination interfaces for GIS shall also be tested per IEC TS 60859 or IEEE 1300.

Outdoor cable terminations

The design and construction of the termination shall essentially meet the latest requirements of IEC 60141-1, IEC 60840, IEC 62067 or IEEE 48.

The terminations required in this specification shall have the following characteristics:

a. Shall be of dry type and suitable for use in terminating XLPE cables with stranded compacted round aluminum conductors.
b. Shouls be cold shrinkable cable termination.
c. Shall have a stress control tubing component with proper electrical stress control at the operating voltage over the insulated cable cores at the termination.
d. Shall have anti-tracking tubing with resistance to tracking and erosion of the material.
e. Shall be designed and manufactured to ensure that all components and materials are suitable for use in the specified service conditions.
f. The complete components and materials shall be free from defects which would be likely to cause them to be unsatisfactory in service.
g. The components and materials shall be manufactured to ensure high moisture sealing capacity, resistance to fungal and insect attack.
h. Outdoor terminations shall be of specific creepage distance of 31.5 mm/kV, pollution level IV conforming and tested to IEC 60815 and shall be provided with sheds for creepage extension.
i. Terminal lugs shall be of tinned high conductivity copper with step-less mechanical shear off bolts.
    - Lugs shall be supplied in pairs complete with a pair of assembly bolts of similar materials.
    - Lugs shall be tested in accordance with BS EN 61238-1 (Class A-Short circuit Test).

The bolts shall have extruded profile. When completely tightened, the shears shall be flush with connector body

Specialized tools

Specialized tools that are required during the terminating process shall be provided for both the joints and the terminations.

Installation Instructions

The supplier shall provide the installation procedures and instructions for the pre-molded straight through joints, indoor dry plug-in and outdoor termination kits to be used as accessories of the cable specified below.

9.1.7 Technical data for 69 kV XLPE cable and accessories

The 69 kV XLPE cable and accessories to be supplied shall comply with guaranteed technical particulars as indicated in Annex A2-13.

9.2 Medium Voltage XLPE Cables

The 2.2kV, 11kV and 33kV cables shall be single core XLPE insulated cables with copper conductors and triple extruded insulation and shall comply with IEC 60502-1, 60502-2, 60502-4.

The materials shall be of first-class quality and designed for continuous satisfactory operation as continuity of supply is of prime importance and to operate satisfactorily under variation of load, voltage and short circuit or other conditions which may occur on the system provided that these variations are within the assigned rating of the apparatus. The materials used shall be suitable for the climatic and soil conditions listed below.

Power medium voltage cables shall be provided with longitudinal and vertical watertight screen. The longitudinal water barrier shall be performed by a water-swellable semi-conducting.

The insulation metallic screen shall consist of plain annealed copper conductor capable to withstands the short-circuit current. The over sheath of the MV cables shall be of PVC and flame retardant. The cables to be supplied shall avoid treeing effects in the insulation. The short circuit capabilities of the cables shall be in accordance with the respective short circuit current values specified for the upstream switchgear by the break time, which should be equal the time delay of infeed protection of upstream MV switchgear.

Single core, screened cables must be laid up in a triangular arrangement in separate trenches.

To avoid excessive contact voltage, the screens of the power cables will be earthed

9.2.1 Regulations and Standards

Unless otherwise specified elsewhere in this specification, the rating as well as performance and testing of the XLPE power cables shall conform to the latest revisions available at the time of placement of order of all the relevant standards as listed, but not limited to specified.

IEC 60228	Conductors of Insulated Cables
IEC60502 Part – 2	Power cables with extruded insulation and their accessories for rated voltages from 1 kV (Um = 1.2 kV) up to 30 kV (Um = 36 kV) – Part 2: Cables for rated voltages from 6 kV (Um = 7.2 kV) up to 30 kV (Um = 36 kV)

IEC61442	Test methods for accessories for power cables with rated voltages from 6kV (7.2kV) up to 30kV (Um=36kV)
IEC 60949	Calculation of Thermally Permissible Short-Circuit Currents, Taking into Account Non-Adiabatic Heating Effects
IEC 60229	Tests on cable over-sheaths which have a protective function and are applied by extrusion
IEC 60230	Impulse tests on cables and their accessories
IEC 60287-Parts 1&2	Electric cables – Calculation of the current rating – Part 1: Current rating equations and calculation of losses – Part 2: Thermal resistance
IEC 60684	Flexible insulating sleeving
IEC 60811-1-1	Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section1: Measurement of thickness and overall dimensions – Tests for determining the mechanical properties
IEC 60811-1-2	Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section 2: Thermal ageing methods
IEC 60811-1-3	Insulating and sheathing materials of electric cables – Common test methods - Part 1: General application – Section 3: Methods for determining the density - Water absorption tests – Shrinkage test
IEC 60811-1-4	Common test methods for insulating and sheathing materials of electric cables – Part 1: Methods for general application – Section Four: Tests at low temperature
IEC 60811-2-1	Insulating and sheathing materials of electric and optical cables – Common test methods - Part 2-1: Methods specific to elastomeric compounds –Ozone resistance, hot set and mineral oil immersion tests
IEC 60811-4-1	Common test methods for insulating and sheathing materials of electric cables – Part 4: Methods specific to polyethylene and polypropylene compounds –Section One: Resistance to environmental stress cracking – Wrapping test after thermal ageing in air – Measurement of the melt flow index – Carbon black and/or mineral content measurement in PE
IEC 60853-1	Calculation of the cyclic and emergency current rating of cables. Part 1: Cyclic rating factor for cables up to and including 18/30(36) kV
BS 7835	Electric cables - Armoured cables with thermosetting insulation for rated voltages from 3.8/6.6 kV to 19/33 kV having low emission of smoke and corrosive gases when affected by fire - Requirements and test methods
IEEE 48-2000	Testing standard for joints and terminations
IEC 60754-1	Test on gases evolved during combustion of materials from cables – Part 1: Determination of the halogen acid gas content
IEC 60332-1-2	Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame

9.2.2 Service conditions

General Operating Conditions

The conditions under which the cables will be required to operate are:

- Installed in duct banks / cable trench with covers

- at a nominal depth of around 1,500mm
- Cable ends rising up concrete, timber, or metal poles and exposed to direct sunlight;
- Ambient air temperature not exceeding 40°C summer day time and 15°C winter night time as determined by a shaded thermometer;
- Ambient soil temperature not exceeding 35°C;
- An altitude not exceeding 1,500m above sea level;
- A high humidity (90%) combined with a high temperature (40°C); followed by a sudden drop in temperature of up to 10°C;
- Soil thermal resistivity 1,5 K m/W
- An area in which the cables may be installed is home to subterranean termite, Mastotermes Darwiniesis and the coastal brown ant, Pheidole Megacephala.
- High Seismicity conditions: 6 out of 12 (Medvedev–Sponheuer–Karnik scale)
- Both end bonding

Operating Conditions – Exposed Cable
Exposed sections of cable will be subject to the following additional service conditions:

- Solar radiation intensity of 1,100W/m²;
- Tropical summer storms with high winds upto 288km/h and an annual rainfall in excess of 1,500mm;
- Areas of coastal salt spray and/or industrial pollution with equivalent salt deposits densities in the range of 2.0 - 3.0g/m².
- Maximum wind pressure 700 N/m2
- level of pollution, very high

Regarding short-circuit rating adiabatic and non-adiabatic values shall be calculated using the Following conditions:

- Conductor initial temperature 90 °C
- Conductor operating temperature at emergency conditions 130 °C
- Conductor final temperature at short circuit conditions 250 °C
- Metallic screen initial temperature 80 °C
- Metallic screen final temperature 180 °C
- Short-circuit duration: 1 s

33kV, 11kV and 2.2kV Systems
The power cables required are for use on 33kV, 11kV and 2.2kV three phase, 50Hz systems.
The neutral points of the 33kV transformers system are directly earthed. Earthed through earthing transformers for 11kV and 2.2kV levels.

The specified cables shall be designed to meet a 25kA (1s) earth fault duties.

9.2.3 Design and construction requirements

2.2kV, 11 kV & 33 kV earthed, single core power cables shall normally be with stranded compacted copper conductor provided with conductor screening (of extruded semi-conducting cross link material) and shall be insulated with XLPE of natural color. Identification of cores shall be by color.

The insulation (XLPE) screening shall be provided consisting of extruded semi-conducting cross link material in combination with a metallic layer of copper tapes. Such screened cores shall be laid up together with fillers and/or binder tapes where necessary and provided with extruded inner sheathing of heat resistant PVC conforming to type ST-2 of PVC ST 2 as per IEC:60502 Part – 2, BS:6622, LSOH to BS:7835.

Maximum continuous operating temperature shall be 90 deg C under normal operation and 250 deg C under short circuit condition. Armoring shall be provided consisting of Double layer of non-magnetic (aluminum) tapes. In accordance to IEC:60502 Part – 2, BS:6622, BS:7835. (amended upto date) and over the armoring a tough outer sheath of PVC compound shall be extruded. The PVC compound for the outer sheath shall conform to type ST-2, FRLS as per IEC:60502 Part – 2, BS:6622, LSOH to BS:7835. (amended upto date). The color of the outer sheath shall be black. The cable shall be manufactured strictly conforming to IEC standard.

Nonerasable Sequential Marking of length shall be provided by embossing on outer sheath of the cable for each meter length.

The quality of insulation should be good and insulation should not be deteriorated when exposed to the climatic conditions.

Inner conductor shielding, XLPE insulation and outer core shielding shall be extruded in one operation by special process to ensure that the insulation is free from contamination and voids and perfect bonding of inner and outer shielding with insulation is achieved. The bidders are requested to elaborate the manufacturing technique adopted by their manufacturers to achieve this motive.

9.2.4 Testing

Type Tests:

All the type tests in accordance with IEC: 60502, BS: 6622, BS: 7835 and amended upto date, shall be performed on cable samples drawn by purchaser.

Type tests are required to be carried out from the lot of supply on a sample of any one size of cable ordered for each voltage grade. In case facilities of any of the type tests are not available at the works of the supplier, then such type test shall be carried out by the supplier at the independent laboratory at the cost of supplier.

Sample for the type test will be drawn by the purchaser's representative and the type test will be witnessed by him.

The following shall constitute type tests:

a) Tests of Conductor:

- i) Annealing test (for copper)
- ii) Tensile test (for aluminum)
- ii) Wrapping test (for aluminum)
- iii) Conductor Resistance test

b) Tests for armoring wires/strips.

c) Tests for thickness of insulation and sheath.

d) Physical tests for insulation:

- i) Tensile strength and elongation at break.
- ii) Ageing in air oven.

iii) Hot test

iv) Shrinkage test.

v) Water absorption (gravimetric).

e) Physical test for outer sheath:

i) Tensile strength and elongation at break.

ii) Ageing in air oven.

iii) Shrinkage test.

iv) Hot deformation,

f) Partial discharge test.

g) Bending test.

h) Dielectric power factor test:

i) As a function of voltage.

ii) As a function of temperature.

i) Insulation resistance (volume resistivity test).

j) Heating cycle test.

k) Impulse withstand test.

l) High voltage test.

m) Flammability test.

Routine Tests:

All the Routine tests as per IEC standard and amended up to date shall be carried out on each delivery length of cable. The result should be given in test report. Partial discharge test must be carried out in a fully screened test cell. It is, therefore, essential that the manufacturer should have the appropriate type of facility to conduct this test which is routine test.

The details of facility available in the manufacturer's works in this connection should be given in the bid.

The following shall constitute routine tests:

a) Conductor resistance test

b) Partial discharge test

c) High voltage test.

The contractor shall also undertake to arrange for the short circuit test as a type test on any one size of each voltage grade i.e on one size of 11 kV and one size of 33 kV earthed grade shielded XLPE cables. If facilities for carrying out short circuit tests are available at the works of the supplier, and provided the certification procedure is approved by the Purchaser, testing at the supplier's works will be acceptable. Short Circuit test shall be witnessed by the purchaser's representative.

The short circuit test shall be preceded and followed by the following tests to ensure that the characteristics of the cable remain within the permissible limits even after it is subjected to the required short circuit rating.

a) Partial Discharge Test.

b) Conductor Resistance Test.

c) High Voltage Test.

The manufactured cable will be acceptable only after such a sample test is successfully carried out at CPRI or at suppliers works and approved by the Purchaser.

9.2.5 Packing and Marking

The following particulars shall be properly legible embossed on the cable sheath at the intervals of not exceeding one meter throughout the length of the cable. The cables with poor and illegible embossing shall be liable for rejection.

a) Manufactures name and/or Trade name.

b) Voltage grade.

c) Year of manufacture.

d) Type of insulation, XLPE

e) Successive Length.

f) Conductor cross-sectional area, mm^2 and material

The cable shall be supplied in continuous standard length of 500 running meters with plus minus 5% tolerance wound on non-returnable wooden drum of good quality and non-standard lengths not less than 100 meters up to 5% of the ordered quantity shall be accepted. Alternately cable can be supplied wound on non-returnable steel drum without any extra cost to the purchaser. Packing and marking shall be as per IEC standard

9.2.6 Cable Terminations:

Outdoor and indoor termination shall be done by cold shrinkable type termination kits. Termination for cable shall be provided in sufficient quantities for complete installations of substations.

The kits should have satisfactory performance record of minimum 5 years supported with proof of customers having had satisfactory use of these kits.

The Joints and terminations should have been type tested and type test reports made available.

The Kits should generally consist of:

(a) Cold shrinkable clear insulating tubes

(b) stress control tubing where necessary,

(c) Ferrule insulating tubing for joints,

(d) Conductive cable break outs for terminations, non tracking, erosion and weather resistant tubing both outer / inner

(e) non tracking erosions and weather resistant outdoor sheds in case of terminations.

(f) high permittivity mastic wedge

(g) Insulating mastic.

(h) Copper crimping lugs.

(i) Tinned copper braids

(j) Wrap around mechanical protection for joints.

(k) Cleaning solvents, abrasive strips.

(l) Plumbing metal.

(m) Binding wire etc. adequate in quantity and dimensions to meet the service and test conditions.

The kit shall have installation instructions and shall be properly packed with shelf life of over 3 years

9.2.7 Technical data for 36 kV XLPE cable

The 33 kV XLPE cable and accessories to be supplied shall comply with guaranteed technical particulars as indicated in Annex A2-14.

9.2.8 Technical data for 11 kV XLPE cable

The 11 kV XLPE cable and accessories to be supplied shall comply with guaranteed technical particulars as indicated in Annex A2-15.

9.2.9 Technical data for 2.2 kV XLPE cable

The 2.2 kV XLPE cable and accessories to be supplied shall comply with guaranteed technical particulars as indicated in Annex A2-16.

10. 33 kV Air insulated Metal-clad Switchgear

For the detailed technical parameters please review additionally the technical data sheet for the 33 kV switchgear in the Annex A2-17.

10.1 Cubical Enclosure

The switchgear respectively the cubical shall comprise of an air insulated metal-clad switchgear suitable for indoor use and shall be constructed in accordance with the latest IEC 62271-200 (Annex A, accessibility type A, IAC classification FLR) regulations. It shall be rated for an operational voltage of 33 kV. All active/live parts of the switchgear and to the switchgear connected parts (e.g. cables and bus connections) have to be inside the metal cad enclosure and protected from touching.

The design is based on a single busbar system and the cubicle is equipped with a circuit breaker, voltage transformer, current transformer and earthing switch.

The circuit breaker compartment shall have a lockable door.

The cubicles shall be designed in order to withstand without damage all loads and forces which occur during transportation and erection. Each bay shall be equipped on the top with hooks suitable for lifting gear; the bay and the hook shall be dimensioned to withstand the forces which occur while lifted.

The various sections of each panel of the switchboard shall be compartmented, typically voltage transformer, CT/cable, circuit breaker and busbar. Anti-condensation heaters shall be provided within individual compartments and have to be switched automatically on when the circuit is de-energized.

The bays shall be equipped with lockable doors and enclosures in order to prevent accidental touching of live parts by protecting them by locking.

A set of automatic earthed shutters shall be provided to cover each group of fixed contacts and prevent access to the live parts on feeder and busbar side.

Each set of shutters shall be capable of being individually operated and individually padlocked closed. Busbar shutters, circuit shutters and voltage transformer shutters shall be painted and labelled in an approved manner. Durable phase color-indications shall be provided in an easy visible position.

Horizontally withdrawable circuit breakers shall be provided in order to place the circuit breakers in a secured and correct position on the supporting structure.

Separate terminal boxes shall be provided on each bay for the main and auxiliary cables. Stainless steel cable glands shall be foreseen for the insertion of cables. Main and auxiliary cables shall be segregated. Terminals carrying different voltages shall be separated. The voltage shall be marked on each terminal.

Undrilled stainless steel gland plates shall be provided. Where single core cables are used, gland plates shall be nonferrous.

10.2 Protection and Control

The grounding of the bus bar sections has to be carried out by using separate earthing switches with manual rotary shaft drives.

All 33 kV cubicles must have protective and control devices:

- Control of the circuit-breakers (local and remote control) via the station control system and remotely,
- All necessary protection relays IED,

- All necessary testing blocks for current and voltage injections,
- All necessary signalizations lamps, switchs selectors, pushbutton, TPL, ...
- Energy meter,

Protection and control and energy meters must be integrated into the station control system and shall be installed in the front panel of the secondary compartment of the switchgear.

10.3 Circuit Breakers

The circuit breakers offered shall be horizontally withdrawable SF6 types. They shall comply and be fully type tested to IEC 62271-1 IEC 62271-100, IEC 62271-200, and 62271-110.

SF6 circuit breakers shall, if the SF6 pressure decreases, send an alarm (1st stage) and be locked (2nd stage) in either open or closed position in order to prevent any further operation.

The circuit breaker shall be equipped with high integrity operating and isolating mechanisms, primary and secondary disconnecting devices, auxiliary contacts, manual tripping facilities, operations counter, mechanical position indicator, control wiring, auxiliary relays and contactors as required.

The circuit breaker shall be equipped with a manual trip device. The drives of the circuit breakers, disconnectors and earthing systems will be supplied by 110 V DC.

Interlock arrangements shall be as stated in IEC 62271-200. Mandatory interlocks shall be mechanical.

Circuit breaker operating mechanism shall be of the spring powered stored energy with provision for automatic reclosing for feeder circuits only. Each equipment shall be provided with visual indicating device to show the circuit breaker "Open" or "closed" it shall operative when the circuit breaker is in the "service" "isolated" and "earthed" positions .It shall be possible to complete the closing tripping indication and interlock circuits when the circuit breaker is isolated.

Locking facilities shall be provided so that the circuit breaker can be locked in each position. The closing mechanism shall be provided with electrical release coils and shall be of "trip free" type. It shall be possible to charge the mechanism spring with circuit breaker in either the "open" or the "closed" position. In normal operation the recharging of the operating spring shall be commenced immediately and automatically upon completion of the circuit breaker closure. A visual mechanical indicating device shall be provided to indicate the state of the spring "spring charged" when the spring is in condition to close the C.B and "spring free" when the spring not in a condition to close the C.B. The mechanism shall be fitted with local manual spring release preferably by push bottom, shrouded to prevent inadvertent operation. The mechanism shall be suitable for motor and hand rewinding (motor should be for a system of 110 VDC) and shall be suitable for remote control for both closing and opening operations.

10.4 Earthing

Each circuit shall be provided with the facility to earth the cable by means of a device having a making capacity and short time rating equal to that of the circuit breaker.

In addition to ensuring adequate electrical continuity between all metal non-current carrying parts of the bay and the main earthing busbar, particular care shall be taken to ensure that:

- Housing of withdrawable HV switching devices shall be explicitly earthed in the service and test positions by appropriate earthing connections.

- External or exposed parts, e.g. bolts, screening, terminals, insulators, bus ducting and cable boxes shall be bonded to the steelwork frame of the bay.
- All earthing connections of voltage and current transformers shall be made directly from the terminal blocks to the main earthing busbar.
- All metallic instrument cases, protective relay cases, switches etc., shall be properly earthed to the switchboard steelwork frame.
- All hinged doors which are equipped with instruments, switches etc., shall be earthed by connecting it to the fixed earthed part of the bay by a suitably sized flexible braid. Safety doors and barriers shall be similarly earthed.

10.5 Busbars and Connections

All busbars, connections and earthing-conductors on the cubicles shall be of hard drawn, high conductivity copper. The busbars shall have heat shrink flexible insulation sleeves. They shall be supported and secured by cast resin insulated connectors, capable of withstanding stresses associated with a 3 sec short circuit current.

High-strength insulation barriers shall be provided at each junction between the adjacent cubicles.

10.6 Voltage Transformers

Inductive voltage transformers shall comply with 61869-1 and 61869-3. The ratings preferred by IEC 61869-3 shall be selected such that the VTs are not loaded to more than 90% of their rated output.

The 3 phase voltage transformers shall be of the encapsulated, withdrawable type and fixed type when are connected to the busbar; they shall be of the 3-limb type and have star-connected primary and secondary windings

10.7 Current Transformers

Current transformers shall comply with IEC 61869-1and IEC 61869-2 and shall have a short circuit current rating, at least equal to that of the switchgear. They shall be accessible safely without de-energizing the busbars and their secondary connections shall be earthed at one point through a removable link.

All current transformers shall be resin-insulated and inter winding insulation shall withstand electrical stresses and the environmental conditions

10.8 Identification Labels

Each bay shall be provided with labels, mounted on the front and rear of a non-removable part of the panel clearly indicating the panel number and function.

10.9 Inspection and Testing

Type and routine tests shall be carried out strictly in accordance with, IEC 62271-100 and IEC 62271-200.

11. 11 kV Air Insulated Metal Clad Switchgear

For the detailed technical parameters please review additionally the technical data sheet for the 11 kV switchgear in the Annex A2-18.

11.1 Cubical Enclosure

The switchgear respectively the cubical shall comprise of an air insulated metal-clad switchgear suitable for indoor use and shall be constructed in accordance with the latest IEC 62271-200 (Annex A, accessibility type A, IAC classification FLR) regulations. It shall be rated for an operational voltage of 11 kV. All active/live parts of the switchgear and to the switchgear connected parts (e.g. cables and bus connections) have to be inside the metal cad enclosure and protected from touching.

The design is based on a single busbar system and the cubicle is equipped with a circuit breaker, voltage transformer, current transformer, and earthing switch.

The circuit breaker compartment shall have a lockable door.

The cubicles shall be designed to withstand without damage all loads and forces which occur during transportation and erection. Each bay shall be equipped on the top with hooks suitable for lifting gear; the bay and the hook shall be dimensioned to withstand the forces which occur while lifted.

The various sections of each panel of the switchboard shall be compartmented, typically voltage transformer, CT/cable, circuit breaker and busbar. Anti-condensation heaters shall be provided within individual compartments and must be switched automatically on when the circuit is de-energized.

The bays shall be equipped with lockable doors and enclosures to prevent accidental touching of live parts by protecting them by locking.

A set of automatic earthed shutters shall be provided to cover each group of fixed contacts and prevent access to the live parts on feeder and busbar side.

Each set of shutters shall be capable of being individually operated and individually padlocked closed. Busbar shutters, circuit shutters and voltage transformer shutters shall be painted and labelled in an approved manner. Durable phase color-indications shall be provided in an easy visible position.

Horizontally withdrawable circuit breakers shall be provided to place the circuit breakers in a secured and correct position on the supporting structure.

Separate terminal boxes shall be provided on each bay for the main and auxiliary cables. Stainless steel cable glands shall be foreseen for the insertion of cables. Main and auxiliary cables shall be segregated. Terminals carrying different voltages shall be separated. The voltage shall be marked on each terminal.

Undrilled stainless-steel gland plates shall be provided. Where single core cables are used, gland plates shall be nonferrous.

11.2 Protection and Control

The 11 kV networks are connected to earth through earthing transformer. The grounding of the bus bar sections has to be carried out by using separate earthing switches with manual rotary shaft drives.

All 11 kV cubicles must have protective and control devices:

- Control of the circuit-breakers (local and remote control) via the station control system and remotely,
- All necessary protection relays IED,

- All necessary sockets for testing,
- All necessary signalizations lamps, switch selectors, pushbuttons, TPL, ...
- Energy meter,

Protection and control and energy meters must be integrated into the station control system and shall be installed in the secondary compartment of the switchgear.

11.3 Circuit Breakers

The circuit breakers offered shall be horizontally withdrawable SF6 types. They shall comply and be fully type tested to IEC 62271-1 IEC 62271-100, IEC 62271-200, and 62271-110.

SF6 circuit breakers shall, if the SF6 pressure decrease, send an alarm (1st stage) and be locked (2nd stage) in either open or closed position in order to prevent any further operation.

The circuit breaker shall be equipped with high integrity operating and isolating mechanisms, primary and secondary disconnecting devices, auxiliary contacts, manual tripping facilities, operations counter, mechanical position indicator, control wiring, auxiliary relays and contactors as required.

The circuit breaker shall be equipped with a manual trip device. The drives of the circuit breakers, disconnectors and earthing systems will be supplied by 110 V DC.

Interlock arrangements shall be as stated in IEC 62271-200. Mandatory interlocks shall be mechanical.

Circuit breaker operating mechanism shall be of the spring powered stored energy with provision for automatic reclosing for feeder circuits only. Each equipment shall be provided with visual indicating device to show the circuit breaker "Open" or "closed" it shall operative when the circuit breaker is in the "service" "isolated" and "earthed" positions .It shall be possible to complete the closing tripping indication and interlock circuits when the circuit breaker is isolated.

Locking facilities shall be provided so that the circuit breaker can be locked in each position. The closing mechanism shall be provided with electrical release coils and shall be of "trip free" type. It shall be possible to charge the mechanism spring with circuit breaker in either the "open" or the "closed" position. In normal operation the recharging of the operating spring shall be commenced immediately and automatically upon completion of the circuit breaker closure. A visual mechanical indicating device shall be provided to indicated the state of the spring "spring charged" when the spring is in condition to close the C.B and "spring free" when the spring not in a condition to close the C.B. The mechanism shall be fitted with local manual spring release preferably by push bottom, shrouded to prevent inadvertent operation. The mechanism shall be suitable for motor and hand rewinding (motor should be for a system of 110 VDC) and shall be suitable for remote control for both closing and opening operations.

11.4 Earthing

Each circuit shall be provided with the facility to earth the cable by means of a device having a making capacity and short-time rating equal to that of the circuit breaker.

In addition to ensuring adequate electrical continuity between all metal non-current carrying parts of the bay and the main earthing busbar, particular care shall be taken to ensure that:

- Housing of withdrawable HV switching devices shall be explicitly earthed in the service and test positions by appropriate earthing connections.

- External or exposed parts, e.g. bolts, screening, terminals, insulators, bus ducting and cable boxes shall be bonded to the steelwork frame of the bay.
- All earthing connections of voltage and current transformers shall be made directly from the terminal blocks to the main earthing busbar.
- All metallic instrument cases, protective relay cases, switches etc., shall be properly earthed to the switchboard steelwork frame.
- All hinged doors which are equipped with instruments, switches etc., shall be earthed by connecting it to the fixed earthed part of the bay by a suitably sized flexible braid. Safety doors and barriers shall be similarly earthed.

11.5 Busbars and Connections

All busbars, connections and earthing-conductors on the cubicles shall be of hard drawn, high conductivity copper. The busbars shall have heat shrink flexible insulation sleeves. They shall be supported and secured by cast resin insulated connectors, capable of withstanding stresses associated with a 3 sec short circuit current.

High-strength insulation barriers shall be provided at each junction between the adjacent cubicles.

11.6 Voltage Transformers

Inductive voltage transformers shall comply with 61869-1 and 61869-3. The ratings preferred by IEC 61869-3 shall be selected such that the VTs are not loaded to more than 90% of their rated output.

The 3 phase voltage transformers shall be of the encapsulated, withdrawable type, they shall be of the 3 limb type and have star-connected primary and secondary windings

11.7 Current Transformers

Current transformers shall comply with IEC 61869-1and IEC 61869-2 and shall have a short circuit current rating, at least equal to that of the switchgear. They shall be accessible safely without de-energizing the busbars and their secondary connections shall be earthed at one point through a removable link.

All current transformers shall be resin-insulated and inter winding insulation shall withstand electrical stresses and the environmental conditions

11.8 Identification Labels

Each bay shall be provided with labels, mounted on the front and rear of a non-removable part of the panel clearly indicating the panel number and function.

11.9 Inspection and Testing

Type and routine tests shall be carried out strictly in accordance with, IEC 62271-100 and IEC 62271-200.

12. Power Transformers

Power transformer to be provided under this project, must be designed according to IEC 60076 as full transformer, outdoor type and three-phase oil immersed.

The conductor material of all windings must be from copper.

All current transformers for protection purposes are to be provided according to the single line diagrams in the transformer and to be mounted at the transformer.

All the transformers shall be designed to have a lifetime of at least 30 years in the conditions prevailing at the installation site.

The design of the transformers shall be based on all relevant IEC standards including but not limited the following requirements:

a. The transformers shall be designed in accordance with the latest requirement of IEC 60076.
b. The transformers shall be three phase outdoor type, oil immersed with on-load tap-changer.
c. The transformers shall be designed for operation in parallel with the existing transformers.
d. The transformers shall be designed for full-load operation at ambient temperature of +40°C
e. The maximum permissible temperature rise of the transformer shall not exceed the following values based on the IEC 60076-2 clause 6.2.:
f. Top insulation liquid: 60 K
g. Average winding: 65 K
h. Hot-spot winding: 78 K
i. The transformers, completely assembled with bushings, cable boxes, and/or flange connections, shall also be designed and constructed to withstand without damages the effects of short circuits as per IEC 60076.
j. The transformers shall be designed with particular attention to the suppression of harmonic voltages to eliminate wave form distortion and from any possibility of high frequency disturbances reaching such a magnitude to cause interference with communication circuits.
k. Neutral points shall be brought out and grounded as specified
l. The transformers shall be designed to ensure that leakage flux does not cause overheating in any part of the transformer.
m. The duration of three phase short circuit currents shall be 2 s according to IEC 60076 -5.
n. The transformers shall be designed to have a life-time of at least 30 years in the conditions prevailing at the installation site.

12.1 Regulations and Standards

This technical specification covers minimum requirements for the nominal rating, kind of compound materials, design, construction and test of power transformers in substations. Power transformers shall be designed, manufactured and tested in accordance with the requirements of the latest revision of the following standards and to this specification:

IEC International Electrotechnical Commission:

IEC 60076 All parts : Power Transformers

IEC / IEEE 602142 : Tap-changers- Part 2: Application guidelines

IEC 60422 : Mineral insulating oils in electrical equipment - Supervision and maintenance guidance

IEC 60137 : Bushings for alternating voltages above 1000 Volts

IEC 60270 : High — Voltage Test Techniques — Partial Discharge Measurements

IEC 61869-2 : Instrument Transformers: Part 1 General Requirements

IEC 61869-2 : Instrument Transformers Part 2 Additional Requirements for Current Transformers

IEC 60529 : Degrees of protection provided by enclosures (IP CODE)

IEC 60034 : Rotating electrical machines

IEC 60071 : Co-ordination of Insulation.

IEC 60156 : Method for Determination of the Electric Strength for Insulating Oils.

IEC 60044 : Current Transformers.

IEC 60214 : On-Load Tap-Changers.

IEC 60296 : Specification for Unused Mineral Insulating Oils for Transformers and Switchgear.

IEC 60354 : Loadi'ng Guide for Oil-Immersed Power Transformers.

IEC 60445 : Basic & safety principles for man-machine interface, marking and identification- Identification of Equipment Terminals and Conductor termination.

IEC 60551 : Determination of Transformer and Reactor Sound Levels.

IEC 60606 : Application Guide for Power Transformers.

IEC 60616 : Terminal and Tapping Markings for Power Transformers.

IEC 60947 : Low-Voltage Switchgear and Control gear.

IEC 60137 : Bushing for alternating voltages above 1000V

ISO International Organization for Standardization:

ISO 1459: Metallic coatings - Protection against Corrosion by Hot Dip Galvanizing - Guiding Principles

ISO 1460: Metallic coatings - Hot dip galvanized coatings on ferrous materials. Gravimetric determination of the mass per unit area

ISO 2178: Non-magnetic coatings on magnetic substrates - Measurements of coating thickness - Magnetic method

ISO 9000: Quality management and quality assurance standards - Guidelines for selection and use

12.2 Power Transformer Data

The transformers shall be **ONAN/ONAF** cooling type and have a vector group **YNd11** with different power rating values.

Please review additionally the technical data sheets for the transformers:

- 69/11kV 15MVA

 The 69/11kV Power Transformers to be supplied shall comply with guaranteed technical particulars as indicated in Annex A2-6.

- 33/11kV 20MVA and 3,5MVA

 The 33/11kV Power Transformers to be supplied shall comply with guaranteed technical particulars as indicated in Annex A2-7a and Annex A2-7b.

- 2.2/33kV 4MVA:

The 2.2/33kV Power Transformer to be supplied shall comply with guaranteed technical particulars as indicated in Annex A2-8.

The transformer shall be placed on a concrete foundation with oil/rainwater collection pit and oil separation arrangement.

12.3 Windings

The values for all insulation and test levels shall be obtained from the description of the general technical requirements of these Specifications.

Electrolytic copper of a high conductivity and insulation material of high quality, class 105 (A) in accordance with IEC 60085 shall be used for all windings.

Windings shall be of best modern design with conductors having constant cross-section along the whole windings, and the current densities shall not exceed 2.7 A/mm2 in any part of the windings.

The insulation material of windings and connections shall be free from insulation compounds subject to softening, shrinking or collapsing during service. Paper shall be used for conductor insulation.

The transformer shall be supplied according to IEC 60085 insulation class A.

All windings and their leads shall be designed and arranged such as to withstand all kinds of transferred over-voltages. Protective capacitors shall not be provided for any of the windings. Non-linear ZnO protective elements in any windings will not be accepted.

The coils must be capable of withstanding movement and distortion caused by all operating conditions as specified in IEC 60076-7. Adequate barriers shall be provided between windings and core and between the windings. All leads or bars from the windings to the terminal boxes and bushings shall be rigidly supported.

The transformer shall have the highest losses at the highest current taps (lowest voltage taps).

12.4 Magnetic Core

The magnetic core shall be made of laminations of non-ageing, cold-rolled, grain-oriented, silicon steel of high permeability (Hi-B-type; W17/50: max. 1.05 W/kg) without burrs.

The thickness of laminations shall be from 0.18 to 0.3 mm

Three limb transformers shall be used.

The following minimum over-fluxing requirements shall apply

a. Continuous: 110% of rated volts/hertz;

b. 1 minute: 125% of rated volts/hertz;

c. 10 seconds: 140% of rated volts/hertz.

Each lamination shall be insulated with high quality insulation coating. The insulating coating shall be very thin < 4 µm. The joints of limbs and yokes shall be designed and constructed to keep the no-load losses and the hot spot temperature in the magnetic core as well as the noise level as low as possible by application of the step-lap core stacking method.

The cross section of the core and limb height shall be chosen to ensure that the natural frequencies of the core do not coincide with the frequencies of the magnetic field.

The maximum magnetic flux density in the legs and yokes of the core shall not exceed 1.65 Tesla at rated voltage and frequency.

The core and its clamping plates shall form a rigid unit structure, which shall maintain its form and position under the severe stresses encountered during shipment, installation, and short circuits. Care shall also be taken to secure uniformly distributed mechanical pressure over all the laminations to prevent setting of the core and to limit noise and vibrations to a minimum under service conditions.

In order to prevent closed magnetic circuit via the tank, the top main core clamping structure shall not be connected to the tank cover.

The magnetic core shall be earthed to the clamping plates structure at one point only through removable copper links, placed in an accessible position beneath an inspection housing/opening on the tank cover, and which, by disconnection, will enable the insulation between the core and clamping plates, etc., to be tested at voltages up to 2.5 kV for the purpose of checking deterioration during service movement of the core during transport.

12.5 Transformer Tanks

The tanks of transformers shall be vacuum proof. The tanks shall have eight (8) jacking points for raising or lowering

The transformer tank shall be with reinforced cover (welded construction with bolted cover); the construction shall be of mild steel and shall be of sufficient strength and rigidity to withstand moving, shipping and handling without any de-formation.

The completely assembled transformer tank including radiators, conservators, and associated oil piping shall be fully vacuum proof.

All seams and joints other than those of such tank covers, which may be jointed to the upper flange of the tank by welding, shall be welded both inside and outside of the tank to secure strong, leak-proof joints.

The shape and arrangement of the tank cover and external stiffeners shall permit rainwater to flow easily and completely to the ground.

The tank bottom shall be of one plane and shall be a self-supporting tank bottom with a minimum thickness of 50 mm.

All connections bolted to the tank shall be fitted with suitable gas and oil resistant gaskets made of such a material that no serious deterioration occurs under service conditions, i.e. heat and oil resistant rubber. All gaskets shall be of closed design (without open ends) and shall be of one piece only. Rubber gaskets used for flange connections of the various oil compartments shall be laid in grooves or in groove-equivalent retainers on both sides of the gaskets throughout their total length.

Transformers shall be equipped with manholes and hand-holes of suitable size to facilitate installation and maintenance (i.e. tap changers, current transformers, bushings etc.). All openings in the cover of the transformer tank for bushings, manholes, and terminal boxes shall be provided with adequate flanges. Covers for inspection openings, hand-holes etc. located on the tank cover shall be provided with adequate gas stoppers. All inspection covers etc. shall be provided with two lifting handles each.

It must be possible to remove any bushing completely without removing the tank cover. Easy access shall be also provided for internal connection of bushings without extensive dismantling any external mounting such as radiators etc.

The complete tank and its cover shall be designed in such a manner as to leave no external pockets in which water can accumulate no internal pockets in which oil can remain when draining the tank and/or in which air can be trapped when filling the tank.

The tank cover and all covers for mounting, cleaning, manholes, hand holes and inspection openings on tank and cable boxes etc. shall be earthed by suitable grounding conductors of the flexible type having a cross section of minimum 95 mm2. Appropriate earthing studs with bolts and washers of stainless steel shall be provided.

In order to prevent tank deformation during operation, spring-loaded pressure relief devices, / explosion vents with trip contact of an approved type shall be mounted onto the tank cover for rapid release of any pressure that might be generated within the tank and cause damage to the equipment. The devices shall operate at a static pressure, which shall be less than the test pressure on tank and shall be designed to prevent further oil flow from the transformer during its operation.

The tank cover shall be provided with dial type thermometers pockets, for oil and winding temperature indicators, with a captive screw cap and be located in the position of maximum oil temperature at continuous maximum rating. Caps shall be provided to prevent the ingress of water to the thermometer pockets when it is not in use.

As a minimum requirement temperature monitoring based on fibre optic sensors, transmission and evaluation shall strictly follow IEC 60076-2 Annex E. All recommendations and proposals given within this annex shall be realized. Any use of the word “should” therein shall be replaced by the word “shall”. In addition to that also tertiary windings accordingly shall be equipped with 1 (one) temperature sensor per phase. Location of the sensors shall be shown in detail in transformer documentation, per sensor an installation photo is required to be presented during factory acceptance test (FAT), showing that oil flow around the sensor is prohibited.

Evaluation unit shall provide the following features:

- Station battery DC supply
- Data logging
- Binary outputs (min 8)
- Analogue outputs - 20 mA (min 8)
- Fiber optic bus communication based on IEC 61850
- Resolution 0,1 K
- Accuracy 1%

Readily configured graphical representation software on e.g. SCADA or separate PC shall be included.

Test protocols shall be presented during factory acceptance test showing function tests

- after installation of any winding

- after core drying
- before connection with feedthrough
- after connection with feedthrough

This equipment shall be type tested in accordance with

- **IEC 61000-4-2** ESD 6/8 kV
- **IEC 61000-4-3** Radiated RFI 20 V/m, 80 to 2500 MHz
- **IEC 61000-4-4** Burst 2 kV
- **IEC 61000-4-5** Surge 2 kV
- **IEC 61000-4-6** Induced RFI 10 V, 150 kHz to 80 MHz
- **IEC 61000-4-8** Magnetic Field 30 A/m, 50 Hz, continuous
- **IEC 61000-4-11** DC voltage dips 100 % / 10 ms and 60 % / 100 ms
- **IEC 60255-5** Dielectric Strength 2 kV AC, 1 min

  5 kV, 1.2/50 µs, 0.5 J

  >100 MΩ at 500 VDC
- **IEC 60255-21-1** Vibration 5–35 Hz, 2 g, X, Y, Z

  100/120/200/240/300/360/400/480 Hz,

  1 g, 4 h
- **IEC 60255-21-2** Shock 10 g, 10 ms, 10 shocks, X, Y, Z
- **IEC 60068-2-1** Dry cold -25° C / 20 hours
- **IEC 60068-2-2** Dry Heat+70° C / 16 hours
- **IEC 60068-2-30** Humidity, damp heat cyclic (12 x 12 hours) + 55° C / 93 % / 6 cycles

The external surfaces of the transformer and all to the transformer attached parts/devices shall be coated with two components epoxy based primer and final coat with a minimum total thickness of 240 µm. The coating shall consist of the following layers:

- One primer coat two-component epoxy zinc-phosphate or two-component epoxy zinc-dust, 100 microns
- One intermediate coat two-component epoxy micaceous iron oxide, 100 microns
- One top coat two-component polyurethane, 40 microns

The final coat color shall be grey.

The internal surfaces shall be coated with epoxy-based paint, which is inert to transformer oil and has good dielectric properties. A minimum of one primer and one final coat shall be applied. The final color shall be white.

The following moving and handling facilities shall be provided for each transformer:

a. Eight (8) jacking pads conveniently located to allow the raising or lowering of the completely mounted and oil filled transformer by means of hydraulic jacks. They must be rated for the most unfavorable load on two diagonals, however, on both sides of the respective corner underneath the upper tank edge,

b. Four (4) lifting lugs, for lifting the complete transformer and tank cover and facilities for the pulling, turning and pushing of the transformer in any direction by means of crane shall be provided for each unit.

c. Bi-directional wheels with blocking facilities for transformers. The wheel blocking devices necessary to fix the position of the transformer shall be supplied together with the transformers, and shall be designed to withstand seismic forces acting upon the transformers.

d. One (1) tank access ladder of galvanized mild steel with lockable hinged door securely fixed onto the tank cover and lower parts of the tank. Ladders shall be provided with handrails of min. 100 cm length at the upper end. Handrails shall be rigidly fixed on the ladders and onto the transformer tank.

e. Filter valves of gate type or globe type for oil inlet and outlet arranged diagonally on lower part of tank. A suitable vacuum valve shall be provided for tanks (main, conservator, radiators, and tap changer) in a convenient height. All of these valves shall be equipped with flanges having adapters with male thread fitted with screwed cap

f. Oil sampling valves (top and bottom) of gate type or globe type with suitable adapters of male thread fitted with screwed cap for direct connection of oil sampling facilities shall be provided and shall be arranged diagonally on one tank wall at a convenient height.

g. Padlocking facilities for all valves including radiator butterfly valves. Padlocks shall be provided for locking all valves in the “open” and “closed” positions Padlocks are part of supply.

h. Two adequate earthing terminals completely made of stainless steel shall be provided and installed diagonally at the bottom of the transformer tank, in such a way that a low-resistance connection to the local earthing system is guaranteed.

12.6 Indicating Plate

The following plates, which can be combined also, shall be mounted easily visible on each transformer in a height of about 1.5 m above ground:

1. A rating plate as specified in IEC 60076, including also space for the Employer's serial number, an in the respective transformer code number.
2. A diagram plate with the internal connections of the windings and the voltage ratios for each tap.
3. A general plate, showing the layout of the transformer, covering the locations of terminals, control devices, valves and all essential transportation details

Inscription shall be written in English.

12.7 Oil Conservator

Oil conservator vessels shall be of the cylindrical type and shall be equipped with elastic diaphragms of the air-bag type.

The conservator vessel shall be mounted at the highest point of the oil system and shall be connected to the highest point of the tank through a straight sloping pipe.

The capacity of the conservator shall be adequate for to allow for oil expansion from 10 °C to 110 °C. Conservator vessels shall be sealed against each other and shall not be located directly on (along) the tank cover.

Adequate isolating valves of gate type or globe type shall permit the removal of the main and tap-changer Buchholz relays while the conservator is still connected to the tank by a pipe bypassing the relays.

The conservator vessel shall contain two compartments, one for oil in the main tank and the other for the oil associated with the current making and breaking contacts of the tap change equipment. There shall be no communication between the two compartments in respect of the oil and air spaces. Each compartment shall be provided with the fittings detailed in this clause as if it were a separate conservator vessel.

The conservator vessels shall be fully vacuum proof and designed in such a way that they can be completely drained by means of drain valves. Conservator vessels shall be furnished with cleaning openings in such a manner as to avoid damage of rubber diaphragms, i.e. the front walls of the conservators shall be completely removable and shall be equipped with two lifting lugs each.

Each conservator compartment shall be equipped with filling valve, drain valve, lifting lugs, etc.

An oil level gauge complete with low-level alarm shall be fitted to each conservator that can be read from ground level. The conservator end flange shall be provided with a welded construction. On the conservator are to be installed the oil indicators with the oil minimum level double-level monitoring (the 1-st with the action for «Alarm»; the 2- with the action for «Trip». All oil indicators have to be tilted by 30° toward the ground so that it is possible to read them from the ground level.

Each conservator vessel shall be fitted with two parallel maintenance free dehydrating breathers.

The dehydrating breathers as well as all filling and draining devices shall be rigidly fastened at an accessible position in a convenient height of approximately 1,5 m above ground level. Furthermore, all of the breathers shall be rigidly fixed onto the tank by appropriate mounting brackets at their lower ends. Dehydrating breather and oil level gauges shall not incorporate any PVC material.

12.8 Piping and Valves

All piping required for the connection/filling of the various parts of the transformers as well as the valves required for oil sampling, draining, filtering, connection of the radiators, drain and vent plugs, etc. are to be included.

All flanges to which the valves are to be connected shall be welded leak-proof onto transformer tank etc. All piping shall be rigidly supported.

All valves for draining, oil sampling, filling, filtering, vacuum application and vacuum equalizing shall be mounted at a convenient floor height and shall be equipped with approved rigid padlocking facilities provided with padlocks for a master key system for each transformer.

All isolation valves and shut-off valves other than butterfly valves for radiators shall be proper slide valves, i.e. globe and/ or gate valves equipped with adequate operation handles and position indicators (“open”/ “shut”). Ball-type valves of any kind shall not be provided.

All filter valves and drain valves shall have adapters’ male thread fitted with screwed captive cap. Oil sampling valves for transformer main tank shall have the same male thread.

Suitable oil sampling valves having adapters with male thread fitted with screwed cap shall be provided for all kinds of OLTC.

12.9 Transformer Insulation Oil

The insulation oil shall be pure mineral oil free from additives; it shall be acid refined with properties complying with IEC 60296 with a fire point ≥135 °C. The insulation oil of all transformers shall be PCB free.

If transportation and storage will be carried out without oil, the transformers are to be pressurized with Nitrogen. Nitrogen bottles, reduction valves, pressure gauges and humidity control equipment are to be provided maintaining a constant monitored gas pressure in the transformer tank during transportation.

In order to facilitate handling and shipping, external accessories shall be removed if necessary and replaced with special shipping covers. Bushing, radiators and other accessories which may be affected by moisture shall be moisture-proof packed in seaworthy packing. Packing material, including oil drums, will not be returned.

12.10 Cooling

The power transformers shall be equipped with detachable flanged radiators for ONAN or ONAF cooling. Dismantling of one of the radiators or air blowers shall be possible without causing the temperature to rise above the permissible values when the transformer is working at the maximum rating.

Radiators and coolers shall be hot dip galvanized; their designed shall be such as to allow ease of cleaning and painting when in position. The design shall also avoid pockets in which water can collect. Each radiator group shall be fitted with drain valve and air release plug.

Shut-off valves shall be provided at the top and bottom connections of each radiator group to permit removal of the radiators from the transformer even under service conditions.

The radiators shall be assembled and fitted to the tank in such a manner as to provide mechanical protection to them and to prevent vibrations. Radiators shall be pressure tested and liquid tight.

Where forced air-cooling is provided it shall be possible to remove the fan, complete with its motor and supporting structure without disturbing or dismantling the cooler framework or pipework. The fans shall not be mounted directly on the radiator fins or radiators itself. Fans shall be numbered and have clearly marked direction of rotation.

The fan motors of squirrel cage type, IP55 protection type, shall be designed for the direct starting and continuous running from the 3-phase substation supply.

The number of fans per radiator shall be calculated on basis of the maximum ambient temperature. The fans shall form an integral part with their individual motors and shall be arranged in groups mounted in fan housings. The fan blades shall be of ionized aluminum alloy and shall be dynamically balanced.

The grounding (earthing) of the air fans motors will be done locally and not through the transformer control panel.

The electrical supply shall be provided by means of a LV incoming circuit breaker. Each motor shall have its own motor starter fitted with thermal and magnetic overload release as well as MCB or MCCB. The control circuit of each fan motor shall be provided with a time delay relay to prevent switching off the fan for at least five minutes after starting of the same.

Stainless steel wire mesh guards shall be provided to prevent accidental contact with the fan blades. Metal guards shall also be provided over all other moving parts. The guards shall be designed so that neither the blades nor other moving parts can be touched.

The control equipment for the cooling plant and all auxiliary devices shall be accommodated in a weather-proof cabinet (protection degree IP 55) mounted onto the transformer with facilities for the selection of automatic or manual control of the cooling plant motors and remote indication/alarms. Manual and Automatic cooling system/fan control shall be integrated into the SCS.

The following standard accessories shall be provided:

a. One (1) butterfly valve each for inlet and outlet for each radiator

b. One (1) upper and lower common header for each cooler bank each connected onto the transformer tank via isolating valves as below

c. One (1) isolating valve (of the slide valve type) each for inlet and outlet for each of the cooling pumps for connection with the tank and common headers of cooler banks
d. One (1) isolating valve (of the slide valve type) for connecting each of the common headers of each cooler bank with the transformer tank
e. One (1) isolating valves (of the slide valve type) for connecting additional upper common headers (if any) directly with the transformer tank or cover
f. One (1) drain plug with screwed cap at the inlets or outlets of each common header suitable for temporary installation of temperature sensors directly in the oil-flow during heat-run tests
g. One (1) air vent plug with screwed cap at the inlets and outlets of each common header suitable for temporary installation of temperature sensors directly in the oil-flow during heat-run tests.
h. Additional air vent plugs and drain plugs on common headers, if required
i. 1 (one) drain plug at the outlet of each radiator
j. 1 (one) air vent plug at the inlet of each radiator

A group alarm shall be initiated if any fan motor fails, however, switching off any further motor of the same group is to be avoided. The following lamp initiating devices having auxiliary normally opened contacts shall be included as applicable for the cooling system:

a. cooling fans failure for each radiator group
b. cooling fans start for each group
c. cooling system switched on manual (local) control
d. cooling system switched on automatic control.
e. the cooling radiators shall be grouped into a separate cooler bank
f. the cooler bank shall be designed to ensure optimum natural circulation
g. the radiators and the piping system shall not hinder an easy access to the transformer tank
h. the cooler bank shall be removable
i. the cooler bank shall be placed on a rigid steel structure

The radiators shall be assembled and fitted to the tank in such a manner as to provide mechanical protection to them and to prevent vibrations. Radiators shall be pressure tested and liquid tight.

12.11 On-Load Tap Changer

The OLTC shall be of the vacuum type.

The transformer shall be provided with a MR Germany or equivalent on load tap changer mounted in the high-voltage winding

The OLTC shall be of the non-rotary type diverter switch principle.

The OLTC shall be at the winding of the highest voltage of the transformer.

The OLTC shall be in conformity with IEC 60214. OLTC shall have been type tested, and related type test certificates shall be supplied with the offer. Only designs, which have been type, tested in accordance with the relevant IEC standards supplemented by these Specifications will be accepted. All equipment related to the OLTC shall be supplied by the original OLTC manufacturer.

The power of the transformers shall remain constant at all tap positions, and the OLTC shall be capable of successful tap changes for the maximum current to which the transformer can be loaded.

The OLTC shall have oil compartments separate from the transformer oil as well as their own closed sub-sections in the oil conservator, oil drain valves oil level indicator with oil level contacts, air-dehydrator etc.

The diverter switch shall be of high-speed transition resistor type. The diverter switch has to be equipped with vacuum interrupters. Overvoltage protection between selected and preselected tapping shall be made by the use of varistors. No leaf springs shall be used.

Metal covers for drive shafts shall be provided on tank cover. The compartment shall be easily accessible for minor inspections of contacts. It must be possible to carry out inspection of tap changer without draining the oil of the transformer. The OLTC shall be suitable for oil change without dismantling the diverter unit.

The OLTC tank should be designed that the OLTC can be removed / replaced without removal of transformer windings / core and top cover of the main tank.

A suitable oil-sampling valve shall be provided for OLTC and shall be mounted at a convenient floor height. The OLTC shall be suitable for oil change without dismantling the diverter unit.

The OLTC shall be designed to withstand all kinds of through-fault currents (maximum) without damage. Spring-loaded pressure relief device with trip contact and metal pin-type operation indicator shall be mounted directly onto the tap changer head (opening at approx. four bars)

The tap-changer gear must be lockable. The necessary equipment shall be provided in a suitable weather-, vermin- and insect-proof cubicle with sufficient ventilation and humidity and temperature-controlled heating.

All signals, remote controls, alarms etc. shall be wired to a common terminal strip in the local control cubicle. The OLTC shall be designed for supervisory as well as for normal remote control and in emergency cases for local control.

OLTC shall be capable of manual control locally and remotely at the transformer control panel. Facilities shall also be provided for the OLTC monitoring as component part of the autotransformer (phase-shifting transformer) monitoring system, and the devices to allow operation of the tap change control using the SCADA system with the open international protocols usage.

OLTC shall be also being capable of automatic voltage regulation using “IED-intelligent electric device’’ transformer controller. Transformers operating in parallel shall be capable of being controlled using, master/slave’’ tap change control schemes.

The contacts shall be designed for a service life of approx. 300,000 operations under rated load, exchange of the diverter switch unit earliest after 1.2 million operations. The service life of the mechanical gear has to be adjusted accordingly.

The equipment shall be so arranged as to ensure that when a tap changer has been initiated, it will be completed independently of the operation of the control relays and switches.

Irrespective of the auxiliary supply or the local control use, the OLTC operation must be carried out only in case of complete readiness for switching-over having been obtained and must be carried out by single action (single movement) providing the proper contact and absence of contact resistance.

If a failure of the auxiliary supply during tap change or any other contingency would cause a non-proper contact closing, a pressure relief device in the tap changer head shall be provided to safeguard the transformer and its auxiliary equipment.

At least the following equipment shall be provided in the cubicle:

a. Step position indicator with engraved position numbers, easily legible from ground floor

b. All electrical control switches and local manual operating gear shall be clearly labelled in an approved manner to indicate the direction of tap changing.

c. Operation counter

d. Lamp, indicating tap changer operation.

e. Crank handle for manual operation

f. Cabinet lamp controlled via door contact

g. Spare plug socket LV, AC 230 V/16 A

h. One heater, thermostatically and hydrostatically controlled

i. MCBs for each auxiliary supply circuit

j. Padlock facilities for front door.

The motor drive, plus all auxiliary equipment for operation of the tap changer, shall be incorporated in a rigid control cabinet, protection class IP 64 and shall be mounted onto the transformer tank in a convenient floor height. The driving gear shall be of the belt-type or equivalent dry-type gear. Oil filled driving gears are not acceptable.

At least the following requirements shall be met by the motor drive:

k. The driving motor shall be rated for 400/230V AC

l. Manual operation in the case of a failure in the electrical supply system

m. Operation from local or remote-control switch shall cause one tap movement only unless the control switch is returned to the "off" position between successful operations

n. Thermal and overload protection to be installed in the motor drive cubicle.

o. Limit switches shall be provided to prevent overrunning of the tap changing mechanism. These shall be directly connected to the operating motor circuit.

p. Mechanical stops shall be fitted to prevent overrunning of the mechanism under any conditions.

q. Provisions to be made for parallel running and automatic operation controlled by a voltage regulating device and parallel control unit

r. For OLTC equipment these stops shall withstand the full torque of the driving mechanism without damage to the tap change equipment.

s. Hand operation by means of a crank handle

t. It must not be possible to operate the electric drive when the manual operating gear is in use.

12.12 Protection, Measuring and Indicating Devices

Beside the protection relays installed in the respective control cubicles located in the control building rooms, the transformers shall be equipped with several protections, measuring and indicating devices supplied by the transformer manufacturer and have devices for the data transmission to SCADA system with the open international protocols usage:

a. Buchholz relays (alarm and tripping contacts) shall be fitted to transformer tank, OLTC compartment and on each compartment where oil is separated from the other oil in the transformer.

Buchholz relays shall be twin float relays, designed for a pipe diameter 80 having DN80 flanges with four bore holes. They must be free from operation caused by pump surges. Covered sight glasses shall be provided, arranged in opposite position to each other. It shall be equipped with a gas sampling and testing device made of aluminum alloy, thoroughly painted.

The Buchholz relay floats shall be hollow, the damper shall be held by magnets. The Buchholz relay shall have a test valve and a test key. For easy access and connection to the gas sampling and testing device, the test valve as well as the test key shall be accessible from the front of the Buchholz relay (in oil-flow direction) above the sight glass.

The Buchholz relay shall be installed in the pipe between the main tank / tap changer and the conservator ascending towards the conservator by 1° to 5°. Contacts shall be of magnetic type, designed for a contact load of 250 VDC/5 A (non-inductive) and 250 VAC/6 A cos φ > 0.8. It shall withstand shocks (25 g, 6 ms) and vibrations (2 – 200 Hz, 1 g) in accordance with IEC 60721-3-4 class 4M6. It shall also withstand magnetic fields of up to 25 mT in any direction resp. polarity.

With accumulation of gas in the top of the Buchholz relay the alarm contact shall be actuated. With loss of insulation liquid the trip contacts shall be actuated. Also with a sudden raise of the flow rate through the Buchholz relay the trip contacts shall be actuated, too.

The pipes connecting the Buchholz relays shall have gate valves on both sides (easily accessible from tank cover) to enable dismantling of the relay without oil leakage. Small piping from Buchholz relay to gas sampling and testing devices shall be covered throughout the total length by approved flexible steel conduits.

b. Pressure relief device of spring-loaded type with metal pin-type operation indicator and trip contact installed for transformer main tank and for OLTC.

The casing of oil-flow operated protection relay shall be made of weather-resistant cast aluminum alloy, thoroughly painted, having flanges minimum DN25 with 4 bore holes. It shall be installed in the pipe between the tap changer and the conservator as close as possible to the tap changer head by ascending towards the conservator by 2° to 4°. The pipes connecting the relay shall have gate valves on the conservator side. Covered sight glasses shall be provided, arranged in opposite position to each other.

The oil-flow operated protection relays shall have a testing feature. Contacts shall be of magnetic type, designed for a contact load of 250VDC/5A (non-inductive) and 250VAC/6A cos φ > 0.8. It shall withstand shocks (10 g, 11 ms), vibrations (2 – 200 Hz, 1 g) and magnetic fields (25 mT) in any direction resp. polarity.

c. The thermometer shall be placed in such a position that accurate reading from the ground level is possible.

Thermometers shall be of the radial dial type with radial type instantaneous (bourdon spring system) and maximum pointer, remote indicator (PT100), and adjustable contact units. The range of temperature indication shall be from -20°C to 140°C for oil temperatures and from 0°C to 160°C for winding temperatures.

Thermometers and thermostats shall be easily accessible when removing the lid. Testing of the switching points shall be easily possible by moving the pointer manually. The measuring system shall not require any recalibration.

Thermometers shall be arranged in an approved manner under corrosion-proof covers above the control kiosk. Capillaries shall be properly protected throughout the total length by appropriate flexible steel conduits and shall enter the instruments from bottom side. To avoid damages at the connection points of capillary tubes to temperature detectors all heads of these sensors shall be suitably and completely covered. Thermometer pockets shall be arranged in the vicinity nearest to the active part and shall not be subjected to impermissible stray flux.

d. Complete image coil winding temperature indicator device equipped with two adjustable maximum contacts for measurement of the hot spot.

e. Oil level indicators shall be installed inclined downwards, the angle shall be about 30°. The scale shall show a horizontal lettering, MIN, the base temperature (+20°C or +30°C, as specified in the technical data sheet) and MAX, arranged in a sector of about 140°, to be easily visible and readable at operators standing location. Floats shall be made of oil resistant solid material, resistant to heat up to 160°C. For oil vessels equipped with rubber bag minimum two pivoted float rollers shall be used, with a float arm >1000 mm the number of pivoted float rollers shall be four.

   Oil level indicators shall be of magnetic type with separate sensor and indicating unit. A minimum of two adjustable contacts shall be provided, designed for a contact load of 250 VDC/0.4A (non-inductive) and 250 VAC/5A cos φ = 1, adjusted to maximum and minimum oil level

f. Maintenance-free dehydrating breather.

g. All thermometers shall be installed in one cabinet with glass door and shall be mounted easily visible on each transformer at an approximate height of 1.75 m above the ground

h. All the process gauges and relays that built-into the transformers and used in the protection and signaling circuit diagrams must have each 2 (two) independent «dry» contacts for action onto the transformers protection main and back-up sets. Not to be provided for the repeater-relay in the cabinets near the transformer for multiplying the signals to be used in the RPA circuits.

All monitoring equipment arranged outside the cabinet(s) shall be of protection degree IP 55 and shall be completely made of corrosion free material. Sight glasses of thermometers and oil level indicators as well as those of oil flow indicators (if any) shall be of sand-storm proof laminated and UV-stabilized safety glass. No sight glasses of transparent plastics shall be provided for any of these indicators.

Electric connections of equipment arranged outside the cabinet(s) shall be through a terminal box made of aluminum alloy, thoroughly painted, being dust-proof and weatherproof by IP-code IP 56 in accordance with IEC 60529. Cable glands have to be arranged in a way that rainwater drains off and does not stay on sealing, cable glands are to be installed in downward direction. In the inner of the connection box a connection diagram shall be shown. Terminals shall be suitable to receive crimped flexible conductors with a cross-section at least up to 2.5 mm².

All equipment providing trip signals shall have at least one alarm contact and two trip contacts for full redundancy.

Where an analogue output is required, the measuring/ monitoring equipment shall be furnished with an additional transducer. Power supply shall be fed directly from station battery supply without any intermediate inverter. The output signal shall be 4...20 mA for the full level range.

Performance of control cables from the measuring/ monitoring/ control devices to terminal boxes/ cabinets shall be as specified in according to part of control cable specifications and data sheets. Control cables shall be supported by cable ladders, cable trays, tubes or similar steelwork particularly provided for fixing of the cables. No direct fixture to transformer/ shunt reactor tank or other equipment/ devices will be accepted.

12.13 Control and Monitoring

A control/alarm equipment for the power transformer shall be provided. The control and monitoring devices are to be equipped with the necessary auxiliary contacts and transmitters for remote and remote supervisory control and monitoring in the respective control cubicles located in the control room and SCADA system with the open international protocols usage.

The Supplier should propose the monitoring system providing but not limited to the following functions:

- the warning and alarm signals based on all the monitoring parameters;
- making the transformer technical state expert assessment and forecast based on the calculation models in the actual time mode;
- calculation of the transformer envisaged service life in the actual time mode;
- mathematic and software support of the obtained data;
- visualization in the transformer state technical data information display device;
- creation and storage of the transformer state technical data base, actuation of the warning and alarm signaling systems, the calculation model- based results and recommendations issue;
- data visualization;
- data transmission to SCADA;
- the cooling modes control.

Monitoring shall be ensured for the following parameters:

- winding insulation deterioration;
- oil gas composition;
- oil moisture content;
- oil upper and lower layers temperature;
- oil circulation availability;
- oil level in conservators;
- HV bushings insulation state (dielectric loss tangent, capacitance).

The transformer monitoring system shall not provide the transformer design change, and shall be supplied together with respective power transformers.

The complete wiring shall be of highly flexible screened stranded copper. Wiring shall also have crimped termination. The minimum cross section of the wiring for power circuits shall be 2.5 mm2, and that for control circuits and step position transmitters shall be at least 1.5 mm2.

12.14 Parallel Operation and Voltage Regulation

The transformers shall be able to be operated in parallel with the existing/future transformers.

12.15 Local Control Cubicles, Cables and Earthing

Each transformer shall be fitted with a control cubicle of welded galvanized sheet steel housing, mounted on the transformer tank, in a position easily accessible from the ground level. The cabinet shall contain all control and protective equipment for the cooling system, as well as the termination of all secondary circuits.

The internal arrangement of the cabinet shall keep the various circuits clearly separate from each other, permitting easy and safe independent maintenance and repair of each item without disturbing the others.

Fluorescent type lighting fixtures of standard commercial size together with door contacts as well as a manual control switch shall be provided for internal illumination.

Electrical connections between sensors, current transformer, and all other accessories with the local control cabinet shall be enclosed in perforated metal raceways or conduits of ample size securely fastened to the transformer tank to prevent mechanical damage or vibrations.

All signals of the monitoring and protection equipment mounted on the transformers (as Buchholz relays, thermometers, oil level indicators etc.) shall be wired to a common terminal strip in a local control cubicle together with all signals from the tap changer control cubicle.

All control cubicles shall have protection class IP 64 and shall be vermin- and insect-proof with sufficient ventilation and equipped with humidity-controlled heating and sufficient illumination switched on and off by door contacts as well as one socket outlet 230 V AC, 16 A.

All cables routed at the transformer, over flanges or atop the transformer attached equipment/devices must be enclosed by stainless steel tubes for protection against mechanical damage. They must be screwed with metal clamps to the transformer or its attached equipment/devices. Further the stainless-steel tubes must be earthed on both sides via copper mesh screwed directly to the tube and to the transformer.

All cubicles and all to the transformer attached equipment/devices must be earthed via copper mesh screwed directly to the cubicle/equipment/devices and to the transformer.

Both sides of all flanges shall be electrically connected to each other by copper mesh, screwed on both sides of each flange.

For the earthing of the transformer on two diagonal places of the bottom of the transformer earthing connections shall be foreseen.

All earthlings and earthing connections shall be carried out for the maximum rated short circuit at the respective substation and voltage level.

All screws shall be self-locking screws. All screws and clamps shall be made of corrosion free metal (stainless steel, no plastic etc.).

Sufficient earthing connection at the transformer for the earthing measures listed above shall be foreseen.

12.16 Terminations

The transformer has to be equipped with the following bushing types for 69kV side:

- Air-Insulated Bushings

The contractor is responsible for the positioning of the termination in order to cope with the local restriction of space. The optimal position of the termination shall be adopted to the local space and installation conditions.

The bushings shall be outdoor type designed for pollution level as specified in the technical requirement and in accordance with IEC 60815. They shall correspond to IEC 60137, shall be free from defects, and shall be thoroughly vitrified.

All bushings shall be at least of the same insulation level as that for the related windings and/or neutral. Each of the bushings shall be designed for such a rated current as to cover all loading conditions of the transformers as specified in IEC 60076-7 without any restriction. The HV bushings must enable the insulation monitoring devices to be connected.

Generally, the insulators shall be of highest quality electrical grade porcelain, homogenous and non-porous, and shall be in one piece.

Bushings for primary voltage power windings shall be of the resin impregnated paper (RIP) type equipped with test tap at the bushing flange.

Secondary winding bushings will be installed on the longitudinal axis opposite one another.

Neutral winding bushings will be fitted on the transversal axis.

All bushing-connecting nuts, bolts, washers, rings, caps on the top shall be of non-magnetic material. All bushings shall be designed for operation and storage in a horizontal position without any restriction. All bushings shall be designed for the highest over-current that can flow through the windings.

The bushings shall be arranged on the tank cover in such a manner, that removal of the same is possible without lowering of the oil to such a level where the windings are exposed to the atmosphere.

Bushing turrets with removable flanged-on covers on the bushing side shall be provided for all bushings. Removable bushing turrets shall be provided with four adequate lifting lugs each.

12.17 Cable Boxes (Air insulated type)

The transformers shall be equipped with cable boxes for 33kV, 11kV and 2.2kV sides to accommodate XLPE single core copper/aluminum cables and air insulated bushings for 69kV side. The Contractor shall provide Employer with calculations to substantiate the rating of the cables installed.

Medium voltage cable box completes with all jointing materials and with gland suitable for XLPE single core cables designed for 33kV, 11kV and 2.2kV earthed system, and should withstand a continuous load of 20MVA transformers and overload of 20% during 2 hours in load conditions.

Primary side should be equipped with surge arresters.

The exact specifications of the cables shall be submitted by Contractor to Employer for approval.

The cable box shall be so designed that in the event of the transformer is to be replaced it should not be necessary to break up the cable jointing at the terminal. The Secondary cable box to be identical to the Primary side but suitable for XLPE single core cables. The cable boxes shall be provided with earth wire connection with the main tank of the transformer.

12.18 Corrosion Protection and Painting

The main tank conservator, Radiators, fan grills, pipework, control boxes or cubicles and marshalling cubicles (all to the transformer attached parts/devices) shall be hot dip galvanized and painted.

External surfaces shall be treated with anticorrosive and water-resistant paint and internal surfaces with oil-resistant anti condensation paint.

The equipment must be so designed that any features, which may encourage the formation of rust, are avoided.

The external surfaces of the transformer and all to the transformer attached parts/devices shall be coated with two components epoxy based primer and final coat with a minimum total thickness of 240 µm. The coating shall consist of the following layers:

- One primer coat two-component epoxy zinc-phosphate or two-component epoxy zinc-dust, 100 microns
- One intermediate coat two-component epoxy micaceous iron oxide, 100 microns
- One topcoat two-component polyurethane, 40 microns

The final coat color shall be grey.

The internal surfaces shall be coated with epoxy-based paint, which is inert to transformer oil and has good dielectric properties. A minimum of one primer and one final coat shall be applied. The final color shall be white.

12.19 Inspection and Testing

All tests shall be performed in accordance with the latest IEC Standards. Additionally, to section 4.4. The following subsections apply to the transformers.

Factory Testing and Factory Test Reports

Factory made structures and equipment must be fully assembled, adjusted and tested at manufacturing plants.

All equipment being supplied shall conform to type tests as per technical specifications. The following factory tests are mandatory:

1. Tests of auxiliary and control circuits;
2. Main circuits resistance measuring;
3. Protection degree check;
4. Tightness test;
5. Mounting diagram check;
6. Performance check.

All tests shall be performed in accordance with IEC 60076 in the presence of the Employer/ Engineer.

All routine tests IEC 60076-1 sub-clause 11.1.2 shall be performed as well as the type tests IEC 60076-1 sub-clause 11.1.3 a) up to d) and the special tests IEC 60076-1 sub-clause 11.1.4 a) up to f), h) up to j) and l) up to n).

The type tests have to be carried out by accredited laboratories. The accreditation must be carried out by an independent organization according to the ISO / IEC 17025. This accreditation certificate must be included with the offer.

All dielectric tests shall be performed in accordance with IEC 60076-3 table 1, including all routine, type and special tests.

During FAT the following routine test protocols shall be presented:

- Vacuum deflection test, IEC 60076-1 sub-clause 11.9, applicable for tank and all other oil-filled compartments (150 Pa to be applied for at least 5 hours)
- Pressure deflection test, IEC 60076-1 sub-clause 11.10, applicable for tank and all other oil filled compartments at min. 100 kPa measured on tank bottom for at least 24 hours

Additional test requirements to be performed are listed in the following:

- Measurement of no-load losses and current, IEC 60076 sub-clause 11.5, the range shall be from 90% to minimum 120% of rated voltage and/ or vice versa in 5% intervals. The highest test voltage of 120% shall be held at this level for at least 15 (fifteen) minutes. A respective magnetizing curve current from 90% to approx. 125% shall be added to the test report.
- Measurement of short-circuit impedance and load loss, IEC 60076 sub-clause 11.4, the measurement shall be performed with all tapping positions.
- Measurement of Frequency Response (SFRA-test), IEC 60076-18, swept frequency shall be used in a range of 10 Hz to 20 MHz. This test is to provide base line readings of the windings in as-new

condition. The test shall be performed after successful completion of all dielectric tests and shall be repeated at site.

- Permissible deviations within frequency ranges according to IEC 60076-18 figure B6
- Measurement of dissipation factor, IEC 60076-1 sub-clause 11.1.2.2 c), tan delta value at 20°C shall be less than 0.5%.
- Measurement of the insulation resistance (R60) between the core and tank at 2500 V DC.
- Measurement of the harmonic content of no-load current at 90%, 100%, 110% and 120% of rated voltage at rated frequency (after no-load test).
- Temperature-rise type test, IEC 60076-2, in case of measurements of top oil temperatures taken in pockets the final top oil temperature shall be corrected by +2 K. The bottom oil temperature shall be measured by at least two points placed either directly into return headers or at return headers of cooling equipment. Measurements on radiator and/ or tank walls are not acceptable. Location of all measuring points, including those for measurements of ambient air temperature, is subject for approval. The oil used during type tests shall have same or higher kinematic viscosity as final oil used at site for operation. For auto-transformers thermo-visual infra-red measurements shall be performed.
- Calibration and current injection test on hot spot indicators based on results of heat run test.
- Applied over-voltage test at 2000 V AC, 60 sec. on wiring, control and supervisory equipment (1000 V AC plus 2 x Un on motors as per IEC 60034-1, and 500 V AC on PT 100, all electronic devices disconnected).

Purchaser reserves the right to witness any or all the tests. The Supplier shall intimate the Purchaser the detailed program about the tests at least three (3) weeks in advance in case of domestic supplies & six (6) weeks in advance in case of foreign supplies.

The reports for all type tests and additional type tests as per technical specification shall be furnished by the Supplier along with equipment/material drawings.

The Supplier must ensure conformity of test reports, certificates and other necessary documents, supplied together with the equipment, to the applicable regulations.

In the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design/ manufacturing changes (including substitution of components) or due to non-compliance with the requirement stipulated in the Technical Specification or any/all additional type tests not carried out, same shall be carried out without any additional cost implication to the Purchaser.

The Supplier, free of cost, shall provide any special equipment, tools and tackles required in future for operating tests.

The Supplier bears all expenses related to the performance of factory acceptance tests (FAT).

For FAT the Bidder shall include in his financial offer of the equipment the following costs:

- For each of the Employer’s representatives: Travel costs (air ticket, within Europe: economy class, intercontinental: business class), local transport, accommodation, travel insurance, cost of venue, Visa expenses, airport taxes and other incidental travel expenses as applicable.

Equipment inspection at the delivery site

The Supplier ensures presence of representatives of a manufacturing plant during the loading, unloading and warehousing in the territory of the respective substations. Presence of a representative of the manufacturing plant is necessary for the respective documentary execution of papers (acts, protocols) as regards integrity and completeness of equipment after shipment, availability of accompanying documents according to the Table of Technical Specifications, henceforth necessary for the execution of warranty obligations during equipment installation supervision under another contract.

The following tests shall be performed at site as a minimum requirement:

- Visual checks
- Measurement of the excitation current with low voltage (AC, 3-phase) when the transformer is completely de-magnetized
- Measuring of d.c. insulation resistance between each winding to earth and between windings at 5000 V DC (R15, R60, R600). The polarization index R10min: R1min shall be greater than 1.1, IEC 60076-1 subclause 11.1.2.2 (b)
- Measurement of dissolved gasses in dielectric liquid from each separate oil compartment except diverter switch compartment, IEC 60076-1 subclause 11.1.2.2 (d)
- Measurement of winding resistance, IEC 60076-1 subclause 11.2, applicable to all tap positions
- Measurement of voltage ratio at all tap positions and check of vector group by voltmeter method, IEC 60076-1 subclause 11.3
- Functional tests on OLTC equipment, IEC 60076-1 subclause 11.7
- Oil tightness test on tank assembled with radiators with a pressure of 30 kPa above normal oil pressure, 24 hours (on oil-filled cable termination boxes at 20 kPa, 5 hours), IEC 60076-1 subclause 11.8
- Check of core and frame insulation at 2500 V DC, 1 min, IEC 60076-1 subclause 11.12
- Measurement of Frequency Response (SFRA-test), IEC 60076-18, swept frequency shall be used in a range of 10 Hz to 20 MHz. This test is to compare with the results recorded at factory before transportation. Therefore, the transformer shall be in the same condition as during base line readings (same bushings, same oil filling, …).
- The maximum permissible deviation performed on one particular transformer shall be for each of the measurements in the ranges A to D according to IEC 60076-18 figure B6 as given in the following table:

	Frequency range [dB]			
	A 0 … 2 kHz	B 2 kHz … 20 kHz	C 20 kHz … 2 MHz	D > 2 MHz
Permissible deviation	7	7	7	9

Permissible deviations within frequency ranges according to IEC 60076-18 figure B6.

With exceedance of such values transformer shall be repaired and fully retested.

- Determination of the breakdown voltage of insulation liquid at power frequency, IEC 60156
- Measurement of the insulation resistances on auxiliary wiring at 1000 V DC
- Re calibration and current injection test on winding temperature indicators (45 min)
- Functional test on cooling plant, including check of rotation direction of motors
- Functional tests on control and supervisory equipment

12.20 Transport

The transformers shall be transported either empty or partly filled up and, in both cases, provided with nitrogen gas charged from bottles fixed at the transformer tank. The Contractor has to take care that during transport and storage at site a sufficient and monitored nitrogen over-pressure will be inside the tank to avoid access of moisture. At each intermediate step of the transport, both at arrival and departure, the pressure of the nitrogen, have to be recorded, i.e. in factory, port of departure, port of arrival and site.

Impact Recorders

Electronic transport monitors (impact recorders with electronic data storage), capable of indicating all horizontal and vertical impacts, shall be rigidly attached to each power transformer. Two impact recorders shall be provided for each transformer transportation unit.

Provisions must be made to ensure that these indicators are sealed, that they will be completely functional without interruption of indicated records during the entire period of shipment, including loading and unloading, and to ensure that the Employer will receive clearly indicated data by breaking the seal. Instructions for interpretation of the recorded data and a user manual for the equipment shall be provided prior to shipment.

12.21 Guaranteed Transformer Losses

Guaranteed No Load Losses shall be the maximum no load loss at rated voltage and frequency and rated tap position.

Guaranteed On Load Losses shall be the on-load losses at a top oil temperature rise of 60 K, rated voltage and frequency, rated voltage tap position and ONAF power rating.

12.22 Noise Limits

The transformers shall be so designed and constructed that harmful vibrations are eliminated and that no avoidable noise will occur at any operating conditions.

The maximum allowed noise limit is 70 dB for 15MVA and 20MVA power transformers (all forced cooling in operation) and 60 dB for 4MVA and 3.5MVA transformers.

The determination of the audible noise level and the measurement methods for the various part of the transformer will be in accordance with IEC 60076-10 and IEC 60551 and will be verified by the relevant test.

The transformers shall be so designed and constructed that harmful vibrations are eliminated and that no avoidable noise will occur at any operating conditions.

This limit shall be permissible to use pads of suitable damping material between the active part of the transformer and the tank bottom and between the transformer or any part of the cooling system and their mountings.

12.23 Evaluation Criteria

Adjustment of Price for the Purpose of Evaluation in the assessment of the received bids, transformer losses will be capitalized as follows:

The evaluated price for transformer shall be multiplied by the total number of transformers to arrive at the total evaluated price.

Any adjustment in price that results from the below procedures shall be added for the purpose of comparative evaluation only, to arrive at an "evaluated bid cost".

Bid prices quoted by Bidders shall remain unaltered.

Evaluated price of Transformer Losses (ETL) = N.a + L.b

Where: N = No load loss (core-loss) at rated voltage in kW

L = Load loss (copper-loss) *at 75°C, 50 Hz, full load, principal tapping, (ONAF) in kW*

a = Cost/kW of no-load loss (core-loss) valued at USD 8,600/kW

b= Cost/kW of load loss (copper-loss) valued at USD 4,500/kW

No adjustments for Noise level and Temperature rise limit resulting in rated output.

The loss determination shall be performed in accordance with IEC 60076. For three winding transformers IEC 60076-8 subclause 7.7 is applicable.

12.24 Failure to Meet Functional Guarantee

Functional Guarantees of the Facilities

The minimum (or maximum) requirements stated in the specification for functional guarantees required in the specification should be respected.

Transformers Losses

No Load Losses: If the no load losses of a transformer exceed the guaranteed value by more than the margins specified hereunder, a penalty as specified for each full kW in excess of the guaranteed value will be deducted from the contract price.

The penalty will be 12,000 USD/kW. It is thereby understood that values of 0.5 kW and above will be rounded up to the next full kW.

On Load Losses: If the on-load losses (plus auxiliary power losses) of a transformer exceed the guaranteed value by more than the margins specified hereunder, a penalty as indicated for each full kW in excess of the guaranteed value will be deducted from the contract price. The penalty will be 8,000 USD/kW.

It is thereby understood that values of 0.5 kW and above will be rounded up to the next full kW For all other values, the margins stated in the IEC standards are applicable, unless specified otherwise elsewhere in these specifications. The values for all insulation and test levels shall be obtained from the description of the general technical requirements of these specification.

Noise Level

Should the noise level (at maximum power output and at Umax) for the transformers, at the specified distance according to IEC, exceed the guaranteed values but not exceed 3 dB, the Contractor must pay liquidated damages (penalty) to the Employer.

The penalty will be 15,000 USD/dB. It is thereby understood that values of 0.5 dB and above will be rounded up to the next full dB."

Rejection

The Purchaser shall have the right to reject any transformer if the actual values are in excess of the guaranteed values by more than the margins specified hereunder (including the tolerances):

• No-load losses	+ 10 %
• Load losses (forced cooling)	+ 10%
• Total losses	+ 10%
• Noise level	+ 3 dB
• Temperature rise limit	+ 0.0 K

For all of the other values the margins stated in IEC standards are applicable, unless specified otherwise elsewhere in these Specifications.

The values for all insulation and test levels shall be obtained from the description of the general technical requirements of these Specifications.

12.25 Information to be given in the bid

Rated values and characteristics as well as constructional features of the transformer and associated OLTC operating mechanism shall be given by filling in the attached technical data schedules.

In addition, the following shall be provided, as a minimum requirement:

- Evidence of successfully performed type tests
- Information regarding overall dimensions of the transformer and associated OLTC operating
- mechanism as well as details necessary for foundation
- General information regarding maintenance of the transformer and associated OLTC operating mechanism and their connections
- Surface treatment and painting specification
- Method statement of partial discharge measurements during ACSD (AC Short Duration) tests.

12.26 Documents to be included in the delivery

Complete sets of electrical and mechanical constructional drawings (including rating plate drawings), factory test reports, operation and maintenance manuals as well as transportation, installation and site tests/commissioning instructions shall be included in delivery.

For identification purposes, rated power and voltages, the serial number of the transformer and the purchaser’s contract number shall appear on all drawings and documents submitted.

In addition, overloading curves shall be submitted on delivery of the transformer.

The overloading curve sheets shall include:

- The curves showing the loading capacity (in per cent of the rated current) in steady-state condition on the principal tapping and the permissible top oil temperature at the loading in question as a function of the cooling air temperature within the range of 0...+50 °C). The overloading curves shall be based on the winding hottest spot temperature of +120 °C and on the top oil temperature of +100 °C, according to which of the two constitutes the limiting factor in each case. The grounds shall be stated on the curve sheet.
- The curves showing the additional short time loading capacity in per cent of the above-mentioned steady state loading capacity (thus not in per cent of the rated current) as a function of the loading

time within the limits of 15...480 min, when the preceding continuous loadings are 50 %, 75 % and 100 % of the corresponding steady-state loading capacity.

- Separate curves shall be prepared for the winding hottest-spot temperatures of +120 °C and
- +140 °C; the oil temperature must not exceed +115 °C. (The curves based on the temperature
- of +120 °C thus represent the additional short time loading capacity resulting from the heat accumulation alone.) Since these curves depend slightly on the cooling air temperature, too, they shall be calculated for a cooling air temperature of +40 °C.
- The data concerning the loading capacity on the extreme tapings in per cent of the loading capacity on the principal tapping. The voltage at the LV terminals is assumed as being kept constant at its rated value.
- Should limitations be imposed on the overloading capacity by the current carrying capacity of any part, this shall be stated on the curve sheet. The final overloading curves shall be based on the results of the temperature rise test.

13. Mobile Transformer Oil Purification Machine

13.1 Regulations and Standards

The equipment and components supplied shall be designed and constructed to meet and operate in accordance with the latest editions of the standards specified below:

IEC 60422: Mineral insulating oils in electrical equipment - Supervision and maintenance guidance

IEC 60156: Insulating liquids - Determination of the breakdown voltage at power frequency - Test method.

IEC 60814: Insulating liquids - Oil-impregnated paper and pressboard - Determination of water by automatic coulometric Karl Fischer titration

IEC 60296: Fluids for electro technical applications – Unused mineral insulating oils for transformers and switchgear

ASTM D2945: Standard Test Method for Gas Content of Insulating Oils

13.2 Technical requirements

The bidder will supply and deliver a Mobile Trailer Type Double Stages High Vacuum Transformer Oil Purification Machine. The items to be supplied under this shall meet the standard according to relevant IEC or equivalent standard in all respect of engineering design, manufacturing and operation point of view. The Bidder must submit the detail product catalog helpful to justify them for intended use. Purchaser reserves the right to decline the acceptance of the Goods, which to its own judgment are not found suitable for the intended use.

Mobile Trailer Type Double Stages High Vacuum Transformer Oil Purification Machine to be supplied shall be highly effective for transformer oil degasification, dehydration, filtration processing onsite at outside. It shall have fully enclosed structure with function of weatherproof.

It shall be fully mobile such that it can be carried out on road and off road. Meanwhile, the Purification Process of Transformer Oil Purifier shall be able to maintain complete cleanness and improve dielectric strength of insulating oil.

Mobile Trailer Vacuum Transformer Oil Purifier shall be very effective, durable, and user-friendly with top-quality components and maintenance-free operation and performance.

The Mobile Trailer Type Double Stages High Vacuum Transformer Oil Purifier shall have following features and Technical Requirements:

- The High Vacuum type oil treatment Machine of capacity of 4000 LPH shall be mobile and shall be suitable for treatment of new oil and reconditioning of used oil in transformer and other oil filled equipment to achieve properties of treated oil within specified limits at the rated capacity.
- ii. High standard vacuum filtration and dehydration machine shall efficiently remove moisture (free as well as dissolved), gases, dirt and oxidation products from mineral-based and synthetic, silicon oils and others.
- The Machine shall be designed for Conditioning of oil i.e. degassing, dewatering and filtering of transformer oil.
- It shall mainly consist of heating, filtration and vacuum system. The Machine shall generally confirm to the latest revision of IEC standards.
- This Machine shall work on low temperature, high vacuum principle.
  The Machine shall be capable of treatment of new oil and reconditioning of used oil at rated capacity on single pass basis such that purified oil shall have following properties or better.

Breakdown voltage : ≥ 70KV

Water content : ≤ 3ppm

Gas content : ≤ 0.05%

Filtering rate : ≤ 0.5 micron

Flash point (close cup) : ≥135 deg C

Interfacial tension performance : > 40 Dynes / cm @ 25 deg C

Power factor performance : < 0.005 % @ 25 deg C

Acid value : ≤0.08mgKOH/g

- Bidder shall furnish along with the bid detailed calculation to establish the sizing and capability of the vacuum pumping system with respect to moisture and gas removal as above.
- Bidder is to submit along with the bid test reports, test methodology to prove the capability of the offered machine.
- The Machine shall have Double stages vacuum pumps, double vacuum dehydration, degasification chambers and blower capable of pulling vacuum down to required value.
- The Machine shall have low watt-density less than 2W/cm2 circulation heater with digital temperature controller.
- The Machine shall be facilitated different pressure gauge of filters, pressure protector, vacuum gauge and digital temperature gauge.
- The Machine shall be provided with control and indication panel with full automation.
- The Machine shall be fitted with hoses for connection of oil lines and vacuum lines to transformers.
- The Machine shall also be suitable for cleaning and degassing of the oil stored in the storage tanks.
- All equipment required as above shall be mounted on a tow-able road worthy trailer unit with 4 nos. pneumatic tires. The equipment shall be suitable for outdoor use. The oil filtration machine shall be manufactured vehicle mounted with four wheels on strong channel base.
- The painting shall be of epoxy coating, Rust Preventive Measures shall be taken.
- The Machine shall be weather proofed suitable for outdoor conditions. All components have adequate strength and rigidity to withstand normal conditions of handling transport and usage and shall be free from edges or corners to avoid injury to operating personnel in normal conditions of use with sufficient safety provision relevant international standards.
- The design of the Machine shall be such that if required the part/s can easily be replaced.
- Technical specifications of Oil Purification Machine shall be as per Annex A2.29 Mobile Transformer Oil Purification Machine

13.3 Design requirements

The features and construction details of 4000 Liters Per Hour mobile outdoor type oil filtration & purification Machine shall be in accordance with the requirements stated hereunder.

Oil Inlet Pump

One no. of electrically driven oil pump shall be provided. The pumps shall be single stage positive displacement gear type. Suitable mechanical seals shall be provided to ensure vacuum tightness. A built-in pressure relief valve to re-circulate the oil to suction side in case of accidental pressure rise shall be provided. A separate bypass valve is provided across the gear pump so that the flow rate through the filter can be adjusted as required. The pumps shall be provided with an interlock with delay such that if there is no oil flow of 30 sec. through the heater, the pump shall trip automatically and if the pump is not operating the heater will not be energized. Interlocking arrangement should be provided between oil inlet pump and heater so that heater cannot be energized unless oil actually flows through the heater tank i.e. in such a way that unless the inlet pump is 'ON' heater cannot be switched 'ON'. Interlocking arrangement shall be provided in the Filter between the Inlet Pump and High-Level Float Switch (located into Degassing Column) to avoid excessive rise of oil in the Degassing Column. Motors shall be of Class 'F' Insulation.

Heaters

An oil heater for heating up inlet oil shall be provided. The oil heater vessel shall be of mild steel welded construction &properly insulated. The vessel shall be constructed for high vacuum & pressure application. Electric heater shall be provided inside the heater vessel to heat up oil from lowest ambient temperature to temperature required for filtration/degasification operation in single pass. The heater shall also be rated for heating the inlet oil from lowest ambient temperature at 80°C in single pass during filling up of transformers. Two separate temperature settings with thermostatic controllers shall be provided for this purpose. Heater Elements shall be of Nichrome / Kanthal wire filament, inserted in Refractory Formers which are located in Protection Tubes. Construction of the Heat Exchanger shall be such that the replacement of Heaters shall be easy and shall not require any special tools. The heating shall be indirect type. The control switches and knobs shall be housed on a control panel. An additional preset temper proof safety thermostat set at the highest temperature shall be provided on the heater to put off the heater and give audio and visual alarm to take care of accidental overheating. The heater body shall be so designed as to allow replacement of heating elements without draining of oil. Suitable pressure relief valve, vent and drain valves & temperature gauges shall be provided. Heaters shall be interlocked with Gear Pump and shall not be in ON position, unless the Inlet Pump is working. Heater Tank shall be adequately thermally insulated to minimize loss of heat.

Coarse Filter/Preliminary Filter

This shall be a preliminary filter mounted at the inlet of gear pump. The main function of this filter shall be to prevent any damage to the Inlet Pump. It shall have provided with suitable magnetic strainer with wire mesh to filter all particles of sizes above 0.5 mm and all magnetic particles. The cover should be top openable with hinge, and it shall be possible to clean the strainer and replacement of the choked cartridges without dismantling the filter from the pipeline. It shall be cleanable filter.

Fine Filter/Edge Filter

This filter shall be operating on the edge filtration principle incorporating chemically treated paper disc cartridges. This is non-hygroscopic throw away type Cartridge Filter and shall prevent flowing of particles above 1-micron size. The Cartridge element shall have large dust holding capacity. The top of the filter housing shall be hinged for easy replacement of filter packs.

Compound (Pressure/Vacuum) Gauge shall be provided on Filter Vessel for Inlet pressure indication to ascertain the condition of Cartridge Elements. A drain valve for cleaning the chamber should be provided for the edge filter. Provision should exist for cleaning the filter either by reverse flow of compressor air or by back flushing. The Cartridge type Filter shall facilitate to achieve desired value of particle size in micron.

External Solenoid Operated Valves

Two valves should be provided at the inlet and outlet of the Machine. Valve at the inlet and Outlet shall open automatically. The moment inlet and outlet pumps are switched on these valves open thus making way for oil to pass. In case of power failure, these valves shall be capable of preventing the oil from the transformer and thus avoiding the possibility of mixing processed oil with unprocessed oil.

Degassing and Dehydration Chamber

The degassing chamber shall be of welded construction and shall be suitable for operation under full vacuum. Incoming transformer oil should be spread over these rings in the form of film and over a longer surface area, thus achieving better degassing and dehumidification. The degassing chamber shall be double stage type suitable for ensuring the desired oil properties. The degassing channels shall have adequate size for complete degassing. Design shall be such as to minimize foam formation. The degassing chambers shall be provided with suitable level monitor for oil or foam level in the chamber and shall trip the inlet gear pump when the level rises above the designed maximum level in order to prevent foam/oil to enter the vacuum pumping system. A slight glass with necessary illuminating lamp shall be provided through which oil flow through the degasser can be viewed clearly. The degasser shall be provided with vacuum gauges, vacuum breaking valves, main and auxiliary vacuum connections and other necessary accessories. One Float Switch on the Degassing Chamber shall be provided for preventing excess rise of level. It shall be electrically interlocked with Inlet Pump. Another Float Switch to control the low level of the oil in Degassing Chamber shall be provided and it shall be electrically interlocked with the Discharge Pump.

Vacuum Pumping System (For Degassing Column)

A Roots-Rotary combination of Vacuum Pumps shall be provided for evacuation of Degassing Chamber. For matching of Vacuum Pump performance both-Roots & Rotary Vacuum Pumps shall be of same manufacturer only

Oil Extraction Pump (Outlet Pump)

Suitable pumping system shall be provided for extracting oil from degasser under vacuum and supplying to transformer/reactor etc., at suitable discharge pressure at the outlet hose nozzle of the Machine, the pump shall be either glandless centrifugal type with canned motors or a combination of gear pump and centrifugal pump with mechanical seals suitable for extracting oil from high vacuum degassing chamber. The oil extraction pump shall be located at a suitable level below the degasser chamber so as to ensure adequate suction head for the pump. The discharge pump should have high suction so as to draw the purified oil from the vacuum chamber and pump it back to the transformer. The pump shall be supplied with solenoid operated non-return valve. Sampling valves shall be provided at the discharge of extraction pump for testing of oil properties. A recirculation line with valves shall be provided to re-circulate a part of the purified oil to the inlet point if necessary, during operation.

Hoses

Separate reinforced rubber hoses shall be provided for each operation for oil suction, oil discharge, transformer vacuum connection and cooling water supply and return. The hoses shall be at least 15-meter-long each and shall be complete with hose quick connect couplers for connection to installations under operation. Hose pipes for oil service shall be suitable for transformer oil application up to temperature of 100° C, full vacuum and pressure up to 2.5 kg/cm². All oil hoses shall be built up around an earthed core or have built in earthed conductor to avoid static electricity accumulation.

Valves and Pipelines

The valves in Oil Line & Vacuum Line shall be of Ball type. All Pipes shall be of ERW and all joints in oil & Vacuum Line shall be flanged & shall have ‘O’ ring Sealing. ‘O’ rings shall be of Nitrile Rubber & shall be of round shape.

Oil sampling valve

A valve shall be provided to collect the sample of oil for testing during operation.

Inlet and Outlet valve

One number Solenoid Valve at Inlet and One number at Outlet shall be provided. Valve at the Inlet & Outlet shall open automatically. The moment oil Inlet & Outlet pumps are switched On. In case of power failure, these valves shall be capable of preventing the oil from entering into the Machine and thus avoiding the possibility of mixing processed oil with unprocessed oil.

Airing Valve

One airing valve for airing the degassing chamber shall be provided.

Material of construction and painting

Oil heater, filter vessel, degasser shall be of mild steel construction. The internal and external surfaces including oil heater, filter vessel, degasifier and structural steel work to be painted shall be shot or sand blasted to remove all rust and scale of foreign adhering matter or grease. All steel surfaces in contact with insulating oil shall be painted with two coats of heat resistant oil insoluble, insulating varnish. All internal paints steel surfaces shall be given a primary coat of zinc chromate, second coat of oil and weather resistant varnish of a color distinct from primary and final two coats of glossy oil and weather resisting paint. All paints shall be carefully selected to withstand heat and extremes of weather. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

Bolts & Nuts

All bolts and nuts exposed to weather shall be hot dip galvanized/cadmium plated and passivated /zinc plated and passivated. Material of construction for vacuum pumps air compressor, air drying plant, air receiver shall be steel of suitable grade. All piping and equipment carrying transformer oil shall be insulated with glass wool/mineral wool insulation.

Lifting Hooks

Lifting Hooks for Machine shall be provided to facilitate ease of Machine Loading/Unloading. An on-line moisture content sensor shall be provided at the outlet of the Machine to measure the PPM value of oil coming out at the discharge. The sensor shall be suitable to measure the PPM value from 3PPM to 100 PPM.

Electric Control Panel

The Machine shall be controlled by a complete automatic PLC controlling system with touch screen, which allows easy and safe operation, it shall also allow operation over buttons on the control panel by manual. The controlling system of the Machine shall have interlocked protective system and pressure protective device which shall avoid overload, over voltage, pumping without oil, heating without oil, oil leak, electricity leak and prevent any damages to equipment due to operating error or power failure. The control panel shall also have alarm system for any fault. In the event of fault, the alarm lamp shall lighten, and fault message shall display on screen. Meanwhile, Timing counters shall keep track for each running time and total running time. HRC Fuses and Switchgear protection equipment shall be provided for protection of Electrical motors. Suitable interlock as described against each equipment shall be provided for safe and trouble-free operation.

Control panel should be equipped with following Electrical Instruments:

a) Three phase digital voltage meter

b) Three phase digital current meter incoming feeder, simultaneous three phase display.

c) Three phase digital current meter for heater currents, simultaneous three phase display.

d) A Mimic diagram with indicating lamps shall be provided on the control panel. All wiring shall be neatly routed, and all wire termination shall be suitably identified with ferrules. The Machine shall be suitable for operation on 400, 3 phase, 4 wire 50Hz AC supply. Control supply voltage should be taken from 400 V/230 V control transformer. All controls and annunciation equipment should be suitable for the voltage.

Instrumentation and Control

Following minimum instruments shall be provided on the oil purification Machine:

a. Compound gauge at oil pump discharge

b. Compound gauge at filter inlet/outlet

c. Pressure Gauge at discharge pump outlet

d. Vacuum Gauges

e. Oil Filtration Machine should be fitted with on-line moisture in oil-PPM indicator.

f. Sight glass at degassifier

g. Temperature indicator cum controller at heater outlet

h. Safety thermostat

i. High/low oil level sensor for vacuum chamber

j. Moisture monitor

k. Oil flow meter (Positive displacement type)

l. Voltmeter

m. Ammeter

13.4 Inspection & Testing

The Machine shall be offered for Inspection & Testing with Transformer Oil on site. Supplier shall demonstrate the Machine performance as per parameters mentioned in the specifications. The supplier should confirm availability of testing and carrying out the following tests on the oil:

- Break Down voltage
- Moisture Content
- Suspended Particles
- Gas Content
- Acidity
- Machine flow rate confirmation
- Electrical Interlock Tests
- Other as per Technical Specification

13.5 Mandatory Spares

The bidder shall supply the following minimum spares parts for five years of successful operation of the equipment at no extra cost to Purchaser.

a. One set of Filter cartridge.

b. One set of O-rings.

c. One set of Oil solenoid valve with coil.

d. Heater element 50% of total population.

e. One tool case

f. One reserve thermometer

g. One set of spanners

h. One set of gaskets

14. Auxiliary Transformers 33/0.4kV 100kVA and 11/0.4kV 160kVA

14.1 General

This specification covers the design, manufacturing, testing, supply, delivery and performance requirements of three phase, 50 Hz, 33/0.4 kV and 11/0.4 kV distribution power transformers with accessories.

All transformers shall have separate primary and secondary windings and be hermetically sealed, oil immersed with natural oil and air cooling (ONAN). The auxiliary transformers shall be three-phase, suitable for outdoor installation.

The design of the tank, fittings, bushings, etc. shall be such that it will not be necessary to keep the transformer energized to prevent deterioration as the transformers may be held in reserve, outdoors, for many years.

14.2 Regulations and Standards

This technical specification covers minimum requirements for the nominal rating, kind of compound materials, design, construction and test of auxiliary transformers in substations. Auxiliary transformers shall be designed, manufactured and tested in accordance with the requirements of the latest revision of the following standards and to this specification:

IEC International Electrotechnical Commission:

IEC 60076 All parts : Power Transformers

IEC 60071: Insulation co-ordination

IEC 60137: Bushing for alternating voltages above 1,000V

IEC 60156: Method for the determination of the electric strength of insulting oils

IEC 60296: Specification for unused mineral insulating oils for transformer and switchgear

IEC 60354: Loading guide for oil-immersed power transformers

IEC 60437: Radio interference test on high-voltage insulators

IEC 60551: Determination of transformer and reactor sound levels

IEC 60616: Terminal and tapping markings for power transformers

IEC 60722: Guide to the lightning impulse and switching impulse testing of power transformers and reactors

ISO International Organization for Standardization:

ISO 1459: Metallic coatings - Protection against Corrosion by Hot Dip Galvanizing - Guiding Principles

ISO 1460: Metallic coatings - Hot dip galvanized coatings on ferrous materials. Gravimetric determination of the mass per unit area

ISO 2178: Non-magnetic coatings on magnetic substrates - Measurements of coating thickness - Magnetic method

ISO 9000: Quality management and quality assurance standards - Guidelines for selection and use

14.3 Technical Requirements

The 33/0.4kV Auxiliary Transformer to be supplied shall comply with guaranteed technical particulars as indicated in Annex A2-9.

The 11/0.4kV Auxiliary Transformer to be supplied shall comply with guaranteed technical particulars as indicated in Annex A2-10.

14.4 Rated Power

The continuous rating of the distribution Transformers shall be 160kVA for 11/0.4kV and 100kVA for 33/0.4kV.

The transformer shall be capable of supplying its rated power being the product of rated voltage and rated current on the line side winding (at center tap) expressed in kVA, as defined in IEC 60076-1.

The transformer shall also be capable of delivering rated current at an applied voltage equal to 105% of the rated voltage.

Likewise, each transformer shall be capable of supplying its rated power continuously under ambient temperature conditions without the temperature rise of the top oil exceeding 50°C and without the temperature rise of the windings as measured by resistance exceeding 55 °C.

14.5 Overload Capacity

The transformer shall be capable of operating in accordance with the loading guidelines of IEC 60354 without exceeding the normal daily use of life and without the transformer winding hot spot temperature exceeding 140°C.

The Contractor shall submit calculations demonstrating that above requirements are met. These calculations shall disregard the effect of winding thermal capacity.

Importance is attached to overload capacity. Transformers incapable of meeting the overload performance specified will not be considered.

14.6 Impedance Voltage

The guaranteed value of impedance measured at 75 °C and center tap shall be 4% for transformers and it shall be subject to the tolerance specified in IEC 60076.

The resistance component of impedance measured at 75 °C on the center tap shall not exceed 25 % for all kVA ratings

14.7 Short Circuit Performance

The transformer shall be capable of withstanding the thermal and dynamic effects of short circuits.

The short circuit characteristics shall be as follows;

- The X/R ratio shall conform to HD 398 / HD 428
- The initial winding hot spot temperature shall be 98 °C
- The final winding hot spot temperature shall be 250 °C

The ability to withstand the thermal and dynamic effects of a short circuit shall be demonstrated in accordance with IEC 60076 and IEC 60354. Calculations / test certificates shall be submitted for approval.

14.8 Flux Density

The flux density at any point of the magnetic circuit when the transformer is connected on the center tap and operating at normal voltage and frequency shall not exceed 1.65 Tesla. Saturation must not occur at 10 % over voltage.

14.9 Noise Level

The transformers shall be designed and constructed in a way that harmful vibrations are eliminated, and the minimum noise occurs at any operating conditions. The transformers shall pass a noise test according to IEC 60076-10 and IEC 60551. The measured values shall not exceed the values as defined in the respective Technical Data Sheets which should be less than 50dB.

14.10 Off-Load Tap Changing Characteristics

Each transformer shall be fitted with 5 taps with ± 2x2.5% voltage variation. Tap changing and the tap changing mechanism shall have the following characteristics:

- Tap changing shall be carried out with the transformer off-load. An externally operated self-positioning tapping switch shall be provided.
- Provision shall be made for locking the tap switch handle with a padlock having a 6 mm diameter hasp.
- Tap changer handles shall be fitted with gasketed covers, so that sealing of the transformer under normal conditions is independent of the switch shaft gland.

14.11 Materials and Construction

The HV and LV windings shall be made of high conductivity copper. Copper foil may be used for the LV winding.

The windings shall be uniformly insulated and the LV neutral point shall be insulated for full voltage. The insulation material of windings and connections shall be high quality, free from insulation softening, shrinking or collapsing during service. Moreover, none of the material used shall disintegrate, carbonize or become brittle under the action of hot oil, under all load conditions.

The core shall be manufactured from non-aging, grain-orientated silicon steel of high permeability with step-lap mitered joints.

The core and coil assembly shall have the core and coils rigidly connected to the tank and suitable closed lugs shall be provided for removing the core and coil assembly from the tank.

14.12 Bushings and Terminals

All bushings shall be so designed that there will be no excessive stressing of any parts due to temperature changes and adequate means shall be provided to accommodate conductor expansion. Insulation levels for bushings shall be at least equal to those specified for the windings.

The Bushings shall be so installed that they are easy to be checked and removed without removing the tank cover and the pipe work.

The creepage distances for the bushings and the insulators shall not be less than 31.5 mm/kV for maximum phase to phase system voltage.

Both HV and LV Bushings shall be complete with Brass terminals suitable for terminating Copper conductors as details given below:

The HV and LV bushings shall be:

- Easily replaceable and cemented in bushings are not acceptable.
- Sufficiently robust to withstand normal transport hazards.

The HV bushings shall be labeled in accordance with IEC 60076. Letters shall be at least 12 mm high. The means of marking shall be either:

- Engraved metal plate or etched anodized aluminum. Identification by adhesive stickers is not acceptable.
- If labeling is to be carried out on the tank, it is preferred that one plate be used rather than individual markings for each phase, to prevent incorrect phase markings.

14.13 Cable Boxes (Air insulated type)

The transformers shall be equipped with cable boxes to accommodate XLPE single core copper cables. The Contractor shall provide Employer with calculations to substantiate the rating of the cables installed.

High voltage cable box complete with all jointing materials and with gland suitable for XLPE single core cables designed for 33kV and 11kV, and should withstand a continuous load of 160kVA and 100kVA transformers and overload of 20% during 2 hours in load conditions.

The exact specifications of the cables shall be submitted by Contractor to Engineer/Employer for approval.

The cable box shall be so designed that in the event of the transformer is to be replaced it should not be necessary to break up the cable jointing at the terminal. The Secondary cable box to be identical to the Primary side but suitable for XLPE single core cables. The cable boxes shall be provided with earth wire connection with the main tank of the transformer.

14.14 Earthing Terminals

All transformers shall be provided with a main earthing terminal of stainless steel welded to the tank and be fitted with a stainless steel M12 bolt, nut, spring washer and a lock washer.

14.15 Tank Fabrication

The transformer tank shall be of rigid construction, shall not leak and shall be designed so that the completed transformer can be lifted and transported without permanent deformation or oil leakage. The Contractor shall state what method of leak testing is used.

The tank shall be fabricated of mild steel or stainless steel. If stainless steel is used it shall not discolor or corrode; a minimum grade 304 L is required.

The minimum thickness of the steel tank shall be 3 mm for mild steel and an equivalent thickness for stainless steel such that its mechanical strength shall be the same as that of the 3 mm thick mild steel tank. Thickness below the minimum value will be considered only in exceptional cases, such as where special protective finishes are used. The Contractor shall provide full information about any such special finish, including any field experience.

The transformer tank and the top cover shall be designed in such a manner as to leave no external pockets in which water can lodge or dust deposits can build up.

The top cover shall be of the bolted type and fitted with neoprene bonded cork seals suitable for temperature as stipulated in this specification. Surfaces at gasketed joints shall be such that an even face is presented to the gasket, thereby eliminating the necessity for the gasket to take up surface irregularities.

The cooling surfaces may be oil filled fins or radiators. Only larger faces of the transformer shall be used to attach cooling surfaces.

All pipes and radiators, which are welded to the tank wall, shall be welded externally.

14.16 Surface Treatment

The transformer tank, radiators and accessories should be adequately protected against corrosion and the Contractor shall submit details of the proposed method of protection.

All surfaces shall be thoroughly cleaned of rust, scale, grease and dirt and other foreign matter and all imperfections shall be removed by means of approved methods.

The transformer tank and its steel attachments shall be hot dip galvanized or metallized, followed by painting. The painting system used should be proven and documented.

The outside of the tank shall be painted Gray.

The inside of the tank shall be painted with an approved oil resisting varnish so that the oil cannot come into contact with the tank metal at any time.

14.17 Tank Fittings and Attachments

The following fittings and attachments shall be provided in all transformers:

- Tap changer (off-circuit with pad lockable switch)
- Cable box with HV bushing assembly
- Cable box LV bushings assembly
- Oil filling and drain valves
- Main earthing terminal
- Lifting eyes pulling eyes and jacking pads
- Stainless steel engraved rating and connection plate in English language
- Pressure relief valve
- Protecting irons
- Oil level indicator
- Terminal marking

14.18 Transformer Assembly

The core and winding shall be dried in a vacuum drying oven. The heating and vacuum drying cycle shall be approved by the Employer. The tank, complete with core and windings, shall be filled with oil under a vacuum.

14.19 Transformer Oil

The transformers shall be supplied filled with class 1 mineral oil conforming to IEC 60296. The Contractor shall submit a detailed specification for the type of oil proposed. The oil shall not contain polychlorinated biphenyls (PCB). The Employer may require evidence that the oil is not contaminated by PCB. If an antioxidant is recommended, its use shall be subject to the Employer's approval.

14.20 Transformer Losses

Guaranteed No Load Losses shall be the maximum no load loss at rated voltage and frequency and rated tap position.

Guaranteed On Load Losses shall be the on load losses at a top oil temperature rise of 60 K, rated voltage and frequency, rated voltage tap position and power rating.

14.21 Evaluation Criteria

In the evaluation of the received bids, transformer losses will be capitalized as follows:

The evaluated price for transformer shall be multiplied by the total number of transformers to arrive at the total evaluated price.

Any adjustment in price that results from the below procedures shall be added for the purpose of comparative evaluation only, to arrive at an "evaluated bid cost".

Bid prices quoted by Bidders shall remain unaltered.

Evaluated price of Transformer Losses (ETL) = N.a + L.b

Where: N = No load loss (core-loss) at rated voltage in kW

L = Load loss (copper-loss) *at 75°C, 50 Hz, full load, principal tapping, (ONAN) in kW*

a = Cost/kW of no-load loss (core-loss) valued at USD 8,600/kW

b= Cost/kW of load loss (copper-loss) valued at USD 4,500/kW

No adjustments for Noise level and Temperature rise limit resulting in rated output.

The loss determination shall be performed in accordance with IEC 60076. For three winding transformers IEC 60076-8 subclause 7.7 is applicable.

14.22 Failure to Meet Functional Guarantee

Functional Guarantees of the Facilities

The minimum (or maximum) requirements stated in the specification for functional guarantees required in the specification should be respected.

Transformers Losses

No Load Losses: If the no load losses of a transformer exceed the guaranteed value by more than the margins specified hereunder, a penalty as specified for each full kW in excess of the guaranteed value will be deducted from the contract price.

The penalty will be 12,000 USD/kW. It is thereby understood that values of 0.5 kW and above will be rounded up to the next full kW.

On Load Losses: If the on-load losses (plus auxiliary power losses) of a transformer exceed the guaranteed value by more than the margins specified hereunder, a penalty as indicated for each full kW in excess of the guaranteed value will be deducted from the contract price. The penalty will be 8,000 USD/kW.

It is thereby understood that values of 0.5 kW and above will be rounded up to the next full kW For all other values, the margins stated in the IEC standards are applicable, unless specified otherwise elsewhere in these specifications. The values for all insulation and test levels shall be obtained from the description of the general technical requirements of these specification.

Noise Level

Should the noise level (at maximum power output and at Umax) for the transformers, at the specified distance according to IEC, exceed the guaranteed values but not exceed 3 dB, the Contractor must pay liquidated damages (penalty) to the Employer.

The penalty will be 15,000 USD/dB. It is thereby understood that values of 0.5 dB and above will be rounded up to the next full dB."

Rejection

The Purchaser shall have the right to reject any transformer if the actual values are in excess of the guaranteed values by more than the margins specified hereunder (including the tolerances):

• No-load losses	+ 10 %
• Load losses	+ 10%
• Total losses	+ 10%
• Noise level	+ 3 dB
• Temperature rise limit	+ 0.0 K

For all of the other values the margins stated in IEC standards are applicable, unless specified otherwise elsewhere in these Specifications.

The values for all insulation and test levels shall be obtained from the description of the general technical requirements of these Specifications.

14.23 Tests

The tests listed hereinafter shall be carried out in accordance with provisions in the referenced standards in the specification.

Routine Tests

Routine tests shall be carried out on all transformers and the tests shall be conducted in accordance with IEC 60076 /other standards as applicable.

The following routine measurements and tests shall be carried out:

- Measurement of winding resistance
- Measurement of voltage ratio and check of polarity and vector group
- Measurement of impedance voltages
- Measurement of load losses
- Measurement of no-load losses and no load current, including measurement of harmonics
- Induced overvoltage withstand test
- Separate source voltage-withstand tests on HV and LV windings
- Bushing routine tests
- Oil leakage test
- Relief Device test

- Dielectric Routine Tests
- Galvanizing tests.

Type Tests

Following shall be regarded as type tests:

- Temperature Rise Test. This test shall be carried out on the tap having maximum losses
    - Short Circuit Withstand test
    - Measurement of zero-sequence Impedances
    - Impulse Voltage Test and Power Frequency Test
    - Acoustic Sound Level Measurement
    - Tank Vacuum Test
    - Measurement of Harmonic Level in no load condition
    - Oil Analysis

Galvanizing Tests

Galvanizing tests shall be carried out on transformer tanks prior to painting. Those shall be routine tests, which shall be part of the routine tests documentation and shall not be charged to the Employer. Testing shall be in accordance with ISO 1460 and is summarized as follows.

The following tests, measurements or inspections shall be carried out on each of the selected samples:

- Visual inspection
- Thickness of galvanizing coat
- Uniformity of galvanizing coat

In the event of disagreement or dispute over the results of the above tests a coating mass test shall be carried out. The result of this test shall be definite and binding.

14.24 Label and Rating Plates

Labels, nameplates, markings and instructions shall be clear and indelible and in the English language. A weatherproof rating plate shall be provided in accordance with IEC 60076 and showing the following items, indelibly marked:

- Type of transformer
- Specification to which standard it was manufactured
- Manufacturer’s name
- Serial number
- Year of manufacturer
- Number of phases
- Rated power
- Rated frequency

- Rated voltage
- Rated currents
- Vector group
- Percentage impedance voltage at rated current
- Type of cooling
- Continuous ambient temperature at which ratings apply
- Top oil temperature rise at rated load
- Total weight
- Volume of oil
- Weight of core and windings
- Table of primary voltages at the 5 tapping positions
- Connection diagram
- Employer’s name

15. Neutral Earthing System with 11kV earthing transformers

The three phase Neutral earthing transformer is to provide an artificial neutral point for the system where the neutral point is not grounded, so that the grounding method of arc suppression coil or small resistance can be used to reduce the capacitance current to ground when the distribution network has a grounding short-circuit fault, to improve the reliability of power supply of the power distribution system.

This specification covers the requirements for the 11 kV high-resistance type neutral earthing system, consisting of earthing transformer and neutral earthing resistor (if needed).

15.1 Design requirements

The key elements of the design philosophy for an earthing transformer are:

1. Earthing transformer short time neutral current rating of 2475 Amps for 2 seconds for 11kV system (to be confirmed by studies).

2. Earthing transformer continuous neutral current rating of 150Amps for 11kV system (to be confirmed by studies).

3. Connection Group ZN interconnected star.

4. Zero sequence impedance as defined by the transformer specification.

5. Supplied with voltage surge protection.

6. The flux density should be such that the core does not saturate during a through fault and a constant zero sequence impedance is maintained under through fault conditions.

7. To be of a proven short-circuit tested design.

8. Naturally cooled.

9. Only local temperature monitoring is required, no remote indication.

10. Internal CTs are required.

11. Pressure relief devices required below oil level for the main tank (with alarm contact).

12. The main tank shall be hermetically sealed.

Earthing transformers will be:

• Supplied with a primary voltage of 11kV,

• Be supplied without secondary or auxiliary windings,

• Procured in ground mounted arrangement with provision to be adapted to a power transformer tank mounted arrangement and with plug in cable connection bushings

Earthing transformers shall include the following main features

- Mineral oil immersed,

- Hermetically sealed and naturally cooled
- Low loss, non-amorphous steel core,
- Steel tank,
- Pressure relief device fitted below minimum oil level,
- Provision of internal toroidal current transformers,
- Provision for oil sampling,
- Termination connections suitable for cable connection.

Earthing transformer

The Earthing transformer completely assembled with cable connections, shall be designed and constructed to withstand without damages the effects of short circuits and of medium and low voltage earth fault short circuit. The steel construction of the earthing transformer shall be provided with lifting lugs for transport of the earthing transformer. It shall be possible to exchange the earthing transformer with help of lift truck in case of a fault. The earthing transformer shall be designed so that the required design data are maintained.

Windings

The insulation levels and test voltages shall be in accordance with Technical Requirement on annex A2-11. The medium- voltage windings shall have a state-of-the-art design with electrolytic copper of a high conductivity. Insulating material shall be of proven design.

Magnetic Core

The core shall be constructed from high grade, cold rolled, non-ageing, low loss, high permeability, grain oriented, cold-rolled grain-oriented silicon steel laminations. The joints of limbs and yokes shall be designed and constructed to keep the no-load losses as well as the noise level as low as possible.

Corrosion Protection

The design of all structures shall take due account of all environmental conditions which may be experienced during the lifetime.

Protection, Measuring and Monitoring Equipment

The warning and alarm contacts have to be connected to the bay control unit of the main transformer panel. Main 87T protection shall take in consideration also the protection the earthing transformer.

Neutral Earthing Resistor (if needed)

The neutral earthing resistor shall be designed so that the required design is maintained.
The resistive elements shall have a low temperature coefficient and be resistor-grade stainless steel or nickel chromium rigidly supported at each end to allow for expansion due to heating. The resistor and the casing shall be designed in such a way that the rated current and earth-fault current can be carried without endangering the staff and overstressing the material. The resistors shall be mounted on corrosion-resistant support frames, using stainless steel hardware. The entire resistor frame shall be mounted on insulators rated for the system voltage. All resistor terminals and interconnections between units shall be stainless steel, using stainless steel hardware including lock washers. High current connections shall be spot or TIG welded as appropriate.
Connections between resistors and bushings or current transformers shall be solid copper or stainless-steel bus or copper cables. The neutral earthing resistor shall be connected from the side via a neutral bushing cable box. The side-mounted earthing point shall be connected to the main earthing system.
The specified resistance is to be at the temperature of 20 °C and it shall be capable of passing the earth-fault current for 10 sec.

Enclosures

The frame of the enclosure shall be constructed with structural steel angles made from steel, welded together, or bolted together with stainless steel hardware. The top of the enclosure shall be solid, slightly overhung and sloped. It shall be embossed with stiffening ribs. The enclosure shall have forged eyebolts in each corner for lifting purposes.

Bolt-on side covers on all four sides shall be used. Screened covers may be furnished for certain applications. Stainless steel hardware shall be used.

A durable nameplate permanently attached to one side cover shall show the Manufacturer and the complete rating.

Painted enclosures shall be suitably sanded, cleaned, primed and painted. Stainless steel and aluminum enclosures (in particular) shall be protected from scratching during manufacture, assembly and shipment. The enclosure shall be connected to the earthing system at two points placed diagonally in the opposite corners.

The insulators shall be of porcelain, housed in cable connection box.

The current transformers to be provided for protection purposes shall be mounted into the resistor.

15.2 Technical data for 11 kV earthing transformer

The 11kV Earthing Transformer to be supplied shall comply with guaranteed technical particulars as indicated in Annex A2-11.

16. AC/DC Power Distribution

16.1 Low Voltage Services

a. General

All AC & DC Auxiliary Supply Set of Panels shall be provided as per specified requirements laid down in the tender document, concept/logic diagrams. Moreover, surge arrestors of at least 2 kV ratings shall be installed on per phase basis on each AC Incoming Supplies. AC Reverse Power Relays be installed on AC Incoming-2 and Generator Incoming Auxiliary supplies. The contractor shall submit the detailed AC & DC system Plan, drawings and calculations for the entire substation at the detail design stage and submit to the Engineer for review and approval.

b. AC Auxiliary System

The rated capacity of incoming breakers of AC/DC Auxiliary Supply Panels shall be as under:

- All AC Incoming Main Circuit Breakers shall be 3-pole, 415 V and Tie Circuit Breakers shall be 4-pole, 415 V and shall have continuous rated capacity of at least 400 Amp, short circuit breaking capacity at least 36 kA for 1 sec and making capacity at least 72 kA for 1 sec.
- The AC system will have three incomers rated 400 Amp each, as mentioned above. They will feed AC Bus-1, AC Bus-2, and the AC Gen Set Bus respectively, having busbar current capacity of 1000A at 400/230V.
- The quantity of the outgoing MCBs in each of AC Auxiliary supply panels shall be enough to ensure normal operation for at least all 69kV bays, 33kV feeders and 11kV feeders (depending on the substation scope). However, still the said set of panels shall be equipped with adequate free space to ensure installation on min. 20% spare outgoing MCBs on the AC Busbars without endangering the normal operation and healthiness of said panels.
- The AC Incomers and the bus section CBs will be electrically interlocked. Normal conditions will be both Incomers ON, bus Section Off, and Gen Set Incomer and Genset main CB Off
- It will be possible to close the bus section only if either of Incomer-1 or Incomer-2 is OFF.
- It will be possible to close the generator Incomer only if both of the incomers are OFF
- Although the Genset CB is interlocked with the OFF status of both of other incomers, a reverse power relay will be provided for the Genset CBs, which will trip both Genset CBs if a reverse flow of power is detected;
- The AC auxiliary system will be designed to work in AUTO or MANUAL mode. In the Manual mode, the CBs will be operated manually, subject to the satisfaction of interlocking conditions described above. In the Auto mode, the CBs will be closed and opened automatically, by the action of under voltage relays. The incomer CBs will be opened if the incomer voltage remains below a threshold value for a set time interval, with simultaneous closure of bus section CB, and will be closed again subject to the detection of healthy voltage by the under-voltage relays, while the bus section CB will open;
- The Genset will start and its main and incomer CBs will close if both incomer under voltage relays detect low voltage, after which both incomers will be given open command, and the Genset CBs will be given close command. Upon detection of healthy voltage on any of the two incomers, Gen Set CBs will be opened by the UV relays, and the incomer with healthy voltage detected will be closed

- The size and the ratings of outgoing feeder CBs will be calculated by the contractor and submitted for approval by the Engineer. The minimum rating of outgoing CBs will be 16Amp, 10kAmp.
- The Generator once started shall run for settable time delay before shut down in case restoration of AC1 & 2.
- Minimum quantity of outgoing 1 and 2 be specified clearly and contactor be asked to submit distribution plan at the time of detail design. Transformer load, switchyard lights, control building light & AC etc. for battery chargers MCB ratings also be specified.

c. 110Volt DC Auxiliary System

All DC Incoming Main Circuit Breakers shall be 2-pole, 110 V.

There will be one (1) Battery banks and two chargers for 110 Volt DC system. The contractor shall perform the 110 Volt battery sizing calculations and 110Volt battery charger sizing calculations, which will be submitted for Approval to the Engineer. If the results of the calculations ask for the ratings higher than those described here in and shown in the tender SLDs, then the ratings will be enhanced as per calculations

- The 69kV, 33kV and 11kV system of control and protection IEDs, MV equipment, SMCS panels will be supplied by 110Volt DC supply;
- There will be two buses of 110Volt DC with a bus section in between. The system will operate either in Manual or Auto modes. The interlocking will ensure that only two out of three CBs will be closed at a time;
- The quantity of the outgoing MCBs in each of DC Auxiliary supply panels shall be enough to ensure normal operation for at least 03 nos. future 69kV bays, 04 nos. future 33kV feeders and 4 nos. 11kV feeders. However, still the said set of panels shall be equipped with adequate free space to ensure installation on min. 15% spare outgoing MCBs on the DC Busbars without endangering the normal operation and healthiness of said panels;
- The auto changeover scheme for the main DCDB will be provided. For this, the MCCBs will have electrical ON/OFF operators, equipped with ON/OFF status contacts as well as trip on fault status contact for use in auto changeover scheme and signal initiation;
- All MCBs of main and sub distribution boards will be equipped with 1 No NC contact to initiate MCB trip alarm;
- Each outgoing DC MCB will be equipped with DC CT / sensor to detect the earth fault on the feeder. The sensor will have Alarm & Trip settings, and the Alarm will be conveyed to the Mini SCADA system on per feeder basis;

d. 48Volt DC Auxiliary System

All DC Incoming Main Circuit Breakers shall be 2-pole, 48 V.

There will be one (1) Battery banks and two chargers for 48 Volt DC system. The contractor shall perform the 48 Volt battery sizing calculations and 48Volt battery charger sizing calculations, which will be submitted for Approval to the Engineer. If the results of the calculations ask for the ratings higher than those described here in and shown in the tender SLDs, then the ratings will be enhanced as per calculations

- All telecommunication equipment will be supplied by 48Volt DC supply;

- There will be one bus of 48Volt DC.
- 48Vdc distribution panel shall be equipped with 04 spare MCB and adequate free space to ensure installation on min. 15% spare outgoing MCBs on the DC Busbar without endangering the normal operation and healthiness of said panel;
- All MCBs of main and sub distribution boards will be equipped with 1 No NC contact to initiate MCB trip alarm;

16.2 Battery

For the substation one set of battery and two chargers are foreseen for 110Vdc and 48Vdc. The 110Vdc set shall be use for all 69kV, 33kV and 11kV equipment and the 48Vdc set shall be used for telecommunication equipment

110Vdc alkaline (NiCd) – Alkaline NiCd battery with two rectifiers, min 250Ah (needed capacity to be confirmed by calculation note) should be provided

The 110 V batteries shall be installed battery cabinet.

48Vdc alkaline (NiCd) – Alkaline NiCd battery with two rectifiers, min 100Ah (needed capacity to be confirmed by calculation note) should be provided

The cabinet front side of the charger shall house the current and voltage measuring devices as well as signal lamps for faults. The Battery auxiliary system shall comply with technical specification in annexes.

16.3 Technical Requirements for 110V and 48V Batteries

The current and voltage measuring devices shall be mounted in the cabinet door. The signal lamps for the signalization of faults shall also be provided in the door.

- Voltage monitoring
- Earth fault monitoring
- Battery circuit monitoring

The indicated battery capacity is based on a discharging time of eight hours.

The battery lifetime shall be rated for at least 15 years.

The following tests shall be performed:

- Verification of proper and complete erection of the batteries;
- Checking of intercell connections;
- First filling with electrolyte and initial charging;
- Checking of electrolyte level and density;
- Checking of voltage of each cell after the charging;
- Measuring of the insulation resistance to earth;
- Charge and discharge tests.

The batteries shall be mounted on insulated plastic or metal frames with consoles, and all interconnections and fixing material as necessary. The capacity of the battery shall be matched to the requirements of the control and protection circuits.

The capacity of the batteries shall be justified by the Contractor, considering a discharge time as specified in the data sheets.

A complete set of test and maintenance accessories suitably boxed, shall be provided for each battery. A syringe hydrometer and a durable instruction card shall be included in each set.

Battery cases shall be of high impact polystyrene translucent plastic.

Cells shall be numbered consecutively, and terminal cells marked to indicate polarity.

A clean ventilated pressurized room, segregated from other subsystems, shall be provided to accommodate battery equipment. The floors and walls shall be alkaline resistant to prevent deterioration or damage resulting from discharges or spillage of the battery electrolyte. The door shall have a notice engraved “keep this door closed” and seals to prevent air movement from the battery room.

The batteries to be supplied shall comply with guaranteed technical particulars as indicated in Annexes A2-19 and A2-20.

16.4 Rectifiers

The rectifier is fed via the primary connection of 380 / 220 VAC +/- 10 %. Should an under voltage of - 15 % occur at the input, an automatic line disconnection is to be provided. At full voltage return, the connection is automatically. Short voltage peaks should not damage the device and should therefore not automatically disconnect.

The characteristics IU acc. to DIN 41773 and/or 41774 or equivalent standard must be fulfilled. Each charger rectifier shall operate in parallel and supply the power demand of the station and at the same time supply the floating current of the battery.

A max.residual ripple of 5% of the voltage is admissible.

The power and voltage measuring instruments shall be mounted in the door of the rectifier cabinet.

Signal lamps for the indication of faults are to be provided in the door:

- Voltage indication
- Short-circuit indication
- Earth fault indication
- Battery circuit indication
- Boost charging

A collective signal alarm shall be transmitted to the control room at the respective substations and indicated.

The fuses to be mounted in the battery circuit are to be provided with monitoring and fuse tripping shall be indicated as alarm in the control room.

The rectifiers to be supplied shall comply with guaranteed technical particulars as indicated in Annexes A2-21 and A2-22.

16.5 Delivery and Commissioning Charging

The cells or cell blocks shall be delivered discharged and dry. They shall be filled with electrolyte and- subsequently - commissioning charged according to manufacturer’s recommendations at site as soon as the erection and assembly works have been completed, however, not later than stated in the manufacturer’s recommendations. A detailed method statement describing the filling and initial charging procedure shall be provided for the Employer’s review before the works may commence.

Once the Contractor has satisfied himself that a battery is correctly charged he shall carry out a discharge test under controlled conditions to demonstrate compliance with the stated performance figures. All battery banks shall be tested in this way and the Contractor shall make provisions for any material / test equipment required to carry out the tests.

The Contractor shall co-ordinate the delivery of the batteries to the site so that they may be commissioning charged within minimum time after arrival at site.

17. Emergency Stand-by Diesel Generator Unit (DGU)

17.1 General

This specification covers the design, manufacture, factory testing, marking, packing, shipping, transportation to site, installation, site testing and commissioning of the Emergency Stand-By Generator Unit and related auxiliary equipment for indoor installation.

Further detailed and specific data are contained in the drawings, Technical Data Sheets and other documents that form part of this Specification.

The Emergency Standby Diesel Generator Unit and related auxiliary equipment to be offered shall be complete in all respects necessary for their effective and trouble free operation when connected to the system.

17.2 Diesel Generator Technical Requirement

The Diesel Generator Unit shall be skid mounted and supply all electrical auxiliaries related to Primary Substations, including common auxiliaries as needed to run the DGUs.

The Diesel Generator Unit shall be automatically started upon a starting signal given by the under-voltage monitoring relays. It shall be possible to start the Unit locally from the local control panel (LCP).

The Bidder/Contractor shall provide all necessary monitoring and control equipment for monitoring and control of the Unit from the control room (CR) and from the LCP.

The DGU shall be provided with an automatic synchronization device to operate the Unit parallel to the grid.

The Bidder/Contractor shall design the DGU according to the specific needs of the equipment to be operated with the standby power as to ensure simple and reliable operation, simple maintenance and highest reliability of the emergency power supply.

The DGU shall comprise the supply of all mechanical, electrical equipment in every respect, which is necessary to ensure reliable, trouble free and economical long-term operation. All measuring and control equipment to verify and maintain the safe and efficient operation of the DGU shall also part of the supply.

The net output is defined as output at the generator terminals minus electrical consumption of permanent auxiliaries needed for the nominal DGU operation. This output shall be measured under site conditions.

The DGU shall be able to work in stand-alone-operation. The Unit shall be equipped with all facilities and auxiliaries for stand-alone-operation, i.e. starting batteries, battery charger and local control panel (LCP), fuel tank, etc.

The diesel engine and the alternator shall be directly coupled and mounted on a common steel base frame by means of re-silent mountings.

The DGU to be supplied shall include but not be limited to the following requirements:

This generator set shall been designed to meet ISO 8528 regulation and must has CE certification. The DGU must be tested according to EU noise legislation 2000/14/EC.

The DGU should be at phase rating, 50Hz, PF 0,8 as following:

Voltage	Standby, kVA	Rating (ESP), kW	Prime, kVA	Rating (PRP), kW
400/230	100	80	110	88

Where, **Standby Rating (ESP)** : Continuous running at variable load for duration of an emergency. No overload is permitted on these ratings. In accordance with ISO 3046.

Prime Rating (PRP) : Continuous running at variable load for unlimited periods with 10% overload for 1 hour in any 12 hour period. In accordance with ISO 8528, ISO 3046.

a) Diesel Engine Specification

Type		**Outdoor (Enclosed Set)**
No. of Cylinders and Build		4
Engine Speed	**rpm**	1500
Aspiration and Cooling		Turbocharged and Aftercooled
Governor		Electronic
Fuel Tank Capacity	**Litre**	Enough for 12h continuous operation

The engine shall be design having the following

- Heavy duty diesel engine
- Four stroke, water cooled, turbocharged and aftercooled
- Direct injection fuel system
- Electronic Governor system
- 12/24 V DC starter and charge alternator
- Replaceable fuel filter, oil filter and dry element air filter
- Cooling radiator and fan
- Starter battery (with lead acid) including Rack and Cables
- Flexible fuel connection hoses and manual oil sump drain valve
- Industrial capacity exhaust silencer and steel bellows
- Jacket water heater (automatic models)
- Operation manuals and circuit diagram documents

b) Alternator Specification

Design	**Brushless single bearing, revolving field/td>**
Stator	2/3 pitch
Rotor	Single bearing, flexible disc
Insulation System	Class H
Standard Temperature Rise	125 - 163°C Continuous
Exciter type	Self-Excited
Phase Rotation	A (U), B (V), C (W)

Alternator Cooling	Direct drive centrifugal blower fan
AC Waveform Total Harmonic Distortion	No load <1.5% Non distorting balanced linear load < 5%
Telephone Influence Factor (TUF)	<50 per NEMA MG-1-22.43
Telephone Harmonic Factor (THF)	<2%

The alternator shall be designed having the following

- Brushless single bearing system, flexible disc, 4 poles
- Insulation class H
- Standard degree of protection IP23
- Self-exciting and self-regulating
- Impregnation with tropicalized epoxy varnish
- Solid state Automatic Voltage Regulator
- Stator winding with 2/3 pitch for improved harmonics
- 4 Pole Output Circuit Breaker
- Anti-condensation heater

c) Control supervision and protection panel

The panel shall be mounted on the genset base frame. The control panel shall be equipped as follows:

- Auto Mains Failure Control Panel
- Generating set control AMF module
- Static battery charger
- Emergency stop push button
- Charge ammeter
- Transfer Switch 4 Pole
- Earth Fault, single set
- Power Outlet Terminal Board Mounted on the Gen-set Base Frame

d) Accessories

- Fuel-water separator filter
- Low fuel level alarm
- Residential silencer
- Soundproof canopy - All canopy parts are designed with modular principles
    - Without welding assembly
    - Doors on each side
    - All metal canopy parts are painted by electrostatic polyester powder pain
    - Exhaust silencer is protected against environment influences
    - Thermally insulated engine exhaust system
    - Emergency stop push button is installed outside of the canopy
    - Easy lifting and moving
    - Easy maintenance and operation
- Chassis
    - The complete gen-set shall be mounted as whole on a heavy-duty fabricated, steel base frame
    - Anti-vibration pads shall be fixed between the engine/ alternator feet and the base frame
    - Base frame design shall incorporate an integral fuel tank (Up to 8h minimum cont. operation)
    - The generating set shall be designed to be lifted or carefully pushed / pulled by the base frame
    - Dial type fuel gauge and drain plug on the fuel tank
    - Forklift pockets within base frame (when available)

- Manual oil drain pump
- Tool kit for maintenance

The DGU to be supplied shall comply with guaranteed technical particulars as indicated in Annex A2-30.

18. Earthing System, Power and Lighting Installations

General

This Specification covers the design, manufacture, pre-assembly and acceptance testing in the Contractor's workshops as well as the supply, delivery, unloading, erection, adjusting, painting, identification, commissioning and acceptance testing of Earthing System and of Power and

Lighting Installations complete in every respect and for satisfactory operation.

Scope of Supply and Services

This subsection sets out the scope of installations covered by this Specification as well as the requested supplies and services, including all necessary auxiliary units and accessories for a reliable continuous operation even if this is not expressly stated in this specification.

Generally, the following equipment is covered by this specification:

- Earthing system

Earthing equipment and material: Copper conductors, earthing cables, copper bars, earthing rods, clamps, connectors, fittings and all accessories in order to construct and establish an effective earthing of all equipment complete in every respect, for:

  - earthing system for the control buildings including earthing ring around the building and underground earthing net outside of the building
  - earthing system and earthing connections for the outdoor equipment, gantries, steel structures, line towers, including underground earthing net around the equipment and foundations

- Lightning protection system

Lightning protection equipment and material: Earth wires, copper conductors, earth connection cables, copper bars, clamps, connectors, fittings and all accessories in order to construct and establish an effective lightning protection, complete in every respect, for:

  - lightning protection of the control buildings including connections to the earthing ring around the building
  - lightning protection system for the outdoor equipment, gantries, steel structures, line towers, including connections to the underground earthing net around the equipment and foundations

- Lighting system and small power distribution

Illumination and small power distribution 400/220 V system including all necessary lighting fittings, armatures, distribution boxes, joint boxes, 3 ph and 1 ph socket outlets, daylight control system, cable installation material and accessories, etc. complete in every respect, for

  - 400/230 V sub-distribution boards for lighting system
  - lighting system for control building inside and outside areas of the building, including 110 V DC emergency lighting system
  - power and protective earthing contact sockets in the control building

Technical Requirements

- Earthing and lightning protection

- General

The scope includes the calculation, design, delivery, erection and testing of an earthing and lightning protection system complete in every respect, i.e. including all necessary accessories even if not mentioned in this specification, but required for the protection of personnel and equipment.

A meshed earthing system shall be installed in the substation area and an earth grid each in the associated buildings (switchgear building, control kiosks and the Control Building).

The earthing system shall be calculated according to IEEE 80. For the construction of the earthing system approved standards, such as VDE 0141, shall be applied. The earthing conductor shall made of copper.

The resistance of the substation earthing system will be measured at selected points after installation and shall not exceed 0.5 ohms with the shields of the cables disconnected.

The step voltage is not especially limited if the requirements for the contact voltage are fulfilled. If, at the boundary of the substation area, excessive step or contact voltages occur, these values shall be reduced by the installation of grading rings.

For calculation of the earthing system, measurements of the earthing resistivity in the substation area shall be taken by the Contractor.

The earthing and lightning protection system shall include but not be confined to:

- the necessary copper conductor for the outdoor earthing mesh system including all main connections to other earthing systems in the vicinity
- the necessary earthing rings in the switchgear rooms, in the local control and protection kiosks and in the Control Building
- the necessary strips for fence earthing
- the necessary connections at the earthing mesh crossing points and junctions
- all connections to the housings of the electrical apparatus and their supports, steel frames, pipes, etc.
- all necessary disconnecting points for measuring purposes which must be readily accessible
- all the necessary lightning protection equipment for the protection of persons and structures such as lightning collectors, lightning rods, potential equalizing systems, spark gaps, lightning arresters etc.
- the required connecting and fixing material such as plugs, screws, angle pieces, expansion strips, conductor support, isolating terminals, earthing and rain gutter clamps, jumper outfits, earthing clamps etc.
- the connection of the earth conductors of the cable system to the substation earthing system.
    - Earthing system

Installations above and below 1000 V will be made safe by protective earthing. This is required to prevent the occurrence of excessive touch potentials on conducting parts of the installations which are not part of the electrical circuits. Platforms, if any, installed at equipment operator positions must be connected to the earthing system. The earthing installations will be designed and constructed in accordance with approved standards.

An earthing mesh of steel strips will be installed, but the Contractor has to check the cross section by an earth fault calculation. The size of the mesh shall be in accordance with the maximum occurring earth fault current to meet the requirements of earthing according to IEEE 80 and IEC 60621. The recommended size of the copper conductor and shall be uniform throughout the area covered by the earthing system.

The conductors to equipment can be laid and fixed on the cable trays and vertical runs for AC power cables. Where this is not possible, earthing conductor supports shall be provided, which are to be fixed on walls, in concrete or masonry by means of plugs.

Cable trays and vertical runs shall be connected to the earthing conductor at intervals of 10 m max. in such a way as to give good connection. This earthing conductor shall likewise be connected to the earthing grid.

Substation fences (if any) shall be connected to the earthing grid every 5 m. The lightning installations for all the buildings, structures, etc. shall also be connected to the earthing system.

- Lightning protection system

For the planning, dimensioning and construction of the lightning protection system, the information given in the "Blitzschutz und Allgemeine Blitzschutz-Bestimmungen" (Lightning Protection and General Lightning Protection Regulations), compiled and published by the German Committee for the Construction of Lightning Conductors e.V., or other approved equivalent local/international standards (IEC62305) are valid.

All outdoor equipment shall be protected against lightning strikes by means of lightning collectors and conductors.

The collectors shall be arranged in such a way that, as far as possible, they collect all lightning strokes without these directly striking the parts to be protected.

One main conductor between the lightning collector (mounted on top of the buildings), and the earthing grid laid in the ground will be provided every 10 m. The max spacing between conductor fixings shall not exceed 1.25 m for horizontal runs and 1.25 m for vertical runs.

All main and secondary conductors which are connected to an earthing conductor will be provided with an accessible isolating point in order to be able to measure the earth resistance.

Nuts and bolts at isolating or other points, shall remain detachable.

- Lighting system
  - General

The scope includes the calculation, design, delivery, erection and testing of the lighting system complete in every respect, i.e. including all necessary accessories and fittings even if not mentioned in this specification, but required and sufficient for the satisfactory illumination of the substation premises.

All lighting fittings and all equipment comprising the lighting sub distribution units must meet the operating requirements in full at an ambient temperature of 40°C and for a relative humidity of up to 100 %. The lighting fittings shall be designed for an operating voltage from 230 V ±10%. For protection against contact with live components, all lighting fixtures must be suitable for the following protection measures:

- protective conductor connection, or
- protective insulation;

and must visibly carry the accepted symbol to indicate this.

In the facility areas subject to danger of explosion (i.e. battery rooms if applicable) the necessary explosion-proof lighting fittings, cable connection boxes and pushbuttons are to be used according to IEC 60079. Sub distribution units shall not be installed in such rooms or areas.

- Sub-distribution boards

Metal-clad sub-distribution boards (protective type IP 43) suitable for flush or surface mounting on the walls shall be provided. Each sub-distribution board must at least be equipped with:

- manual feed-in change-over switches with I - 0 - II positions,
- one voltmeter with voltmeter switch for measurements between the
- individual phases and the neutral as well as between two phases;
- 5 busbars for 3-phase system, neutral and earth;

- the necessary single-pole MCBs for lighting circuits and control;
- the necessary single-pole MCBs for domestic power outlets (sockets);
- the necessary single-pole MCBs for power sockets;
- the necessary current relays and contactors for push-button energizing, de-energizing of lighting circuits.

The sub-distribution boards are to be designed so that after handing over 15% reserve feeders are still available.

- Internal lighting

Generally, lighting fixtures wired for three-phase supply and fitted with compensated fluorescent tubes are to be provided for the control building.

The lighting fixtures are to be selected so that they can be used for single or strip lighting. The room lights shall generally be controlled by pushbuttons via current impulse relays. The pushbuttons must be located at the access doors to the appropriate rooms.

The internal lighting must be designed to give the lighting intensities according to the relevant standards and the use of different rooms. An aging factor of 20% must be taken into account, and therefore the lighting intensities of the fittings when new (new value) must be achieved as a minimum during the Tests on Completion.

Location, Room	**Type of lighting fixture**	**Illuminance, lx**
Central Control Room	3	300
Switchgear building	2, 4	200
MV switchgear room	2, 4	300
Battery Room	2	200
AC/DC Room	2	200
Toilets	1 or 2	100
Corridor, basement, staircase	3	100
Aux. Transformer Room (if available)	2, 4	100

Key to light type numbers of above table:

1 free-beaming fluorescent lighting fitting, protection IP 32

2 watertight fluorescent lighting fitting, protection IP 54

3 fluorescent lighting fitting, protection IP 32, with cover

4 lighting fitting with halogen lamp, protection IP 54

Throughout the rooms and grounds the lighting density must be 200 lx on local measuring and control stands and instrument panels.

The fluorescent lighting fitting should be equipped with fluorescent lamps of 1 x 58 W or 2 x 58 W. The halogen lighting fitting should be equipped with halogen lamps 1 x 250 W or 1 x 400 W.

The color of the light produced by the lamps must be selected according to requirements. If different lamps (e.g. halogen and fluorescent lamps) are used in the same room, then lamps giving the same color of light are to be used in accordance with the requirements.

Internal lights must be connected in 3-phase circuits so that only every third lamp will fail in the event of failure of a single phase. Cables with a cross-section of at least 2.5 mm2 are to be used as lighting cables for fluorescent lamps.

- Emergency lighting

The emergency lighting shall be operated from the 110 V DC station battery system. This has to be taken into account when calculating the capacity of the battery and charger.

In the event of a black-out the emergency system shall be switched on automatically. A manual change-over facility shall also be provided.

The emergency lighting shall be designed simply as emergency escape route lighting. At least one emergency light must be visible from every point in the room. The lighting intensity must be at least 50 Lux.

- Outdoor lighting

Cables with a cross-section of at least 2.5 mm² are to be laid as lighting cable for fluorescent lamps.

The lights must be connected in a 3-phase circuit, so that in the event of failure of one phase only each third lamp will fail. A 5-core power copper cable with a minimum cross-section of 6 mm² is to be laid as lighting cable for metal-vapor lamps.

Control of external lighting shall be effected automatically with day light controlled switching circuits. For each lighting sub-distribution unit of external lighting purposes there must be provided one separate day light controlled switching circuit.

The street lighting fittings are to be installed as totally enclosed anti-glare column-top luminaries cut-off type angled at 15° to the horizontal with a light source height and a light source spacing according to the required minimum lighting intensity.

The housing of the lighting fitting, which is subdivided into a lamp compartment and an auxiliary gear compartment, shall be fitted with metal vapor lamps of ellipsoidal or tubular shape. The electrical components housed in the auxiliary gear compartment, such as power factor correction capacitors, stabilizing impedance, starter and suppressors are to be mounted jointly on an insulating board capable of being swung out, fixed in position and removed for maintenance purposes. Each lighting column must contain the necessary internal wiring (3 x 2.5 mm² copper, PVC) from each lighting fitting on the top of the lighting column to the connection compartment above the ground.

For safety reasons the lamp housing shall be provided with a door switch to disconnect the starter voltage on opening the fitting.

The power factor correction equipment of the lighting fitting must achieve a power factor of no less than 0.9.

Suitable starters are to be provided for the halogen lamps, so that hot lamps can be restarted immediately or at any time during the cooling stage.

The spectacular reflectors mounted in the lamp compartment shall be provided with facilities for adjusting the focusing of the lamp in two perpendicular axes.

For the external lighting reflectors installation, the switchyard steel structures shall be used.

In any other place, one-piece steel poles with continuous taper and welded on steel mounting plate shall be used.

The corrosion protection of the lighting poles shall be ensured by hot-dip galvanizing on the inner and outer surfaces.

The lighting poles are to be provided with the following equipment as a minimum:

- cable entry hole in the flange plate
- cable connection compartment above ground, with welded-on mounting bar including fixing screws for attachment of the lighting column boxes
- lighting column connection boxes. These are to be made of thermoplastic material with transparent cover, fitted with fuse base and fuse, also connecting terminals for low voltage cables to a maximum of three cables each 4 x 6 mm², including cable glands
- PVC copper cable 3 x 2.5 mm² between the lighting column connection boxes and each lighting fitting
- earthing screws with suitable bimetallic feature are to be provided for attaching the lead-coated copper conductor of the earthing system
- pole top lighting fittings (one, two or four lighting fittings on one lighting pole according to the requirements) with halogen lamp.
- Suitable pole foundations are to be provided

- Power and domestic sockets
    - General

The power and protective sockets are intended for the plug-in connection of mobile electrical equipment for repairs and maintenance of any kind. The mobile electrical equipment must be fitted with the necessary 3-phase and earthing contact plugs.

- Power sockets

A sufficient number of power sockets shall be provided and installed in each control and protection kiosk, switchgear room, Control Building and nearby the power transformers.

Plugs and sockets must be in accordance with local form.

Generally, different power sockets are to be used, with stainless steel metal casings resistant to impact, direct sun etc. and suitable for service wall mounting. The sockets are to have a degree of protection of at least IP 65.

All the sockets shall be of outdoor type, even if installed indoors, and shall operate satisfactorily under direct sunlight.

Each socket system shall be equipped as follows as a minimum requirement:

- with the necessary wire inlets at the top of the power socket casing for the incoming and the outgoing feeders including the necessary glands or blanking plugs;
- with the necessary fuses in the top of the metal casings;
- with the necessary main manual switch before the fuses of the socket circuits in the top of the metal casing;
- with a three-phase socket 400 V, 32 A, 5-pole (three-phase, neutral and earth) in local form in the bottom of the metal casing;
- with two AC single-phase sockets 230 V, each 16 A, screwed, 3-pole, (phase, neutral and earth) in local form, in the bottom of the metal casing;
- with all the necessary fuse bases, connection and its intermediate terminals and any other attachment fittings.

All sockets shall be provided with plugs.

The power supply of the sockets shall be generally provided with the PVC power cables.

For the internal wiring in the metal casing, stranded copper conductors with PVC insulation shall be used.

- Domestic sockets

In rooms such as switchgear, battery, control, office etc. the domestic power outlets (sockets) are to be provided in adequate quantity in accordance with the requirements, surface-mounted. All sockets shall be provided with plugs.

The power supply shall be provided from the lighting distribution boards. The power outlets must be 16 A, 3-pole type, i.e. phase, neutral and earth. All sockets must be in accordance with local form. In the corridors, one power outlet must be arranged every 10 m.

Generally plastic-insulated power outlets for 230 V AC are to be provided. The power outlets (sockets) shall be fed via the single-pole MCB's of the lighting distribution units via three-core cables. Not more than five power outlets (sockets) may be fed from one circuit. The conductor cross-section must be at least 4 mm^2 for the cables supplying the sockets.

19. Fire Alarm System

General

This Specification covers the design, manufacture, pre-assembly and acceptance testing in the Contractor's workshops as well as the supply, delivery, unloading, erection, adjusting, painting, identification, commissioning and acceptance testing of the Fire Alarm and Fire Fighting System complete in every respect and for satisfactory operation.

Scope of Supply and Services

This subsection sets out the scope of installations covered by this Specification as well as the requested supplies and services, including all necessary auxiliary units and accessories for a reliable continuous operation even if this is not expressly stated in this specification.

Generally the following equipment is covered by this specification:

- Fire Alarm Center (main Board)
    - fire alarm center (main board) with all necessary self-supervising
    - fire alarm circuits, interconnection to the MiniSCADA computer, free standing, including redundant DC supply and audio-visual alarm, with all accessories in order to establish an effective and reliable fire alarm system
- Fire alarm system for the substation building
    - fire alarm system for the building including all fire alarm detectors and the fire alarm cables for connection to the detectors and to the fire alarm center (main board)
    - lot of installation material and accessories for fire alarm detectors and fire alarm cables including clamps, connectors, splitting boxes, joint boxes etc.
- Portable firefighting equipment, quantity shall be defined as per local regulations,
    - portable CO2 bottles approx. 6-8 kg, as minimum one portable CO2 bottle fire extinguisher per each room entry shall be foreseen.
    - carrier mounted CO2 bottles approx. 50kg – min. one per each transformer, 1 per each MV Switchgear room.

Fire Extinguishers

Portable and mobile fire extinguishers shall be provided for the switchgear room.

The appliances shall comply with relevant international and local standards. All apparatus shall be suitable for operation by one person alone and is to be easily recharged. The discharge shall be non-corrosive and free of chemicals prone to give off toxic gases when heated.

The Contract shall include supply and installation of all wall brackets and fittings. Four recharge units shall be provided for each type and size of equipment.

- Portable wall mounted extinguishers

Portable, wall mounted, hand held extinguishers shall be 5 to 6 kg pressurized control discharge CO_2 units.

(a) Construction and operation

The body of the extinguisher shall be seamless, welded or brazed as appropriate. The extinguisher shall be capable of being released by means of a lever-operated valve provided with a safety pin. Extinguishers shall be capable of controlled partial discharge.

(b) Marking

All extinguishers shall be painted and marked in accordance with relevant standard. In addition, they shall be marked in the English language with clear instructions for use.

(c) Housings for portable fire extinguishers

Where extinguishers are provided in external positions or other areas where they may be subjected to the whether they shall be hung inside protective cabinets. The protective cabinets shall be red in color and marked with the words "FIREEXTINGUISHERS" in English, in white. The cabinet shall provide protection for rain and wind blown dust and have a pull off front cover allowing ease of access to the extinguisher.

(d) Mounting

Where extinguishers are provided internally they shall be wall mounted and attached in a manner affording quick release from the supporting bracket. They shall be installed so that the top of the extinguisher is not more than 1.5 meters above the floor. In no case shall the clearance between the bottom of the extinguisher and the floor be less than 0.1 meter. The extinguishers shall be positioned so that the instructions for operation face outwards.

- Mobile trolley extinguishers

The extinguishers shall be 50 kg CO2 units. The equipment shall be mounted on a metal frame with wheels and handle to make it mobile and maneuverable.

The CO_2 Container shall be of steel construction and shall have been pressure tested to at least twice its operating pressure. The container shall hold 50 kg.

The hose conducting the extinguishing agent to the discharge nozzle shall be 10 meters long and made of braided synthetic flexible hose. The hose shall be permanently connected to the container. The hose shall be stored in a manner allowing easy removal for use.

The unit shall have at least two wheels, which shall have rubber or synthetic tires and a minimum overall diameter of 300 mm. The overall width of the unit shall not exceed 800 mm.

A single easily accessible valve shall be used to release the extinguishing agent and shall be designed for controlled partial delivery.

The unit shall be capable of total discharge in at most 60 seconds.

The extinguishers shall be painted and marked in English with clear instructions for use, which shall include "FOR USE ON ALL FIRES". Mobile fire extinguishers shall be protected from the prevailing climatic conditions, and shall be clearly visible and accessible.

- Signs

Electrical hazard warning signs in English shall be positioned each entry door.

Fire Alarm System

- General

The purpose of the fire alarm system is to guarantee a reliable and fault-free early-warning system in the event of fire, so that orders for extinguishing the fire can be issued from a central point.

The fire alarm system shall be designed in accordance with DIN VDE 0833 the relevant VDS (VerBund der Schadensversicherer) guidelines and local standards**,** and shall conform to the latest state-of-the-art in the field of fire alarm system engineering. The fire alarm system provides for early detection of fires by means of automatically activated detectors. Push-button actuation must be provided for manually operated fire alarms in staircases, next by exits and on all escape routes. For outdoor installation, the necessary push-button fire alarms are to be provided in pillow type or wall mounted housings. Sirens for indoor and outdoor installation must be provided for warning the operating personnel.

In all rooms the necessary automatic fire detectors are to be incorporated in the luminous ceiling.

The whole of the facility area to be monitored is to be divided into individual alarm sections, the latter being so arranged as to enable rapid and positive identification of fires.

Detectors installed in false floors, suspended ceilings, cable ducts, air conditioning or ventilation systems are also to be combined to form separate alarm sections. Detectors belonging to a particular alarm section are to be incorporated in alarm lines, the automatic and manual fire alarms being connected via separate alarm lines to the common fire alarm central station in the central control room. The arrangement and number of detectors is determined by the type of fire detector used, by the room configuration (size, height, form of floor and roofing, etc.) as well as by the ambient conditions in the rooms to be monitored.

Detectors installed in inaccessible points such as cable ducts, false floors, cable basements, etc. are to be connected in parallel to external optical alarm indicators installed close by and in readily visible positions.

No restrictions on the proper functioning of fire alarm by reason of movement of air, optical radiation, smoke, dust, vibration, high humidity, etc. are acceptable.

Moreover, fire alarms shall be located in the outgoing air flows of air conditioning and ventilation systems. The alarm signal receiving units must be so designed that by use of a standardized alarm unit socket, any of the types of detector may be used with equal facility on any of the fire alarm circuits.

The fire alarm central station must be housed in sheet-steel enclosed cabinets and located in the central control room or nearby in an appropriate location. Both optical and audible signals must be given when a fire alarm or fault alarm occurs. Power supply for the fire alarm system shall be taken from the safe AC busbar, emergency supply shall be maintained by a rectifier/battery set (1 (one) x 100%), designed for 4 (four) hours discharge time.

- Fire alarm central station

The fire alarm central station is to be implemented in all-electronic technology using plug-in units and assemblies and the modular construction principle, and shall be accommodated in metal clad enclosed panels with type IP 31 enclosure for wall-mounted/free standing installation.

The arrangement and functioning of the fire alarm central station shall be such as to permit as a minimum the following:

- The fire alarm and fault annunciation system shall be designed with optical and audible alarms. Whereas the audible alarm must be resettable, the optical indication shall persist until the annunciation is finally extinguished or the fault cleared.
  If a fault warning is followed by a fire alarm annunciation, the fault indication must be stored and suppressed until the fire alarm condition has been cancelled. Provision shall be made for clear audible identification of the alarm/fault signal.
  Furthermore, fire alarm signals and fault signals shall be strictly segregated.
- An automatic fire alarm signal shall be transmitted externally to the central control room.
  The individual fire alarm lines and function lines of the firefighting equipment and facilities, as well as important functional groups of the fire alarm central station shall be continuously monitored for faults and breakdowns e.g. for
  - wire breakage of each alarm line
  - short-circuit of each alarm line
  - earth fault of the fire alarm system
  - power supply system faulty
  - main fuses and MCB's failure

- alarm modules disconnected from plug-in frame.

All fault signals shall be optically and audibly indicated. For checking out the functioning of the complete fire alarm system including the fire alarm lines and fire alarm devices, testing facilities shall be provided. When testing a circuit, initiation of fire alarm warnings in external facilities shall be prevented. After testing, the tested circuits shall automatically reset to normal operation.

Simulation (e.g. test pins) of all relevant fault signals as listed above as well as of all fire alarms shall be possible in order to check-out the externally connected firefighting facilities.

The fire alarm central station shall be provided with potential-free change-over contacts wired to a central terminal board as follows:

- contacts to control the fire protection doors
- contacts to control the air-conditioning and ventilation equipment
- contacts for spare.
- Activation of fire protection doors shall be signaled as a group annunciation to the fire alarm central station and included in the alarm annunciation system.

- Layout display board

For indicating fire alarm and fault annunciations from the fire alarm system, a layout display board has to be provided in the panel in the central control room. This board shall include a graphic display to show a simplified ground plan of the individual buildings and shall feature signal lamps for the separate optical indication of the alarm line, and shall include the annunciator with alarm test, reset and acknowledge buttons. Preferably a separate monitor with appropriate graphics etc. shall be supplied.

- Detection systems

The fire detector system elements and the associated mountings are to be provided with sturdy, corrosion-proof plastic housings.

The fire alarm detectors are to be provided with optical means for signaling their activation (light-emitting diode), and are to be suitable for the connection of an additional optical, external alarm indication.

The fire alarm detectors shall reset ready for operation following each alarm, without outside intervention, and shall plug-in and be provided with suitable means to prevent unauthorized removal or disconnection and for connection to the fire alarm central station.

The following detector types as a minimum shall be used for fulfilling the requirements as a whole:

- Ionization detectors (if required) - For the early identification of visible and invisible fire aerosols, consisting of ionization chamber, alarm electronics, optical alarm indication, response delay pre-settable to suit ambient conditions, detector socket, variable response sensitivity and connection possibility for a parallel optical alarm indication.
- Optical smoke detector - For early identification of visible smoke generation, consisting of photoelectric alarm electronics, optical alarm indication, detector socket and connection possibility for a parallel optical alarm indication.
- Flame detector - For early identification of fire outbreaks and open flames, consisting of optical unit, alarm electronics, optical alarm indication, detector socket, and variable response sensitivity and connection possibility for a parallel optical alarm indication.
- Thermo-differential and thermo-maximum detector - For early identification of fires as they break out with rapid temperature rise and little smoke generation, consisting of temperature sensor, alarm electronics, detector socket and connecting possibility for a parallel optical alarm indication.

- Manually operated push buttons

Push-button fire alarms are used for the manual initiation of an alarm and are to be connected to the fire alarm central station.

These are to be installed in the necessary number at readily accessible points located e.g. on escape routes, corridors and stairways, exit doors, transformer etc. and are to consist

  - push-button, only operable after smashing the replaceable glass window fitted in the housing
  - interlocking mechanism, which holds the push-button in the operated position and cannot be released until the glass window has been replaced or reset by key
  - plastics or aluminum housing, painted red, type of enclosure IP 54
  - instructions for use are to be provided on the operating side.
- Sirens

The protection degree of the sirens for indoor and outdoor installation must be at least IP 54.

The outdoor sirens are to be arranged on the control building. The arrangement of the indoor sirens must meet the requirements at site for satisfactory warning of the operating personnel.

The control of the sirens shall be performed automatically by the fire alarm system, but manual operation from the central control room must also be possible.

20. Substation Control and Monitoring System (SCMS):

20.1 Applicable Standards and Regulations:

The Substation Control and Monitoring System (SCMS) specified in this document shall be manufactured and tested in accordance with the latest editions or amendments of the applicable IEC and ISO standards listed in the following table.

Environmental Conditioning:

CEI 60068-2-1 : Environmental testing: Cold

CEI 60068-2-2 : Environmental testing: Dry heat

CEI 60654 : Operating conditions for industrial-process measurement and control equipment: Climatic conditions

CEI 60870-2-2 : Telecontrol equipment and systems: Environmental conditions (climatic, mechanical and othernon electrical influences)

Electromagnetic Compatibility (EMC) Standards:

CEI 61000-4-2 : Electromagnetic compatibility (EMC)– Electrostatic discharge immunity test

CEI 61000-4-3 : Electromagnetic compatibility (EMC) – Radiated, radio-frequency, electromagnetic field immunity test

CEI 61000-4-4 : Electromagnetic compatibility (EMC) – Electrical fast transient/burst immunity test

CEI 61000-4-5 : Electromagnetic compatibility (EMC) - Surge immunity test

CEI 61000-4-6 : Electromagnetic compatibility (EMC) - Immunity to conducted disturbances, induced by radio-frequency fields

CEI 61000-6-5 : Electromagnetic compatibility (EMC) – Immunity for equipment used in power station and substation environment

CEI 60870-2-1 : Telecontrol equipment and systems: Power supply and electromagnetic compatibility

CEI 60255-26 : Measuring relays and protection equipment - Electromagnetic compatibility requirements

Safety requirements

CEI 61010-1 : Safety requirements for electrical equipment for measurement, control, and laboratory use – General requirements

CEI 61010-2-030: Safety requirements for electrical equipment for measurement, control, and

laboratory use- Particular requirements for equipment having testing or measuring circuits

Interfaces Standards

CEI 61850 : Communication networks and systems for power utility automation - ALL PARTS

CEI 60870-5 : Telecontrol equipment and systems - Part 5: Transmission protocols - ALL PARTS

Quality standards

ISO 9001 : Quality management

The Bidder shall provide with its bid valid certificates proving that the proposed manufacturers and suppliers are ISO 9001 certified and RoHS compliant. Manufacturers who do not have sufficient experience in the manufacture, installation and testing of SCMS as specified and/or who are not ISO 9001 certified and RoHS compliant will not be accepted.

The standards listed in the table below are of particular importance for documentation.

Standards IEC and ISO for documentation

IEC 60617	Graphical symbols for diagrams
IEC 61082-1	Preparation of documents used in electrotechnology – Part 1: Rules
IEC 61131	Programmable controllers
IEC 61355	Classification and designation of documents for plants, systems and equipment
IEC 61506	Industrial-process measurement and control - Documentation of application software
IEC 62023	Structuring of technical information and documentation
IEC 81346-1	Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations - Part 1: Basic rules
IEC 81346-2	Industrial systems, installations and equipment and industrial products – Structuring principles and reference designations - Part 2: Classification of objects and codes for classes
IEC 81714	Design of graphical symbols for use in the technical documentation of products
ISO 5457	Technical product documentation - Sizes and layout of drawing sheets
ISO 7200	Technical product documentation - Data fields in title blocks and document headers **ISO 14617** Graphical symbols for diagrams

20.2 Structure of Substation Control and Monitoring System

The digital control system shall consist of:

- A set of standard control and protection units in cabinets or panels, interconnected by a local communication network using the standardized and open protocol (IEC 61850).
- A standard unit contains all the equipment required for the protection, automation and local control of the bay. A bay can be an outgoing feeder, an incoming feeder, a transformer, a busbar coupling, a MV generator, a supervision bay or a general bay. Each bay has a Local/Remote switch allowing the management and control in local or remote mode. The remote mode corresponds to a control of the bay from the operator/engineering station or a remote HMI. For the general unit, remote mode is control of the entire substation from remote HMI.
- The Bidder shall provide a control architecture based on a self-healing local area network with configurable switches. The communication network architecture can be star or loop (ring) based on the proposed equipment. The failure of a network cable or switch must not result in the complete failure of the system. The local communication network will be composed of switches with Ethernet and optical ports, Category 6 and multimode fiber optic cables. In addition, each unit includes a switch for connection to the LAN.
- Two redundant substation computers for data processing and substation automation.

- An operator station (Human Machine Interface, HMI) carrying out the local supervision and control of the substation, the recording of states, the archiving and printing of data and reports necessary for the local control of the station.
- An operator/engineering station performing the engineering and maintenance functions of the entire SCMS, the protection relays and IEDs installed in the substation as well as the post-mortem analysis of the system and substation data. In addition to these functions, the operator/engineering station provides the operator station function. Regardless of the status of the substation or bays (local or remote), signals, alarms and telemetry are displayed on both stations. However, the control is only allowed from one of the 2 stations at a time.
- A satellite synchronization clock allowing the time synchronization of the local network subscribers with a resolution of 1ms or better. A synchronized wall clock displaying local time will be installed above the operator desk.
- Two printers (1 color laser and 1 dot matrix).

Communication between the bay's units, operator and engineering stations and gateways will be in accordance with Ethernet TC/IP UCA2/IEC 61850, 100/1000 Mbit/s.

The different architectures are presented in § 5.7.17.2.2. The proposed system shall be proven, high reliability and compliant with IEC 61850 interoperability standards and compatible with telecontrol.

20.3 Design

The Substation Control and Monitoring System (SCMS) shall be designed as a communicating "Bay" according to the IEC 61850 standard:

- The addition of a new feeder or a "transformer Bay" shall be easy by simply changing the configuration and adding the corresponding hardware.
- Each Bay shall have a management and behavior independent of the rest of the system: for example, management of the operating mode, interlocking, status logging, etc. It is connected to the other units by a cable. It is connected to the other units by logical data exchanges associated with the topology, but, in the event of loss of communication with the other units, it can have a degraded mode behavior ensuring all the protection, automation and control functions of the unit.
- Each bay must have its own switch for connection through a self-healing local network (loop or star architecture).
- An equipment or unit failure shall not affect the operation of the rest of the system from the point of view of both local and remote control.
- The SCMS must allow a bay to be operated locally or in maintenance mode independently of the rest of the substation. In this case, the bay will only be managed from the local HMI at the bay level: depending on the case, the information from this unit will or will not be transmitted. In a maintenance situation, the transmission of information to higher levels (control room and remote HMI) will be inhibited to avoid transmission of inconsistent data.
- The SCMS equipment must be able to manage at least 2 configuration databases in order to allow simple and efficient evolutions. Only one database is active per device, the other being in reserve. The consistency of the databases of the different equipment is guaranteed at the SCMS level. The change of database can be done either by the HMI or by the engineering platform.

- At least 50% reserve capacity will be provided for additional data transfer, in addition to the reserve capacity required for the specified future circuits. This capacity will not affect system performance and is for all equipment, computerized substations and substation terminal equipment.
- The system shall allow for 30% expansion capacity in number of slots and 20% expansion capacity for the I/O of each slot.
- The SCMS shall support future integration of UCA2/IEC 61850 equipment.
- SCMS shall support XML format for configuration in accordance with IEC 61850.

20.4 Operating modes

The SCMS allows different operating modes for High Voltage facilities:

- Level 2: Remote control of the substation from a centralized remote HMI (At Fond Cole).
- Level 1: Local control of the substation from the operating consoles located in the substation control room.
- Level 0: Local control from the control panel of each unit of the substation:
    - From the HMI interface of the bay controller
    - From local control panel (TPL switches)
    - From direct control buttons of circuit breakers and disconnectors.

At any given time, control is only authorized from one point: the remote HMI or the control room or control panel of the unit. Under no circumstances may a facility be controlled at any given time from two separate locations or by two separate individuals.

The SCMSs shall comply with the IEC 61850 standard, which is the reference standard for high voltage substation digital control systems.

Access rights to the operator station shall be controlled by means of passwords. The allocation of user rights to each of the six levels required is shown in Table below.

Individual users signing on to each level shall also be identified and logged.

Function	Level 1 (operator)	Level 2 (Maint.)	Level 3 (Engineer)	Level 4 (Operator Supervisor)	Level 5 (System Administrator)
Operator authorization				x	x
System Exit					x
Alarm Acknowledge	x			x	x
Print events and alarms	x	x	x	x	x
Save log file to removable media			x	x	x
Erase log file		x	x		x
Program Trending curves			x		x
View secondary plant	x	x	x	x	x

View control network	x	x	x	x	x
Set protection Relays		x	x		x
Substation local/ remote control				x	x
System configuration					x

Table 9: SCMS operating modes

20.5 Architecture of substations according to their operation

20.5.1 Bay controller cabinets

The dimensions of the Bay controller cabinets are as follows:

- Height: 2000mm
- Width: 800mm
- Depth: 600mm

The cabinets are equipped with a pivoting frame:

- Useful height: 41 U
- Opening angle: 120 degrees

Cabinets shall further:

- Allow for the integration of 19-inch frames into a rigid and stable structure under all normal conditions of use and maintenance
- Have a lockable transparent door
- Isolate logic inputs and outputs, analog inputs and auxiliary power supplies by means that comply with current regulations
- Be grounded by a conductor of at least 16 mm².
- Ensure protection against heat, moisture, mold and rodents
- Have an interior lighting

20.5.2 Bay Controller

At the Bay level, the Bay Controller and the protection terminals will perform all functions at the Bay level concerning control, supervision and protection, inputs for status indication and outputs for commands. They will be directly connected to the HV devices without the need for interpositions or transducers. Each Bay Controller will be independent of the others (except for interlocking) and its operation will not be affected by any faults in other Bay Controllers of the substation.

The Bay Controllers shall be capable of local and remote control, data acquisition and local automation and shall provide the following functions.

The functions should be as close to the process as possible in a decentralized architecture. Taking this into account, the following functions will therefore be allocated to the Bay control level:

- The Bay control functions;
- Bay protection functions;
- Data collection functions.

In application for:

- The high voltage levels;
- Protection and slice control functions will be performed by different units;
- Medium voltage levels.

The internal program logic of the Bays, the control sequences, the collection of signals and information, the control outputs and the signal processing required by the different equipment units of the corresponding Bays will be executed by the intelligent devices (IEDs).

The devices will be placed together with the input/output equipment in the local control cabinets in the control room of the same building. The devices on the bay control level will be powered by 110 VDC of the uninterruptible power supply of the substation.

Bay Level Control Functions

The various high and medium voltage switchgear in the substation will be controlled from different locations:

- From the remote HMI;
- From the operator workstations;
- From the Bay controllers;
- Local panel;
- From individual equipment.

It will be ensured that manipulation will only be possible by one operator at a time. Very clear control priorities will be defined and will prevent that the manipulation of a switch can be initiated at the same time from different control levels. Priority will always be given to the lowest activated control level.

Bay controller - Local Mode

The object concerned must first be selected from the local HMI on the display of the corresponding intelligent device. The selection shall not be possible under blocking or locking conditions. In addition, an appropriate alarm notification should appear. If the selection is valid, the status indicator shall show the possible direction and the appropriate ON or OFF button shall be pressed to open or close the corresponding object. Control operations from other locations (e.g., remote) will not be possible in this operating mode.

Bay controller - Remote Mode

The authority for control in this mode lies with the remote level unit. Facilities can only be controlled remotely. Control from lower control levels will not be possible in this mode.

It will be possible to adopt other control philosophies through the parameterization.

Interfaces

All Bays controllers will be provided with an optical interface for connection to the Bay switch according to IEC 61850.

In addition, these computers will be provided with a local communication port allowing the connection of a laptop computer.

Monitoring, control and configuration of all input and output logic signals, all binary inputs as well as relay outputs for all functions and signals will be possible both locally and remotely.

Local HMI

A local HMI, at the intelligent device level, will allow control and monitoring of individual Bays from the Bay level. It must have the resolution to ensure display of the Bay's single-line elements with associated measurements and alarms, command and control management, and status logging display.

The local HMI will be front-mounted and will be based on a user-friendly, menu-structured program run through a permanently installed HMI unit with the IED device.

A Bay diagram will show the switching status and measured values of the substation.

The operating values of currents and voltages as well as active and reactive powers will be available. Analog values for activated functions (e.g., impedance in the case of distance protection) will also be available.

In addition, an alarm notification for unit alarms shall also be included in the local HMI.

Control supervision

The collection and perfect processing of all the switchgear states of the entire substation shall be ensured at all times. Unclear information such as intermediate states, switchgear faults, data transfer faults, etc. shall never result in switching operations.

The control, adjustment and synchronization functions shall require perfect collection and processing of all station information. The information shall be current and valid.

Anomalies in the control and regulation facilities such as switching on the load of a disconnecting switch, switching in an asynchronous state, etc. shall be avoided. In case of remote or station level control and regulation facilities are missing, a backup means of control must be available.

Select-before-execute procedure

A "select-before-execute" procedure shall be used when handling circuit breakers. For safety reasons, the commands will always be given in two phases:

- Selection of the object and
- Initiation of the command.

These two phases will be carried out using a single contact each and the final command will only be executed when both contacts are closed.

Locking of the station

Locking infrastructures will be installed in the equipment to prevent damage and accidents in the event of incorrect operation.

On the other hand, software-controlled interlocking through the intelligent Bay devices will be used for the Bay itself. The substation interlocking systems will be provided via the substation communication bus. The bid will further describe the scenario applied when a Bay's intelligent device is turned off or offline.

Primary interlocking of substation inlets will be resolved through parallel wiring as specified.

The substation lockout system will simplify the addition of new feeders (line, transformer, etc.). Future modifications and extensions will be possible without interfering with the operation of other parts of the installation.

It will be easy to understand the configuration of the interlocking systems and it will be easy to change it when upgrading the substation after adding future units. Changes can be made by the Owner's personnel or the Operator without the presence of the Contractor.

The functionality and design of interlocking systems shall be based on interlocking hardware with parallel copper wiring as indicated. These systems shall be extremely secure and reliable.

The following interlocking concepts shall be applied for switching and operating the substation:

- A disconnect switch will only be operational when the corresponding circuit breaker is in the OFF state and all relevant grounding switches have been removed.
- A grounding switch is only operational when the disconnect switches have been opened and the relevant location has been cleared of voltage.
- Closing of a circuit breaker will only be possible if all the earthing switches are removed and the protective relays and latching relays are not actuated or, if they are, the faults have been cleared and the respective latching relays have been replaced.
- A busbar switchover will only be possible if the busbar and bus coupler disconnectors are in the closed position without interruption of the power supply.
- If a pressure drop signal is received by the gas detection device for circuit breaker SF6, the trip and close signals will be latched.
- Other interlocks deemed necessary during the engineering phase.
- A bypass function will be provided to bypass the interlock function if necessary.

Lockout services will be provided for future remote operations and maintenance lockouts for local operations.

The lockout system will be designed so that testing is possible during normal operation.

Synchronism Check Function

The synchronism check and power-up functions will be distributed across the intelligent control and protection devices and will have the following characteristics:

- Adjustable voltage, phase angle and frequency difference.
- Power up of the dead line-live bus, live line-dead bus or line-dead bus.
- The parameters of the manual closing and reclosing commands can be adapted to the operating times of the specific devices.

Voltage selection

The voltages that are relevant for the synchronism check functions depend on the topology of the substation (e.g., the states of the circuit breakers and/or disconnectors). The ideal voltage for synchronization is derived from the auxiliary contacts of the circuit breakers, disconnectors and grounding switches and will be selected automatically by the control and protection devices (IEDs).

Self-monitoring

The corresponding electronic system will be provided with permanent self-monitoring functions as well as test functions.

Each circuit board will include circuits for automatic testing of its own functions. These circuits will interact with a test and diagnostic program controlled by the central unit.

Faults in a unit will be indicated through the illumination of a red LED placed on the front edge of the unit and signalized at the highest operating levels. The error messages/indications that will be generated will allow the location of the fault up to the board level.

The time required to find and replace a faulty unit will be reduced to a minimum.

The self-monitoring will also include the power supply system, the internal bus system and the ability of the CPU to communicate with different circuit boards.

Data Collection Functionality

In general, the following basic data collection functions will need to be performed by the Bay controllers.

- Signal acquisition
- Acquisition of measured and counted values
- Monitoring of command execution
- Calculation of measured values derived from the operation
- Generation of signal groups

The status of each switchgear (e.g., circuit breaker, disconnect switch, grounding switch, transformer tap changer, etc.) will be continuously monitored. Each detected change of status will be immediately indicated on the local HMI single line and reported at the substation and remote levels. Alarms will be triggered in case of spontaneous status changes.

The states of the devices will be indicated by two auxiliary switches Normally Closed (NC) and Normally Open (NO).

An alarm will be triggered if the state changes are inconsistent or if the time required to operate the state change mechanism exceeds a predefined limit.

Analog inputs for current and voltage measurements with an accuracy of 0.5% will be provided. Active (W), reactive (Var), frequency (Hz) and rms power values for voltage (U) and current (I) will be calculated.

The measured values will be displayed locally on the substation HMI and reported to higher levels. Threshold limit values will be selectable for alarm indications.

Additional digital inputs for the acquisition of active and reactive power in the line and transformer sections will be guaranteed if required.

Analog inputs

The technical requirements for the VT and CT inputs are:

- Current acquisition directly from CT: 1 A ac
- Voltage acquisition directly from the VT: 110 VAC
- On-line calculation of P and Q (rms).
- Accuracy 0,5% of the assigned value or better.
- Frequency sampling ≥ 1000 Hz.
- 5 kV HV isolation for each measurement circuit.

Technical requirements for 4-20 mA analog inputs are:

- Current circuit acquisition : 0-20 mA, 4-20 mA.
- Input resistance ≤ 200 Ω,

- Accuracy 0.5% of rated value or better.
- Galvanic separation for each input.

Digital inputs

The technical requirements for the digital inputs are:

- Acquisition of digital inputs on the 110 V DC level without intermediate relays.
- Galvanic separation of the process and maximum 8 inputs per common connection.

All digital inputs will have an input filter for blocking network disturbances.

Digital Outputs

The technical requirements for the digital outputs are:

- 110 V dc
- Capacity at 110 V dc ≥ 5 A
- Breaking capacity at inductive load with L/R<40ms, at rated voltage: 0.2 A
- Galvanic separation of the process.

The digital and analog input/output quantities as listed in this document are minimum requirements. Any additional requirements identified by the substation equipment supplier during the engineering, site acceptance and installation phases shall be included.

20.5.3 Substation controller

Two computers with the characteristics specified in the data sheet are to be provided. The system software shall be installable from a transportable media (e.g., CD, DVD). The computers shall be powered by an uninterruptible power supply.

20.5.4 Operator workstation and Operator/Engineering workstation

The operator workstation and operator/engineering workstation are used as the SCMS human-machine interface for local substation operation. The two workstations are identical except that the operator/engineering workstation is equipped with additional software and is normally used to perform post-mortem analysis, maintenance, and engineering functions.

Each workstation consists of a PC-based computer with two color monitors and a windowed graphical presentation to view, monitor, and control any authorized SCMS component.

A DC powered buzzer will be installed in the control room to signal alarms. The buzzer will turn off once the alarm has been acknowledged. An external horn will operate in parallel with this alarm at the SCMS room horn.

All visualization, control and command functions are subject to password and user profile management, which determines the access and action rights for each user.

HMI technical characteristics

The SCMS workstations must be operated in graphic mode. They must be based on the Windows™ 10 professional operating system equipped with at least the latest generation 64-bit processor. Workstations must be connected on the redundant LAN.

Each SCMS Operator/Engineer workstation shall be equipped with a minimum of:

- Two monitors,

- Mouse,
- Alphanumeric QWERTY keyboard,
- Audio output for audible alarm with adjustable volume,
- Redundant local area network connection,
- SSD hard disk with the possibility of expansion by adding additional units,
- Sufficient memory to achieve the desired performance,
- Graphic interface supporting at least two screens,
- Two 100Mbit/s-1Gbit/s Ethernet communication ports connected to the workstation's redundant network or to the self-healing network interconnection device.

Operator/Engineering workstations shall support the following functionality:

- Two graphic displays depending on function,
- Multi-window, scroll, zoom in and out,
- Alphanumeric text and graphic symbols for one-line diagrams to be defined during the detailed design phase,
- Enlarged font size,
- A minimum of 65536 displayable colors from a choice of available colors,
- Dynamic coloring of the network on a one-line diagram (i.e., isolated part of the network),
- Selective highlighting, color assignment, inverse video, display intensity for each character/symbol individually or grouped,

Workstations Displays

- Two color LED technology flat panel display monitors must be provided with each workstation. High contrast monitors must be at least 56cm (22 inches) diagonal and support high resolution display.
- Monitors must meet international standards for flat panel display quality (ISO 13406).

Operator/Engineer workstations must support the following features:

- Multi-windowing on monitors in "extended desktop" mode (single pointing cursor, constraint-free display on two monitors), scrolling, zooming and minimizing functions,
- Enlarged programmable character size,
- Support of alphanumeric text and animated graphics for one-line diagrams to be defined during the detailed design phase,
- Dynamic coloring of the network on a one-line diagram (i.e., isolated part of the network),
- Selective highlighting, color assignment, inverse video, display intensity for each character/symbol individually or grouped.

20.5.5 Time Synchronization

All the functions of the system shall use a common time stamp, this is particularly the case for:

- Driving in the broadest sense (including local and telecontrol functions) with the dating of signals, alarms, measurements and commands,
- Incident analysis: chronological analysis of events, disturbance analysis and fault location

- Maintenance and administration.

In case of loss of external synchronization (GPS signal), the chronology of information will always be ensured, whether it is a matter of status logging or historical lists of any kind. The system will continue to provide the time at the required accuracy for a minimum of 8 hours. Beyond this limit, a drift of 10ms per day will be allowed.

In case of loss of the internal time synchronization equipment, the driving information will be declared as loss of system synchronization in local driving and in telecontrol.

In the event of a retiming of the internal clock with respect to the GPS synchronization interface, the system will ensure the consistency of the dating of the information flow occurring just before and after this retiming. In particular, it will guarantee the conservation of the sequence of dated information, at the possible cost of a temporary lack of synchronism, and will minimize the values of the corrections made to the dating on successive signals.

The information will be displayed in local time using a wall clock having the characteristics as per the associated data sheet.

The Contractor shall be responsible for the supply, installation and commissioning of:

- The GPS synchronization clock with its external antenna
- The synchronized wall clock
- Cables and equipment necessary to synchronize the facility's IEDs with the clock's synchronization outputs.

20.5.6 Interfacing Relays

Interfaces with metering and measurement equipment (Transformer tap changers, etc.) shall be BCD or Gray code, or analog.

The interfaces for energy and power metering will be by pulse with accumulation in the system or directly by transducers (4-20 mA type), or via communication port when the IED is connected directly to the CTs and VTs.

The control interface of the circuit breakers will be realized directly by the IED or through interposition relays. The characteristics of the control outputs to the circuit breakers are as follows:

- A make and hold current of 5 A continuous, 30 A for 500 ms, 250 A for 30 ms
- A breaking capacity of 5 A at 125 V DC (L/R = 40 ms)

By direct acquisition on CTs and VTs, the following measurements will be available:

- RMS value of currents and voltages
- Frequency
- Active powers
- Reactive powers
- Apparent powers - Power factor
- Phase shift
- Total Harmonic Distortion (THD) & Total Demand Distortion (TDD), harmonics will be measured up to rank 15
- Amplitudes
- Synchronism information : ΔF, ΔV, $\Delta \phi$

20.5.7 Switches

It can be distinguished:

- Substation switches installed at the supervisory Bay level
- Bays switches installed at the level of the other Bays

The switches are configurable type. They are installed in each bay and ensure the internal communication of the substation.

The UCA2/IEC 61850 protocol is required for data exchange between the different units of the substation, the local HMIs and the telecontrol gateways or telecommunication gateways (TG). It will be used for equipment synchronization, control, reports, point-to-point exchanges and transfers of disturbance, waveform and Qualimetry files.

The communication between the control, command and protection equipment of the substation is based on a 100/1000 Mbit/s Ethernet local area network. The communication between the units is realized on multimode optical fiber sections while the internal communication within a unit can be realized by optical fiber or 1000Base-T copper link. The self-healing ring or redundant star design of the network will be resilient to failures to ensure continuity of service in the event of equipment loss or damage to a network segment. In the event of a failure, the maximum failover/reconfiguration time will be less than 1 ms.

Each switch shall have a spare electrical port to allow the connection of a laptop.

20.6 Supervision System

20.6.1 General presentation

The operator/engineer station (HMI) display shall always show:

- The latest alarms that have occurred
- The date, time, name of the operator connected and the name of the station
- A set of icons grouped in a banner with the commands of screen copy, connection/disconnection of the operator, stop of the horn, launching of third-party applications (software for relay parameterization, disturbance analysis, word processing...)
- A navigation bar allowing direct access by a simple click to the different detail views, to the alarm viewer, to the status recorder, to the measurement panel...

In each one-line diagram, the lines, busbars and devices will be represented in color according to the level and presence of voltage according to the color code.

All the ergonomics & human factors eyes, shall be compliant with IEC/BIS standard BS EN ISO 26800

In order to distinguish the different states, the following representations will be used:

- Under voltage: Background and borders of the color of the voltage
- Out of tension: Empty bottom, borders of the color of the tension
- Unknown voltage: Hatched background, borders in the color of the voltage
- Grounding: Yellow background, green borders

20.6.2 Main functions

The HMI must perform the functions of supervision, control, archiving and maintenance. The most important functions are detailed below.

Supervision:

- Presentation of the one-line topology: general view of the substation, view of each voltage level, detail view of each Bay. This includes the dynamic position of circuit breakers, disconnectors, measurement values, counters, graphical representation of alarms, etc. .... Any spontaneous change, such as the opening of a circuit breaker, will be represented with a specific color and status.
- Presentation of the system architecture: general view of the system, detail view of each slice (ECU, IEDs, PT, PAD, etc.). This includes the dynamic state of the equipment (active, fault, disconnected, maintenance, test). Any spontaneous change will be represented with a specific color and status.
- Presentation of the alarm list, acknowledge and clear buttons
- Presentation of the logbook (real-time list of all system and process data).
- Presentation of the event list (status logging)
- Presentation of the measurement curves in real time or extracted from the archives. Invalid data must be indicated graphically.
- Presentation of disturbance and Qualimetry files
- Printing of all or part of the archived status changes, alarms or status of the different logical inputs/outputs. Report generation must be possible directly via the HMI (possible solution via Crystal Report).

Control:

- Control of primary equipment, via dedicated windows (pop-up) allowing, depending on the configuration of the device, direct commands or Selection before execution (SBO), forcing of interlocking or validation of synchrocheck.
- Possible forcing, substitution or deletion of information in order to correct incorrect or unavailable data.

20.6.3 Circuit breaker monitoring

The wiring of each circuit breaker trip circuit will be monitored by a continuous process (acting permanently regardless of the position of the circuit breaker) that will transmit an alarm to the local and remote operator (telecontrol) if a fault is detected.

20.6.4 Monitoring of metering equipment

The VT (voltage transformer) and CT (current transformer) metering equipment will be continuously monitored to detect the slightest failure of one or more phases. CT monitoring will be based on the zero-sequence current principle. The CT monitoring will allow to discriminate the fuse fusion faults from those directly affecting the CT (internal fault). It will be based on the inverse voltage.

20.6.5 Archiving

Archiving will allow:

- The storage of status changes, measurements, disturbance files, Qualimetry and all operator actions
- Storage of all SCCN databases and technical documents for each IED

- The minimum duration of archiving is 3 months

The data will be stored on the hard disks of the operator station and the engineering station. An ex- traction of these data will be possible to keep a backup on removable media (CD, DVD, USB key ...).

20.6.6 Maintenance

The following functions will be offered:

- Modification and evolution of the SCMS configuration databases
- Setting up the IEDs
- Load IED configuration data

Displaying information of each SCMS equipment with detailed and clear presentation

20.6.7 Configuration

The Contractor shall be responsible for the initial configuration of the Control System.

The system shall incorporate a configuration tool to generate the databases that will be loaded into the various system equipment (HMIs, substation and unit computers etc...).

The configuration tool will be unique for all the functions and equipment of the system, for example it will be possible with this tool to:

- Build the single line representation of the different equipment,
- Describe the electrical elements such as alarm labels,
- Configure the elements of the system, assign the different inputs/outputs to a component,
- Build and validate the elements of automatism, the management of the state and the control of the circuit breakers for example,
- Address the elements of the system according to the IEC 61850 protocol.

The configuration tool will be object oriented and will allow, from models, to instantiate them to create the elements of the configuration of the System application. The configuration software will be provided with a database of models which, for each Bay model, will group all the information of the Bay (graphic, electrical, system, automation and communication).

The system configurator will manage and number the database versions and edit the differences between two database versions. It will use the XML language as defined in IEC 61850 for data export and import functions. A partial sorting and extraction tool will be available.

20.6.8 Command procedure

A command can be executed in two modes: Direct command or Select Before Operate (SBO). In case of refusal of a command, a dedicated window is presented to the operator with a clear and textual indication of the cause of the refusal. In case of blocking due to an interlock mismatch or a manual lock, the user can, in this window, if he has the related rights, override this lock. Before execution, the user can visualize in a simple and graphic way the non-conforming equations.

Several conditions defined during the configuration will be checked on the command passage:

- Command duration (time between two command sequences on the same device)
- Operating mode of the unit and the substation

- Topological interlock
- Current PLC cycle on the device or equipment
- Synchro check
- Equipment locking
- Uniqueness of command: Only one command at a given time for the same device

20.6.9 Alarm management

Alarms are generally generated when the status of a logical information changes, when a measurement threshold is crossed or when an internal fault occurs in the system. The alarms are defined in immediate or delayed treatment (with a predefined time) and can be associated with an audible or luminous signal (also immediate or delayed). The alarms must be associated with any change of state (opening, closing, inconsistency, etc.) or with each threshold of a measurement (positive or negative crossing). They can have different levels of severity.

Alarms are presented via the HMI at the station level using:

- A dedicated window with:
  - A chronological list of alarms that can be combined with sorting criteria by equipment and voltage level
  - A time stamp for each alarm/event with a precision of ± 1 ms.
  - The last N alarms (N being fixed during configuration) with different colors for each alarm level
- Graphic symbols defined during the configuration and associated to each organ, allowing to know directly the alarms and their location in the different views

Each alarm can be acknowledged and cleared from the HMI, depending on the operator's rights.

The operator can acknowledge the alarms individually or by group. Independently of the acknowledgement, the sound or visual signal can be stopped by the operator manually or automatically after a given delay (defined during the configuration). An alarm can be deleted only if the cause of its appearance is no longer valid (inactive alarm) and if it has been previously acknowledged by the operator. It will be possible to configure each alarm as "automatically deleted" if and only if it has been acknowledged and the cause of it has disappeared.

20.7 Automations

20.7.1 Interlocking

The management of the interlocking of the substation shall be done primarily on a topological basis. The topological interlocking shall analyze the positions of all the circuit breakers and disconnectors of the substation and authorize or inhibit the commands according to predefined rules, for example according to the mechanical and electrical characteristics of the devices. The function can be either centralized in the substation computers or totally distributed in the Bays.

The topological interlocking function applies to the following equipment:

- Circuit breakers
- Disconnectors
- Grounding disconnectors

The topological interlocking function can be associated with Boolean type equations in order to satisfy maintenance needs. The management of openings and closings via the interlocking are independent. The interlocking can be overridden by the operator if he has sufficient rights.

Depending on the voltage level, the commands from the local control can be controlled by an interlocking automatism, if the bay is electrically connected to the rest of the system. If communication with other bays via the UCA2/IEC 61850 Ethernet network is not available or if some information is missing, a local interlocking function will be used, taking into account only the bay information. An operator with rights can override the interlock.

20.7.2 Voltage regulation

The voltage regulation function is used to maintain a voltage on the secondary of a transformer within the limits set by the operator. The secondary voltage is controlled through a tap changer. The voltage regulator shall comply with IEC 61850.

The voltage regulator shall be capable of handling one or more transformers in parallel. The voltage regulator shall also provide:

- The "homing" (return to a neutral position) to take into account the primary voltage of the busbar on which the transformer is connected
- Minimization of the circulating current

The position of the taps and the increase/decrease command as well as the choice of the regulation mode must be possible from the operator station in addition to the local functionalities.

20.8 Bay Unit description and installation

In general, each Control System Bay Unit includes:

- All safety equipment (short-circuiters, ICTs and voltage and current test boxes), lines and transformers allowing the maintenance operator to intervene safely in the unit.
- The IEDs required for data acquisition (unit computer or BCU - Bay Control Unit), equipment protection and automation. The Bay controller will include an interactive interface to supervise and ensure the operation of the unit.
- The necessary manageable switches with electrical and optical Ethernet ports.
- A control panel for local control of circuit breakers and disconnectors directly by push button. The positions of the circuit breakers and disconnectors as well as the voltage and current measurements are displayed on the control panel. A Local/Remote switch will allow to select the control mode of the unit.

20.8.1 Description of the 69 kV - Control System

The units will be equipped in accordance with the equipment listed below, and will be separated between control panel (including BCU, AVR for Transformer only, synoptic with TPL, switches, test blocks, …) and protection panel (including protection relays, switches, test blocks,…) for each bay.

Common Alarm Cabinet

It is equipped with:

- An IEC 61850 Unit controller: RTU

- A manageable switch,
- A local/remote switch
- A section lockout switch
- An interface relays ensuring the securing of alarms (substation fault and danger alarm)
- Terminal blocks, terminal block markers
- Testing blocks for current and voltage injection

Line Bay Cabinets

It is equipped with:

- A manageable switch,
- An IEC 61850-unit Controller
- A main protection relay n°1,
- A main protection relay n°2,
- A local/remote switch,
- A Section Lockout Switch,
- Safety devices (short-circuiting devices, voltage and current test boxes),
- Interface relays ensuring the security of alarms (substation fault and danger alarm)
- Terminal blocks, terminal block markers
- Testing blocks for current and voltage injections

Transformer Bay Cabinets

It is equipped with:

- A manageable switch
- An IEC 61850-unit controller
- A main protection relay n°1,
- A main protection relay n°2,
- A voltage regulator
- A local/remote switch
- A section lockout switch
- Safety equipment (short-circuiting devices, voltage and current test boxes)
- Interface relays ensuring the security of the alarms (substation fault and danger alarm)
- Terminal blocks, terminal block markers
- Testing blocks for current and voltage injections

Sectioning and Bar Control Cabinets

It is equipped with:

- A manageable switch,
- An IEC 61850-unit controller
- Central busbar differential protection unit,
- A local/remote switch
- A section lockout switch
- Safety devices (short-circuiting devices, voltage and current test boxes)
- Interface relays ensuring the security of alarms (substation fault and danger alarm)
- Terminal blocks, terminal block markers
- Testing blocks for current and voltage injections

Metering Cabinet

It is equipped with:

- All energy meters (one for each bay)
- Terminal blocks, terminal block markers
- Testing blocks for current and voltage injections

20.8.2 Description of the 33 kV and 11kV - Control System

Each feeder will be equipped in accordance with the equipment listed below and mounted directly on the LV feeder compartment. A separate control panel (including BCU, AVR, synoptic with TPL, switches, test blocks, …) and protection panel (including protection relays, switches, test blocks,…) will be provided for each 33/11kV and 33/2.2kV transformer.

Each cabinet will be equipped with:

- A manageable switch,
- A main protection relay,
- Measurement unit 1,
- A local/remote switch
- A Unit Lockout Switch
- Safety equipment (short-circuiting devices, voltage and current test boxes)
- Interface relays ensuring the securing of alarms (substation fault and danger alarm)
- Terminal blocks, terminal block markers
- Testing blocks for current and voltage injections

20.8.3 Cabinet connection principles

The Contractor shall be responsible for:

- The creation of information exchange tables between the various systems (Calculators/concentrators, Operator workstations).

- The establishment of the control sheets in agreement with the customer,
- The establishment of the TIP (Tele-information Plan) in agreement with the customer,
- The realization of a file of conception of the system views,
- The realization of files of test taking again the tables of exchanges and addresses for realization of the FAT and the SAT,
- The programming of the system views,
- The programming of the protection relays and the unit computers,
- Specification of the means to be implemented in the factory acceptance platform,
- Tests.

20.9 Automatic Event Data Collection System

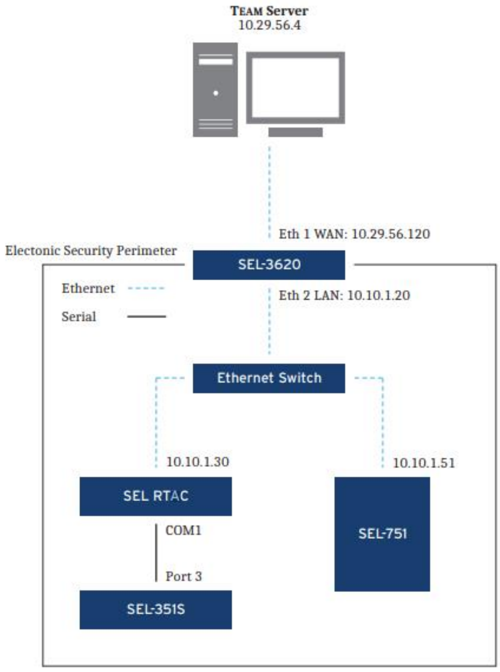
The Existing Network distribution feeders and generators are all protected by multifunction, microprocessor based protection relays that features automatic event and sequence of events (SOE) recorders. These devices are also synchronized using GPS time sync devices. To facilitate timely retention of data for security, protection system performance assessments and post-fault investigation a two-tiered system has been implemented to facilitate storage of Event and SOE data. The first tier is local collection and storage at the substation level for data originating at the respective station. The second tier is a central database that collects and stores data from all substations, facilitating easier and faster analysis particularly for system-wide events. This Supervision system is installed at Fond Cole.

The main components of this system are:

1. SEL-2401/SEL-2407 Satellite Synchronized clock – Provides IRIG-B time signals for equipment at each substation
2. SEL-3530 Real-Time Automation Controller (RTAC) – Automatically collects and stores Event and SOE data via serial or Ethernet connected relays locally and uploads to central database
3. Managed network switch – Facilitates Ethernet connections between local devices, engineering access to data and upload of data to central database
4. SEL-3620/SEL-3622 – Security, access control and relay password management for SEL relays in compliance with NERC-CIP standards.

   SEL acSELerator TEAM software – Collects, stores and facilitates access to event and SOE data

Figure below shows a basic indicative diagram of how these components are arranged



The following provides a general description of how the system operates and compatibility with non-SEL devices:

"SEL-TEAM or SEL-5045 software polls and store reports (SOE and CEV) into the PostgreSQL database called AcSELerator Database. The database has no licensing. The software AcSELerator Quickset is the GUI (graphical user interface) of the SEL-TEAM software. The licensed SEL-TEAM software runs in a Windows Operating System as Services that are continuously running to perform the Tasks. Tasks are periodic with automatic polling and synchronizing of the SOE and CEV reports. The protocol used by the Tasks is the SEL Protocol.

SEL Protocol is interleaved Binary and ASCII messages. Automatic SEL Protocol messages can be sent to SEL relays by the Task of SEL-TEAM, but this type of communication is slower than when SEL-TEAM polls/listens to the SEL-RTAC database. SEL-TEAM cannot retrieve data directly from non-SEL devices.

The SEL-RTAC acts as the substation reports and data concentrator, stores all these reports locally in its internal RTAC Database and then "sync" these to the SEL-TEAM / AcSELerator Database. This optimizes the communication network burden and it is encrypted so it enhances cybersecurity.

Since the SEL-RTAC can poll non-SEL relays (relays from other manufacturers) then the RTAC's SSD can be used to gather reports from non-SEL relays to then "sync" to SEL-TEAM. SEL-RTAC can gather reports from non-SEL relays if they meet the following criteria:

- *a. Alstom Event Collection (Courier Protocol)*
- *b. SEL-2245-2 card and SEL-Axion system*
- *c. GE relays by using the Modbus protocol.*
- *d. IEC-61850 relays that use the MMS File Services protocol.*

A maximum of 1024 COMTRADE events can be stored in the RTAC with the oldest record being deleted when a new event is triggered and 1024 is exceeded. The SEL-2245-2 can record two back-to-back events. A new record can be triggered as soon as the current one has finished recording. A trigger condition that occurs before the current recording finishes is ignored. These records are first stored locally to prevent data loss and then transferred to the RTAC for downloading via the built-in web server."

The Employer would ideally prefer a system that is compatible with the existing system to minimize maintenance and training burden, to ensure that all data is available at the same location (Fond Cole) and can be manipulated by the same tools. If that is not offered, the offer should include a system that contains equivalent features.

21. Telephone Communication

21.1 General

The present section outlines the Technical Requirements applicable for the design, supply, installation and commissioning of private automatic branch exchanges (PABX) and associated telephone equipment for a complete operational private telephone network to be installed in substations as part of the Employer electricity network.

The private automatic branch exchange and associated telephone sets will be used to enable voice communications among operators to coordinate, operate, supervise and manage the complete distribution network.

The private telephone network system consists in the following components:

- Telephone private automatic branch exchange (PABX) of VoIP technology;
- Telephone sets (attendant console, indoor and outdoor subscriber, multiple line);
- Protective line devices;
- Main distribution board.

These Technical Requirements shall always be read in conjunction with the General Technical Requirements.

21.2 Technical Data Schedules

See Annex A2-27 Telephone Communication Technical Requirements

21.3 Complementary Requirements

21.3.1 Equipment Technical Particularities

This section provides the equipment technical particularities for the design and supply of the Telephone Private Automatic Branch Exchange system.

21.3.2 Private Automatic Branch Exchange (PABX)

The PABX(s) shall be located in the telecommunication room of Fond Cole Substation along with other communication equipment.

The PABX shall be of modular construction with provision for expansion. Printed circuit cards shall be supported by insulating guides, terminated on multicontact connectors and properly secured to the frame. Means shall be provided to extract cards or modules easily for maintenance and installation.

Interconnection between cards shall be made by use of multiconductor cables terminated by compatible connectors. All hardware components shall be treated against corrosion and fungus caused by humidity or moisture. It must be possible to enable or disable any shelf, plug-in unit, including common equipment where spares are provided, without affecting other parts of the system. It shall be possible to remove or insert any peripheral circuit pack without degrading service to any other part of the system. It must not be necessary to remove any components in order to access and / or test other components or connectors. The circuit packs shall be clearly labelled and visible from the front as to the functions of the card. Furthermore, it shall be possible to read serial numbers, if used, without removing the cards. Enclosure shall allow access to interior from the front or back by means of doors or removable panels.

The PABX shall be fully digital and stored program controlled. It shall be possible to interface with analog, digital and ISDN subscriber lines and trunks, as defined by ITU standards. It shall be of modular design and housed in dust-proof cabinets. The equipment shall be designed in such a way that the heat dissipation should not require built-in forced cooling fans/ventilation. The Supplier shall take appropriate caution and undertake the necessary measures to preclude RFI/EMI to and from the other site telecommunications systems.

The PABX shall be supplied to provide for the initial requirements as specified by the Scope of Work of Section I.G., and 100% spare capacity. It shall also be designed for future expansion (ultimate capacity) equivalent to at least 100 % of the installed capacity. The PABX shall be flexible and allow for easy growth of trunks and extensions over the initial installed quantities up to the ultimate capacity. The addition of common elements and memory should not be necessary to achieve the ultimate capacity.

The configuration, hardware and software supplied shall be the most current that has a proven record of satisfactory service, defined as a minimum of 20 commercial systems with an in-service life exceeding of 6 months.

The PABX shall be capable of being programmed and reprogrammed as necessary to the required system numbering plan for the area, region, inter-region and national connections.

Multiconductors interconnection cables (5 meters length minimum) will be fitted at one end to the PABX by means of a plug-in connector and at the other end to the wall-mounted Main Distribution Frame (MDF) terminals. All PABX circuits shall be terminated to the MDF. All external cables in the PABX enclosure shall enter through bottom plate.

The PABX will be supplied along with one attendant console and provision for operation with various attendant consoles including their cabling accessories to allow connection to the MDF.

The PABX shall include an automatic transfer device which, upon power failure, will connect the trunks to designated extensions. Public central office trunk circuits shall be protected by a surge protecting device and line isolators. The PABX shall be provided with an interface to allow connection to a digital terminal and a printer used for maintenance and programming.

21.3.3 Features

The PABX shall be provided with the features as specified in the Technical Data Schedule of the Private Automatic Branch Exchange. The main features consisting in:

- Feature Classes: The features to the extensions shall be software programmable. An extension user shall receive a number unobtainable tone in response to an attempt to gain access to a non-assigned feature;
- Conference Call Capability: The PABX shall have the Conference Capability allowing for conference calls up to four conferees. Conference capabilities shall be assignable to all extensions, subject to access restrictions. The PABX shall allow the attendant to be included as one conferee;

- PABX Recovery: In the event of loss of power or other type of temporary failure, the PABX shall be capable of automatic recovery without any action from the operator. A dead system load and restart shall be accomplished within 15 minutes from initiation for the system at ultimate capacity;
- Password Protected Facilities: It shall be possible to give authorized users a password to access a set of protected features. This password shall be related to the user’s extension number. A user shall be identified with his extension number that relates the user’s password to his allowances. It shall be possible to program an extension in such a way that a password has to be dialed whenever an outgoing call is to be made;
- Call Forward: The call forward (don’t answer) shall re-route a call to a secondary destination when a primary extension fails to answer the call within a pre-determined time. If the secondary extension is busy, the call shall continue ringing on the primary extension. If the primary extension is busy, an incoming call shall also be forwarded to the secondary destination (call forwarding when busy). Several primary extensions may share the same secondary destination. Call forward (when absent) shall re-route a call to a secondary destination when a primary extension has dialed an absent code. Call forward (when busy) shall be rerouted if the called extension is busy. This feature shall be enabled or disabled by the user from his extension;
- Abbreviated dialing: Common pool abbreviated dialing enables entitled extension users or operators to dial short codes that are provided for dialing frequently used destinations. Group abbreviated dialing is similar to the common pool abbreviated dialing but with the restriction that it is only available to a specific group of extensions, the extensions included in a particular group shall be programmable in the PABX. Individual abbreviated dialing enables designated extensions the ability to store personal set of external numbers for short code dialing;
- Add-On Conference: It shall be possible for the extension user to establish a three-party conference. The add-on conference can involve three extensions, two extensions and one trunk or one extension and two trunks. During the add-on conference, a tone shall be given to all parties;
- Call Pickup: It shall be possible for extensions within the same pickup group to answer calls ringing on other extensions (same group) by dialing a code from the initial dial tone condition;
- Call Transfer: All extensions' users have the facility to transfer a call (internal or external) to another party. Only after the new destination has answered the call can the calling extension effect the transfer by going on hook;
- Camp on Busy: It shall be possible to connect a call to a busy extension and place it in a waiting queue until the required destination becomes free;
- Call Waiting: When the operator or an extension camp into a busy extension, the called busy extension shall be informed that a call is waiting by receiving a short burst of call waiting tone. The called party shall be in the speech condition for this to be effective (an off-hook extension who is dialing shall not receive the tone);
- Forced release of trunk by priority user: It shall be possible for a priority call to always find a trunk free to establish a call. The existing connection shall receive an indication before termination;
- Night service: When no attendant is in service, it shall be possible to provide service to internal or external callers. The night service feature shall allow a specially nominated extension to provide this service. De-activation of night service shall be from the Attendant Console

All other system features necessary for the efficient handling of calls on the site and between the site and other PABXs connections are to be provided whether specifically identified in this section or not.

Where feature software packages contain features in addition to those specified as required all features contained in those software packages are to be installed and available for implementation at the Purchaser’s option.

21.3.4 Grounding

The Supplier shall engineer and design the grounding connections for the PABX equipment cabinets and the various components of the distribution network in accordance with local and international recommendations, codes and standards.

All cable shields shall be connected to the single ground at one end only. Shield drain wires terminating on equipment shall be connected by solder terminals or by use of crimped tinned copper lugs or pin. Shield drain wires terminating on the distribution panels shall be connected by use of crimped tinned copper lugs or pins. Where the shield is left disconnected it shall be sealed and insulated in order to isolate it from other metal parts in its surroundings.

21.3.5 Power Supply

The PABX shall be fed at 48Vdc or 220 Vac from the SBEE NDCC and BUNDCC Control Center battery supply or the UPS system ensuring uninterruptible power supply.

21.3.6 Software

The PABX software shall allow configuring the PABX to suit specific customer needs and includes as a minimum the features described in the technical data schedules.

Main configuration software shall be placed on CD-ROM or other equivalent storage devices to allow reloading, following a power failure. Remaining software shall be stored in a nonvolatile type memory.

The software shall be modular and allow for the following features:

- It shall be possible to perform the installation and the rearrangement of any telephone set in the system without affecting others on the same system;
- It must be possible to perform any feature changes (including removal of set data from software) at the set level at any time without disrupting service to that set or disconnecting calls in progress;
- It must be possible to perform software diagnosis on any part of the system without affecting service to any part of the system;
- It shall be possible to program a variety of common groups of features for telephone sets through the use of programmable default values. This ability should not preclude the capability of single feature entry;
- All software commands, outputs and diagnosis display should remain unchanged in format, meaning and information content throughout the life time of the system, regardless of later-generation development.

21.3.7Telephone Sets

All telephone sets shall have a designation area suitable for identifying the set with the telephone number. Interior sets may have stenciled numbers placed in number holders. All exterior telephone sets and stations shall have engraved or painted plates provided to identify the telephone or station number with letters a minimum of 30 mm high. The plates shall be attachable to the set, enclosure or adjacent mounting location.

All interior telephones shall have a label attached which provides room for the entry of up to 5 emergency numbers.

21.3.8 Digital or SIP Phone Set

The Supplier shall supply digital phone sets for all substations equipped with programmable keys and message waiting indication. It shall be support, through system configuration and programming, all features provided by the PABX.

21.3.9 Engineering services

The Supplier is responsible for the design and engineering activities leading to the proper supply, installation and commissioning of a Telephone Private Automatic Branch Exchange system that will satisfy the functionality and operability criteria described in these Technical Specifications. The particularities of operation and network configuration of the private telephone network is defined with more details in the description of the Scope of Works.

The Supplier shall prepare and submit for review to the Purchaser the analysis, calculation and equipment configuration, such as telephone numbering plan and access procedures, necessary to ensure that the design meets the performance objectives of the private telephone network. The Supplier shall be available to participate to design review meetings at the Purchaser's facilities.

The engineering documents to be delivered by the Supplier shall include, in addition to the general documents, a detailed description of the private telephone network configuration to be implemented by the Supplier.

The Supplier shall insure full compatibility of proposed equipment with existing network facilities and with others proposed by the Supplier to allow full integration of the new facilities.

The exchange will be used for the operation of the distribution network substations. It will be linked with existing exchanges by 4 wires E/M trunks directly or through digital links. There will be subscribers in all substations connected directly or through telecommunication channels (remote subscribers). The exchange will also give access to the public network by means of HV line isolators (included in supply).

As the power electrical grid coordination is dependent on the availability of private phone network, the exchange shall provide access to the operators without blocking.

The Supplier is fully responsible and accountable for the proper operation of the equipment under the specific environmental conditions of the various sites such as temperature and humidity.

21.3.10 Interfacing with other equipment

It is the responsibility of the Supplier to obtain all the necessary information on equipment to be interconnected with the private exchanges of existing private network in order to provide the proper interfacing (Refer to Technical Data Schedules). As an example, compatibility of E/M wire signaling shall be verified.

The Supplier shall be responsible to ensure proper interface of the Telephone Private Automatic Branch Exchange system at Fond Cole Substation with the following facilities:

- Subscriber lines from substations to be connected to the telecommunication terminal and transiting through the optical fiber backbone up to the substations. The Supplier shall be responsible to fully implement the telecommunication networks supporting these subscriber lines as specified in the Scope of Works;

- Digital, SIP and analogue subscriber lines for the telephone distribution at the all the substations. The Supplier shall be responsible to terminate the digital subscriber lines at the Main Distribution Frame (MDF);
- The required 48 Vdc or 220Vac power circuit to the PABX cabinet from the redundant battery and UPS systems distribution panel.

21.3.11 Spare Parts and Maintenance Facilities

The spare parts and maintenance facilities required for the proper continuous operation and maintenance of the telephone private automatic branch exchange system and public address system shall be provided by the Supplier. As a basic guideline, the list may include (but not limitative):

- Power supply module;
- Trunk module;
- Digital set module;
- Subscribers set module;
- CPU module;
- Bus extension card;
- Network module;
- Fuses or circuit breakers;
- Programming terminal with software;
- Isolator module.

22. Telecommunication Network

The new telecommunication system will mainly be based on Fiber Optic Cables constituting the new Distribution telecommunication Backbone of Employer.

Refer to the Diagram (Figure 2) below to be linked where the communication media is defined.

The new telecommunication network will provide services mainly for the data exchanges between substations such as supervisory SEL system, remote workstation and telephone communication between the various substations.

The new fiber optic telecommunication system shall be supervised and controlled by a centralized Telecommunication Management System (TMS) located at the Fond Cole Substation.

The following schematic diagram represents the Employer transmission fiber optic network.

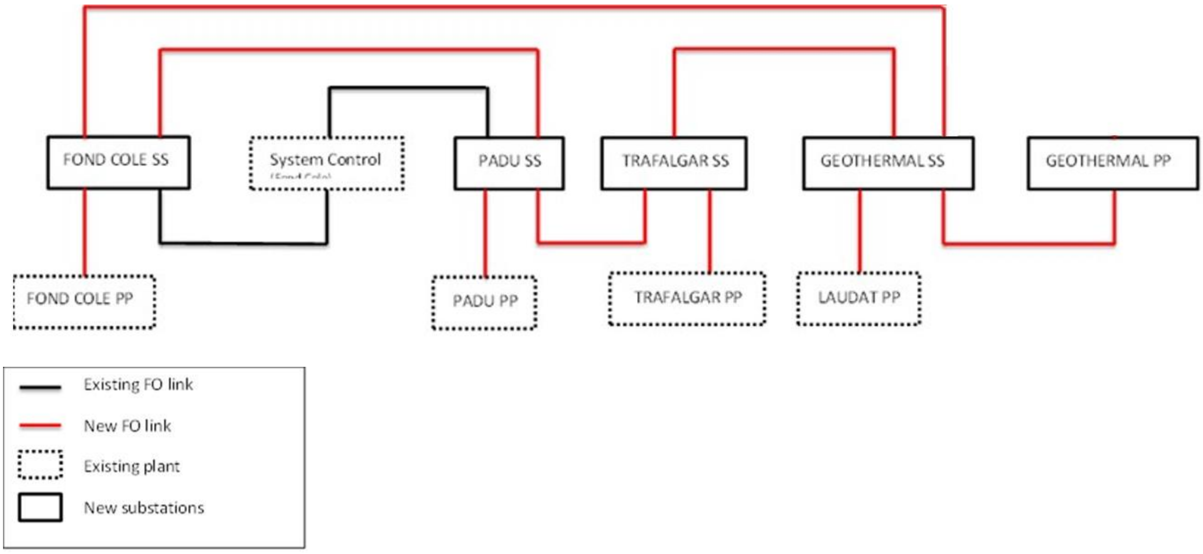


Figure 2: Employer's future fiber network in the Roseau Valley

Data transmission will be a point-to-point configuration. Redundancy is required for telecommunication between the different substations. Data exchange link between both Substations and Powers plants will be implemented as well.

A new telephone exchange PABX will be implemented in Fond Cole Substation with extension located in the various substations and Powers Plants and with Head-Office per Public network Public Switched Telephone Network (PSTN).

22.1 Physical Fiber optic Topology

The Supplier shall structure the telecommunication Backbone in physical fiber optic rings, the design proposed hereunder is for bidding purpose only; the final design shall be proposed by the Supplier during the Design Specification Phase.

Supplier shall provide equipment's nodes and repeaters for sufficient transmission capacity. Nodes Equipment's will be implemented in Employer substations and connection will be made to Optical Distribution Frame ODF by means of patch cords or fiber optic cable.

Substations which are not part of Rings shall be connected to the physical rings as segments in Dedicated Back-up Protection Path (1+1) optical path protection scheme.

The connection of the substation to the telecommunication Backbone shall be physically redundant as these connections are critical to the SEL Systems, telephone communication and inter-substations connections.

22.2 Fiber Optic equipment:

All works and supplies required to constitute the links listed in the above table.

22.3 Telephone system:

All works and supply for phone exchanges to be located in substations for voice communication between various Employer substations and Power Plant.

22.4 Description of supply:

22.4.1 Telecommunication Fiber Optic equipment:

- Optical platform and access multiplexer located in all the Substation cabinet to stablish the various loops and radial links of the SBEE network;
- All Optical Distribution Frame, patch cord, optical cables, as well as all works, installation and material to complete the links as indicated in the diagram above;
- Configuration, programming, testing and commissioning.

22.4.2 Telephone system:

- One telephone exchange to be located in Fond Cole Substation;
- Telephone sets located in the various substations and facilities: for the operator (indoor)
- Configuration, programming, testing and commissioning.

22.4.3 Data exchange:

The new telecommunication network will provide services mainly for the data exchanges between substations such as:

- Supervisory SEL system based in DNP3 TCP/IP exchange.
- Phone communication between the various substations.
- Exchange between SCMS substations and Power Plant DCS or RTU.
- Telecommunication Management System (TMS) located at the Fond Cole Substation.

22.5 Technical Requirements of Fiber Optic Telecommunication

The present section outlines the standard technical requirements applicable to the design, procurement, manufacturing, testing, installation and commissioning of the fiber optic equipment's that will provide communications between the various Substations and Power Plants.

The network architecture to be implemented shall be of a ring topology type with adequate transmission and synchronization protection scheme to achieve operational requirements.

The SDH network shall support the services related to the telephony, future SCADA, future teleprotection, SEL supervision system based on DNP3 TCP/IP protocol and administrative data exchange required to operate and manage the distribution network.

These Technical Requirements shall always be read in conjunction with the "General Technical Requirements": Annex A2-28 Optical Platform Technical Requirements

22.5.1 International Standards

INTERNATIONAL TELECOMMUNICATION UNION

- ITU-T G.700 series: Hierarchical digital interfaces related recommendations.
- ITU-T G.800 and G.900 series: Synchronous digital hierarchy (SDH) applicable recommendations.
- ITU-T V11: Electrical characteristics for balanced double-current interchange circuits operating at data signaling rates nominally up to 10 kbit/s
- ITU-T V24: List of the definitions for interchange circuits between Data Terminal Equipment and Data Circuit-Terminating Equipment
- ITU-T V28: Electrical characteristics for unbalanced double-circuit interchange circuits.
- ITU-T V35: Data transmission at 48 kilobits per second using 60 – 108 kHz group band circuits.

INTERNATIONAL STANDARD ORGANIZATION

- ISO 90001: Quality systems-model for quality assurance in design, development production, installation and servicing.

ELECTRONIC INDUSTRIES ASSOCIATION

- EIA-RS 232C: Standards for electrical characteristics or generators and receiver for use in digital systems.
- EIA 485: Standards for electrical characteristics or generators and receivers for use in balanced digital multipoint systems.

INSTITUTE OF ELECTRICAL AND ELECTRONIC ENGINEER

- IEEE 802: Standards for Local and Metropolitan Area Networks

AMERICAN NATIONAL STANDARDS INSTITUTE

- C37.90.2-1995: IEEE Standard for Withstand Capability of Relay Systems to Radiated Electromagnetic Interference from Transceivers.

22.5.2 Equipment Technical Particularities

This section provides the equipment technical particularities for the design and supply of the fiber optic equipment's and other fiber optic links requirements.

The equipment shall use the most up-to-date technologies optimizing the physical dimensions, power consumption and reliability. It shall be of a flexible and modular structure type. Compact unit design and flexible shelf architecture shall allow for housing of various units, from aggregate units down tributary units, on the same shelf. The equipment shall provide reliable and space-efficient dropping of various applications. The configuration shall be done by inserting the appropriate interface cards. Any future expansion or upgrading of the equipment shall be allowable with an optimized part reuse.

The equipment shall be fully integrated product and will provide the fiber optic interface, channel and specialty interfaces and also an encompassing Network Management System (NMS). All alarms, performance monitoring and configuration setting about the equipment status shall be available through a local PC or through a central Network Management System.

The supplied equipment shall provide the following facilities:

- Tributaries;
- Common parts protection;
- Ring self-healing protection;
- High order tributary cross connects;
- Lower order cross connects;
- Access to overhead channels;
- Monitoring through the network management system;
- High modular commonality with other telecommunication equipment.

Each circuit availability and reliability shall be the key elements in the system design. The power units will be redundant and paralleled on the same shelf. Route diversity shall be achieved considering collapsed ring configuration and also by assigning both a priority and back-up path. This shall ensure that if a common unit such as an aggregate or a fiber is lost, traffic is still maintained between sites with extremely fast switching time (3 ms) between route diversity fiber paths.

Since the SDH multiplexer equipment shall be of a highly modular design, the Supplier shall configure and provide each of them with the modules that will satisfy the applications as described in the Scope of Work. The equipment shall be 19" rack mountable.

All interface units shall be interchangeable during operation and maintenance without the need to shut down the equipment. No requirement of external cooling (i.e., fans) shall be required and equipment shelves can be mounted directly on top of each other.

i. Synchronization Subsystem

The synchronization function unit shall be monitoring the integrity of the synchronization sources in compliance with the ITU-T G.813 recommendation.

ii. Control Subsystem

The control subsystem shall support the real time management functions such as traffic, protection switching and performance data acquisition. The control system shall be invariably implemented by software.

The processing unit shall monitor alarms from individual units providing major and minor alarm status. The unit shall be equipped with alarm indicators, which will summarize the incoming alarms.

The control software shall be well protected against power failure. Any software upgrades shall be downloaded either by a local terminal PC or remotely.

The control subsystem shall support interfaces with network management system. The software shall be based on latest version of MS-Windows.

iii. Power Subsystem

The power supply needed for the telecommunication equipment's shall be protected as 1+1 redundant, with one unit able to power a fully equipped shelf and another power unit in stand-by. The removal of any power supply unit shall not affect any system operation. Each power unit shall be fuse protected as a standard feature. An alarm relay and front panel LED shall provide indication of abnormal power unit operation.

iv. Network Management System

The Supplier shall supply a Network Management System (NMS) located at the Fond Cole Substation. The NMS shall manage and supervise all telecommunication equipment's and shall consist in a workstation computer running system management software providing the following features:

- Real-time alarm surveillance and capture;
- System performance (BER);
- System configuration;
- Fault and maintenance management.

The Network Management System software shall allow the user to monitor and configure a system from any node through the use of a portable PC terminal. Visibility shall include monitoring, configuration and alarm reporting. Manual path switching shall also be available.

A network management interface shall allow the user access to a series of powerful, menu driven, industry standard (MS Windows) screens, which will provide the user complete monitoring information and configuration control of the system.

The network management program will run on a workstation running latest Windows edition.

The NMS shall allow for remote monitoring, testing, path switching and reconfiguration of any node from any other node in the system.

The NMS shall provide for simultaneous monitoring and configuration from more than one node. The NMS shall allow multiple user access for maintenance personnel to have real time network information for testing and troubleshooting as well as the potential of back up control centers.

An industry standard graphical user interface (Microsoft Windows) for displaying the desired level of detail shall be provided. A “drilling” scheme shall be incorporated to provide the user access to all levels of the network including a seamless integration of NMS communications right.

v. Optical Distribution Frame

The Supplier shall supply optical distribution frames (ODFs) sized to provide termination to the optical interfaces and the incoming fiber optic cable. The panels shall be of a rack-mount type. All optical adapters provided within the ODFs shall be of FC type.

vi. Cabinet

Equipment’s and optical distribution frames shall be housed in metallic free standing modular cabinets IP 50 (IEC 60297) with proper ventilation to avoid overheating. Cabinet shall come with all wiring and terminal to allow connection between modules and terminal blocks for external cables.

The terminal blocks strips shall be of metallic rails mounted terminal plate type. Exterior cables will enter from bottom plate of cabinet by means of cable glands.

The cabinet will carry a nameplate indicating the specific equipment identification provided by the Owner and link destination. Cabinet shall include hinged doors for convenient access to all modules and terminal blocks.

vii. Power Distribution Panel

The power supply system shall include a dc distribution panel with redundant 48 Vdc power supplies that shall be housed in a power supply cabinet equipped with circuit breakers and output terminals suitable for the loads and including spares outputs for future uses. This power supply facility shall provide power to all telecommunications facilities requiring uninterruptible dc power supply.

viii. Engineering Services

The Supplier is responsible for the design and engineering activities leading to the proper supply, installation and commissioning of Optical Fiber Communications System that will satisfy acceptable functionality and operability criteria. The particularities of operation and network configuration of this system is defined with more details in the description of the Scope of Work.

The Supplier shall prepare and submit for review to the Purchaser the analysis, calculation and equipment configuration necessary to ensure that the design meets the performance objectives for each link and of the overall network. The Supplier shall be available to participate to design review meetings at the Purchaser’s facilities.

The following performance criteria shall be considered in the design calculations:

- Maximum bit-error-rate (BER) of 10-66 for links and the data interfaces;
- Self-healing protection of no more than 3 ms.

The engineering documents to be delivered by the Supplier shall include, in addition to the general documents, the following specific Communications System documents:

- links performance calculations;
- channel plan.

The Supplier shall insure full compatibility of proposed equipment with existing network facilities and with others proposed by the Supplier to allow full integration of the new facilities.

ix. Interface with Other Equipment

The Supplier shall be responsible to ensure proper interface of the SDH Optical Fiber Communications System with the following facilities:

- The required redundant 48 Vdc power supply circuits for telecommunications facilities at
- The 48 Vdc main distribution panel;
- The junction of the fiber optic cable to the transmission line cable;
- The voice and data circuits to the system supporting the telephony, future SCADA, future teleprotection, SEL supervision system and LAN networks at the interface distribution frames as specified in the Scope of Work.

x. Spare Parts and Maintenance Facilities

The spare parts and maintenance facilities required for the proper continuous operation and maintenance of Communications System shall be provided by the Supplier. The maintenance facilities shall allow the following:

- Communications test equipment to verify the communications performance during the operation or in such a way to avoid interfering with normal course of operation;
- Maintenance accessories specific to the supplied equipment: extension card, jumpers, jacks;
- Software for PC along with any specialized interface or cable.

All equipment shall include adequate supervision and tests facilities to allow preventive and corrective maintenance. Typically, the following shall be provided:

- Visual Indication;
- Power supply;
- Input/output modules;
- Loss of signal;
- Synchronization loss;
- Transmitter/receiver failure;
- Test points;
- Digital port for connection of terminal or portable computer for diagnostic;
- Power, voltage, current in and out of equipment;
- All input/output signals of equipment interconnected with other equipment.

The Supplier shall supply All spare parts and instruments specifically identified (mandatory and recommended) by the Supplier and approved by the Purchaser;

23. Remote Engineering Workstation

23.1 General

All necessary software shall be provided for a remote workstation installed in Fond Cole which is to be used as a service unit for engineering, analysis and modifications.

Access to the SHMI shall be possible by means communication equipment in order to access engineering data, program protection relays and make use of the local event printer.

In addition, a laptop-based service with all necessary software shall be provided to be used as a service unit for on-site engineering, analysis and modifications. The software shall also enable the laptop to double as an REW.

23.2 Functions

The remote workstation and Laptop-based service unit shall be used for the following purposes:

a) System entry
b) Application programming
c) Program testing
d) Fault tracing
e) Graphical program documentation
f) Loading and dumping of programs
g) Commissioning
h) Reading of values in the data base
i) Changing peripheral parameters and relay settings
j) Disturbance record analysis

23.3 Monitoring

The remote workstation and laptop-based service units shall permit the user to investigate changes of status and analogues in the substation. The service aid shall be able to monitor data in the running substation control system and to present changing variables on the display screen, selected in tabular form or in graphic representation.

NB: At the commissioning phase and for each substation, all tests of control and monitoring from local substation HMI and remotely from the remote engineering workstation, at Fond Cole, should be done successfully before energization

24. Communication to the Remote Engineering Workstation

The telecommunication equipment shall include:

Supply and installation of Fibre Optic Access Cables (FOAC) including all trenching, protection pipes, civil works, cable trays, etc, for the safe and proper installation of the cables from the FO joint boxes at the gantries/entry of the line to the ODF at the substation communication room.

Supply and installation of suitable Optical Distribution Frames (ODF) / patch panel with single mode pig tail terminations at the control building

SDH terminal and multiplex equipment, Redundant Power Supply Module, Redundant control board, PCM access multiplexer, digital comfort telephone set, any other necessary equipment to establish communication between all substation network.

The Bidder shall supply all cabling, accessories and services required for proper operation of the telecommunication equipment at the substation as well the integration into the overall telecommunication system.

Each substation should be equipped with all necessary telecom and SCMS equipment for a connection to a future National Control Center at Fond Cole

25. Protection Devices, Functions and Associated Items

25.1 Protection coordination study

The contractor shall elaborate a protection coordination study for the whole 69kV, 33kV and 11kV system which shall include:

- Short circuit calculation;
- Setting of the new relays;
- Impact of the new equipment and its settings to the setting of the existing relays in other neighboring substations.

25.2 Mains protections solutions

- **69 kV grid**: The main 69 kV line GFI will be erected from Geothermal with an UGC (1.5 km) + Over head line (4.8km), then an UGC (2.5 km) will be installed from end tower to GIS building in Fond Cole substation. The GIS busbsar 69 KV in Fond Cole will be protected with a differential busbar relay. Some autoreclosing system will be done depending of the root of the tripping.

- **33 kV and 11 kV grid**: All the link will be erected in UGC technology. All the feeders will be protected with a current differential relays without autoreclosing functions. Auto reclosing will be available only for 11kV outgoing feeder for distribution network.

- **P**ower transformers will be protected by current differential relays as a main protection. Overload relays, oil overpressure, temperature wiring probe (inside the transformer), fire protection shall be provided also.

types of feeders and voltage level	Mains protections	Back up protections
OHL 69 kV + UGC	Overall differential relay + instantaneous over current relay (UGC) or differential relays for the UGC link (Geothermal side).	overload and directional active power notes : Selectivity of the UGC relay for auto reclosing or not
BB and tie feeder 69 kV GIS substation	differential bus bar	
Transformer 69 kV, 33kV	transformer differential	overload ; oil over pressure ; temperature wiring probe ; fire protection
UGC 33 kV UGC feeder	differential relay	over current phases and neutral
UGC 33 kV bus bar	over current phases and neutral instantaneous	
UGC 33 kV and 11 kV outgoing and tie feeders	over current phases and neutral instantaneous	over current phases and neutral delayed

Table 10: Main and backup protection used to protect 69kV, 33kV and 11kV network

25.3 ANSI functions used

The following table lists the main ANSI functions which will be used in the protection system of the 69kV, 33 kV and 11kV grids.

21 - Distance Relay	51N - Neutral Time Overcurrent
32P - Directional Power	51P - Phase Time Overcurrent
32R - Reverse Power	50/87 - Instantaneous Differential
49-Overthermal relay	51 - AC Time Overcurrent Relay
32R - Reverse Power	51N - Neutral Time Overcurrent
50 - Instantaneous Overcurrent Relay	51P - Phase Time Overcurrent
50BF - Breaker Failure	67G - Ground Directional Overcurrent
50G - Ground Instantaneous Overcurrent	67N - Neutral Directional Overcurrent
50N - Neutral Instantaneous Overcurrent	67Ns – Earth fault directional
50NBF - Neutral Instantaneous Breaker Failure	67P - Phase Directional Overcurrent
50P - Phase Instantaneous Overcurrent	79 - AC Reclosing Relay / Auto Reclose
50/51 - Instantaneous / Time-delay Overcurrent relay	87 - Differential Protective Relay
50Ns/51Ns - Sensitive earth-fault protection	87B - Bus Differential
50/87 - Instantaneous Differential	87L - Segregated Line Current Differential
51 - AC Time Overcurrent Relay	87T - Transformer Differential

Table 11: ANSI functions to be used to protect 69kV, 33kV and 11kV network

25.4 General Information and Requirements

The protection equipment provided shall be suitable to protect the electrical system in the event of the occurrence of faults such as phase faults, earth faults, busbar faults, feeder faults, breaker failure, etc. The Contractor shall ensure that the equipment offered is suitable for the application and that the relay characteristics satisfy the tripping time and load current requirements. Should relays with different characteristics or operating principles to those specified hereafter be offered, the Tenderer shall state the reason for offering such a relay as well as the advantages of the said scheme over the one specified. The price for non-numerical relays shall be entered in the price schedule total if no offer is made on the numerical relay.

The protection measuring relays shall be based on the latest generation proven numerical technology, to allow a wide range of protection, control and measurement functions, with comprehensive communication facilities for integration with the overall substation control system. The system shall have forward compatibility with future equipment for a period of at least ten years.

Each relay element shall be provided with a sufficient number of correctly rated, electrically separate normally open contacts to cater for tripping of the two trip coils in each circuit-breaker directly, making use of two separate isolated DC supplies. Relay elements shall also be fitted with sufficient, suitable contacts for interconnecting to the bay processor and for blocking functions where necessary.

The circuit-breaker tripping supplies shall be provided from duplicated 110 V battery/charger units and shall be dedicated to tripping and related relay auxiliary supplies. The tripping supply circuits shall under no circumstances be used for closing, indication, monitoring, etc.

Redundancy shall be built into the tripping circuits by means of the following features:

a) Dual tripping supplies provided from duplicated 110 V battery/charger units.

b) Dual circuit-breaker tripping coils.

c) Main and back-up protection working in different modes and powered off different instrument transformers and power supplies.

d) Trip circuit supervision with circuit-breaker opened and closed on both tripping circuits.

e) Cross-tripping from relays to both tripping circuits.

Where trip contacts on relays are not adequately rated, high-speed shunt reinforcing contacts shall be provided. However, preference shall be given to direct operating relays. The Contractor shall present calculated values of the relevant parameters of tripping and closing circuits for approval of contact ratings.

All relays where possible shall be withdrawable, with suitable protection against open circuiting of current transformer circuits, where applicable. The tripping contacts of all relays shall also be so arranged that tripping does not occur while or when a relay is being withdrawn.

Operating of a relay element shall be clearly and positively indicated on the relay by an indicating light or alpha-numeric display. The indication shall always positively identify the type of fault and where applicable the affected phase, busbar or bus-zone.

The adjustable settings on all relays shall be easily accessible, from the relay front panel, from the service aid (laptop), from the local SHMI and from the engineering network. At no time shall the relay protection functions be compromised by the downloading of new settings to the relay. Protection settings shall be completely alterable from the relay front panel, service aid (via the E-LAN), the REW and the SHMI.

Users shall be able to completely re-configure relays and protection functions via a service aid, the E-LAN and the SHMI.

Each protection relay and function shall have at least two complete setting groups which may be selected from the relay front panel, a laptop computer, the E-LAN and the SHMI. The alternative setting group shall be selected by either enering an opto-isolated input assigned to this function, or by a suitable command via the serial communication port of the relay. These inputs shall be enered from an internally generated DC source and must not be affected by induced power frequency AC signals in the wiring.

Test blocks for each separate current transformer circuit shall be provided. The test block shall have 14 sockets and 28 terminals to allow, through the insertion of a test plug, short circuiting of the CT circuits and secondary injection testing by external testing equipment, or current measurement to be made while the circuit is in service. Insertion of the multi-finger test plug shall isolate the trip contacts of the relays whilst allowing external monitoring of the trip contacts. Three multi-finger and three single-finger test plugs, complete with shorting and bridging links, shall be provided with the test blocks.

Relays and auxiliary coils specified for operation from a nominal 110 V DC substation battery supply, shall operate reliably and satisfactorily at any voltage between minimum limits 80 % to 120 % of 110 V DC, and shall be capable of withstanding the voltage level associated with boost charging of the station battery. Where relays require auxiliary power at a voltage other than 110 V DC, provision shall be made for the necessary DC to DC convertor equipment. Preference shall, however, be given to equipment operating directly from 110 V DC.

The relays shall all be of robust construction and shall have a positive action without chatter.

All relays shall be flush mounted.

The manufacturer's name, type and designation number and ordering code of each type of relay offered, together with the corresponding pamphlet or brochure reference, shall be entered by the Tenderer in the Schedule of Particulars and Guarantees. The necessary brochures with sufficient information on each device, including the explanation of the order code shall be provided.

Where applicable, the ordering code of the relay shall also be specified as an indication of the choice of options which are intended to be supplied.

Full details, including any technical literature, descriptive and illustrative publications and catalogue pamphlets of the protection scheme and equipment offered shall be included in the Tender Document.

25.5 Details Requirements for protection relays

Various protection relays are covered in the remainder of this clause and in the Particulars and Guarantees. Information about the specific protection schemes covered by this enquiry is included in the following clause and in the form of block schematic diagrams of the schemes required.

The final arrangement of the protection circuits shall be agreed with and shall be to the approval of the Engineer.

The stated requirements are the City Client's minimum requirements for the protection of the various circuits and Tenderers are at liberty to expand on the requirements detailed hereunder.

Line differential relay

Numerical based relay in accordance with the 61800 standard.

Flush mounting installation, 19" rack or panel mounted support. The relay shall compare local and remote phase and sequence currents to provide operation in less than one cycle. The relay shall operate for unbalanced faults with currents below line charging current. Mismatched CTs shall be accommodated by relay setting. Distortion caused by CT saturation of one or both ends shall not cause misoperation.

The relay shall incorporate phase, residual ground, and negative-sequence overcurrent elements. These shall have directional control available for use if potentials are available. A system to automatically select the most stable polarizing source for ground directional elements shall be included.

Trip time < 20ms.

The relay shall have options for a single or multimode fiber-optic interface. The relay shall accommodate up to 5 ms of channel asymmetry.

The relay shall operate with one or two communications channels. When two channels are used as hot standby, the relay shall switch to the unfaulted channel with no protection interruption.

The relay shall selectively coordinate with inverse-time overcurrent protection on a tapped load using total current from all line terminals.

The relay shall incorporate a four-shot single/three pole trip/autorecloser with four independently set open time intervals. Independently set reset times from reclose cycle and from lockout shall be available. Simultaneously support relay-to-relay eight bit direct logic communication.

The relay shall include six steps of frequency protection. All elements shall be settable for under- or overfrequency.

The relay shall incorporate phase and phase-to-phase under- and overvoltage combination elements as well as sequence overvoltage elements for protection and control.

The relay shall be able of automaticallyrecording oscillographic records of 15, 30, or 60 cycles containing local and remote currents, local voltages, system frequency, and dc system voltage. Events shall be stored in nonvolatile memory. The relay shall also include a Sequential Events Recorder (SER) that stores the latest 512 entries.

The relay shall include 16 status and trip target LEDs.

The relay shall include a breaker wear monitor with user-definable wear curves, operation counter, and accumulated interrupted currents per phase.

The relay shall measure and report the substation battery voltage presented to the relay power supply terminals. Two user-selectable threshold parameters shall be provided for alarm and control purposes. Voltage level at the time of tripping shall be monitored and recorded.

The relay shall include a fault locating algorithm to provide an accurate estimate of fault location without communications channels, special instrument transformers, or prefault information.

The relay shall include programmable logic functions for a wide range of user configurable protection, monitoring, and control schemes.

The relay shall include an interface port for a demodulated IRIG-B time synchronization input signal. The line current differential protection shall not rely on this or any other external time synchronization. Battery backup real-time clock, synchronized to demodulated IRJG-B input or to substation master clock.

Front and serial communication ports with communication speed from 300 to 19200 baud. Password protection for securing remote communications.

Front key for display.

Software for setting and data analysis, communication cable

Nominal rated current	1 amp or 5 amp AC
Nominal rated voltage	110 V AC
Rated frequency	50 Hz
Tripping mode	Three phase
Relay characteristic angle	To suit system and line X/R ratios
Setting range	To suit given line parameters for different primary system configurations
Insulation test voltage	2 kV for 1 minute
Impulse test voltage	5 kV surge
Tripping relay operating time	15 – 100 ms

The relay shall provide the facility for the installation of a Directional Earth Fault feature, if this is required in the future.

Transformer differential protection relay

The relay shall consist of a modern numerical, self-monitoring IED utilizing programmable scheme logic to provide independent transformer biased differential protection and over-fluxing protection. It shall offer a user-friendly interface, a display of measured steady state and fault quantities, alternative setting groups, isolated serial communication, remote setting and full interrogation by the substation control system, time tagged event/disturbance recording, plant control capability and start contacts.

The relay shall obtain its power supply from a dedicated DC Main Trip Supply circuit, and shall function independently of any control IEDs in the bay.

The relay shall be stable for all through-faults without compromising the sensitivity to in-zone faults.

The biased differential protection shall utilize six biased current inputs (two per phase) and be able to compensate internally for CT ratio and vector group mismatch.

The differential protection operation shall be blocked for normal magnetizing in-rush currents (inrush restraint), by means of either a high-speed waveform recognition technique and/or a second harmonic restraint technique.

The differential protection shall detect over-fluxing (over-excitation) of the transformer and allow for a definite time delayed alarm output as well as an inverse time delayed trip output. A 3-phase VT supply shall be obtained from the 33 kV VT's of the transformer.

The relay shall have programmable output relays, which can be allocated to the different relay functions.

The relay shall perform continuing self-monitoring. A separate output relay, that has one make and one break contact, shall be provided to indicate both healthy and relay defective conditions.

An alternative group of settings shall be provided for both the phase fault and earth fault protection functions. The alternative setting group shall be selected by either enering an opto-isolated input assigned to this function, or by a suitable command via the serial communication port of the relay. These inputs shall be enered from an internally generated DC source and must not be affected by induced power frequency AC signals in the wiring.

The relays shall provide and display the following control and measurement features:

a) Measured or derived quantities such as phase currents and zero sequence currents. When CT ratios are entered into the relay, measured quantities and settings shall be displayed in primary quantities.

b) Circuit breaker maintenance data ie. sum of the square of the fault current interrupted by the circuit breaker for each individual phase and also the number of times the relay has issued a trip command.

c) Fault records such as setting the trip LED and displaying the responsible protection function(s) and fault currents.

Time tagged event recording with a 1 ms resolution incremented every millisecond shall be provided. This data must be automatically uploaded to the SHMI as soon as the recording has been completed, and the storage facilities within the relay shall allow for first-in-first-out buffering of the event records.

Transformer HV and LV restricted earth fault protection relay- backup protection

The relay shall consist of a modern numerical, self-monitoring IED utilizing programmable scheme logic to provide independent restricted earth fault protection, separately on the 33 kV and 11 kV sides of the transformer. It shall offer a user-friendly interface, a display of measured steady state and fault quantities, alternative setting groups, isolated serial communication, remote setting and full interrogation by the substation control system, time tagged event/disturbance recording, plant control capability and start contacts.

The combined REF relay shall obtain its power supply from a dedicated DC Trip Supply circuit, and shall function independently of any control IEDs in the bay.

The relay shall be stable for all through-faults without compromising the sensitivity to in-zone faults.

The restricted earth fault (REF) protection for the HV and LV side of the transformer shall utilize six line current inputs and two neutral current inputs, one from each of the transformer neutral circuits, and shall be able to compensate internally for CT ratio mismatch. Separate trip elements shall be provided for each of the REF functions.

The relay shall have programmable output relays, which can be allocated to the different relay functions.

The relay shall perform continuing self-monitoring. A separate output relay, that has one make and one break contact, shall be provided to indicate both healthy and relay defective conditions.

An alternative group of settings shall be provided for protection functions. The alternative setting group shall be selected by either enering an opto-isolated input assigned to this function, or by a suitable command via the serial communication port of the relay. These inputs shall be enered from an internally generated DC source and must not be affected by induced power frequency AC signals in the wiring.

The relays shall provide and display the following control and measurement features:

a) Measured or derived quantities such as phase currents and zero sequence currents. When CT ratios are entered into the relay, measured quantities and settings shall be displayed in primary quantities.

b) Circuit breaker maintenance data ie. sum of the square of the fault current interrupted by the circuit breaker for each individual phase and also the number of times the relay has issued a trip command.

c) Fault records such as setting the trip LED and displaying the responsible protection function(s) and fault currents.

Time tagged event recording with a 1 ms resolution incremented every millisecond shall be provided. This data must be automatically uploaded to the SHMI as soon as the recording has been completed, and the storage facilities within the relay shall allow for first-in-first-out buffering of the event records.

Combined over-current and earth fault protection relay (Feeder protection)

The relay shall be a modern numerical, self-monitoring instrument utilizing programmable scheme logic to provide multiple, independent three-phase and earth fault protection curves. It shall offer a user-friendly interface, a display of measured steady state and fault quantities, alternative setting groups, isolated serial communication, remote setting and full interrogation by the substation control system, time tagged event and disturbance recording, plant control capability and start contacts.

Additional functions required of the combined over-current/earth fault protection

- Directional and non-directional time overcurrent protection with additional functions
- Optimization of the tripping times by direction comparison and protection data communication
- Detection of ground faults of any type
- Ground fault detection

The relay shall obtain its power supply from a dedicated DC Trip Supply circuit.

Where bay VTs are not available, an accurately derived or imaged busbar voltage shall be supplied to the relay for voltage and power measurement information.

Over-current elements shall conform to the following:

a) The relays shall contain three independent over-current stages for both phase elements ($I_{>}$, $I_{>>}$, $I_{>>>}$) and for earth fault elements $I_{o>}$, $I_{o>>}$, $I_{o>>>}$). Measurement shall be based on the Fourier derived value of the power frequency component, with harmonics up to and including the sixth suppressed.

b) The $I_{>}/I_{o>}$ elements shall operate when the power frequency component of the current exceeds the set threshold. The time/current characteristic associated with these elements must provide a selection of inverse definite minimum time (IDMT) curves, or be settable to a fixed (definite) time delay.

c) The $I_{>>}/I_{o>>}$ and $I_{>>>}/I_{o>>>}$ elements shall provide instantaneous functions that are not affected by offset waveforms, such as those occurring with power transformer inrush currents. This shall allow the instantaneous elements to be set down to 35% of the anticipated peak transformer inrush current. To a first approximation, the peak inrush is given by the reciprocal of the per unit series reactance of the transformer. These over-current stages shall also have selectable definite time settings.

The relay shall be provided with a start function (and programmable relay output) that responds to the current exceeding either the $I_{>}$ or $I_{o>}$ thresholds.

The relay shall have programmable output relays that could be allocated to the different relay over-current functions.

The relay shall perform continuing self-monitoring. A separate output relay, that has one make and one break contact, shall be provided to indicate both healthy and relay defective conditions.

An alternative group of settings shall be provided for both the phase fault and earth fault protection functions. The alternative setting group shall be selected by either enering an opto-isolated input assigned to this function, or by a suitable command via the serial communication port of the relay. These inputs shall be enered from an internally generated DC source and must not be affected by induced power frequency AC signals in the wiring.

The relays shall provide and display the following control and measurement features:

a) Measured or derived quantities such as phase currents and zero sequence currents. When CT ratios are entered into the relay, measured quantities and settings shall be displayed in primary quantities.

b) Circuit breaker maintenance data ie. sum of the square of the fault current interrupted by the circuit breaker for each individual phase and also the number of times the relay has issued a trip command.

c) Fault records such as setting the trip LED and displaying the responsible protection function(s) and fault currents.

Breaker failure protection with internal and external initiation and a programmable relay output shall be available as an integral relay feature.

Time tagged event recording with a 1ms resolution incremented every millisecond shall be provided, with access via the communication port.

Transformer voltage regulating relay panel

The voltage regulator is to be used for the automatic control of transformer motor driven on-load tap changers. The regulator shall be a modern numerical, self-monitoring instrument utilizing programmable scheme logic to provide multiple, independently programmable control features. It shall offer a user-friendly interface, a display of measured quantities, isolated serial communication, remote setting and full interrogation by the substation control system, time tagged event/disturbance recording, plant control capability and start contacts.

The relay shall obtain its power supply from a DC Control Supply circuit, and shall function independently of any other control IEDs in the bay.

The relay shall provide the following voltage regulating features:

a) The tap change controller’s regulating voltage, dead band, initial activation time delay and inter-tap time delay shall be user settable.

b) Line drop compensation shall be provided which simulates resistive and reactive components of the voltage drop across a feeder.

c) An over-current situation on any or all of the three phases shall be provided to inhibit tap changing.

d) Voltage blocking (set to 80% of the nominal voltage) shall be provided to inhibit tap change operations.

e) Should a VT failure be detected, the voltage blocking function shall inhibit tap changing.

f) Overvoltage monitoring.

g) Parallel control of 2 to 6 parallel transformers in 1 group, 2 or 3 transformers in each of 2 groups, or 2 transformers in each of 3 groups, by means of a circulating reactive current scheme.

The relay shall use signal inputs derived from the switchgear to automatically detect which transformers are operating in parallel.

The relay shall provide the following supervisory functions:

a) Tap changer position display and control from the front of the unit.

b) User-selectable automatic and manual control of the tap changer, with manual tap changing being possible from the front of the relay and remotely via the communications port.

c) Tap changing in progress shall be clearly indicated on the relay.

d) Tap changer runaway detection to detect incorrect tap changer operation, inhibit further operation and present an alarm.

The relay shall be able to provide the tap position and the transformer voltage as default displays, with preference given to the display of actual primary system voltage values on a 8-character alphanumerical LC display. The type of tap position indication transducer or method must be determined in during the detailed design stage.

The relay shall perform continuous self-monitoring. A separate output relay, that has one make and one break contact, shall be provided to indicate both healthy and relay defective conditions.

Control of the voltage regulating relay shall take place as follows:

a) If the relay is on remote and the transformer bay is switched to remote control mode, the tap position must be selectable from the SHMI or the SCADA, whichever is in control of the substation;

b) If the relay is on remote and the transformer bay is switched to local control mode, the relay must be manually controllable from the bay local position; and

c) If the relay is on auto, the tap position shall be automatically selected by the voltage regulating relay regardless of the substation and bay control mode selected.

Inter-trip send and receive facilities

Inter-tripping shall be facilitated via the digital protection channels, which form a part of the communication equipment specified elsewhere in this Enquiry document.

Provision shall be made on the terminal blocks of each panel for terminating the inter-trip circuit loops to the yard marshalling kiosk and isolator and back to the fibre optic communication equipment panel via the relay panel.

Inter-trip circuits shall be taken through isolating MCBs with auxiliary contacts for control system monitoring.

Two spare normally open contacts shall be provided on the inter-trip send relay, over and above the full relay contact requirement.

A self-resetting auxiliary inter-trip receive relay is used to cross-trip to the two trip circuits. It also provides a contact to the BYC for inter-trip receive indication.

Synchronizing check relay and busbar voltage imaging

A reflected busbar 3-phase voltage, sourced from incomer line VTs and derived from each feeder primary equipment configuration, must be bus-wired through each panel to provide the "running" busbar voltage reference for synchronizing where required.

The reflected busbar voltages must also be used for the measurement and indication on the bus- coupler, bus-section and transformer panels, or other bays where there are no VT's available.

Where required, a synchronizing-check relay is to be incorporated, so that connecting-up of two systems through the circuit-breaker may only take place whilst the voltages of the two systems are synchronized or close to synchronism. Provision shall also be made for dead-line and dead busbar charging. The relay shall measure phase angle difference and slip frequency, and shall block for differential voltage above setting.

The synchronizing-check scheme shall be designed so as to prevent the circuit-breaker from closing if the operator holds the control switch in the closed position and waits for the synchronizing-check relay to operate.

Overriding the relay synchronization check function shall be performed via a clearly marked push-button mounted on the protection and control panel.

26. Power and control cables, bus ducts

26.1 Generals

LV cables having a cross section greater than 16 mm2 are to be of XLPE cable type; LV cables of smaller size of PVC insulated type.

For cables, which are subjected to ambient temperature above 60°C, Teflon- or silicone-insulated cables must be provided.

All cables laid on the surface of walls, steel frames etc., must be protected against mechanical damage by galvanized steel tubes or robust PVC pipes. In all areas where the cable conduits can be damaged, e.g. walk-ways, only steel tubes shall be installed.

For running out power cables, heavy screw jacks and spindles shall be used. The cable has to be continuously pulled from the upper side of the drum in the same direction and runs over rollers. The rollers shall be placed into the trench at intervals of 1 m max. At corners or when pulling cables into ducts, special rollers have to be used. Sharp edges in the trenches or at the ends of the cable ducts have to be covered in such a manner that no damage of the cable occurs.

During the approval procedure, the Contractor shall provide a cable schedule listing all cables and their destination, including details with regard to number of cores, core size, cores in use and spare cores, cable length etc. for each substation.

26.2 Low voltage cables

All low voltage cables shall be in compliance with relevant IEC standards. The low voltage cables for the 400/230 V voltage level are to consist, depending on requirements, of single, two, three and four-core low voltage power cables. The minimum cross-section of low voltage power cable should be 2.5 mm^2. PVC insulated and sheathed cable, suitable for continuous operation at 70°C (max.) is to be provided, each core with one solid round copper conductor with colored insulation. The short circuit capabilities of the low voltage power cables shall be in accordance with the respective short circuit current values specified for the upstream switchgear by the break time, which should be equal the time delay of infeed protection of upstream LV switchgear.

The DC cables shall consist, depending on requirements, of single, two or four-core cables. The connections between batteries or rectifiers and the DC switchgear should generally consist of single-core power cables.

As a protective measure against excessive contact voltage, the screens of 400 / 230 V cables are to be connected to the PE-bar (protective multiple earthing).

26.3 Instrument transformer cable

In principle, an instrument transformer cable may transmit the current for different purposes (e.g. protection, measuring, metering), each voltage transformer circuit must be wired via a separate MCB to the switchgear control cabinets.

The instrument transformer cables are to be designed for an insulation voltage of Uo/U = 0.6 / 1 kV. For instrument transformer cables laid inside buildings, a minimum cross-section of 2.5 mm^2 is required; outside the buildings a minimum cross-section of 4 mm^2 is required.

Cables for control, measuring and signalization.

All control cables (including instrument, measuring and signaling cables) shall be of the stranded conductor type.

The number of cores in multi-core cables shall be selected from the following: 2, 3, 4, 7, 12, 19, 27 and 37.

For each type of cable, 10% spare capacity shall be provided.

All cables leading outside the relay rooms and/or control rooms shall have a common screen (Al foil or Cu foil). The screen shall be earthed on both ends and shall be adequate to conduct the accruing current.

26.4 Cables for lighting

The lighting cables shall be standard multi-core cables with copper conductors. The common core covering shall consist of non-hygroscopic filler.

The PVC sheath shall be oil-resistant and treated in order to prevent the cables from spreading fire and shall be colored black for external lighting and white for internal lighting.

Cables used in areas where ambient temperatures are above 60°C shall be heat-resistant. Heat-resistant cables must be suitable for continuous operation at an ambient temperature of 80°C. For this reason, the cable insulation shall consist of Teflon or silicone.

The minimum cable cross-sections and the colors of the wiring conductors shall be provided according to the Tender’s Section "General Technical Requirements".

All cabling and wiring must be possible from the front of panels/cubicles etc. The individual instrument transformer secondary circuits must be wired to the plug-in unit and switchgear cubicle terminal strip. In the case of current transformers, the necessary terminals must be equipped with short-circuit links.

26.5 Cable connection and sealing ends

All cables laid are to be prepared according to requirements and are to be connected to existing terminal strips, terminal screws, apparatus terminals etc. All cables are to be fixed to the appropriate supporting structures.

Cable sealing ends for all cables supplied under this contract shall be provided, including those for connection to outdoor gantries.

Medium voltage cables may be terminated by prefabricated plugs or stress cones.

The minimum bending radius, the maximum tensile stress rates and the cable spacing shall be taken into consideration on cable laying.

The minimum creepage distance of 2.5 kV/ cm shall be considered for cable sealing ends in case of indoor and outdoor terminations/cable connection hood (based on system maximum voltage phase to earth).

The bidder shall provide all material for proper mounting and earthing of the sealing ends as well as the fastening of the cables, if necessary.

Any cable jointing sleeves, which may be required, must also be made of plastic. Sleeves for cable branch T-joints are to be avoided under all circumstances.

Straight through joints shall be of the heat shrinkable type.

The cable terminations and sleeves used must be made of synthetic material resistant to burning and must contain the necessary additives for reducing flammability.

The cables must always be fixed at the sealing ends to cable supports, which are to be provided by means of corrosion resistant and anti-magnetic cable clamps.

26.6 Cable trays

Separate cable trays and cable risers are to be provided for the cables listed below:

- Power cables above 1000 V;
- Power cables below 1000 V;
- DC power cables;
- Instrument transformer cables;
- Control, measuring and signaling cables above 60 V.

All cable tray T-junctions, crossovers, incoming and outgoing branches, bends etc. must consist of prefabricated tray elements to ensure that crushing of a cable at the transition points is reliably avoided.

The space between the individual cable trays and risers must be large enough to ensure that the power, instrument transformer, control, measuring and signaling cables as well as cables of the communication systems do not cause mutual interference.

Power and control cables shall be laid segregated.

27. Control, Indicating, Synchronizing, Metering and Relay Panels and Ancillary Apparatus

27.1 General

The panels shall be supplied complete with the equipment specified herein including; terminal blocks, wiring and other miscellaneous devices as indicated or required. The equipment shall include all required auxiliary current and voltage transformers, auxiliary relays, protective devices, fuses and resistors, whether or not they are explicitly specified. All instruments, relays, circuit breakers, coils, contacts and similar features shall be suitable for the apparatus controlled or the purpose intended.

The Contractor shall locate and arrange terminal blocks so that external cable connections can be made in neat and proper fashion.

27.2 General Construction

Control, synchronizing, metering and relay panels shall be of the free standing self-contained metal enclosed type and shall be made of specially selected smooth and robust sheet steel panels of not less than 2.5 mm thick unless otherwise approved. Panels shall be bolted at the bottom to suitable steel channel sills to be supplied as part of this Contract. Suitable grouting and anchor bolt holes shall be provided in the channel sills. Panels shall be reinforced where necessary to prevent distortion or the mal-operation of relays or other apparatus by impact, having regard to the number and size of cut- outs and the size of the panel.

Cubicles shall be drip-proof, dust-proof and vermin proof. Equipment shall be arranged to give reasonable access to all components mounted on the panel front and inside. To assist in achieving this, cubicle widths shall not be less than 600 mm wide and the depth shall not exceed the width. The width between apparatus mounted on the cubicle side shall not be less than that which will permit full and easy access to all terminals and to apparatus mounted on the panels. Panel size shall be 80 cm wide, 220 cm high; 5 cm from sides, 10 cm from top and 40 cm from bottom shall be left free.

All screws and bolts used shall be provided with lock washers or other locking devices. To prevent warping of panels, all heavy devices shall be adequately supported by means of brackets or straps.

The panels, trim, doors and frames shall match, and shall present a neat appearance when assembled as a control board, which shall, as far as is practicable, be the standard manufacture of the Contractor and shall be suitable for extension by the simple addition of further units of panels.

Each panel shall have a hinged door with fully concealed hinges to allow the door to swing through not less than 105 degrees from the closed position. Some form of restraining devices shall be provided to limit the swing and prevent damage to hinges and equipment. Each door shall be supplied with a lock and removable keys. All locks shall be keyed alike and two keys per lock shall be provided.

Rear access cubicle doors shall be hinged to lie back flat to avoid restricting access. Hinges shall be of the lift-off type. Doors shall be secured by integral handles and provision shall be made for padlocking. A set of padlocks shall be provided for each suite of panels. Barrel locks incorporated in the door handle are not acceptable. Each cubicle door shall be closed by a handle that operates on 3-point closing device (e.g. Espagnolette type).

Handles and padlocks shall not be more than 1.5 meters above floor level. Top and bottom doors shall not be interlocked and cross stiffeners shall not impede access to the cubicle. Molded gaskets of non-ageing materials shall be used to provide close sealing.

A lamp shall be fitted inside each cubicle and so arranged that all wiring be illuminated as evenly as possible without dazzle. The lamps shall be controlled from a door limit switch.

Heaters shall be provided in panels operated from a control switch and thermostat. Circuit labels shall be provided on the front and back of the panels and on the outside of cubicle doors.

The arrangement of equipment and the design of the control shall be such that adequate space is provided for inspection and maintenance of wiring, terminals and equipment. The front of the panels shall accommodate flush mounted instruments, control and position indicating switches, annunciator and mimic bus, all arranged neatly and symmetrically. The inside of the panels shall accommodate terminal blocks, plastic cable ducts and any other devices as required. Principal apparatus shall be flush mounted on the front of the cubicle.

All exterior surfaces shall be free from holes, seam, dents, weld marks, loose scale and other imperfections. All ferrous metal surfaces of the control board shall be cleaned, or given an equivalent preparation, after all welding is completed and then lately primed with a surface and primed suitable for use as an undercoat for the finish. Both the exterior and interior surfaces shall be semi-gloss finished with not less than two coats of lacquer or enamel of appropriate shade and color and similar to the finish given to existing cubicles.

27.3 Control Panels

One control cubicle may accommodate apparatus associated to one primary circuit. The construction of the panels shall be as per sub - clause 4.7.2. Each cubicle shall be provided with a front door. The door shall consist of a full length and width translucent (glass-plate) window contained in a steel frame. The door shall be closed by a handle that operates on a 3-point closing device (e.g. Espagnolette type) and provision shall be made for padlocking as specified for rear doors.

Control cubicle must include all necessary control devices:

- Bay controller Unit (local and remote control) via the station control system and remotely from remote engineering workstation at Fond Cole,
- Ethernet switches (FO, Cat6), any other necessary communication device
- All necessary sockets for testing, terminals, MCBs, wiring, heating resistor, thermostat, door open contact,...
- Synoptic with necessary TPL for equipment control
- All necessary signalizations lamps, switches selectors, pushbuttons, TPL, ... on the front side of the panel

27.4 Relay Panels

Separate cubicles must be provided for the protection relays associated with one primary circuit (bay). Equipment shall be mounted on the swing-out frame of the panel/cubicles. Each cubicle shall be provided with a front door. The door shall consist of a full length and width translucent (glass-plate) window contained in a steel frame. The door shall be closed by a handle that operates on a 3-point closing device (e.g. Espagnolette type) and provision shall be made for padlocking as specified for rear doors.

Protection cubicle must include all necessary protection devices:

- All protection relays (local and remote configuration) via the station control system and remotely from remote engineering workstation at Fond Cole,
- Ethernet switches (FO, Cat6), any other necessary communication device
- All necessary sockets for testing, terminals, MCBs, wiring, heating resistor, thermostat, door open contact,...
- All necessary signalizations lamps, switches selectors,... on the front side of the panel

27.5 Metering Panel

The contractor should supply a separate energy meter cubicle that regroups all bays metering devices and should be able to include more apparatus for future extension

27.6 Substation Central Unit Panel

The contractor should supply a separate cubicle for station computers (Servers) with a keyboard and a display, two main switches of the IEC 61850 loop, GPS synchronization module and any other equipment related to local SCMS system. Only operator workstations and printers will be installed on the desk.

27.7 Common Alarm Panel

Separate cubicle must be provided for common control and - according to the Scope of Work. The panels shall contain the common alarm system of the plant mainly the RTU which collects (from equipment not able to be connected directly to the IEC61850 loop) all signalizations and alarms, especially the following information:

- AC and DC systems: alarms, MCB positions, rectifier chargers signals, supply sources availability and permutation,
- WatchDog of all BCUs and protection relays of installed bays and feeders,
- All bells, common lamp test button, alarm-reset button, horn reset button, etc.
- Any other equipment/information (to be specified during study phase)

All equipment in the panel shall be flash mounted. The cubicle's door shall be closed by a handle that operate on 3-point closing devices and provision shall be made for padlocking as specified for rear door.

27.8 Control and Selector Switches

All control and instrument switches shall be of the rotary control board type with operating knobs on the front and operating contact mechanisms on the rear of the panels. Each switch shall be provided with ample contact stages and suitable arrangements to perform the functions of the control system. Contacts of all control and instrument switches shall be self- aligning and shall operate with a wiping action. A positive means of maintaining high pressure on closed contacts shall be provided.

The covers or plates on the switches shall be readily removable for inspection of the contacts. All control and instrument switches shall be suitable for operation on 500 volts AC or 110 volts DC circuits. All such switches shall be capable of satisfactorily withstanding a life test of at least 20,000 operations with rated current flowing in the switch contacts.

All control and instrument switches shall be capable of continuously carrying 20A without exceeding a temperature rise of 30 ºC and shall be capable of interrupting inductive leads of not less than 4A for 110V d-c or A.C.

All switches shall be located at a convenient operating height and so constructed, mounted and wired to facilitate the maintenance of contacts without the need to disconnect wiring. Switches shall have locks incorporated in the design. Control switches must be lockable in the inactive or neutral position and selector switches in all positions.

Each control and instrument switch shall be provided with an escutcheon clearly marked to show each operating position. The switch identification shall be engraved on the escutcheon or on the separate nameplates. Labels shall clearly indicate all positions and function of each switch.

a) Control Switches

Control switches shall be of either the handle type or, where specified, discrepancy type and shall be arranged to operate clockwise when closing the circuit devices and anticlockwise when opening. Discrepancy type switches shall be arranged so that two discrete movements are required to effect operation, i.e. from either the dressed to open or dressed to close position the switch must be pushed to permit rotation to the operate positions.

Handle type switches shall be so designed that when released by the operator the handle and mechanism shall return automatically to the centered neutral position and interrupt the supply of current to the operating mechanism of the circuit device. Discrepancy switches when released from the operate position shall return automatically to the associated dressed position. They shall have a black square mounting base and a black operating knob with a luminous strip, back lit by a built-in pilot lamp.

When locked it shall not be possible to move discrepancy switches to the operate positions, they shall be free to move to either of the dressed positions.

Discrepancy switches shall not be lit when dressed to the same position as the primary device but shall show a flashing light when switch and device are in disagreement. The switch shall show a flashing light during the period that the controlled device takes to move fully from one position to the other.

Operating knobs shall be in line with the mimic diagrams to indicate a closed circuit breaker or disconnector and at right angles to the mimic diagram to indicate an open circuit breaker or disconnector. Discrepancy of positions between operating knob and circuit breaker or disconnector shall be indicated by the luminous strip being lit by a flashing light provided by the built in pilot lamp, where agreements of positions shall be indicated by no light. Circuit breaker or disconnector closing shall be done by aligning the operating knob in line with the mimic diagram, pushing it in and turning it a certain angle to the right. Circuit breaker or disconnector opening shall be done by aligning the operating knob at a right angle to the mimic diagram, pushing it in and turning it a certain angle to the left.

The switches shall be provided with the necessary momentary contacts for circuit breaker operation and other contacts as required for lamp circuits, interlocking, remote annunciation, etc.

They shall be two pole switched for make and single pole switched for break operations.

A lamp test facility shall be provided in association with any discrepancy switch.

All control switches shall have additional labelling giving the reference identification of the primary device.

b) Selector Switches

Selector switches shall have spade type handles.

Instrument and selector switches shall be of the maintained contact type with the required number of positions. Instrument switches shall have round notched or knurled black oval handles.

Where key operated switches are specified, these shall be operated by inserting and n turning the key to the required position. The key shall be removable in the 'off' position only. All key switches for a particular voltage level at a substation shall have a common lock change number such that with one key available only one switch can be in an operated position at any one time.

c) Discrepancy Position Indicators

Discrepancy position indicators shall be similar to the discrepancy control switches except that there is no control circuit involved and that the mounting bases shall be round rather than square. The contacts shall be of the maintained contact type.

d) Push-buttons

Push-buttons shall be of the flush panel mounted, heavy duty type, rated 500 V with contacts rated 20 A continuous, interrupting capacity at 110 VDC shall not be less than

4 A. Number and type of contacts shall be as required by the switching functions.

The lamp tests button shall be installed in the common control panel or on one of the control panels.

e) AC Ammeters and Voltmeters

Digital ammeters and voltmeters shall be furnished for AC distribution panels or elsewhere it is needed.

f) D.C. Ammeters and Voltmeters

D.C ammeters shall be furnished with suitable shunts and shunt-leads. D.C voltmeters shall be self-contained type with scales as specified.

g) Energy Meters

All energy meters shall be fitted with appropriate communication interfaces i.e. V.24 X 21, serial and Ethernet for remote access and SCADA.

The energy meters shall be electronic/numerical polyphase type. The energy meter shall have metering and data processing system with fully hardware and software for meter configuration programming, data collection and data processing. The energy meter shall also measure and display system frequency, power factor, active and reactive energies import/export, apparent energy, time, date, maximum demand values, etc.

The detailed specifications are Class ± 0.2% and class ±0.5% for reactive

The energy metering equipment shall be precision grade for the purpose of:

Measuring and processing of active and reactive energy in both import and export directions, apparent energy calculation and provide a summation feature for operational information.

At least three (3) separate maximum demand indicators with an excess demand function and choice of integration period.

Meters shall be of the 3-element, 3-phase, 4-wire type, also for single-phase connection, suitable for unbalanced loading and adapted to the voltage and current transformers associated with them.

Measuring circuits shall be self-contained. The power supply shall be self contained or rated as per the available station DC voltage supply. Internal circuits should remain unaffected for any kind of vibration.

Registers shall be direct numerical reading with the appropriate number of digits.

The energy meters shall have IEC standard communication protocol. With respect to communication, particular emphasis shall be placed on high levels of flexibility, data integrity and utilization of standard common in energy automation. The design of the communication modules on the energy meters shall have automatic communication facilities including remote reading. Shall have also serial interface for parameter settings/programming. The front panel of the energy meter shall have soft touch keys or push buttons to scroll the parameters and programming.

The energy meters shall be capable to measure, store and display the active and reactive energy values in forward and in reverse directions. The reactive energy value for inductive and capacitive.

All integrating meters shall comply with the following limits of accuracy:

- **Conditions of Test**

Current expressed as a percentage of the marked current	**Power Factor**	**Precision grade for Meters**
125% to 20% inclusive	± 0.2%	±2.0%
Below 20% downto 10% inclusive	± 0.2%	±2.0%
Below 10% downto 5% inclusive	± 0.2%	±2.0%
125% to 20% inclusive	±0.5%	±2.0%
Below 20% downto 10% inclusive	±0.5%	±2.0%

The energy meter shall store the data in non-volatile memory and shall retain the data even during power failure for at least 96 hours

The energy meters at the specified substations shall be of accuracy Class of ±0.2% for active and class ±0.5%for reactive.

The energy meters shall start and measure all the parameters with the minimum current of less than 1% of the nominal current.

The energy meters shall be flush mounted type.

The energy meters to be supplied shall comply with guaranteed technical particulars as indicated in Annex A2-31.

h) Indicating Lamps

All indicating lamps and lamp holder assemblies shall be suitable for continuous operation at the maximum Site ambient temperature. The lamps shall be overrated to prevent frequent failure at the operating voltage. They shall preferably be designed for operation at 65 volts dc with integrally mounted resistors for connection at 110 volts D.C. lamps.

The circuits for positions indication on the panels of control boards shall be arranged so that all lamps are simultaneously steady-lit by general switches, mounted as specified.

Indicating lamps and lamp holders shall be arranged so that replacement of lamps and the cleaning of glasses and reflectors employed can be readily effected from the front of panel. With both facials and indicators all special tools to aid the changing of bulbs, lens or inscription masks shall be provided in duplicate quantity at each substation.

To reduce heating and fouling of the panels, lamps, which are continuously illuminated, shall have the minimum consumption consistent with good visibility of indications in a brightly-lit room. Wherever a lamp is mounted on a panel a lamp test push button shall be fitted. Indicating lamp glasses on control and relay panels shall conform to the following standard color code:

Color of Glass	**Indication**
Red	Device closed
Green	Device open
White	Indications normally alight
Amber	Alarm indication (on which action is necessary)
Blue	Circuit earthed

i) Synchronizing Apparatus

In each circuit equipped with an electrically operated circuit-breaker connections between the control switch and the closing coil of the circuit-breaker shall be made through a synchronizing selection arrangement, so that it is impossible to close the circuit-breaker until the appropriate synchronizing selection arrangement is made.

A switch shall be provided with the synchronoscope to enable it to be disconnected and the voltmeters left in circuit. It shall be possible to activate auto synchronizing mode from the NCC and locally at the control panel.

The connections of regulating voltmeters shall be arranged so that they are connected in circuit by means of the synchronizing selection arrangement of any panel equipped with synchronizing voltage transformers.

Where busbar voltage transformers are not provided, an automatic voltage selection scheme shall be provided to derive a busbar voltage reference from the circuit voltage transformers. The direct paralleling of voltage transformer secondary is not permitted.

Care must be taken with the design of the scheme to ensure that "Islanding" does not occur.

The scheme shall employ isolating transformers across red and yellow phases with the secondary yellow phase earthed. All synchronizing equipment shall be 110 volts.

Synchronizing check relays shall not operate when one synchronizing voltage or any auxiliary supply is absent or due to transient conditions when being switched in. Synchronizing relays shall be programmable for various switching conditions i.e. dead bus dead line, live line dead bus, live bus dead line and live bus live line.

A voltage check feature shall be incorporated to inhibit synchronizing if either voltage is less or more than a preset value, which shall be adjustable in steps from 80% to 100% of nominal rated voltage. It shall be possible to program a blocking phase angle difference in the synchronizing relay and the range of phase angle shall lie between 0-45 degrees.

The synchronizing relay shall prevent closure when the phase difference exceeds 35°, but alternative settings of 20° and 45° shall be available also. Closure shall be prevented also if the slip exceeds a setting, which shall be adjustable over the approximate range 0.25% - 0.1%. Means shall be included to prevent against synchronizing in the event of the control switch being closed prematurely and to guard against the possibility of the check contact being welded.

For remote control of circuits other than generators an override relay shall be provided to permit closing under condition as may be set in the synchronizing relay.

The no-voltage relays shall form the dead line or dead bus checking arrangements and shall comprise the following:-

Each circuit shall be provided with a remote controllable synchronizing selection switch to enable MANUAL- OFF-CHECK positions to be selected. This switch shall be key operated locally, the key being released in the OFF position only. In both the MANUAL and CHECK position the synchronizing instruments shall be connected to the appropriate voltage transformers and the circuit breaker closing circuit prepared. This switch shall operate for both remote and supervisory control modes only.

When specified a system synchronizing facility shall be provided in place of the check synchronizing system above. In this the synchronizing circuitry shall seal in after close command from either remote or supervisory position and shall arrange to close the circuit breaker when the two systems are within suitable synchronism.

The system synchronizer shall reset either after closure of the circuit or after a time lapse, which shall be adjustable between 1 and 20 minutes. A 'system synchronizer operating' indication shall be given when system is energized and, at the expiry of the timed period, a fail to synchronize indication shall be given if closure has not been achieved.

27.9 Relays, Fuses, Links and Ancillary Apparatus

All relays shall be mounted in such positions that no part requiring inspection or adjustment is less than 450 mm or more than 2 meters above floor level. Where practicable the clearances between relay stems or connecting studs shall not be less than 30 mm and in no case less than 25 mm.

Unless otherwise stated all relays for front of panel mounting shall be flush pattern and withdrawable. Current circuits shall be automatically shorted when the relay is withdrawn

The use of permanently energized relays is not acceptable.

Relays associated with the three phases shall be marked with the appropriate phase identification and the fuses and links shall also be suitably labelled. In addition to the labelling to identify relays on the front of panels, all relays and components shall be identified from the rear of the panels.

MCBs with two (2) NC auxiliary contacts and fuses of approved type shall be provided on each panel to facilitate the isolation of all sources of electrical potential to permit testing or other work on the panel without danger to personnel or interference with similar circuits on other panels. Carriers and bases shall be of molded plastic material colored white for links and black for fuses. Fuse carriers shall be clearly marked with the correct fuse rating.

MCBs associated with tripping supplies shall be located within the cubicle.

Trip and inter-trip isolating links shall be provided in series with all tripping relay contacts; these links shall be mounted at the front of the relay panels so as to be accessible during relay testing.

Other fuses and links shall be accommodated either within the cubicle or at the rear above the cubicle doors.

All shall be grouped and spaced according to their function in order to facilitate identification with distinct segregation between main and back-up protections.

Spare MCBs of at least 50% of each type and size shall be provided and delivered to the Employer.

All current transformer circuits shall be equipped with appropriate shorting and isolating links. They shall be of the bolted type. The material used shall be phosphor bronze or stainless steel. It shall be possible to safely short and isolate current transformers under load conditions.

All incoming circuits in which the voltage equals or exceeds 125 volts shall be fed through insulated MCBs, the supplies being connected to the bottom terminal

27.10 Earthing Arrangements

All control and relay panels shall have a continuous earth bar of a sectional area of not less than 5x30 mm run along the bottom of the panels with provisions each end to be connected to the main earthing system at the back of the panel. All joints shall be tinned. Metal cases of instruments and metal bases of relays on the panels shall be connected to this bar by copper conductors of a sectional area of not less than 2.5 mm2. The earth bar shall be bolted to the frame of each panel in such a way as to make a good electrical contact with the panel - Provisions shall be made for connection, by cable lugs, of the control panel earth to the station earthing system.

Current transformer and voltage transformer secondary circuits shall be complete in them and shall be earthed at one point only, through links situated in an accessible position. Each separate circuit shall be earthed through a separate link, suitably labelled. The links shall be of the bolted type, having M6 nuts and provision for attaching test leads.

The earth links for protective and instrument current transformer secondary circuits shall be mounted inside the relay panels. Earth links for metering current transformer secondary circuits shall be mounted at the switchgear.

For voltage transformers consisting of single-phase units, separate earth links for each secondary winding shall be provided and shall be situated at the voltage transformer. For other voltage transformers the earth links shall be mounted inside the relay panels.

27.11 Cable Termination

For the reception of external cables removable gland plates shall be provided. All cables shall enter vertically from below and at their point of entry to the equipment they shall be sealed by fitted boards. These shall be of an approved, non-flammable, insulating, and vermin proof material. Cable glands and conduits shall project at least 20 mm above the gland plate to prevent any moisture on the plate draining into cable crutches or conduits. Means shall be provided to drain water off the surface of the gland plate.

Separate gland plates shall be provided for each circuit plate with glands suitable for PVC/PVC/SWA/PVC cable.

27.12 Testing Facilities

Testing facilities for secondary injection of current transformers, metering and protective relay systems shall be provided on each panel/cubicles. These facilities shall be such that testing can be carried out without disconnection of any permanent wiring. If these facilities are provided as part of draw-out type relays any test plug appropriate to the design shall be provided.

27.13 Tests

The following routine tests shall be carried out:

- Mechanical test: each board panel shall be checked for alignment of panels and devices for rigidity of structure and for accuracy of fastenings and supports;

- Dimensional verification:- each panel shall be checked for its accuracy in dimensions, specially the width, holes, coupling studs for attaching other panels, door tightness, etc.;
- Test to ensure the required degree of protection in accordance with IEC 529:1976;
- General examination;
- Operational tests.

27.14 Criteria for the Acceptance of Relay Panels

The negative result of a type test, if considered by the Employer’s Representative as essential for reliable operation of relay panel, may involve rejection of the panel. The Employer’s Representative will accept the repetition of the test if the Contractor proposes to modify the panel within a reasonable period of time and to repeat at his own expense, all type tests.

All routine tests shall have a positive result within the tolerances allowed, when applicable. If the negative result of a test is prejudicial to the operation of the device, each unsound device shall be replaced or repaired at the full expense of the Contractor.

27.15 Drawings, Circuit Schematics, Wiring Diagrams

The Contractor shall submit all drawings, circuit schematics and wiring diagrams for approval during study phase.

28. Additional Equipment, Spare Parts and Tools

The scope of supply includes tools, wear and tear parts, and spare parts for 5 years' operation. For another five years the supply with function compatible spare parts must be ensured.

For each relay type with the same protection functions / configurations shall have one (1) unit as spare parts. 10 % are to be provided of the supplies of each aux. relay, electronic cards, lamps, measuring instruments; however at least one piece.

Supplier has to provide for the Employer the necessary tools to carry out repair and maintenance work at the devices supplied. The list of the tools has to be mutually agreed between the Contractor and the Employer.

Beside the two sets of the usual electrical and fitter tools, it is necessary to also provide special tools for the devices and switchboards supplied.

28.1 Spare Parts

SPARE-PARTS FOR 69kV GIS

Item	Description	Quantity
1	Complete Sum of CB	1
2	Complete Sum of CB gasket	2
3	Operating mechanism for CB	1
4	Motor for driving CB	1
5	Sum of closing and tripping coils	1
6	Complete Sum of Disconnector	1
7	Complete Sum of earthing switch	1
8	Complete Sum of DS Gasket	2
9	Operating mechanism for Disconnector	1
10	Operating mechanism for earthing switch	1
11	Motor for driving Disconnector	1
12	Motor for driving earthing switch	1
13	Current transformer (1nos) for each ratio	1
14	Complete Sum of CT Gasket	2
15	Voltage transformer	1
16	Complete Sum of VT Gasket	2

SPARE-PARTS FOR POWER TRANSFORMER- 69/11kV

Item	Description	Quantity
1	HV air-bushing (phase and neutral), each type	1
2	11kV insulators (mounted inside cable box)	1
3	Set of contactors for tap changer driving mechanism	1
4	Set of relays for tap changer driving mechanism	1
5	Set of auxiliary relays for tap changer driving mechanism	1
6	Oil level Indicator for main tank	1
7	Oil level Indicator for OLTC	1
8	Cooling fan complete	1
9	Oil temperature indicator with probe	1
10	Winding temperature indicator with probe	1
11	Set of OLTC contacts	1
12	Set of OLTC transition resistors	1
13	MCB of each type and rating installed	1
14	Buchholz relay	1
15	Tap changer pressure relay	1
16	Set of gaskets of each type and size used in the transformer	1
17	Valve of each type and size installed in the transformer	1
18	Counter for OLTC operations	1
19	Silica gel Breather	1

SPARE-PARTS FOR POWER TRANSFORMERS- 33/11kV

Item	Description	Quantity
1	33kV insulators (mounted inside cable box) (phase and neutral), each type	1
2	11kV insulators (mounted inside cable box)	1
3	Set of contactors for tap changer driving mechanism	1
4	Set of relays for tap changer driving mechanism	1
5	Set of auxiliary relays for tap changer driving mechanism	1
6	Oil level Indicator for main tank	1
7	Oil level Indicator for OLTC	1

8	Cooling fan complete	1
9	Oil temperature indicator with probe	1
10	Winding temperature indicator with probe	1
11	Set of OLTC contacts	1
12	Set of OLTC transition resistors	1
13	MCB of each type and rating installed	1
14	Buchholz relay	1
15	Tap changer pressure relay	1
16	Set of gaskets of each type and size used in the transformer	1
17	Valve of each type and size installed in the transformer	1
18	Counter for OLTC operations	1
19	Silica gel Breather	1

SPARE-PARTS FOR POWER TRANSFORMERS- 2.2/33kV

Item	Description	Quantity
1	33kV insulators (mounted inside cable box)	1
2	2.2kV insulators (mounted inside cable box)	1
3	Oil level Indicator for main tank	1
4	Cooling fan complete	1
5	Oil temperature indicator with probe	1
6	Winding temperature indicator with probe	1
7	MCB of each type and rating installed	1
8	Buchholz relay	1
9	Set of gaskets of each type and size used in the transformer	1
10	Valve of each type and size installed in the transformer	1
11	Silica gel Breather	1

SPARE-PARTS FOR OUTDOOR EUIPMENT – 69kV

Item	Description	Quantity
1	69kV composite cable termination with integrated surge arrester	3

SPARE-PARTS FOR AC-DC EUIPMENT		
Item	**Description**	**Quantity**
1	110 VDC battery element	3
2	48 VDC battery element	3
3	Spare parts for 110 VDC Rectifier	1
4	Spare parts for 48 VDC Rectifier	1

SPARE-PARTS FOR SCMS		
Item	**Description**	**Quantity**
1	Station computer (Server)	1
2	Operator/engineering station including software	1
3	Main ethernet switch	1
4	Line differential protection relay	1
5	Cable differential protection relay	1
6	Transformer differential protection relay	1
7	Busbar Differential protection relay	1
8	Voltage regulator relay	1
9	Bay Control Unit	1
10	RTU	1

SPARE-PARTS FOR MV SWITCHGEAR – 33kV		
Item	**Description**	**Quantity**
1	MCB Miniature Circuit Breakers, each	3
2	Pushbuttons, each	3
3	Signaling Lamps, each	3
4	Auxiliary Relays & Socket - Set, each	3
5	Capacitive Voltage Indicator, each	3
6	Circuit Breaker, each	1
7	C.B. coil and motor set, each	3

8	C.B. blocking coil set, each	3
9	Female (fixed) contact for circuit breaker, each	3
10	Current Transformers (CT's),each	3
11	Voltage Transformers (VT's), each	3
12	Earthing Switch complete set, each	3
13	Insulation Tubes set for busbar (T-boot)	3
14	Hydraulic Lifting Trolley for Circuit Breaker	1

SPARE-PARTS FOR MV SWITCHGEAR – 11kV

Item	Description	Quantity
1	MCB Miniature Circuit Breakers, each	3
2	Pushbuttons, each	3
3	Signaling Lamps, each	3
4	Auxiliary Relays & Socket - Set, each	3
5	Capacitive Voltage Indicator, each	3
6	Circuit Breaker, each	1
7	C.B. coil and motor set, each	3
8	C.B. blocking coil set, each	3
9	Female (fixed) contact for circuit breaker, each	3
10	Current Transformers (CT's),each	3
11	Voltage Transformers (VT's), each	3
12	Earthing Switch complete set, each	3
13	Insulation Tubes set for busbar (T-boot)	3
14	Hydraulic Lifting Trolley for Circuit Breaker	1

NB: All mandatory and recommended spare parts will be listed in the price schedules.

28.2 Special Tools Specifications

SF6 leak detector

- Sensitivity : adjustable, maximum 14g / yr(0.49oz/Yr).
- Alarm mode : Sound, light.
- Operating Temperature & Humidity : 0°C ~ 50°C with 90%RH.
- Power Supply : 1.5V AAA battery.

Mobile SF6 Evacuating and refiling cylinder cart

- Operating voltage: 220 - 240 V / 50 - 60 Hz alternating current
- Weighing range: 0 - 125 kg with tare function / accuracy: ± 25g
- Weight indication
- Power supply: internal battery (12 V / 2.5 Ah) with battery charger / running time in continuous operation up to 20 hours or 220VAC
- Protection class: IP65
- Operating temperature: -10 to +40 °C
- Vacuum pump for air (16 m3/h [at 50 Hz]), final vacuum < 1 mbar
- Ball valve with hand wheel
- Gauge 0 to -1,200 mbar
- Two >4 m long wire-braided hoses DN8
- Coupling tongue parts DN8 and DN20
- SF 6 bottle connection W 21.8 x 1/14"
- Pressure reducer for SF6 (0 up to 10 bar), indication in bar / psi / kPa
- Electrical connecting cable min 3 m
- Operating manual

Portable SF6 Gas Analyzer

- No gas emissions
- Modular interchangeability of the sensors
- Flow rate: 20 L/h (SF)
- Measuring time: variably calculated by the system, max. 9 minutes
- Operating temperature: 14 °F to 122 °F (-10 °C to +50 °C)
- Measuring parameters with only one sample:
    - SF6 volume percentage (%), measuring range 0-100 vol%, Accuracy +- 0,5 vol%
    - Moisture concentration, measuring range -60 to +20°C, Accuracy +- 2°C
    - SO2 concentration (ppm), measuring range 0-100ppm, Accuracy <+- 2% of measuring range
- Battery operated and/or external power supply 220VAC
- Number of measured values to be stored: max. 500
- Interface: USB/LAN
- Weight: <40 kg

Tools for Electrician

Toolbox containing the following:

- Combination Pliers (225mm, 165mm),
- Diagonal Cutting Pliers (210mm, 165mm)
- Long Nose Pliers (205mm, 165mm)
- Cable Shear 38mm²
- Wire Stripper 160mm
- Tape Measure 5m
- Adjustable Spanner 200mm
- Junior Hacksaw 150mm
- CROCODILE CLIP, electrical, 1 line, black, 4 mm, with screw
- TAPE, insulating, plastic, 19mm wide, black, roll
- LAMP, FRONTAL, head band, use 2 AA/LR6 batteries
- RIVETING GUN, + 450 rivets, d. 4 to 4.8mm, thick 1.3 to 13mm
- SOLDERING GUN, 220V, 200W
- HAMMER, nail claw, carpenter type, 200g, steel + plast. hand
- KNIFE, for electrician, with wire stripper, total L.185 mm
- PLIER, combination, 1000V insulated, 185mm length
- PLIER, strip, with elbow blade nose, for wire 0.5 to 6mm2

- PLIER, strip, 1000V insulated, 0.8 to 6mm2, adjust. Screw
- SCREWDRIVER, 1000V, flat head, 1.5mm x 35mm blade, 2.5mm x 75mm blade, 3mm x 75mm blade, 3.5x75mm blade, 5.5x100mm blade, 6.5mm x 150mm blade, 8mm x 200mm blade, 10mm x 250mm blade,
- SCREWDRIVER, TESTER, 110-250V, with clip
- SCREWDRIVER, 1000V, Phillips head n.00 x 35mm blade, n.00 x 75mm blade, n.0 x 75mm blade
- Crimping hydraulic tool for MV cables from 25mm² to 630mm²
- Crimping hydraulic tool for LV cables from 0,5mm² to 16mm²
- Digital CLAMPMETER: Clip-on type; cap up to 300 A and 500 V capacity complete with test leads and case, AC/DC. [UNI-T or Equivalent]
- DIGITAL MULTIMETER: Ac/dc volt measure 10-1000v continuity test current and ohm measure
- SOLDERING IRON
- PORTABLE ELECTRIC DRILL MACHINE: Double insulated; capacity 8 mm; with chuck & key and cable; suitable for an electric supply of 220 V, A.C., Single phase, 50Hz [Lacela or Equivalent]
- Allen Key Set: Made from high grade alloy steel 9pcs Ball Point End Key Set
- Size Stardand-Long- Extra Long, Function: For Torx Screw And Nuts
- ELECTRICIAN KNIFE: steel blade; 120 mm long Stainless-steel blade construction for extra strength and durability, Strong back spring holds blade in position

Tools for Mechanic (Complete Sum of keys corresponding to the nuts and bolts of the transformer and other equipment in the substation)

Toolbox containing the following:

- HAMMER, nail claw, carpenter type, 800g, steel + plast. Hand
- Combination Pliers (225mm, 165mm),
- Diagonal Cutting Pliers (210mm, 165mm)
- Long Nose Pliers (205mm, 165mm)
- ADJUSTABLE WRENCH: 6” and 10” long standard model with 150 angle, span upto 24 mm length upto 200mm
- SOCKET SET: Metric, chrome plated Socket Set with Spark Plug Tool, comprising sockets from 3mm to 32 mm with steel box.
- SCREW DRIVERS SET: Flat & Phillips with insulated, and split-proof metal tipped/hammer able handle with varying blade length up to 6”
- Open Ended Spanners set: Insulated open end spanners: 6 x 7 mm, 8 x 9 mm, 10 x 11 mm, 12 x 13 mm, 14 x 15 mm, 16 x 17mm, 18 x 19mm, 20 x 22 mm, 21 x 23mm, 24 x 27mm, 25 x 28 mm, 30 x 32 mm
- Chrome vanadium material body, entirely hardened and tempered
- Portable electric drill machine: 1000w, 220V, with chuck and key
- Allen Key Set:Made from high grade alloy steel, 9pcs Ball Point End Key Set, Size Stardand-Long- Extra Long, Function: For Torx Screw and Nuts
- Punching Tool

Infrared thermometer (-20°C to 700°C)

- Temperature range: -20°C to 700°C
- Accuracy: +-1,5°C
- Field of view: 12:1
- Resolution: 0,1°C
- Response time: 500ms
- Spectral response: 8-14µm
- Emissivity adjustable: 0.1 to 1
- Power: 9V battery

29. Testing and Commissioning

The Contractor shall carry out the site/field tests as per the Specifications and the approved program which may be adjusted, when so directed by the Employer, according to the actual conditions prevailing on site. They include:

Tests and Checks prior to Pre-commissioning

In the course of erection of each item of the equipment all test will be done as per chapter Inspection & Testing and other equipment specific chapters. Note that erection, testing and commissioning shall be done in the presence of the equipment manufactures. The cost for the same shall be included in the supply of the equipment.

Substation Inspection and Punch List compilation

On completion of the works, a final inspection of the substation will be conducted in the presence of the Employer, Consultant and the Contractor. On this occasion the equipment, structures, towers, gantries, buildings will be inspected and the presence of such items as name plates/labels, the earthing point clamping devices, etc. will be verified. The Employer's Project Manager in liaison with the consultant will prepare a list of minor defects and omissions (Punch list) will be issued to the Contractor to begin repairs immediately after receiving the same. (GCC 24.4 and 24.5).

Notification of Pre-Commissioning Tests

Upon successful completion of final inspection of the line, the Contractor shall, in accordance with sub-clause 24.1 and 24.2 of the Contract, notify the Employer that the works are ready for Pre-Commissioning and the Pre-Commissioning Tests will then take place.

Pre-Commissioning Tests

a) Documentation

No later than 14 days prior to the commencement of the Pre-Commissioning tests, The Contractor shall provide to the Employer (as per GCC 24):

- Tools, appliances and spare materials required for maintenance of the transmission line as detailed in technical specifications.
- All outstanding drawings and documentation to be provided under the Contract
- The Operating and Maintenance.

b) Operation and Maintenance Manuals

The Contractor shall provide:

- Operation & maintenance manuals for the equipment and auxiliary systems supplied (for Substation Lot).
- Health & safety manual.
- Environmental and social management manual.
- Training manual.
- Maintenance plan/schedule for recommended (preventive) maintenance.
- Spare parts list (incl. ordering and delivery specific information) and storage plan.

c) Equipment Operation and Maintenance Manuals

The operation and maintenance manuals shall contain the following:

- Safety instructions.
- Manufacturer's contact information.
- Component and material descriptions.
- Outline and assembly drawings.
- Connection and wiring diagrams (for Substation Lot).
- Installation (assembly) instructions.

- Operation instructions.
- Maintenance instructions.
- Maintenance schedule.
- Troubleshooting instructions.
- Spare parts list.
- List of tools and consumables.

The Contractor shall include other necessary information to maintain the equipment on a regular basis, exchange components, handle trouble shooting, contact Manufacturer's service personnel etc.
The maintenance instructions shall be divided into sections describing in detail the preventive maintenance and the trouble shooting procedures (instructions and recommendations).

d) Time Schedule

The Contractor shall prepare and submit the Time Schedule which shall be developed and maintained using the standard scheduling tool/software of Microsoft Project.
The Project Schedule shall be divided into the following Project specific main tasks and milestones:

- Contract milestones
- Scheduled payment milestones
- Design & engineering
- Manufacturing & testing
- Transportation
- Training
- Permitting
- Construction/civil works
- Installation
- Checks after erection
- Pre-commissioning
- Commissioning
- Trial operation.

Updates, analysis and forecasts shall be included in the Monthly Progress Report and shall be performed in relation to the Base Line Schedule which will be discussed during the kick-off meeting.
The updated schedule shall show the base line (time schedule frozen) and the actual scheduled tasks in one document.
Submission of documents as outlined in the Document Schedule shall be in accordance with the Time Schedule.
The Contractor shall take note and shall be prepared to coordinate his Time Schedule with the Contractor of other Lots as far as necessary and to the degree requested by the Employer/Engineer.
It is the entire responsibility of the Contractor to plan and coordinate the necessary commissioning activities and requirements as early as possible to avoid any delays and influences on its own Time Schedule and the schedule of other Contractors.
This topic will be further discussed during the kick-off meeting.

30. CCTV Camera Surveillance System in Substations

30.1 General

The specification covers design, supply, installation, testing and commissioning of the complete CCTV surveillance system including cameras, Network video recorder, mounting arrangement for cameras, cables

etc. for effective visual monitoring of total substation premises.
The number of CCTV cameras and their locations shall be decided to monitor at least:

- All of the Transformers including switchyard area.
- Key areas of control room building, switchgear building, fire-fighting pump house, Substation main gate, gates of switchyard, corridors etc.

The cameras can be mounted on structures, buildings or any other suitable arrangement to be provided by the contractor and agreed by the Employer.

30.2 Technical Requirements

The system shall use video signals from various types of indoor/outdoor CCTV color cameras installed at different locations, process them for viewing on workstation/monitors in the control room and simultaneously record all the cameras after compression to better standards and streamed over the IP network. Mouse-keyboard controllers shall be used for Pan, Tilt, Zoom and other functions of desired cameras. The system shall provide sufficient storage of all the camera recordings for a period of 30 days or more at @25 fps or better quality using necessary compression techniques. It shall be ensured that data once recorded shall not be altered by any means. The recording resolution and frame rate for each camera shall be user programmable. The provision for transfer of recorded data to separate external media shall be ensured.
The surveillance CCTV System shall operate on AC 230V, 50 Hz single-phase power supply.

30.3 System Requirements

a) All camera recordings shall have Camera ID & Location/area of recording as well as date/time stamp. Camera ID, Location/Area of recording & date/time shall be programmable by the system administrator with user ID and Password.
b) System to have facility of additional camera installation beyond the original planned capacity
c) System should provide facility of simultaneous recording, playback and network operation.
d) System shall have provision for remote monitoring
e) The offered system shall have facility to export the desired portion of clipping (from a desired date/time to another desired date/time) on external media. Viewing of this recording shall be possible on standard PC using standard software like windows media player, VLC etc.
f) Housing of cameras meant for indoor use shall be of IP 66 or better rating whereas outdoor camera housing shall be of IP 66 or better rating.
The equipment should generally conform to electromagnetic compatibility requirements for outdoor equipment in extra high voltage switchyards.

30.4 Video Surveillance Application Software

a) Digital video surveillance control software should be capable of display and manage the entire surveillance system. It should be capable of supporting variety of devices such as cameras, video encoder, Servers, NAS boxers/Raid backup device etc.
b) Surveillance control software should be compatible with MS Windows operating system.
c) The software should have inbuilt facility to store configuration of encoders and cameras.
d) The software should be able to control all cameras i.e., PTZ control, Iris control, auto/manual focus, and color balance of cameras, selection of presets, Video tour selection etc.
e) The system shall provide user activity log with user ID, time stamp, action performed, etc.
f) The software for clients should also be working on browser-based system for remote users. This will allow

any authorized user to display the video of any desired camera on the monitor with full PZ and associated controls.

31. Detailed Requirements for Civil Works

31.1 General:

The works related to the project will be executed on a turnkey basis, supply, and installation.

Therefore, the works shall include, without being limited to, calculations, design, manufacture, assembly, supply, customs clearance, delivery, unloading, installation, adjusting, painting, identification, commissioning, acceptance, and testing of new equipment to be installed, complete in every respect and suitable for satisfactory operation.

This section details the main items to be provided and the works to be carried out by the contractor under this contract.

However, the Contractor is required to ascertain whether any additional works are necessary so as to render the plant in accordance with the requirements of the contract.

Any additional equipment, or works, not specified but intrinsically required for the proper operation of the plant, are deemed to be included.

Any quantities which may be set out shall be considered as minimum estimated quantities.

From the commencement date up to the signing of the provisional take-over certificate, the Contractor shall - at his own expense - secure the equipment and materials as well as protect them against damages, weathering, removal, or destruction.

Soil investigations shall be carried out at all stations in order to determine the bearing capacity of the soil and the ground-water table.

Chemical analyses shall be carried out for the soil and the groundwater if encountered to identify the degree of aggression to the concrete.

If the soil- and/or the groundwater investigation shows an unacceptable degree of aggression special measures like increased concrete cover, application of protective membrane or special concrete resisting to chemical aggression shall be uses. A report proposing the adequate measures has to be submitted to the Employer prior the start any activity.

Structural calculation for dimensioning of all construction elements shall be carried out by the contractor.

The chosen substations' levels must avoid any future risk of flooding.

The switchgear to be installed in each new substation of the project is directly related to the corresponding available area and the dedicated budget.

Three 69 kV switchgear types can be defined:

AIS (Air Insulated Switchgear) → requires a large installation area, so it was not applicable to any substation due to the constraints on the substation locations.

GIS (Gas Insulated Switchgear) → requires a high budget but allows for a smaller installation area; it was only used in the Fond Cole substation, due to the very limited space available at the site.

N.B.: The Metal Enclosed Switchgear (MES) was used in all substations for the 33 kV and/or 11 kV switchgears.

As mentioned before whatever switchgear type that was chosen, the bottom level of the required foundations as well as the foundation type will mostly depend on the soil investigation's results.

The chosen substation levels must avoid any future risk of flooding. Thus, the Contractor will be responsible in addition for installing a drainage system all around and inside the substations that must be connected to the nearest existing rainwater drainage system to avoid all these possible risks.

The contractor will be responsible then to ensure an adequate site installation, for each substation, that will be detailed below.

Then during the execution phase, the contractor will be responsible of the following operations without being limited to: excavation, lowering water level if it exists, formwork, reinforcement, concrete pouring, backfilling, compaction, levelling operations, etc....

It shall be the Contractor's obligation to construct fences and shelters, lighting, security services, and all relevant measures to fulfil these duties.

For all substation’s building, the thermal performance level must be sufficient to avoid as much as possible the air conditioning installation and to reduce significantly the electricity consumption from inside.

In addition, the buildings must be robust and must not require maintenance of their outer envelope and their roof, for a period of at least 30 years, from their date of commissioning.

The scope of this contract described in the above sections and elsewhere in the tender documents shall cover all supplies and services required to meet the purpose of the plant, safe, reliable, and contractual intended use of the facilities, even if these are not expressly mentioned in detail in the subsequent sections.

All work not expressly called for in this Specification, but necessary for the complete and proper installation and operation of the equipment and accessories at the discretion of the Engineer shall be performed and provided by the Contractor at no additional cost to the Employer.

Any terminal points which are not specified/included in Bid Specification, but required for safe and reliable operation of the plant shall be deemed to be included in the scope of works and the Contractor shall carry out such terminal connection works at no extra cost to the Employer.

All preparatory works for terminal point connections, such as drawings, shall be under the directives of the Employer/ Engineer.

Supply of necessary equipment, clean-up, etc. will be the Contractor’s responsibility.

The Employer should not be required to utilize its resources for such work.

The requirements detailed in the following paragraphs shall be read in conjunction with the detailed technical specifications and technical schedules.

All temporary works and equipment, necessary to keep the substation in operation during the execution of the works, are included in the scope of supply and services.

The Contractor will be wholly responsible for ensuring that all materials used in the work and temporary works comply with the approved standards and that all processes of workmanship are carried out with a high degree of efficiency, in accordance with an approved program, and in compliance with the contract requirements.

In case discrepancies occur between the items of the scope of supply and services stated hereby and the ones derived from the respective drawings and in case certain items of the scope of supply are identified hereby but not in the respective drawings or vice versa, the Contractor is requested to interpret the project requirements by considering this document and all its parts in conjunction and collectively.

The same principle applies to the price schedules.

The most stringent requirements shall apply in case of deviations.

The itemized relevant unit prices in the BOQ price schedules shall include all costs of all supply and services, which are needed for the functional plant, but not exclusively mentioned elsewhere in the specification

If a contradiction has occurred between the general and the particular parts of the specifications, the particular requirements shall be taken into account.

In case of indoor switchgears, the substations roofs will be in reinforced concrete, designed and installed so as to minimize maintenance over the design life of the substation. It will be surrounded by parapets.

Guttering and downpipes must be external and must be UV protected PVC. Internal guttering on roofs is not permitted.

The walls will include lintels, for doors, and windows.

All surfaces must be of a suitable durable finish so as to minimize maintenance over the design life of the substation.

All building floors must be in reinforced concrete and must be of suitable surface finish for the movement, installation and maintenance of the various electrical equipment.

Reinforced concrete columns must be placed in accordance with the approved plans.

Vertical edges will be chamfered 15 x 15 mm.

In case of GIS substations, the building dimensions must be sufficient to allow easy equipment installation:

The height of the basement must be sufficient for cables placement with respect to the minimum radius of curvature.

The height between the crane's hook and the ground must be sufficient for the dismantling and the displacement of one of the compartments without the total dismantling of the GIS in case of maintenance

The capacity of the overhead crane must be sufficient for lifting the largest GIS compartment.

The GIS must be at least 2 m away from the 4 walls surrounding it.

For all the outdoor steel structures, in an AIS substation, they shall be hot dip galvanized.

So, the purpose of this section is to define the technical specifications to be performed by the Contractor regarding the new substations (Fond Cole, Trafalgar and Padu) and the existing power station of Laudat.

31.2 Civil Work Material

For all building materials the corresponding test certificates have to be provided.

All necessary performance tests have to be arranged on time and have to be submitted for approval.

Performance tests have to be carried out for each type of concrete. The exclusively valid criterion is the concrete pressure resistance after 28 days.

31.3 Concrete

Concrete Characteristics:

The Contractor must choose the concrete composition for which he is responsible.

The Contractor should submit the concrete formulation and the results of his studies to the Project Owner for approval.

It is not authorized to pour concrete before the complete validation of the concrete composition studies and the test results.

The concrete formulation must meet the requirements of these specifications and must present the best workability according to the climatic conditions and the structure type to be carried out.

Three types of concrete can be distinguished:

1. **Lean concrete** that will not be subjected to resistance testing.
2. **Concrete for all underground structures** like foundations.
3. **Concrete for upper-ground structures.**

The concrete resistance will be at least **C25 Mpa**.

The Contractor is responsible for choosing the relative exposure class, and he must take into account the results of his geotechnical studies, in particular the aggressiveness of the soil, the possible presence of corrosive agents, and the presence of water table.

Concrete Component:

Aggregate:

Aggregates must comply with the BS EN 12620 standard.

The contractor must choose the relative granulometric classes, in order to obtain a concrete granulometry that respect perfectly the art rules.

The used of river sand is authorized if it respects the chloride classes and required resistance, otherwise, the contractor should use crushed sand.

The sand equivalent test will be at least equal to 80% for the reinforced concrete structures, and 65% for the foundations.

The different categories of aggregates, mainly sands, will be stored separately protected from atmospheric precipitation and infiltration.

In addition, the water content should be controlled permanently.

Provisions must be made so that during concreting operations, which can last 24 hours, the water content in the sands, must not vary by more than 0.5%, with respect to the sand's weight.

The stocked quantities must be sufficient for at least 10 days of concreting production.

The sands must be stored in an area protected by a roof, on a concrete slab sufficiently inclined to facilitate the drainage.

Protection against alkali reaction:

Preferably, the used aggregates must be classified as non-reactive.

If it was necessary, aggregates classified as potentially alkaline reactive could be used.

In this case, the Contractor must provide the alkaline percentages in each component of the concrete to the Project Owner.

All measurements of the alkaline content for these various components should be carried out by a specialized laboratory and must take into account the variability of these percentages.

Cement:

The used cement will comply with the standard BS EN 197-1.

The contractor shall submit for the Project Owner's approval, the proposed hydraulic binder datasheets.

The contractor should provide the Project Owner with the results of the tests carried out by the cement manufacturer.

The Customer has the right to carry out other tests in an independent laboratory.

If these tests' results were in accordance with the specifications, they will be the responsibility of the project owner, and if not, they will be the responsibility of the Contractor.

The contractor should provide samples and laboratory tests to the project owner.

The contractor must carry out a statistical control of the weight of the cement bags, at the request of the Client.

Water:

The used water in the concrete mixing must comply with the standard BS EN 1008.

The Project owner reserves the right to periodically check the quality of the used water.

The water must be clean and free of all substances that can affect the concrete quality.

Additives:

The concrete of the superstructures as well as the concrete of the foundations allows the use of an additive (plasticizer) that will be added to the concrete mix to make high-concrete strength.

The Contractor must include the cost of using these admixtures in the concrete prices.

If any used additive was not included in the concrete formulation studies, it will be a subject of a written request from the Contractor and authorization from the project owner.

The use of chlorides, particularly as accelerators, is prohibited.

The admixtures should preferably be adapted to standard BS EN 934-2.

Ready Mixed Concrete:

The use of ready-mixed concrete plants is preferred and will be subject to the approval of the Project Owner.

The various points to be met are:

1. The maximum allowable concrete transportation time must be limited to 1h 30 minutes under normal temperature conditions.
2. The ready-mixed concrete should meet the composition of the concrete proposed by the Contractor, and should be approved by the project owner
3. All the certificates that prove the plant's conformity should be available and should meet the requirements of this specification
4. The quality of materials (aggregates, water, cement, etc.), as well as their storage (cleanliness, separation, protection of materials against rain, sun, etc.), should be inspected by the Contractor and the Project Owner before the approval of the ready mixed concrete plant.

The use of retarding admixtures and plasticizers in concrete may be tolerated after the contractor's justification of their use, and the approval of the Project Owner.

In all cases, the Contractor should submit, a detailed proposed concrete production, with the technical data sheets and the reports of the last carried out calibrations on the ready mixed concrete plant possibly selected

On-site Mixed Concrete:

In general, the on-site concrete production is not authorized.

If there is no ready-mix concrete plant or if the installed one does not meet the above criteria, in particular in terms of time transportation, the exceptional use of concretes mixed on the site may be subjected to the approval of the project owner.

In all cases, the use of mixed concretes on site will be limited only to locations subjected to the problem. The concerned area must be clearly identified.

Recommendations:

As mentioned before, it is recommended to use the Ready mixed concrete, but if it was not possible the On-site Mixed concrete can be used after the approbation of the project owner.

All necessary equipment used to secure the continuity of concreting operations must be provided by the Contractor.

Aggregates must be stored relatively to their types, in a sloping area.

The water content of the aggregates should be controlled and corrected permanently.

The Project owner reserves the right to control the quality of the materials and reserves the right to request any additional tests that he considers necessary.

The contractor must evacuate immediately from the site all kinds of refused materials, with a material tracking note specifying clearly the relative approved destination.

Concrete batching tolerance

The concrete compositional weight tolerances are defined as follow:

1. +/- 5% for each category of aggregates,
2. +/- 1% for water
3. +/- 1% for cement

N.B.: Random samples may be taken at the request of the Client.

Validation of the formulation of Ready mixed concrete:

The concrete composition and formulation, proposed by the Contractor, must be validated after passing the tests detailed below.

These tests are to be carried out by the Contractor under his responsibility and at his expense, in all the power stations of the project.

It is not authorized to pour concrete on-site before the final validation of the concrete composition and formulation that should be submitted for approval.

The contractor should carry out the tests as indicated in standard NF P18-404 or equivalent, that concern a total of nine batches for each type of concrete.

1. 3 batches should be prepared according to the nominal concrete formula
2. 2 mixes derive from the nominal formula by modifying the ratio (weight of sand/total weight of aggregates) by +10% for one and -10% for the other,
3. 2 mixes derive from the nominal formula by modifying the quantity of cement by +25 kg/m3 for one and -25 kg/m3 for the other,
4. 2 mixes derive from the nominal formula by modifying the quantity of water by +5% for one and -5% for the other.

The justification of the compatibility between the transport time and the implementation if the plant is far from the site, will be necessary.

For samples preparation, the molds must be provided by the Contractor.

When making the samples, it is advisable to obtain a tightness as similar as possible to that achieved during the structure construction.

The contractor will be responsible for batch’s volume.

Validation of the formulation of on-site mixed concrete:

The functional requirements of site-mixed concrete should be the same as those of ready-mixed concrete.

The concrete composition and formulation are subject to the same validation procedure described for ready-mixed concrete.

It is not authorized to pour concrete on-site before the final validation of the concrete composition and formulation that should be submitted for approval.

31.4 Tests and Quality Control

The concrete composition shall be determined on base of the results gained from a performance test executed by an authorized laboratory by consent with the local site management

If a ready-mixed concrete plant is used, the Contractor shall make available to the Client all the relative concrete delivery notes, that contain all the information required accordingly to the standard BS EN 206 1.

For the foundations and superstructure's concrete, the required tests per batch are as follows:

1. Consistency test (according to standard BS EN 12350-2)
2. Compressive strength according to standards BS EN 12390-1 to BS EN 12390-3: (3 samples for the 7-day tests, 3 samples for compression tests at 28 days)
3. A test to determine the density,

The contractor should carry out the tests accordingly to the standard BS 8500-1 or equivalent.

The considered resistance will be the arithmetic mean of the obtained results.

The contractor takes per casting day:

1. 3 samples for the 7-day tests and 3 samples for the 28-day tests for any poured volume less than 50m3
2. 3 samples for the 7-day tests and 3 specimens for the 28-day tests for each additional 50m3 poured on the same day

31.5 Covered-up works and covered-up work reports

Construction works for building over ground structures shall start only after arrangement of the underground structures, soil backfilling in pits cavities, trenches and site layout.

Covered-up works are subject to inspection with issue of covered-up work reports.

The Contractor shall prepare the reports on:

1. Connection of ground wires to the general earthing circuit and grounding devices in full scope (to confirm that they are in the ground);
2. Compliance with the technology of layer-by-layer soil compaction when constructing foundations, and technology of implementing groundwater paving using fat batter clay with width of not less than 1 m at the bases of towers;
3. Verification of conformance of soils to design data;
4. Acceptance of foundations, including geodesic verification of their compliance with the actual position (in plan and height);
5. Performance of welding works;

6. Corrosion protection of metals;
7. Acceptance of assembled structures.

31.6 Execution / Application of Concrete

Unset concrete must be completely set by mechanical vibrators; the concrete has to be brought-in layer-wise according to the vibrators' efficiency.

31.7 Steel Reinforcement:

The reinforcements must comply with ASTM/ACI standards or equivalent.

The Contractor should submit for project owner approval the dimensional, mechanical, and compositional characteristics of the proposed steel reinforcements.

Used reinforcements must systematically have a provenance sheet and a relative certification.

The reinforcements shaping is authorized only in the Contractor's workrooms located in his site installation.

Rebar welding is prohibited.

The bars must not show any deformation, staining, or other defects.

Accidentally deformed bars will be treated.

The contractor stores the reinforcements as follows:

1. In the site installation area
2. With a systematic cleaning of storage areas
3. The reinforcements should not be in contact with the ground and moisture

If the steels are delivered assembled in cages, these must be transported with care to the places of use so that no element undergoes permanent deformation.

31.8 Sealing product:

This section concerns the supply, at the Contractor's expense, of the sealing product for fixing equipment parts supplied by the selected manufacturers for this project.

The used sealing must be a specific shrinkage-compensated product, such as Sikagrout® 212 Sealing, Sikagrout® 131 CeraCem® from SIKA, or Masterflow® 830DC from BASF® or equivalent.

This product should be submitted for project owner's approval.

31.9 Formworks

The Contractor shall submit for Project Owner approval:

1. Formwork wood,
2. Scaffolding
3. accessories

The contractor is responsible for his choice, and should guarantee smooth concrete surfaces without any type of deformation.

The shoring of the concrete structure must be carried out with rigid elements in order to eliminate all kinds of deformation risks during concrete pouring operations.

The Contractor shall submit the proposed formwork system to the Project Owner for approval.

The use of a fixation system with twisted or parallel wires passing through the concrete is prohibited.

31.10 Concrete Cover

The thickness of covering concrete above the reinforcement steel must not be less than 5 cm.

31.11 Anchor Bolts

Where cable channels include cable trays, they are to be fastened at hot-dip galvanized (layer > 50 µm) concrete-imbedded anchor bolts. The anchor bolts shall be provided with a rust-proof coat before they are imbedded into the concrete. Min. 2 cm concrete must be between reinforcement and galvanized anchor bolts; no metal joining is allowed.

31.12 Cable Entries

Cable entries at buildings shall lead through 100 % water tight bushings.

31.13 Backfilling:

The Contractor is required to prove in an approved laboratory that the backfill materials comply with the requirements set out in this chapter.

The Backfill should not contain any sources of invasive alien plant species.

The contractor must be responsible for all the carried-out tests

If a non-compliance take place, the Project Owner have the right to require any other additional tests, at the Contractor's expense that he deems necessary.

The bottom of all excavated areas shall be trimmed, levelled and well rammed to achieve at least 98%

Compaction.

The bottom level of excavations shall be inspected and approved by the Engineer before pouring operations.

Backfill materials can be extracted from the excavated soil, but if the relative materials do not satisfy the previous clauses cannot under any circumstances be reused as backfill.

31.14 Civil Technical requirements:

Site survey:

Before the commencement of the works the Contractor shall survey the site to establish the ground levels over the substation area plus 5.00m minimum along its outer sides.

The site survey plan shall be prepared showing the survey results, the levels of all roads or existing buildings nearby the site, and the proposed layout of the new works.

Temporary access and measures:

The Contractor shall provide a temporary graded access road to the sites for the construction and maintenance operations, with all the necessary temporary required measures for the protection of the existing buildings, facilities, and services.

Services:

The Contractor shall be responsible for the provision of electricity, water, drainage, and all other necessary services for the execution of the works.

Concerning the existing services encountered during the works shall be left in position and carefully supported and guarded against damage, in order that it may remain in full use until the completion of the Works.

It is the responsibility of the Contractor to obtain from the concerned authorities the records of any existing services.

Damage charges shall be paid by the Contractor in accordance with the local regulations.

Site records:

The Contractor shall keep in the site accurate and up to date records and drawings of the Works.

The Engineer shall be supplied with copies of these records.

Soil Investigations:

The Contractor carries out the all-necessary studies and investigations for the dimensioning of all the civil engineering works for which he is responsible.

The Topographical studies must include:

1. The definition of the various existing buried networks, by using Lidar Technology or other that must be proposed for approval.
2. The representation of all these networks with the proposed routings on the working plans
3. The ground surveys
4. Etc.

During the geotechnical studies, the Contractor will perform electrical and thermal resistivity measurements as well as soil temperature measurements.

The carried-out investigation reports, are appended to this document and are given for information only.

The Contractor is responsible for clearly indicating throughout his studies the following points:

1. Altimetry, slopes, embankments, and supports,
2. Cut and fill, type of filler materials and volumes,
3. Soil treatment,
4. Design and methodology of work according to seasonality,
5. Other dimensioning points.

In addition, he is responsible to make a hydrological study (runoff, drainage, stormwater treatment, outlets), and hydrogeological study (impacts related to aquifers, infiltration of discharges, etc.), for each site.

In case of a new substation or a substation extension, the Contractor is responsible for studying the landscaping, that concerns both the surroundings and the interior of the substation.

Landscaping includes:

1. The flora,
2. Fences,
3. Access and gates,
4. Graveled surfaces,
5. The surfaces reserved for future developments for example,
6. Etc

The Contractor should carry out detailed studies concerning the rainwater collection and drainage structures, runoff water treatment (offset pits, hydrocarbon separators, settling basins, storm rain control, and discharge devices, infiltration, lifting stations, containment devices, manholes and control structures, interception ditches for external watersheds, etc.).

All these structures are designed taking into account future extensions and in particular, future waterproofed surfaces.

The Contractor shall take into account the impact of the works on the existing drainage system, and he should study the connection to the existing sanitation system after verification of its conformity or, if necessary, to the public network.

In all substations, the Contractor should put minimum 1 testing points under each transformer, 1 under the control building, and 1 in the switchyard limits, with full testing according to the above list.

31.15 Substation Building Requirement

Protection against small animals:

Measures must be taken to avoid damages caused by the presence of small animals.

These measures include an appropriate choice of materials and provisions to prevent the access of these animals to the buildings while ensuring satisfactory ventilation of the various locals.

The ducts must be closed, after the cable's passage.

The used products must meet the following requirements:

1. The sealing device must be made of materials offering proven resistance (mechanical and/or chemical) to rodent attacks.
2. The closing device must be hermetic and not allow any passage of more than 5 mm in diameter.
3. The closure device must allow subsequent interventions, in particular, the addition, replacement, or removal of any electrical cables.
4. The sealing device must be made of rot-proof materials.

5. The closing device must offer a sufficient thermal resistance

6. The sealing device must be made of non-flammable materials

7. The sealing device must not cause a life reduction of the electrical cables.

8. The used products must not be harmful to human health and the environment.

The following materials are prohibited:

1. Cement (does not allow complete sealing of the interstices between the cables).

2. Plaster (not permanently resistant to rodent attacks).

3. Polyurethane foam (not permanently resistant to rodent attacks).

4. Materials containing Crystalline Silica.

5. Anti-insect screens should be installed on the ventilation grids to prevent any insect penetration. It must be rot-proof and must resist rodent attacks with a mesh size ≤ 2.5 mm² (plastic mesh is prohibited).

6. When a passage opening of more than 5 mm exists at the level of the door frames, it is necessary to put in place a lasting solution to reduce the gaps.

Reactions and resistance to fire:

In terms of fire resistance and fire reactions, the main elements of the superstructure (frames, walls, partitions, doors, ceilings, gratings, etc.) are classified as follow according to "Euro classes"

For fire resistance:

• REI 90 minimum for all building walls except for the GIS.

• REI 90 minimum for doors

• REI 120 minimum for GIS buildings

For fire reaction, A2 fl-s1, for floors (equivalence M0 for the concrete slab), and A2-s1-d1 for the remaining construction products, which refer to a limited combustibility.

Building Roof:

The roofs will consist of a solid reinforced concrete slab with parapets.

A metal coping will be fixed on the parapets, without piercing It.

These aluminum or other metal copings, installed on the upper part of the parapet, will prevent water infiltration into the concrete and will also protect the masonry against bad weather defects.

A minimum slope of 1% will be provided.

The roof must ensure perfect waterproofing and effective thermal protection of the building. It will consist of 2 layers with SBS along with a protection.

The roof should be only accessible for maintenance visits.

A galvanized steel crinoline ladder that allows access to the roof must be installed.

Raised Floor:

The raised access floor system shall be with removable load-bearing panels 600 x 600 mm minimum

supported on adjustable pedestals and stringers, with a minimal thickness of 0.5 m.

Pedestals and stringers shall be of galvanized steel and shall permit Snap-On connection and lateral locking of the ends of stringers.

Panels shall be interchangeable and relocatable.

Thick aluminum foils on the bottom side and finished on top with antistatic vinyl.

The system shall not excessively move when subjected to pedestrian and light-wheeled traffic.

The minimum required fire resistance class = M0 non-inflammable

False Ceiling:

Removable false ceiling 60*60 cm type can be used in the various substations.

The ceiling must have a correct finish appearance, covered by a smooth painting surface:

1. If the cables were visible, they must be placed in cable trays,
2. The partitions must reach the ceiling height,
3. The assembly of roof elements must not present any risk for the maintenance work under the roof.

It will be characterized by the following:

1. Exposed structures must be of galvanized steel profiles.
2. They are arranged in parallel rows every 60 cm and will be suspended under the reinforced concrete slabs by an appropriate hanger fixed to the support.
3. They will receive perpendicularly every 60 cm a spacer of the same type.
4. The whole will form a square module.
5. The ceiling tile should have an MO fire classification.

N.B.: The minimum required height between false ceiling and raised floor will be 3.5 m

Exterior walls:

The exterior walls will consist of 2 walls layer having a minimum thickness of 15 cm each and 5 cm in between to ensure thermal insulation.

The exterior walls' faces must be smooth, and waterproof.

For the walls of hollow concrete block, the Contractor shall justify the position of the horizontal and vertical stiffeners, with a maximum spacing of 3 m.

A large surface sample must be provided before the painting operations begins.

Interior partitions:

Internal walls should be made of hollow blocks both sides plastered and painted, 20 cm thick minimum with horizontal and vertical stiffeners every 3 m maximum. Additionally, RC lintels will be incorporated into the walls to support doors and windows.

Skirting boards

Internal hardwood skirting shall be made from clear, properly seasoned hardwood and the face in direct contact with plastered wall shall be painted with two coats of approved preservative before fixing.

The skirting shall be 100mm high and 20mm thick and the outer edge is to be rounded.

Skirting shall be fixed to the wall by plugs and brass screws and varnished to the approval of the Engineer.

Outside skirtings shall be made of the same type as the floor finish or painted plaster must be subjected to the Engineer approval.

Carpentry and Joinery

Doors

Doors must:

1. Allow materials handling
2. Be fireproof 2 h minimum,
3. Be of one or two leaves with 0.70 mm steel facings
4. Open outwards
5. Equipped with an anti-panic bar
6. Have a thermal transmittance ud ≤ 2 w/m²k

Locks accessories should be of good quality and resistant to site conditions.

A sample of all fittings should be subject to the principal's approval.

Each lock should have a different key from the other, supplied in 2 copies.

A pass allowing to open all the doors will be provided in 2 copies.

All the doors of the air-conditioned rooms are equipped with an automatic "door closer".

The exterior doors shall be carried out as escape door, which can be opened from the inside at any time (even if locked from outside).

All doors shall be fire resistant with a 0.9 m minimum in width, except those of the WC and shower room that can be 0.7 m in width minimum and can be of wooden material.

Unless otherwise specified, all locks should benefit from anti-corrosion protection by the hot-dip galvanizing process, where the minimum thickness should be 95 microns.

No retouching on site will be carried out by cold galvanizing.

The GIS and HTA premises will be equipped with at least 2 opposite doors:

1. 1 door for equipment access. It can be with an opening leaf or a rolling shutter depending on the specificity of the project.

The dimensions depend on the equipment size (HTA, GIS).

1 door for “emergency exit” access with an opening leaf, fitted with an exterior handle and an anti-panic bar from inside.

The minimum passage dimensions are 0.90m wide and 2.20m high.

External ventilation grilles:

Manufacture and installation of hot-dip galvanized steel ventilation grilles, lacquered.

These grilles will be sized in such a way as to ensure the minimum airflows.

The Contractor is then responsible for submitting a detailed relative calculation note.

The ventilation grilles integrated into the exterior carpentry should include hot-dip galvanized steel, and insect-proof grilles.

Windows:

The windows will be metal frames with painted double glazing, reflecting solar radiation, or glass bricks.

The layout of the buildings must be made so that the control room and the break room are equipped with windows and give priority to outside light.

The dimensions of the carpentry are given as an indication, the dimensions will be taken on-site before any start of manufacture, according to the contractor provided layout.

The special technical clauses will specify the minimal need.

Tiles:

*Sealed tiling 40*40:*

Fine porcelain tiles of 40*40, 8 mm thick, laid on a mortar bath, with a smooth appearance.

It will not be placed in rooms receiving a raised floor.

*Anti-acid tile 20*20:*

Ceramic tiles of 20*20, 8 mm thick, resistant to battery acid, laid on a bath of mortar, with a smooth appearance, or equivalent can be used in battery rooms.

The anti-acid Tiling on the floor must also cover the walls to a minimum height of 1.50m.

*Straight plinths 20*10:*

Around the locals, there will be a supply of matching skirting boards for flooring, with dimensions of 20*10 cm, the joints will be perfectly aligned with the ground.

*Straight antacid skirting boards 20*10:*

Supply and installation of matching skirting boards for flooring dimensions 20*10 cm, the joints will be also perfectly aligned with the floor.

Shower tray base:

A cement base all around the shower trays will be installed by the plumber.

Floor drain:

Supply and installation of stainless-steel bell siphon, with 90 mm of diameter.

Wallcovering 20*20:

Supply of porcelain tiles to match the floor covering, 20*20 cm and 20*10 cm, laid with adhesive mortar against walls and partitions over the entire height.

Brush mat:

Supply and installation of brush mats and foot scraper grids including:

2. Reservation in tiling with smoothed screed at the bottom
3. Stainless steel frame to seal, exact dimensions corresponding to the layout of the floor covering.

Sealing:

Sealing of the GIS Local:

In the GIS building, it must be ensured that heavy gases will not escape and pollute the atmosphere of other locals.

So, it will be necessary to ensure an effective sealing that separates the GIS room and the basement, subjected to SF6 releases, from the other adjoining rooms or galleries.

Sealing of basements against water infiltrations:

Basements must not show water infiltration.

Cable entries at buildings shall lead through 100 % water tight bushings.

All cable entry points shall be equipped with water- and fireproof wall bushings of the type Hauff or equivalent (fire proof sealed form inside and waterproof from outside).

If there is a risk, we can proceed to the basement tanking.

The sealing at the level of cable arrivals must be ensured. If necessary, rubber sealing can be used for the crossing of concrete walls.

Surfaces' cleaning and painting:

The Contractor shall submit the name of the proposed paint supplier and applicator, for approval.

All painting of outdoor equipment shall be carried out strictly in accordance with the paint system manufacturer's recommendations and the application shall be checked and approved, in writing, by an authorized representative of the paint manufacturer.

The Contractor shall ensure that sufficient precautions are taken in packing and crating operations, to avoid the damage to the protective treatment during transportation to the site.

Any paintwork damage which occurs during transport shall be rectified on site at the contractor expenses.

All painting works are intended to give a minimum life of 10 years in a severe environment, with a need for only minor remedial work in that period.

Where paint coatings are proposed for the protection of equipment surfaces exposed to corrosive conditions, the coatings shall be formulated to be suitably corrosion-resistant and shall be high voltage spark tested at works and at the Site prior to commissioning.

Priming coats of paint shall not be applied until the surfaces have been inspected and approved by the Engineer or his duly appointed representative.

Paintings:

The products will be delivered to the site in closed containers bearing the mark of origin and identification.

Plasters and paints should not be applied at a temperature below 5 degrees in an atmosphere likely to produce condensation or on a frozen or overheated surface.

The internal walls of the cable basement are to be painted with dust-proof painting.

Corrosion protection, sealing, and galvanic couple

The building must be designed and built for a lifespan of at least 30 years.

It must be designed in such a way to limit maximum the operations of rehabilitation and maintenance of its outer envelope during its service life.

The supplier will take all measures to avoid the corrosion effects on equipment and infrastructure due to the probable galvanic couple between metals.

As mentioned before, all exterior metallic structures shall be Hot deep galvanized.

Water Supply and Sanitary Installation:

Control building and housing staff are supplied with water and receives sanitary installation.

For the supplied sanitary installation, a general shut-off valve with a drain valve at the low point should be provided at the entrance to the building.

The water distribution should be carried out by hard-coated copper tubes or by reticulated tubes with visible or recessed paths.

Recessed pipe passages (particularly wall crossings) must be sheathed.

The minimum diameters required will be 8/10 for the WC and 12/14 for the other sanitary appliances.

The services include the supply and installation of sinks, showers, and toilets.

An eyewash should be provided from outside, next to the entrance to the battery room.

The sanitary installation should be supplied with hot water by an electric water heater.

Evacuation of rainwater and wastewater:

For all buildings, the rainwater should be collected from the roof by using gutters and manholes.

Then this water will be evacuated to the general drainage system.

The used water channels will be submitted to the project owner for approval.

Roof drainage pipes should be placed from the outside of the building, to prevent all risks of water infiltration.

These pipes must withstand climatic conditions and UV rays, and it is preferable that they be cast iron.

Expansion Joints:

An expansion joint is provided to allow the movement of structural members due to temperature, humidity, or any other factor without causing stress, which can lead to cracks.

In a GIS building, the use of an expansion joint at the level of the footprint equipment will be avoided as much as possible. If it was necessary, the GIS must be designed accordingly.

Walkway:

A walkway around building must be constructed with a width of approximately 1 meter covered with non-slip tiling, positioned 17 cm above ground level

Grade Slab:

The minimum thickness of the grade slab should be 20 cm.

Details of the Substation layout and Building/Room

The dimensions shown in general arrangement drawings are approximate and have to be fitted to the supplied equipment. The dimension of the building, rooms and doors has to be sufficient for the erection works of the major equipment.

31.16 Transformer Foundation

The contractor is responsible to choose the best type of foundation under transformers based on the results of his geotechnical investigations and should submit a detailed relative calculation note for approval.

These foundations will be based on natural ground level and on a surface of lean concrete with a minimum thickness of 10 cm.

A concrete screed will take place above this foundation with a slope of 1cm/m.

A grating will be placed above this screed to facilitate circulation.

The used grating could be either fire resistant or hot deep galvanized.

The rails will be placed on two concrete beams below the transformer. These rails will be extended to the heavy road.

Transformer oil pit must be placed below each transformer to capture any oil in the event of a transformer oil spill and prevent migration to adjacent transformers and equipment.

Interiors of transformer oil pit shall be thoroughly cleaned by shot blasting or other approved methods and, shall be coated with an approved corrosion-preventing compound.

The concrete in the tank must be protected from the inside of the transformer oil pit (where the oil will accumulate) with epoxy paint or equivalent. This paint must resist hot oil in order to be waterproof, and in order to block oil infiltration

The exterior shall be thoroughly cleaned by shot blasting or other approved methods and given one coat of primer, two coats of contrasting color or durable oil and weather-resisting paint, and a final coat of gloss paint.

The capacity of the transformer oil pit will be at least 1.5 * the total volume of the transformer.

The walls that surround the transformer oil pit must have a fire resistance of 4 hours minimum. Firewalls surrounding the transformers must have a minimal thickness of 0.3 m, and a fire resistance of 4 h minimum.

For more details, please refer to the relative plans in the appendix of this document

31.17 Oil Pits and Oil Catchment System

The catchment system for the transformers shall collect oil spillage and rainwater. The capacity of the catchment system shall be no less than 1.5* the total capacity of one autotransformer and cooling system including tap changer compartments plus 3 days rainy season average rainfall.

The layout of the catchment system shall allow sufficient space between the actual transformer/cooler and the inside of the wall to permit access for maintenance.

Above the catchment, system / oil catchment pans a flame retarding, fire protection grating (type LHD or equivalent) shall be provided.

Appropriate measures shall be taken to prevent pollution of the environment by discharging ejected oil.

The drainage pipe must be fire and corrosion resistant.

The drainage system must be on a slight uniform grade, 1 percent or less, to prevent excessive mixing of oil and water

31.18 Requirements for outdoor area

1. Substation fences

The fencing of the switchyard shall be coated with rust proofing paint. Details will be clarified within in the course of the project.

2. Access Road:

The roads shall be made of the following composition:

1. Gravel filter layer
2. Gravel or grit supporting layer
3. Bituminous supporting layer
4. Bituminous top layer

The street surface shall be flush with the height of the plant.

The edging or bordering shall be of basalt – surface flush – of at least 8.0 cm. The street width is 4.0 m.

The dimensioning of the street construction must be under consideration of the existing soil characteristics for the loading: heavy load transportation. The radial and longitudinal descent is to be executed according to the regulations and the specific situation of the site ground

Internal asphalt access roads shall be constructed

3. Firewalls:

A transformer firewalls must be designed and installed to separate the transformers in case of fire, they should be characterized by the following:

1. The firewall must have a **four-hour fire rating minimum**
2. The firewall must extend **300 mm minimum** above the height of any installed transformer
3. The firewall and its foundation must be designed to support wind and seismic loadings.
4. The firewall must be made from reinforced concrete panels, which are water, UV and hot transformer oil (100°C) resistant and resilient to the in-service conditions over the design life of the installation
5. It can be prefabricated or casted on site.

4. Sidewalks:

Sidewalks shall be made of the following composition:

1. Gravel filter layer
2. Supporting layer precast concrete blocks, thickness ≥ 8,0 cm

The edging or bordering shall be of concrete – surface flush – of at least 8.0 cm.

The dimensioning of the sidewalk construction must be under consideration of the existing soil characteristics for the loading: passable. The radial and longitudinal descent is to be executed according to the regulations and the specific situation of the site ground.

5. Sewerage:

The roof drain of the new building shall be into the rain dewatering system of the substation.

6. Landscaping:

The landscaping of the terrain shall be planned and implemented.

31.19 Site installation

The Site Installation Plan designates the location of the various necessary equipment and elements to install on-site during the execution phase.

It determines respectively the location of the following:

1. Construction machinerie (cranes, nacelles, bulldozers, etc.)
2. Storage areas for the various generated trash during the work execution;
3. storage areas for materials;
4. Rest areas for the workers.
5. Toilets
6. Car parking
7. Assembly point in case of emergency
8. etc.

Hence this section aims to globally define the minimum requirements relating to these areas on site, that can be defined as follow:

Staff accommodation:

The characteristics of the Site installation depend on the following criteria:

1. If the site personnel will be housed on-site or in the immediate vicinity of the project.
2. The sizing of accommodation and dormitories, by taking into account the comfort of the contractor's employees or subcontractors.
3. The size of the site installation depending on the staff number expected on site.
4. If necessary, the number of staff per accommodation will be proposed by the contractor taking into account the following factors:
5. Social, environmental, and gender aspects. (In addition to the overall number of people, the number of male and female staff should be taken into account)
6. Limit the number of staff sharing accommodations, in compliance with health rules (in particular COVID-19) and gender
7. Provide an adequate air conditioning system

Kitchens:

The contractor must install, at each Site Installation:

1. A refectory with an area of 1.3m² minimum
2. A cafeteria with a rest area

Sanitary facilities

The contractor provides the following for the installation of sanitary facilities:

Sinks:

1. 1 sink for 10 workers
2. With adjustable temperature
3. Appropriate ways of drying or wiping, etc. (maintained whenever necessary)

Showers:

1. Mandatory
2. The showers (at least one for eight people)
1. Separate facilities if mixed staff

Dressing rooms:

The Contractor shall install equipped dressing Rooms in accordance with the following requirements:

1. dressing rooms with sinks installed near the passage of workers
2. Mandatory lighting
3. Mandatory air conditioning
4. Floor and walls (easily cleanable)
5. Sufficient ventilation
6. Maintains a constant state of cleanliness
7. Separate facilities if mixed staff
8. If dressing rooms and washbasins were in separate rooms, a communication passage between them will take place without going outside or through storage areas
9. The surface of the dressing rooms will be at least 1m²
10. A sufficient number of seats must bed considered on site
11. Individual cupboard

Lavatory, urinals:

The contractor provides the following for the installation of sanitary facilities:

1. 1 cabinet and 1 urinal for 20 men
2. 2 cabinets for 20 women
3. Lavatories for female staff
4. General provisions;

5. toilet Flush
6. Lighting
7. Waterproof and easily cleanable floors and walls
8. Solid doors
9. Evacuation of effluents in accordance with health regulations
10. Toilet paper
11. Separate facilities in case of mixed staff

The Holder is responsible to provide all these facilities and the toilets and urinals must be cleaned and disinfected at least once a day.

Care infirmary

The contractor must provide on each site a specific security plan that includes the following elements:

1. Rescue and evacuation arrangements that include:

1. First aid instructions for accident victims and the sick;
2. The number of site workers trained to provide first aid in an emergency;
3. Existing medical equipment on site;
4. Quick steps to take, to a hospital any accident victim who appears to have serious injuries.
5. Measures ensuring the hygiene of the working conditions and that of the premises intended for the workers.

<u>In Fond Cole substation:</u>

a nurse must be present on-site.

The recruitment of the qualified nurse must be carried out on the basis of specifications to be submitted for approval to the contracting authority.

<u>Provisions</u>

The premises must include:

6. A waiting room of 6 to 9 m2;
7. A 9 to 12 m2 nursing office-treatment room, lockable, which can be made up of two separate rooms of approximately 6 m2;
8. A sanitary room with WC, showers, and washbasin with cold and hot water;

First aid kit

Provide a first aid kit in case of an accident at each site.

In addition, the Contractor must install an equipped infirmary room at Fond Cole substation.

Guard room:

A Guard room must be provided at the level of the main entrance with dimensions of 1.50 x 1.50 m²

Water supply:

The contractor will install at his own expense a municipal water meter to ensure the water supply to the site installation.

An overhead water tank with a minimum capacity of 1000L will be installed.

Assembly point:

It is essential to provide a secure waiting area, known as the "assembly area" so that personnel can gather safely in the event of an emergency.

It is also necessary to indicate the assembly point with indicative signs specifying its position.

All personnel must be made aware by the site QHSE manager of the existence of these assembly points.

Figure 3: Assembly Point

Emergency alarm:

The Contractor must equip the various site installations with a visual and audible alarm system in case of an emergency.

Project identification backboard:

The contractor must install Site Signage backboards at each entrance to the Site installation.

These backboards must include information relating to the project, the project stakeholders, and the nature of the works under construction.

Parking zone:

The contractor provides safe and secure parking for cars.

Storage area, and warehouse:

The contractor provides a suitable area for the storage of materials, reinforcement, formwork, cement, etc.

A dedicated space for special work such as welding, cutting of certain materials, etc must be reserved on site.

Power Supply and Lighting:

For the entire duration of the works, the Contractor will pay for the electricity and lighting supply of its site facilities.

If generators were used on site, they must comply with the maximum tolerated noise level of 65 dB (A).

The contractor provides a 50kVA electrical cabinet to supply the storage area, premises, offices, etc.

Communication:

The Contractor will provide an effective communication network between the different working zones during the construction period.

The contractor will provide mobile phones to its personnel.

For the entire duration of the work, the Contractor will provide an internet communications infrastructure in the offices and in the meeting room.

Offices and meeting room:

The Contractor must make available to the Project Owner and its representatives all the necessary offices and premises for meetings. They will be supplied with electricity, water supply, air conditioning, and provided with Internet access, adequate furniture (chairs, desks, cupboards, etc.), adequate lighting, and sanitary facilities.

The Contractor must ensure the security of the offices 24 hours a day throughout the duration of the project.

Each site office will be equipped for 2 people.

They will include:

1. Two desks and a meeting table equipped with four office chairs
2. office storage cabinet
3. One printer per office

They will be equipped with a power supply, fire detection, and extinguishing system, air conditioners, and a fast internet connection via wifi.

Provide the following common facilities per site:

1. 1 sink
2. 1 refrigerator
3. 1 WC
4. drinking water
5. 1 coffee machine

The Contractor must also provide a meeting room for 15 people intended for the use of the contracting authority and located directly next to its main offices.

The meeting room will be air-conditioned and will be equipped as follows:

1. 1 writing board with erasable markers,
2. 1 connected screen for projections (Bluetooth option),
3. 1 digital projector
4. 1 meeting table and its 15 chairs equipped with electricity
5. 1 Internet access (Wi-Fi)

Lifting and transporting equipment around the Site:

The contractor will provide all the needed lifting, handling, and transport equipment on Site.

Lifting equipment must all have up-to-date certificates of conformity and periodic regulatory inspections.

Sanitary system:

The contractor will design, build, operate and maintain during the Construction Period a sanitary system including the collection, treatment, and disposal of wastewater.

Any septic tank installed by the contractor will be drainable.

Temporary or mobile sanitary facilities will also be provided on construction sites, for a minimum of 30 workers.

Transportation of the Contractor's personnel and materials on site:

The Contractor must provide, at his own expense, all the necessary transportation vehicles for his personnel and the supplied materials on site.

Storage area:

An area must be reserved for the storage of trash generated throughout the execution phase.

Dangerous trashes must be stored in a well-protected metal cage with a lock.

This area must be as far as possible from the guard room.

Generator:

A Generator with an electrical cabinet + CO_2 extinguishers, and ABC, are to be provided at the various sites.

Machines' reparation:

The repair of the various Machines must be carried out outside the site, except in the event that they cannot move the machine before repair, they then proceed to repair it on-site according to a procedure that takes into account the various requirements of Safety.

32. Annexes for SUBSTATIONS

Annex A2: Guaranteed Technical Data

Annex A2-1: 69kV GIS Busbar Guaranteed Technical Data

Annex A2-2: 69kV GIS Circuit Breaker Guaranteed Technical Data

Annex A2-3: 69kV GIS Disconnector Switch and earth Switch Guaranteed Technical Data

Annex A2-4: 69kV GIS Current Transformer Guaranteed Technical Data

Annex A2-5: 69kV GIS Voltage Transformer Guaranteed Technical Data

Annex A2-6: 69/11kV 15MVA Fond Cole Power Transformer Guaranteed Technical Data

Annex A2-7a: 33/11kV 20MVA Fond Cole Power Transformer Guaranteed Technical Data

Annex A2-7b: 33/11kV 3.5MVA Padu Power Transformer Guaranteed Technical Data

Annex A2-8: 2.2/33kV 4MVA Trafalgar Power Transformer Guaranteed Technical Data

Annex A2-9: 33/0.4kV Auxiliary Transformer Guaranteed Technical Data

Annex A2-10: 11/0.4kV Auxiliary Transformer Guaranteed Technical Data

Annex A2-11: 11kV Earthing Transformer Guaranteed Technical Data

Annex A2-12: 69kV single core Outdoor cable terminations with integrated surge arresters Guaranteed Technical Data

Annex A2-13: 69kV XLPE Cable Guaranteed Technical Data

Annex A2-14: 33kV XLPE Cable Guaranteed Technical Data

Annex A2-15: 11kV XLPE Cable Guaranteed Technical Data

Annex A2-16: 2.2kV XLPE Cable Guaranteed Technical Data

Annex A2-17: 33kV Metal-Clad switchgear Guaranteed Technical Data

Annex A2-18: 11kV Metal-Clad switchgear Guaranteed Technical Data

Annex A2-19 110VDC Batteries Guaranteed Technical Data

Annex A2-20 48VDC Batteries Guaranteed Technical Data

Annex A2-21 110VDC Batteries Rectifiers Guaranteed Technical Data

Annex A2-22 48VDC Batteries Rectifiers Guaranteed Technical Data

Annex A2-23 240 VAC Uninterruptible Power Supply Guaranteed Technical Data

Annex A2-24 Substation Control and Monitoring System Guaranteed Technical Data

Annex A2-25 Protection Relays Guaranteed Technical Data

Annex A2-26 Measuring Instruments Guaranteed Technical Data

Annex A2-27 Telephone Communication Guaranteed Technical Data

Annex A2-28 Optical Platform Guaranteed Technical Data

Annex A2-29 Mobile Transformer Oil Purification Machine Guaranteed Technical Data

Annex A2-30 Diesel Generator Guaranteed Technical Data

Annex A2-31 Energy Meter Guaranteed Technical Data

Annex A3: Drawings

Annex A3-1 (a-b-c-d-e-f-g-h): Layout for Trafalgar SS

Annex A3-2: SLD for Trafalgar SS

Annex A3-3: SCMS for Trafalgar SS

Annex A3-4 (a-b-c-d-e-f-g): Layout for Padu SS

Annex A3-5: SLD for Padu SS

Annex A3-6: SCMS for Padu SS

Annex A3-7 (a-b-c-d-e-f-g): Layout for Fond Cole SS

Annex A3-8: SLD for Fond Cole SS

Annex A3-9: SCMS for Fond Cole SS

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Annex A2-1: 69kV GIS Double Busbar Guaranteed Technical Data

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	Busbar			
	Manufacturer and Country of Origin			
1	**Bus Arrangement**		Double busbar Horizontal	
2	**Bus Duct Proposed**		1 or 3 Phases	
3	**Rated Voltage**	kV(rms)	72.5	
4	**Rated frequency**	Hz	50	
5	**Grounding**		Effectively earthed	
6	**Rated power frequency withstand Voltage (1 min) line to earth**	kV (rms)	140	
7	**Impulse withstand BIL (1.2/50 µsec) Line to earth**	kVp	325	
8	**Rated short time withstand current (3 sec)**	kA (rms)	25	
9	**Rated peak withstand Current**	kA (peak)	80	
10	**Guaranteed maximum gas losses for complete installation as well as for all individual sections in %.**		As per IEC- 62271-203	
11	**Rated current normal/ at site (at 50°C design ambient temperature)**	A	1250	
12	**Seismic Level**		6 out of 12 (Medvedev–Sponheuer–Karnik scale)	
	General			
1	**Gas density detector provided**		yes	
2	**Operation counter provided**		yes	
3	**Space heater provided for cubicle**		yes	
4	**Enclosure Protection**		IP55W	
5	**Number of possible operations without maintenance under:** Rated short circuit breaking current Rated normal current	 No No	 10 2000	
6	**Rated SF6 pressure**	kgf/cm2	0.5% per Annum	
7	**Padlocking provision for local cubicle**		yes	
8	**UHF sensors for PD detection**		yes	

	Numbers			
9	**Mechanical dimension(LxWxH)**	mm x mm x mm		
	<u>Local Control Cubical</u>			
1	Degree of Protection			
2	Padlocking arrangement			
3	Location in GIS		In front	

Annex A2-2: 69kV GIS Circuit Breaker Guaranteed Technical Data

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	<u>Circuit breaker</u>			
1	**Manufacturer**			
2	**Country of Origin**			
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC 62271-203, IEC 62271-100	
5	**Type**		GIS	
6	Poles		Three Pole	
7	**Rated Voltage**			
	Nominal	kV	69	
	Maximal	kV	72.5	
8	**System neutral earthing**		Effectively earthed	
9	**Rated current**			
9-1	Continuous at 50 degree ambient : Line Transformer Coupler	A A A	1250 1250 2000	
9-2	Short time for 3 sec at max. kV	KA	25	
10	**Frequency**	Hz	50	
11	**Temperature rise above 45°C ambient**		As per IEC	
11-1	Contacts			
11-2	Terminals			
12	**Rated short circuit breaking current**			
13	**Rated short circuit making current**			
13-1	Peak	kA	80	
14	**Interrupting time at 100% capacity**			
14-1	Maximum opening time	ms		
14-2	Total interrupting time	ms		
15	**Total Closing time**	ms	Not more than 200	
16	**Max. difference in the instants of closing/opening of contacts (ms) between poles**		As per IEC	
17	**Rated operating duty cycle**		O-0.3s-CO-3 min-CO	

18	**Reclosing auto reclosing**		Three phase	
19	**First pole to clear factor**		1.5	
20	**Maximum capacitive current breaking capacity (rms)**	A		
21	**Rated insulation levels**			
21-1	Full wave impulse with stand voltage (1.2x50 micro sec.)			
	- between line terminals and ground	kV	325	
	- between terminals with circuit breaker open	kV	375	
21-2	One minute power frequency withstand voltage			
	- between line terminals and ground		As per IEC	
	- between terminals with circuit breaker open		As per IEC	
22	**Operating mechanism**			
22-1	Type		Spring operated	
22-2	Number of mechanism per breaker		1	
22-3	Single/three phase auto-reclosure		3	
224	Operating voltage of closing and tripping coil	VDC	110	
22-5	Operating voltage range -Closing -Tripping	% of rated voltage	85-110% 70-110%	
22-6	Closing and tripping current	A		
22-7	Spring charging motor rating -Capacity -Rated voltage	kW VDC	110	
22-8	Time required by motor to charge the spring completely	sec	<30	
23	Anti pumping device provided		yes	
24	Trip-free feature provided		yes	
25	**Number of N.C. contacts**		Min 8 (with 20% of spare – NC)	
26	**Number of N.O. contacts**		Min 8 (with 20% of spare – NO)	
27	Rating of Auxiliary contacts		10A at 110V DC	
28	Breaking capacity of Aux. Contacts.		2A DC with the circuit time constant of not less than 20 ms.	
29	**Total weight of the circuit breaker**	kg		

Annex A2-3: 69kV GIS Disconnector Switch and earth Switch Guaranteed Technical Data

	Description	Unit	Minimum Required Data	Data Offered By The Bidder

	Disconnector Switch and earth Switch			
1	**Manufacturer**			
2	**Country of Origin**			
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC	
5	**Type**		GIS	
6	Poles		Three Pole group operated	
7	**Rated Voltage**			
	Nominal	kV	69	
	Maximal	kV	72.5	
8	**System earthing**		Effectively earthed	
9	**Rated current**			
9-1	Continuous at 50 degree ambient : Line Transformer Coupler	A A A	1250 1250 2000	
9-2	Short time for 3 sec at max. kV	kA	25	
9-3	dynamic short circuit withstand current withstand current of isolator and earth switch	kA	80	
10	**Frequency**	Hz	50	
11	**Temperature rise above 45 degree C ambient**		As per IEC	
11-1	Contacts			
11-2	Terminals			
12	**Rated insulation level:**			
12-1	One minute power freq. Withstand voltage:			
	To earth	kV	140	
	Across isolating distance	kV	160	
12-2	1.2/50 micro sec. Lighting impulse withstand voltage (+ve or –ve polarity			
	To earth	kV	325	
	Across isolating distance	kV	375	
13	**Main contacts**			
13-1	- Material of fixed contacts		provide	

13-2	- Material of moving contacts		provide	
13-3	- Material of the contacts of the earthing switch		provide	
14	**Auxiliary power supply**			
14-1	Control circuit	VDC	110	
14-2	Operating motor	VDC	110	
15	**Operating mechanism**		Motor & Manual Operated	
15-1	Operating motor	W		
16	**Types of interlocks furnished**		Electrical and manual	
17	**Number of N.C. contacts**		Min 6	
18	**Number of N.O. contacts**		Min 6	
	<u>Earthing Switch</u>			
1-1	Operating Mechanism		Manual and Motor Operated	
	Operating motor	W		
1-2	Type of Interlocks		Electrical and manual	
2	**Number of N.C. contacts**		Min 6	
3	**Number of N.O. contacts**		Min 6	
4	Rated mechanical terminal load		As per IEC	
5	**Operating duty cycle**		O - 0.3sec – CO - 3min – CO	

Annex A2-4: 69kV GIS Current transformers Guaranteed Technical Data

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	<u>Current Transformer</u>			

1	**Manufacturer**			
2	**Country of Origin**			
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC 62271-203, IEC 66044-1	
5	**Type**		GIS: indoor metal enclosed	
6	**Rated Primary Voltage**			
	Nominal	kV	69	
	Maximal	kV	72.5	
7	**System earthing**		Effectively earthed	
8	**Rated frequency**	Hz	50	
9	**Insulation level**			
9-1	Impulse withstand voltage (crest)	kV	325	
9-2	Power frequency withstand voltage 1min (rms)	kV	140	
9-3	250/2500 µsecond switching impulse voltage (dry & wet)		As per IEC	
10	**Short time for 3 sec at max. kV**	kA	25	
11	**Rated Peak Short circuit Current**	kA	80	
12	**Rated VA burden for each core**	VA	100	
13	**Maximum temperature rise over an ambient temp of 40°C**		As per IEC 60044-1	
14	**One minute power frequency withstand voltage between sec. Terminal & earth**	kV	5	
15	**Number of cores in each CT:** **Line** **Transformer** **Coupler**		 4 4 2	
16	**Accuracy class**		5P20 for protection 0.2 for metering PS for diff / Bus	
17	**Current Ratio** **Line** **Transformer** **Coupler**	A	 400-200/1-1-1-1A 400-200/1-1-1-1A 800-400/1-1A	

18	**Overvoltage factor**		1,1	
19	**Rated continuous thermal current**		1.2x	

Annex A2-5: 69kV GIS Voltage transformers Guaranteed Technical Data

	Description	**Unit**	**Minimum Required Data**	**Data Offered By The Bidder**
	<u>**Voltage Transformer**</u>			
1	**Manufacturer**			
2	**Country of Origin**			

3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC 62271-203, IEC 66044-2	
5	**Type**		GIS: indoor metal enclosed	
6	**Rated Primary Voltage**			
6-1	Nominal	kV	69/√3	
6-2	Maximal	kV	72.5/√3	
7	**System earthing**		Effectively earthed	
8	**Rated frequency**	Hz	50	
9	**Insulation level**			
9-1	Impulse withstand voltage (crest)	kV	325	
9-2	Power frequency withstand voltage 1min (rms)	kV	140	
9-3	250/2500 µsecond switching impulse voltage (dry & wet)		As per IEC	
10	**One minute power frequency withstand voltage for secondary winding**	kV	3	
11	**Short time for 3 sec at max. kV**	KA	25	
12	**Rating**			
12-1	Voltage Ratio	KV	69/√3: 0.11/√3 : 0.11/√3	
12-2	Rated burden	VA	50	
12-3	Accuracy class		3P for protection 0.2 for metering	
13	**Overvoltage factor**			
	- continuous,		1.1	
	- 30 seconds		1.5	
14	**Number of secondary windings**		2/3	

Annex A2-6: 69/11kV 15MVA Fond Cole Power Transformer Guaranteed Technical Data

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
1	**Manufacturer and Country of Origin**			
2	**Year of manufacturing experience**	Years		
3	**Manufacturing's Designation as per submitted catalogue**			

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
4	**Applicable standards**		IEC60076, IEC60296, IEC60354	
5	**Type**		Power Transformer, three-phase	
6	**Rated frequency**	Hz	50	
7	**Service altitude**		1000 m	
8	**MVA ratings Rated power**			
8-1	HV	MVA	11.25/15MVA	
8-2	LV	MVA	11.25/15MVA	
9	**Cooling System**			
10	**Type of cooling**		ONAN/ONAF (75% /100%)	
11	**Number of coolers**	Pcs		
12	**Cooling operation**		Auto/ Manual	
13	**Control voltage for cooling and heating**	V AC	230	
14	**Supply voltage of protection devices**	V DC	110	
15	**Supply voltage of fans**	V AC	230/400	
16	**Nominal system voltage “Un” and rated voltage on principal tapping**			
16-1	HV	kVrms	69	
16-2	LV	kVrms	11	
17	**Maximum voltage for which system equipment is designed “UM” phase to phase**			
17-1	HV	kVrms	72.5	
17-2	LV	kVrms	12	
18	**Type of insulation**			
18-1	HV Side		Uniform	

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
18-2	LV Side		Uniform	
19	**Rated withstand voltage for transformer windings**			
19-1	a) 69 kV winding (Um=72,5 kV)	kV	72.5	
	- Rated switching impulse withstand voltage	kV peak	-	
	- Rated lightning impulse withstand voltage	kV peak	325	
	- Rated short-duration induced or separate source AC withstand voltage	kV rms	140	
19-2	b) 11 kV winding (Um=12 kV)	kV	12	
	- Rated switching impulse withstand voltage phase-to-earth	kV peak	-	
	- Rated lightning impulse withstand voltage	kV peak	95	
	- Rated short-duration induced or separate source AC withstand voltage	kV rms	28	
20	**Noise Level (with all ventilators)**	dB	<70	
21	**Impedances at 75°C and at rated frequency expressed in percent of Un2/M**			
	HV/LV	Max		
	HV/LV	Nominal	10%	
	HV/LV	Min		
22	**No Load loss (I2R+stray) at 75°C with HV and LV fully loaded (Balance of load on MV) ONAF**			
	On principal tapping	kW	8 (Max)	
	On extreme plus tapping	kW		
	On extreme minus tapping	kW		
23	**Load loss (I2R+stray) at 75°C with HV and LV fully loaded (Balance of load on MV)**			
	On principal tapping	kW	60 (Max)	

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	On extreme plus tapping	kW		
	On extreme minus tapping	kW		
24	**Main Terminals**			
	Bushings cable boxes		69 kV side (bushings) 11 kV cable box	
	Type of bushings required			
	Bushings Insulation level			
	HV (LI/LTAC)	kV Peak	---------	
	LV (LI/ LTAC)	kV Peak	---------	
	LVN (LI/ LTAC)	kV Peak	---------	
	Minimum Specific Creepage Distance (SCD)	mm/kV	31.5	
25	**Short Circuit Levels**			
	System Symmetrical fault level on 69 kV side	kA	25	
	System Symmetrical fault level on 11 kV side	kA	25	
	Duration of the symmetrical short circuit current	s	2	
26	**Vector Group**		YNd11	
	Tap Changer			
1	Type of tap changer		On load	
2	Operations per year		Maintenance free	
3	HV/LV rations provided by taooung range, per unit of the principal tapping voltage		69 (-4, +4) 1.25% of HV	
4	Number of approximately equals steps		9	

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
5	Approximate change per step in percent of HV (Un)	%	1.25%	
6	Control voltage		High Voltage	
7	Manufacturer		MR Germany or equivalent	
	Oil Characteristics			
1	Mineral oil standard		IEC60296	
2	Dryness of the oil after on-site installation		Water Content ≤5ppm	
3	Oil type		pure mineral oil free from additives	
	CURRENT TRANSFORMER			
1	Manufacturer		to be specified	
3	Rated voltage	kV	69	
4	Rated frequency	Hz	50	
6	**On phases**			
	Secondary currents	A	1	
	Primary currents	A	200-400	
	Number of protection cores		2	
7	**On neutral**			
	Secondary currents	A	1	
	Primary currents	A	200	
	Number of protection cores		1	
	Main dimensions			
1	Total weight	kg		
2	Transport weight	kg		

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
3	Volume of oil	kg		
4	Total length x width x height, including bushings	mm		
5	Shipping length x width x height	mm		

Annex A2-7a: 33/11kV 20MVA Fond Cole Power Transformer Guaranteed Technical Data

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
1	**Manufacturer**			

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
2	**Country of Origin**			
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standards**		IEC60076, IEC60296, IEC60354	
5	**Type**		Power Transformer, three-phase	
6	**Rated frequency**	Hz	50	
7	**Service altitude**		1000 m	
8	**MVA ratings Rated power**			
8-1	HV	MVA	15/20MVA	
8-2	LV	MVA	15/20MVA	
9	**Cooling System**			
10	**Type of cooling**		ONAN/ONAF (75% /100%)	
11	**Number of coolers**	Pcs		
12	**Cooling operation**		Auto/ Manual	
13	**Control voltage for cooling and heating**	V AC	230	
14	**Supply voltage of protection devices**	V DC	110	
15	**Supply voltage of fans**	V AC	230/400	
16	**Nominal system voltage “Un” and rated voltage on principal tapping**			
16-1	HV	kVrms	33	
16-2	LV	kVrms	11	
17	**Maximum voltage for which system equipment is designed “UM” phase to phase**			
17-1	HV	kVrms	36	

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
17-2	LV	kVrms	12	
18	**Type of insulation**			
18-1	HV Side		Uniform	
18-2	LV Side		Uniform	
19	**Rated withstand voltage for transformer windings**			
19-1	a) 33 kV winding (Um=36 kV)	kV	36	
	- Rated switching impulse withstand voltage	kV peak	-	
	- Rated lightning impulse withstand voltage	kV peak	170	
	- Rated short-duration induced or separate source AC withstand voltage	kV rms	70	
19-2	b) 11 kV winding (Um=12 kV)	kV	12	
	- Rated switching impulse withstand voltage phase-to-earth	kV peak	-	
	- Rated lightning impulse withstand voltage	kV peak	95	
	- Rated short-duration induced or separate source AC withstand voltage	kV rms	28	
20	**Noise Level (with all ventilators)**	dB	<70	
21	**Impedances at 75°C and at rated frequency expressed in percent of Un2/M**			
	HV/LV	Max		
	HV/LV	Nominal	10%	
	HV/LV	Min		
22	**No Load loss (I2R+stray) at 75°C with HV and LV fully loaded (Balance of load on MV)**			
	On principal tapping	kW	10 (Max)	
	On extreme plus tapping	kW		

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	On extreme minus tapping	kW		
23	**Load loss (I2R+stray) at 75°C with HV and LV fully loaded (Balance of load on MV) ONAF**			
	On principal tapping	kW	70 (Max)	
	On extreme plus tapping	kW		
	On extreme minus tapping	kW		
24	**Main Terminals**			
	Cable boxes		33 kV cable box 11 kV cable box	
25	Type of bushings required			
	Bushings Insulation level			
	HV (LI/LTAC)	kV Peak	---------	
	LV (LI/ LTAC)	kV Peak	---------	
	LVN (LI/ LTAC)	kV Peak	---------	
	Minimum Specific Creepage Distance (SCD)	mm/kV	31,5	
26	**Short Circuit Levels**			
	System Symmetrical fault level on 33 kV side	kA	25	
	System Symmetrical fault level on 11 kV side	kA	25	
	Duration of the symmetrical short circuit current	s	2	
27	**Vector Group**		YNd11	
	Tap Changer			
1	**Type of tap changer**		On load	
2	**Operations per year**		Maintenance free	

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
3	**HV/LV rations provided by taooung range, per unit of the principal tapping voltage**		33 (-4, +4) 1.25% of HV	
4	**Number of approximately equals steps**		9	
5	**Approximate change per step in percent of HV (Un)**	%	1.25%	
6	**Control voltage**		High Voltage	
7	**Manufacturer**		MR Germany or equivalent	
	Oil Characteristics			
1	**Mineral oil standard**		IEC60296	
2	**Dryness of the oil after on-site installation**		Water Content ≤5ppm	
3	**Oil type**		pure mineral oil free from additives	
	CURRENT TRANSFORMER			
1	Manufacturer		to be specified	
3	Rated voltage	kV	33	
4	Rated frequency	Hz	50	
6	**On phases**			
	Secondary currents	A	1	
	Primary currents	A	400-800	
	Number of protection cores		2	
7	**On neutral**			
	Secondary currents	A	1	
	Primary currents	A	200	
	Number of protection cores		1	

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	Main dimensions			
1	**Total weight**	kg		
2	**Transport weight**	kg		
3	**Volume of oil**	kg		
4	**Total length x width x height, including bushings**	mm		
5	**Shipping length x width x height**	mm		

Annex A2-7b: 33/11kV 3.5MVA Padu Power Transformer Guaranteed Technical Data

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
1	**Manufacturer**			
2	**Country of Origin**			
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standards**		IEC60076, IEC60296, IEC60354	
5	**Type**		Power Transformer, three-phase	
6	**Rated frequency**	Hz	50	
7	**Service altitude**		1000 m	
8	**MVA ratings Rated power**			
8-1	HV	MVA	3,5MVA	
8-2	LV	MVA	3,5MVA	
9	**Type of cooling**		ONAN	
10	**Nominal system voltage “Un” and rated voltage on principal tapping**			
	HV	kVrms	33	
	LV	kVrms	11	
11	**Maximum voltage for which system equipment is designed “UM” phase to phase**			
	HV	kVrms	36	
	LV	kVrms	12	
12	**Type of insulation**			
	HV Side		Uniform	
	LV Side		Uniform	
13	**Rated withstand voltage for transformer wingings**			
	a) 33 kV winding (Um=36 kV)	kV	36	

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	- Rated switching impulse withstand voltage	kV peak	-	
	- Rated lightning impulse withstand voltage	kV peak	170	
	- Rated short-duration induced or separate source AC withstand voltage	kV rms	70	
	b) 11 kV winding (Um=12 kV)	kV	12	
	- Rated switching impulse withstand voltage phase-to-earth	kV peak	-	
	- Rated lightning impulse withstand voltage	kV peak	95	
	- Rated short-duration induced or separate source AC withstand voltage	kV rms	28	
14	**Noise Level**	dB (A)	<60	
15	**Impedances at 75°C and at rated frequency expressed in percent of Un2/M**			
	HV/LV	Max		
	HV/LV	Nominal	7%	
	HV/LV	Min		
16	**No Load loss (I2R+stray) at 75°C with HV and LV fully loaded (Balance of load on MV)**			
	On principal tapping	kW	1.8 (Max)	
	On extreme plus tapping	kW		
	On extreme minus tapping	kW		
17	**Load loss (I2R+stray) at 75°C with HV and LV fully loaded (Balance of load on MV)**			
	On principal tapping	kW	12 (Max)	
	On extreme plus tapping	kW		
	On extreme minus tapping	kW		
18	**Main Terminals**			

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	Cable boxes		33 kV cable box 11 kV cable box	
19	Type of bushings required			
	Bushings Insulation level			
	HV (LI/LTAC)	kV Peak	---------	
	LV (LI/ LTAC)	kV Peak	---------	
	LVN (LI/ LTAC)	kV Peak	---------	
	Minimum Specific Creepage Distance (SCD)	mm/kV	31,5	
20	**Short Circuit Levels**			
	System Symmetrical fault level on 33 kV side	kA	25	
	System Symmetrical fault level on 11 kV side	kA	25	
	Duration of the symmetrical short circuit current	s	2	
21	**Vector Group**		YNd11	
	Tap Changer			
1	**Voltage Variation**		Off-load tap changer with 5 positions in the HV winding giving ±2 x 2.5 %.	
	Oil Characteristics			
1	**Mineral oil standard**		IEC60296	
2	**Dryness of the oil after on-site installation**		Water Content ≤5ppm	
3	**Oil type**		pure mineral oil free from additives	
	CURRENT TRANSFORMER			

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
1	Manufacturer		to be specified	
3	Rated voltage	kV	33	
4	Rated frequency	Hz	50	
6	**On phases**			
	Secondary currents	A	1	
	Primary currents	A	400-800	
	Number of protection cores		2	
7	**On neutral**			
	Secondary currents	A	1	
	Primary currents	A	200	
	Number of protection cores		1	
	Main dimensions			
1	**Total weight**	kg		
2	**Transport weight**	kg		
3	**Volume of oil**	kg		
4	**Total length x width x height, including bushings**	mm		
5	**Shipping length x width x height**	mm		

Annex A2-8: 2.2/33kV 4MVA Trafalgar Power Transformer Guaranteed Technical Data

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
1	**Manufacturer**			
2	**Country of Origin**			
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standards**		IEC60076, IEC60296, IEC60354	
5	**Type**		Power Transformer, three-phase	
6	**Rated frequency**	Hz	50	
7	**Service altitude**		1000 m	
8	**MVA ratings Rated power**			
8-1	HV	MVA	4MVA	
8-2	LV	MVA	4MVA	
9	**Type of cooling**		ONAN	
10	**Nominal system voltage “Un” and rated voltage on principal tapping**			
	HV	kVrms	33	
	LV	kVrms	2.2	
11	**Maximum voltage for which system equipment is designed “UM” phase to phase**			
	HV	kVrms	36	
	LV	kVrms	3	
12	**Type of insulation**			
	HV Side		Uniform	
	LV Side		Uniform	
13	**Rated withstand voltage for transformer windings**			
	a) 33 kV winding (Um=36 kV)	kV	36	

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	- Rated switching impulse withstand voltage	kV peak	-	
	- Rated lightning impulse withstand voltage	kV peak	170	
	- Rated short-duration induced or separate source AC withstand voltage	kV rms	70	
	b) 2.2 kV winding (Um=3 kV)	kV	3	
	- Rated switching impulse withstand voltage phase-to-earth	kV peak	-	
	- Rated lightning impulse withstand voltage	kV peak		
	- Rated short-duration induced or separate source AC withstand voltage	kV rms		
14	**Noise Level**	dB	<60	
15	**Impedances at 75°C and at rated frequency expressed in percent of Un2/M**			
	HV/LV	Max		
	HV/LV	Nominal	7%	
	HV/LV	Min		
16	**No Load loss (I2R+stray) at 75°C with HV and LV fully loaded (Balance of load on MV)**			
	On principal tapping	kW	2 (Max)	
	On extreme plus tapping	kW		
	On extreme minus tapping	kW		
17	**Load loss (I2R+stray) at 75°C with HV and LV fully loaded (Balance of load on MV)**			
	On principal tapping	kW	13.5 (Max)	
	On extreme plus tapping	kW		
	On extreme minus tapping	kW		
18	**Main Terminals**			

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	cable boxes		33 kV cable box 2.2 kV cable box	
19	Type of bushings required			
	Bushings Insulation level			
	HV (LI/LTAC)	kV Peak	---------	
	LV (LI/ LTAC)	kV Peak	---------	
	LVN (LI/ LTAC)	kV Peak	---------	
	Minimum Specific Creepage Distance (SCD)	mm/kV	31,5	
20	**Short Circuit Levels**			
	System Symmetrical fault level on 33 kV side	kA	25	
	System Symmetrical fault level on 2.2 kV side	kA	25	
	Duration of the symmetrical short circuit current	s	2	
21	**Vector Group**		YNd11	
	Tap Changer			
1	**Voltage Variation**		Off-load tap changer with 5 positions in the HV winding giving ±2 x 2.5 %.	
	Oil Characteristics			
1	**Mineral oil standard**		IEC60296	
2	**Dryness of the oil after on-site installation**		Water Content ≤5ppm	
3	**Oil type**		pure mineral oil free from additives	
	CURRENT TRANSFORMER			

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
1	Manufacturer		to be specified	
3	Rated voltage	kV	2.2kV and 33kV	
4	Rated frequency	Hz	50	
6	**On phases**			
	Secondary currents	A	1	
	Primary currents	A	100-200 (for 33kV side) 600-1200 (for 2.2kV side)	
	Number of protection cores		2	
7	**On neutral**			
	Secondary currents	A	1	
	Primary currents	A	100	
	Number of protection cores		1	
	<u>Main dimensions</u>			
1	**Total weight**	kg		
2	**Transport weight**	kg		
3	**Volume of oil**	kg		
4	**Total length x width x height, including bushings**	mm		
5	**Shipping length x width x height**	mm		

Annex A2-9 33/0.4kV Auxiliary Transformer Guaranteed Technical Data

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
1	**Manufacturer**			
2	**Country of Origin**			
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standards**		IEC60076	
5	**Type**		Three-phase	
6	**Rated frequency**	Hz	50	
7	**Service altitude**		1000 m	
8	**Transformer winding configuration**		2-winding	
9	**Rated Voltage**			
9-1	HV side	kV	33	
9-2	LV side	V	400	
10	**Number of Phases**		3	
11	**Rated power**	kVA	100	
12	**Type**		Oil immersed, hermetically sealed (bolted type)	
13	**Cooling**		Self-cooled (ONAN)	
14	**Voltage Variation**		Off-load tap changer with 5 positions in the HV winding giving ±2 x 2.5 %.	
15	**Windings**		Copper only	
16	**Core**		Grain orientated silicon steel, step-lap mitered joints	
17	**HV and LV Bushings**		Outdoor plug-in type, Cable boxes	
18	**Vector Group**		Dyn11	
19	**Noise Level**	dB	<50	
20	**Neutral CT**		yes	
21	**Phases CT**		yes	
22	**Percentage impedance voltage on normal tap and KVA base at 75°C corresponding to HV/ LV rating and applicable**		Impedance 4.0% + Tolerance 10% (No	

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	tolerances (Negative tolerance will not be allowed):		Negative Tolerance)	
23	**Maximum permissible No Load and Load Losses (Watts)**			
24	**No Load Losses at rated voltage and rated frequency**	W	180 (Max)	
25	**Load Losses at rated current and at 75°C**	W	1500 (Max)	

Annex A2-10 11/0.4kV Auxiliary Transformer Guaranteed Technical Data

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
1	**Manufacturer**			
2	**Country of Origin**			
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standards**		IEC60076	
5	**Type**		Three-phase	
6	**Rated frequency**	Hz	50	
7	**Service altitude**		1000 m	
8	**Transformer winding configuration**		2-winding	
9	**Rated Voltage**			
9-1	HV side	kV	11	
9-2	LV side	V	400	
10	**Number of Phases**		3	
11	**Rated power**	kVA	160	
12	**Type**		Oil immersed, hermetically sealed (bolted type)	
13	**Cooling**		Self-cooled (ONAN)	
14	**Voltage Variation**		Off-load tap changer with 5 positions in the HV winding giving ±2 x 2.5 %.	
15	**Windings**		Copper only	
16	**Core**		Grain orientated silicon steel, step-lap mitered joints	
17	**HV and LV Bushings**		Outdoor plug-in type, Cable boxes	
18	**Vector Group**		Dyn11	
19	**Noise Level**	dB	<50	
20	**Neutral CT**		yes	
21	**Phases CT**		yes	
22	**Percentage impedance voltage on normal tap and KVA base at 75°C corresponding to HV/ LV rating and applicable**		Impedance 4.0% + Tolerance 10% (No	

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	tolerances (Negative tolerance will not be allowed):		Negative Tolerance)	
23	**Maximum permissible No Load and Load Losses (Watts)**			
24	**No Load Losses at rated voltage and rated frequency**	W	220 (Max)	
25	**Load Losses at rated current and at 75°C**	W	1650 (Max)	

Annex A2-11 11kV Neutral Earthing System Guaranteed Technical Data

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
1	**Manufacturer**			
2	**Country of Origin**			
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standards**		IEC 60076, DIN EN 50464-1;	
5	**Type**		Oil-immersed, hermetically sealed earthing transformer, type-tested	
6	**Rated frequency**	Hz	50	
7	**Service altitude**		1000 m	
8	**Transformer winding configuration**		1-winding (ZigZag)	
9	**Number of Phases**		3	
10	**Rated power**	kVA		
11	**Cooling**		Self-cooled (ONAN)	
12	**Max. design temperature**	°C	+50	
13	**Perm. temp. rise of winding/oil**	K	65 / 60	
14	**Nominal voltage**	kV	11kV ± 2x2.5%	
15	**Rating voltage**	kV	12kV ± 2x2.5%	
16	**Vector group**		ZN	
17	**Lighting impulse withstand voltage**	kV	75	
18	**AC withstand voltage, 1 min.**	kV	28	
19	**Short time current**	A	2475 (preliminary data) subject to suppliers final design and network studies	
20	**Rated operation time**	s	2 (preliminary data) subject to suppliers final design and network studies	
21	**Zero sequence reactance**		(preliminary data) subject to suppliers final design and network studies	
22	**Continuous neutral current**	A	150	

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
			(preliminary data) subject to suppliers final design and network studies	
23	**Neutral Resistor** (if needed)	Ω	1266.7 Ω (preliminary data) subject to suppliers final design and network studies	
24	**uk%**	%	6% (preliminary data) subject to suppliers final design and network studies	
25	**Current transformer in the Star point**	A	250/1/1A (preliminary data) subject to suppliers final design and network studies	
26	**Winding material**		Copper	
27	**HV bushings**		Outdoor plug-in type, Cable boxes	
28	**Type of installation, protection**		Outdoor, IP44	
29	**Neutral CT**		yes	

Annex A2-12 69kV single core Outdoor cable terminations with integrated surge arresters Guaranteed Technical Data

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
1	**Manufacturer**			
2	**Country of Origin**			
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC 60840, IEEE 48, IEC 60815	
5	**Cable Type**		XLPE, Single aluminum core with corrugated aluminum metallic sheath	
6	**Highest System Voltage (Um)**	kV	72.5	
7	**Rated Voltage (Ur)**	kV	69	
8	**System earthing**		Solidly grounded	
9	**Rated frequency**	Hz	50	
10	**Type Termination**		outdoor composite	
11	**Rated lightning impulse withstand voltage BIL**	kV	325	
12	**Conductor cross section**	mm²	To be confirmed by design for 15MVA: → 240mm²	
13	**Diameter over cable insulation - prepared**	mm		
14	**Minimum creepage distance**	mm/kV	31.5	
15	**Min. arcing distance**	mm		
16	**Applied standard for the integrated surge arrester**		IEC 60099	
17	**Rated voltage Ur of the integrated surge arrester**	kV		
18	**Nominal discharge current of the integrated surge arrester**	kA	10	
19	**Line discharge class of the integrated surge arrester**		4	
20	**Max. rated short circuit current of the integrated surge arrester**	kA	63	

21	**Outdoor cable terminations characteristics**		To specify	
22	**Specialized tools for termination process**		To specify	
23	**Installation procedures and instructions**		To provide	
24	**All materials be compatible and suitable for the continuous operating temperature of the cable of 90°C and short circuit temperature of 250°C (5 second duration)**		yes	
25	**Silicone rubber with an excellent adhesive property**		yes	
26	**Contents of the kit and Material used**		To Specify	

Annex A2-13 69kV XLPE Cable and accessories Guaranteed Technical Data

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	69kV XLPE Cable			
1	**Manufacturer**			
2	**Country of Origin**			
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC 60840 – IEC502	
5	**Type**		XLPE, Single core	
6	**Highest System Voltage (Um)**	kV	72.5	
7	**Rated Voltage (Ur)**	kV	69	
8	**System earthing**		Solidly grounded	
9	**Rated frequency**	Hz	50	
10	**Conductor material**	-	Stranded compacted aluminum class2	
11	**Cross section of wires**	mm²	To be confirmed by design: 15MVA → 240mm²	
12	**Rated short circuit current (1 s.)**			
12-1	Conductor	kA	25	
12-2	Screen	kA	10	
13	**Design continuous operation at rated full load current, the max. temp. of conductor shall not exceed**	°C	90	
14	**The conductor temperature after a short circuit for 1.0 sec. shall not exceed (deg c)**	°C	250	
15	**Basic insulation level**			
15-1	(1.2 / 50 Micro second wave)	kVp	350	
15-2	1-min. power frequency withstand voltage	kV	140	
16	**Conductor shield**			
16-1	Material		SEMICON	

16-2	Minimum thickness	mm	1.5	
17	**Insulation**			
17-1	Material		Super clean XLPE	
17-2	Minimum thickness	mm	9	
18	**Insulation shield**			
18-1	Material		SEMICON	
18-2	Minimum thickness	mm	1.5	
19	**Watertight layer**		water-swellable semi-conductive tape	
20	**Metallic shield**			
	Material		Corrugated Aluminum	
21	**Jacket**			
21-1	Material		LMDPE	
21-2	Minimum thickness	mm	3	
22	**Continuous current @90°C**			
22-1	in ground	A		
22-2	in single ductbank	A		
	Electrical parameters			
1	**Electrical Stress**			
1-1	Conductor Shield	kV/mm		
1-2	Insulation Shield	kV/mm		
2	**Conductor Resistance**			
2-2	DC @ 20°C	Ω/kM		
2-3	DC @ 90°C	Ω/kM		
3	**Capacitance**	Pf/kM		
4	**Charging current**	A/kM		
	Dimensional			
1	**Bending radius (single core cables)**	mm	approx.15 x d	
2	**Maximum Pulling Tension**			
3	**Conductor Diameter**	mm		
4	**Diameter over Insulation**	mm		
5	**Diameter over Sheath**	mm		
6	**Overall Jacket Diameter**	mm		
7	**Net weight of the cable**	Kg		

	Single core plug-In SF6 gas cable terminations for GIS switchgear			
1	**Manufacturer and Country of Origin**			
2	**Year of manufacturing experience**	years	5	
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC 60840, IEEE 48, IEC 62271-209	
5	**Cable Type**		XLPE, Single aluminum core with corrugated aluminum metallic sheath	
6	**Highest System Voltage (Um)**	kV	72.5	
7	**Rated Voltage (Ur)**	kV	69	
8	**System earthing**		Solidly grounded	
9	**Rated frequency**	Hz	50	
10	**Type Termination**		Dry plug-in GIS switchgear	
11	**Rated lightning impulse withstand voltage BIL**	kV	325	
12	**Conductor cross section**	mm^2	To be confirmed by design: 15MVA → $240mm^2$	
13	**Diameter over cable insulation - prepared**	mm		
14	**Max. diameter over outer cable sheath**	mm		
15	**Minimal creepage distance**	mm/kV	31.5	
16	**Dimensions comply with IEC 62271-209**		yes	
17	**Pressure-tight resin housing**		yes	
18	**Operates in SF6**		yes	
19	**Pre-fabricated and factory-tested silicone-rubber stress cone**		yes	
20	**No special tools required to install the termination**		yes	
21	**Insulated cable gland for sectionalization**		yes	
22	**Type tested according to IEC 60840, IEC 62067 and IEC 62271-209 standards**		yes	

23	**All materials be compatible and suitable for the continuous operating temperature of the cable of 90°C and short circuit temperature of 250°C (5 second duration)**		yes	
24	**Silicone rubber with an excellent adhesive property**		yes	
25	**Contents of the kit and Material used**		To Specify	
	Cold shrinkable outdoor Cable termination for Transformer cable box			
1	**Manufacturer and Country of Origin**			
2	**Year of manufacturing experience**	years	5	
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC 60840, IEEE 48, IEC 60815	
5	**Cable Type**		XLPE, Single aluminum core with corrugated aluminum metallic sheath	
6	**Highest System Voltage (Um)**	kV	72.5	
7	**Rated Voltage (Ur)**	kV	69	
8	**System earthing**		Solidly grounded	
9	**Rated frequency**	Hz	50	
10	**Type Termination**		Cold shrinkable	
11	**Rated lightning impulse withstand voltage BIL**	kV	325	
12	**Conductor cross section**	mm²	To be confirmed by design: 15MVA → 240mm²	
13	**Diameter over cable insulation - prepared**	mm		
14	**Minimum creepage distance**	mm/kV	31.5	
15	**Min. arcing distance**	mm		
21	**Outdoor cable terminations characteristics**		To specify	
22	**Specialized tools for termination process**		To specify	
23	**Installation procedures and instructions**		To provide	
24	**All materials be compatible and suitable for the continuous operating temperature of the cable of 90°C and short circuit temperature**		yes	

	of 250°C (5 second duration)			
25	**Silicone rubber with an excellent adhesive property**		yes	
26	**Contents of the kit and Material used**		To Specify	

Annex A2-14 33kV XLPE Cable and accessories Guaranteed Technical Data

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	33kV XLPE Cable			
1	**Manufacturer**			
2	**Country of Origin**			
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC60502	
5	**Type**		XLPE, Single core	
6	**Highest System Voltage (Um)**	kV	36	
7	**Rated Voltage (Ur)**	kV	33	
8	**System earthing**		Solidly grounded	
9	**Rated frequency**	Hz	50	
10	**Conductor material**	-	Stranded compacted Cooper	
11	**Cross section of wires**	mm²	To be confirmed by design: For 20MVA: 240mm²/phase For 4MVA: 120mm²/phase For 3,5MVA 120mm²/phase For 100kVA 120mm²/phase	
12	**Rated short circuit current (1 s.)**			
12-1	Conductor	kA	25 (for 240mm²) 17 (for 120mm²)	
12-2	Screen	kA	according to cross section	
13	Design continuous operation at rated full load current, the max. temp. of conductor shall not exceed	°C	90	
14	The conductor temperature after a short	°C	250	

	circuit for 1.0 sec. shall not exceed			
15	Insulation		XLPE	
16	Outer Sheath		PVC	
17	Screen		Copper	
18	Armouring		Double layer of non-magnetic (aluminum) tapes.	
19	**Continuous current @90°C**			
19-1	in ground	A		
19-2	in duct	A		
	Electrical parameters			
1	**Electrical Stress**			
1-1	Conductor Shield	kV/mm		
1-2	Insulation Shield	kV/mm		
2	**Conductor Resistance**			
2-2	DC @ 20°C	Ω/kM		
2-3	DC @ 90°C	Ω/kM		
3	**Capacitance**	Pf/kM		
4	**Charging current**	A/kM		
	Dimensional			
1	**Bending radius (single core cables)**	mm	approx.15 x d	
2	**Maximum Pulling Tension**			
3	**Conductor Diameter**	mm		
4	**Diameter over Insulation**	mm		
5	**Diameter over Screen**	mm		
6	**Overall Jacket Diameter**	mm		
7	**Net weight of the cable**	Kg		
8	**Fire retardant**		yes	
9	**Moisture resistant**		yes	
10	**Water proof armour**		AWA	
	Indoor and Outdoor Cold Shrinkable Cable termination			
1	**Manufacturer and Country of Origin**			
2	**Year of manufacturing experience**	years	5	

3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC60502, IEC61442, IEEE48	
5	**Cable Type**		XLPE, single core copper with aluminum armour	
6	**Highest System Voltage (Um)**	kV	36	
7	**Rated Voltage (Ur)**	kV	33	
8	**System earthing**		Solidly grounded	
9	**Rated frequency**	Hz	50	
10	**Type Termination**		outdoor and indoor cold-shrinkable	
11	**Power frequency voltage withstand test**		70kV/1 min. No breakdown no flashover	
12	**Room temperature partial discharge test**		Test voltage 36kV, Partial discharge < 5pC	
13	**Thermal cycle test**		Heating: 100°C for 4 hours Cooling: -25°C for 4 hours Holding: 20°C for 1 hour	
14	**High temperature partial discharge test**		Test Voltage 36kV Test temperature 95-100°C, Partial discharge < 5pC	
15	**Lightning impulse voltage test**		170 kV positive and negative polarities each 10 times, No breakdown, No flashover.	
16	**Outdoor joint / termination short-term power frequency voltage test**		Wet, at 95kV, for 15 min. No flashover, No breakdown.	
17	**Short circuit current for conductor (1 second)**		34.3kA	
18	**Short circuit current for sheath (1 second)**		10.1kA	
19	**Outdoor joint / termination radio**		5 microvolts at 10	

	interference test		kHz 50 microvolts at 100 kHz 250 microvolts at 1 MHz	
20	**Pressure leak test**		No gas shall escape at 0.2 MPa for 1 hour	
21	**Conductor cross section**	mm^2	To be confirmed by design: For 20MVA: $240mm^2$/phase For 4MVA: $120mm^2$/phase For 3,5MVA $120mm^2$/phase For 100kVA $120mm^2$/phase	
22	**Diameter over cable insulation - prepared**	mm		
23	**Minimum creepage distance**	mm/kV	31.5	
24	**Min. arcing distance**	mm		
25	**Outdoor cable terminations characteristics**		To specify	
25	**Specialized tools for termination process**		To specify	
26	**Installation procedures and instructions**		To provide	
27	**All materials be compatible and suitable for the continuous operating temperature of the cable of 90°C and short circuit temperature of 250°C (5 second duration)**		yes	
28	**Silicone rubber with an excellent adhesive property**		yes	
29	**Contents of the kit and Material used**		To Specify	

Annex A2-15 11kV XLPE Cable and accessories Guaranteed Technical Data

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	11kV XLPE Cable			
1	**Manufacturer**			
2	**Country of Origin**			
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC60502	
5	**Type**		XLPE, Single core	
6	**Highest System Voltage (Um)**	kV	12	
7	**Rated Voltage (Ur)**	kV	11	
8	**System earthing**		Earthed through earthing Transformer	
9	**Rated frequency**	Hz	50	
10	**Conductor material**	-	Stranded compacted Cooper	
11	**Cross section of wires**	mm²	To be confirmed by design: For 20MVA 2x630mm²/phase For 15MVA 2x400mm²/phase For 3,5MVA 120mm²/phase For 160kVA 120mm²/phase Earthing TRs 120mm²/phase 11kV switchgears link 2x400mm²/phase	
12	**Rated short circuit current (1 s.)**			
12-1	Conductor	kA	25 (for 630mm² & 400mm²)	

			17 (for 120mm²)	
12-2	Screen	kA	According to cross section	
13	Design continuous operation at rated full load current, the max. temp. of conductor shall not exceed	°C	90	
14	The conductor temperature after a short circuit for 1.0 sec. shall not exceed	°C	250	
15	Insulation		XLPE	
16	Outer Sheath		PVC	
17	Screen		Copper	
18	Armouring		Double layer of non-magnetic (aluminum) tapes.	
19	**Continuous current @90°C**			
19-1	in ground	A		
19-2	in duct	A		
	<u>Electrical parameters</u>			
1	**Electrical Stress**			
1-1	Conductor Shield	kV/mm		
1-2	Insulation Shield	kV/mm		
2	**Conductor Resistance**			
2-2	DC @ 20°C	Ω/kM		
2-3	DC @ 90°C	Ω/kM		
3	**Capacitance**	Pf/kM		
4	**Charging current**	A/kM		
	<u>Dimensional</u>			
1	**Bending radius (single core cables)**	mm	approx.15 x d	
2	**Maximum Pulling Tension**			
3	**Conductor Diameter**	mm		
4	**Diameter over Insulation**	mm		
5	**Diameter over Screen**	mm		
6	**Overall Jacket Diameter**	mm		
7	**Net weight of the cable**	Kg		

8	**Fire retardant**		yes	
9	**Moisture resistant**		yes	
10	**Water proof armour**		AWA	
	Indoor and Outdoor Cold Shrinkable Cable termination			
1	**Manufacturer and Country of Origin**			
2	**Year of manufacturing experience**	years	5	
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC60502, IEC61442, IEEE48	
5	**Cable Type**		XLPE, single core copper with aluminum armour	
6	**Highest System Voltage (Um)**	kV	12	
7	**Rated Voltage (Ur)**	kV	11	
8	**System earthing**		Grounded through earthing transformer	
9	**Rated frequency**	Hz	50	
10	**Type Termination**		outdoor and indoor cold-shrinkable	
11	**Power frequency voltage withstand test**		24kV/1 min. No breakdown, No flashover.	
12	**Room temperature partial discharge test**		Test voltage 12kV. Partial discharge <10pC	
13	**Thermal cycle test**		Heating: 100°C for 4 hours Cooling: -25°C for 4 hours Holding: 20°C for 1 hour	
14	**High temperature partial discharge test**		Test Voltage 12kV Test temperature 95-100 °C, Partial discharge < 10pC.	
15	**Lightning impulse voltage test**		95 kV positive and negative polarities each 10 times, No breakdown, No	

			flashover.	
16	**Outdoor joint / termination short-term power frequency voltage test**		Wet, at 42kV, for 15 min. No flashover, No breakdown.	
17	**Short circuit current for conductor (1 second)**		17.5	
18	**Short circuit current for sheath (1 second)**		10.1	
19	**Outdoor joint / termination radio interference test**		5 microvolts at 10 kHz 50 microvolts at 100 kHz 500 microvolts at 1 MHz	
20	**Pressure leak test**		No gas shall escape at 0.2 MPa for 1 hour	
21	**Conductor cross section**	mm^2	To be confirmed by design: For 20MVA 2x630mm^2/phase For 15MVA 2x400mm^2/phase For 3,5MVA 120mm^2/phase For 160kVA 120mm^2/phase Earthing TRs 120mm^2/phase 11kV switchgears link 2x400mm^2/phase	
22	**Diameter over cable insulation - prepared**	mm		
23	**Minimum creepage distance**	mm/kV	31.5	
24	**Min. arcing distance**	mm		
25	**Outdoor cable terminations characteristics**		To specify	
26	**Specialized tools for termination process**		To specify	
27	**Installation procedures and instructions**		To provide	
28	**All materials be compatible and suitable for**		yes	

	the continuous operating temperature of the cable of 90°C and short circuit temperature of 250°C (5 second duration)			
29	**Silicone rubber with an excellent adhesive property**		yes	
30	**Contents of the kit and Material used**		To Specify	

Annex A2-16 2.2kV XLPE Cable Guaranteed Technical Data

	Description	Unit	Minimum Required Data	Data Offered By The Bidder
1	**Manufacturer**			
2	**Country of Origin**			
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC60502	
5	**Type**		XLPE, Single core	
6	**Highest System Voltage (Um)**	kV	3	
7	**Rated Voltage (Ur)**	kV	2.2	
8	**System earthing**		Earthed through earthing Transformer	
9	**Rated frequency**	Hz	50	
10	**Conductor material**	-	Stranded compacted Cooper	
11	**Cross section of wires**	mm²	To be confirmed by design: For 4MVA 2x500mm²/phase	
12	**Rated short circuit current (1 s.)**			
12-1	Conductor	kA	25	
12-2	Screen	kA	10	
13	Design continuous operation at rated full load current, the max. temp. of conductor shall not exceed	°C	90	
14	The conductor temperature after a short circuit for 1.0 sec. shall not exceed	°C	250	
15	Insulation		XLPE	
16	Outer Sheath		PVC	
17	Screen		Copper	
18	Armouring		Double layer of non-magnetic (aluminum) tapes.	
19	**Continuous current @90°C**			

19-1	in ground	A		
19-2	in duct	A		
	Electrical parameters			
1	**Electrical Stress**			
1-1	Conductor Shield	kV/mm		
1-2	Insulation Shield	kV/mm		
2	**Conductor Resistance**			
2-2	DC @ 20°C	Ω/kM		
2-3	DC @ 90°C	Ω/kM		
3	**Capacitance**	Pf/kM		
4	**Charging current**	A/kM		
	Dimensional			
1	**Bending radius (single core cables)**	mm	approx.15 x d	
2	**Maximum Pulling Tension**			
3	**Conductor Diameter**	mm		
4	**Diameter over Insulation**	mm		
5	**Diameter over Screen**	mm		
6	**Overall Jacket Diameter**	mm		
7	**Net weight of the cable**	Kg		
8	**Fire retardant**		yes	
9	**Moisture resistant**		yes	
10	**Water proof armour**		AWA	
	Indoor and Outdoor Cold Shrinkable Cable Termination			
1	**Manufacturer**			
2	**Country of Origin**			
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC60502, IEC61442, IEEE48	
5	**Cable Type**		XLPE, single core copper with aluminum armour	
6	**Highest System Voltage (Um)**	kV	3	
7	**Rated Voltage (Ur)**	kV	2.2	
8	**System earthing**		Grounded through	

			earthing transformer	
9	**Rated frequency**	Hz	50	
10	**Type Termination**		outdoor and indoor cold-shrinkable	
11	**Power frequency voltage withstand test**			
12	**Room temperature partial discharge test**			
13	**Thermal cycle test**			
14	**High temperature partial discharge test**			
15	**Lightning impulse voltage test**			
16	**Outdoor joint / termination short-term power frequency voltage test**			
17	**Short circuit current for conductor (1 second)**			
18	**Short circuit current for sheath (1 second)**			
19	**Outdoor joint / termination radio interference test**			
20	**Pressure leak test**			
21	**Conductor cross section**	mm^2	To be confirmed by design: For 4MVA	
22	**Diameter over cable insulation - prepared**	mm		
23	**Minimum creepage distance**	mm/kV	31.5	
24	**Min. arcing distance**	mm		
25	**Outdoor cable terminations characteristics**		To specify	
26	**Specialized tools for termination process**		To specify	
27	**Installation procedures and instructions**		To provide	
28	**All materials be compatible and suitable for the continuous operating temperature of the cable of 90°C and short circuit temperature of 250°C (5 second duration)**		yes	
29	**Silicone rubber with an excellent adhesive property**		yes	
30	**Contents of the kit and Material used**		To Specify	

Annex A2-17 33 kV Metal Clad Switchgear Guaranteed Technical Data

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
1	**Manufacturer**			
2	**Country of Origin**			
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC 62271-200	
5	**Type**		air insulated	
6	**Installation**		Indoor	
7	**Rated frequency**	Hz	50	
8	**Operational voltage**	kV	33	
9	**Rated voltage**	kV	36	
10	**Rated lightning impulse withstand voltage**			
	Common value	kV	170	
	Across the isolating distance	kV	195	
11	**Rated power frequency withstand voltage**			
	Common value	kV	70	
	Across the isolating distance	kV	80	
12	**Rated normal current for Busbar**	A	1600	
13	**Rated short-time withstand current (3s)**	kA	25	
14	**Rated peak withstand current**	kA	80	
15	**Type of busbars**		Single	
16	**Method of earthing**			
17	**Busbar earthing**		make prove	
18	**Bay outgoing side**		make prove	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
19	**busbars segregated**		Yes	
20	**Material of cover and Portions**		metallic	
21	**Material of Shutters**		Metallic/earthed	
22	**Busbars and joints fully encapsulated**		Yes	
23	**Busbar and feeder shutters lockable with individual manual and automatic features**		Yes	
24	**Material of HV conductor**		Copper	
25	**Material of contacts**		Silver plated copper	
26	**Emergency manual trip facility (during failure of DC supply)**		Yes	
27	**Earthquake magnitude**	MSK	7	
28	**Porcelain Color**		brown	
29	**All meters, switchgear & relays flush mounted type**		yes	
30	**Total weight of the cubicle**	kG		
31	**Mechanical dimension (LxWxH)**	mm x mm x mm		
	<u>CIRCUIT BREAKER</u>			
1	**Manufacturer**		to be specified	
2	**Type**		SF6 withdrawable	
3	**Rated max voltage**	kV	36	
4	**Rated normal current**			
	Incoming Feeder, bus-section Feeder	A	1250	
	Outgoing Feeder	A	1250	
	Auxiliary transformer Feeder	A	630	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
5	**Rated frequency**	Hz	50	
6	**Rated lightning impulse withstand voltage**			
	Common value	kV	170	
	Across the isolating distance	kV	195	
7	**Rated power frequency withstand voltage**			
	Common value	kV	70	
	Across the isolating distance	kV	80	
8	**Rated short-circuit breaking current (3s)**	kA	25	
9	**Rated peak withstand current**	kA	80	
10	**Rated operating sequence**		O-0,3 s – CO – 3 min – CO	
11	**First pole to clear factor**		1,5	
12	**Type of operating mechanism**		3 pole	
13	**Single/Three phase autorecloser**		yes	
14	**Manual spring discharge facility**		Yes	
15	**Type of power device**		Motor-Spring	
16	**Interlocking**		Electrical & Mechanical	
17	**Voltage of power supply to the spring actuation electric motor circuits**	VDC	110	
18	**Voltage of power supply to the control circuits**	VDC	110	
19	**Nominal heater and lighting voltage**	VAC	230	
20	**Opening time**	ms	≤60	
21	**Total closing time**	ms	≤100	
22	**Operating counter provided**		yes	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
23	**Space heater provided for cubicle**		yes	
24	**Number of auxiliary contacts**		Min : 6No,6NC,6MBB	
25	**Pad locking provision for local cubicle**		yes	
26	**Total weight of the cubicle**			
	BUSBARS			
1	**Rated current at 50°C (Corresponding site rating)**	A	1600	
	DISCONNECTOR AND EARTHING SWITCH			
1	Manufacturer		to be specified	
2	Type designation		to be specified	
	at busbar side			
	at line side			
3	Rated voltage	kV	36	
4	Rated frequency	Hz	50	
5	Rated lightning impulse withstand voltage common value	kV	170	
6	Rated power frequency withstand voltage common value	kV	70	
7	Rated short time (1 s) current	kA	80	
8	Type of contacts		Copper	
9	Interlockings		Electrical & Mechanical	
10	Are the disconnector and the earthing switch mechanically interlocked to each other		yes	
	CURRENT TRANSFORMER			
1	Manufacturer		to be specified	
2	Type		Cast-resin multicore,	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
			multi-ratio, indoor	
3	Rated voltage	kV	36	
4	Rated frequency	Hz	50	
5	**Rated lightning impulse withstand voltage common value**	kV	170	
6	**Rated power frequency withstand voltage common value**	kV	70	
7	**BUS COUPLER**			
	Secondary currents	A	1	
	Primary currents bus coupler	A	800-400	
	Number of measuring cores		-	
	Number of protection cores		2	
8	**INCOMING TRANSFORMER**			
	Secondary currents	A	1	
	Primary currents incoming	A	200-100 (Padu & Trafalgar) 800-400 (Fond Cole)	
	Number of measuring cores		1	
	Number of protection cores		2	
9	**OUTGOING FEEDERS**			
	Secondary currents	A	1	
	Primary currents outgoing	A	800-400	
	Number of measuring cores		1	
	Number of protection cores		2	
10	**Accuracy class rating and capacity of measuring core**	VA	0.5/10	
11	**Accuracy class rating and capacity of protection core**	VA	10 P 20/20	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	<u>VOLTAGE TRANSFORMERS</u>			
1	**Manufacturer**		to be specified	
2	**Type**		Inductive cast - resin single pole insulated	
3	**Rated voltage**	kV	36	
4	**Rated frequency**	Hz	50	
5	**Rated lightning impulse withstand voltage common value**	kV	170	
6	**Rated power frequency withstand voltage common value**	kV	70	
7	**Transformation factor**		33000/√3; 110/√3; 110/√3	
8	**Number of secondary windings**		2	
9	**Accuracy class rating and capacity of metering core**		0.2/50	
10	**Accuracy class protection**		3P	

Annex A2-18 11 kV Metal Clad Switchgear Guaranteed Technical Data

No.	**Description**	**Unit**	**Minimum Required Data**	**Data Offered By The Bidder**
1	**Manufacturer**			
2	**Country of Origin**			
3	**Manufacturing's Designation as per submitted catalogue**			
4	**Applicable standard**		IEC 62271-200	
5	**Type**		air insulated	
6	**Installation**		Indoor	
7	**Rated frequency**	Hz	50	
8	**Operational voltage**	kV	11	
9	**Rated voltage**	kV	12	
10	**Rated lightning impulse withstand voltage**			
	Common value	kV	75	
	Across the isolating distance	kV	85	
11	**Rated power frequency withstand voltage**			
	Common value	kV	28	
	Across the isolating distance	kV	32	
12	**Rated normal current for Busbar**	A	2000	
13	**Rated short-time withstand current (3s)**	kA	25	
14	**Rated peak withstand current**	kA	80	
15	**Type of busbars**		Single	
16	**Method of earthing**			
17	**Busbar earthing**		make prove	
18	**Bay outgoing side**		make prove	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
19	**busbars segregated**		Yes	
20	**Material of cover and Portions**		metallic	
21	**Material of Shutters**		Metallic/earthed	
22	**Busbars and joints fully encapsulated**		Yes	
23	**Busbar and feeder shutters lockable with individual manual and automatic features**		Yes	
24	**Material of HV conductor**		Copper	
25	**Material of contacts**		Silver plated copper	
26	**Emergency manual trip facility (during failure of DC supply)**		Yes	
27	**Earthquake magnitude**	MSK	7	
28	**Porcelain Color**		brown	
29	**All meters, switchgear & relays flush mounted type**		yes	
30	**Total weight of the cubicle**		kG	
31	**Mechanical dimension (LxWxH)**	mm x mm x mm		
	CIRCUIT BREAKER			
1	**Manufacturer**		to be specified	
2	**Type**		SF6 withdrawable	
3	**Rated max voltage**	kV	12	
4	**Rated normal current**			
	Bus-section	A	2000	
	Incoming and Outgoing Feeder	A	1250	
	Auxiliary transformer Feeder	A	630	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
5	**Rated frequency**	Hz	50	
6	**Rated lightning impulse withstand voltage**			
	Common value	kV	75	
	Across the isolating distance	kV	85	
7	**Rated power frequency withstand voltage**			
	Common value	kV	28	
	Across the isolating distance	kV	32	
8	**Rated short-circuit breaking current (3s)**	kA	25	
9	**Rated peak withstand current**	kA	80	
10	**Rated operating sequence**		O-0,3 s – CO – 3 min – CO	
11	**First pole to clear factor**		1,5	
12	**Type of operating mechanism**		3 pole	
13	**Single/Three phase autorecloser**		yes	
14	**Manual spring discharge facility**		Yes	
15	**Type of power device**		Motor-Spring	
16	**Interlocking**		Electrical & Mechanical	
17	**Voltage of power supply to the spring actuation electric motor circuits**	VDC	110	
18	**Voltage of power supply to the control circuits**	VDC	110	
19	**Nominal heater and lighting voltage**	VAC	230	
20	**Opening time**	ms	≤60	
21	**Total closing time**	ms	≤100	
22	**Operating counter provided**		yes	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
23	**Space heater provided for cubicle**		yes	
24	**Number of auxiliary contacts**		Min : 6No,6NC,6MBB	
25	**Pad locking provision for local cubicle**		yes	
26	**Total weight of the cubicle**			
	BUSBARS			
1	**Rated current at 50°C (Corresponding site rating)**	A	2000	
	DISCONNECTOR AND EARTHING SWITCH			
1	Manufacturer		to be specified	
2	Type designation		to be specified	
	at busbar side			
	at line side			
3	Rated max voltage	kV	12	
4	Rated frequency	Hz	50	
5	Rated lightning impulse withstand voltage common value	kV	85	
6	Rated power frequency withstand voltage common value	kV	28	
7	Rated short time (1 s) current	kA	80	
8	Type of contacts		Copper	
9	Interlockings		Electrical & Mechanical	
10	Are the disconnector and the earthing switch mechanically interlocked to each other		yes	
	CURRENT TRANSFORMER			
1	Manufacturer		to be specified	
2	Type		Cast-resin multicore,	

No.	**Description**	**Unit**	**Minimum Required Data**	**Data Offered By The Bidder**
			multi-ratio, indoor	
3	Rated max voltage	kV	12	
4	Rated frequency	Hz	50	
5	**Rated lightning impulse withstand voltage common value**	kV	75	
6	**Rated power frequency withstand voltage common value**	kV	28	
7	**BUS COUPLER**			
	Secondary currents	A	1	
	Primary currents bus coupler	A	2000/1000	
	Number of measuring cores		-	
	Number of protection cores		2	
8	**INCOMING TRANSFORMER**			
	Secondary currents	A	1	
	Primary currents incoming	A	1200/600	
	Number of measuring cores		1	
	Number of protection cores		2	
9	**INCOMING GENERATOR & LINK TO EXISTING 11kV SWITCHGEAR**			
	Secondary currents	A	1	
	Primary currents generator & link	A	400/200	
	Number of measuring cores		1	
	Number of protection cores		2	
10	**OUTGOING FEEDERS**			
	Secondary currents	A	1	
	Primary currents outgoing	A	800-400	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	Number of measuring cores		1	
	Number of protection cores		2	
11	**Accuracy class rating and capacity of measuring core**	VA	0.5/10	
12	**Accuracy class rating and capacity of protection core**	VA	10 P 20/20	
	VOLTAGE TRANSFORMERS			
1	**Manufacturer**		to be specified	
2	**Type**		Inductive cast - resin single pole insulated	
3	**Rated max voltage**	kV	12	
4	**Rated frequency**	Hz	50	
5	**Rated lightning impulse withstand voltage common value**	kV	75	
6	**Rated power frequency withstand voltage common value**	kV	28	
7	**Transformation factor**		11000/√3; 110/√3; 110/√3	
8	**Number of secondary windings**		2	
9	**Accuracy class rating and capacity of metering core**		0.2/50	
10	**Accuracy class protection**		3P	

Annex A2-19 110VDC Batteries Guaranteed Technical Data

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
1	Manufacturer		to be specified	
2	Type		alkaline (NiCd)	
3	Rated voltage	VDC	110	
4	Voltage each cell	V	2	
5	Rated capacity at 10-hours discharge	Ah	Min 250	

Annex A2-20 48VDC Batteries Guaranteed Technical Data

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
1	Manufacturer		to be specified	
2	Type		alkaline (NiCd)	
3	Rated voltage	VDC	48	
4	Voltage each cell	V	2	
5	Rated capacity at 10-hours discharge	Ah	Min 100	

Annex A2-21 110VDC Batteries Rectifiers Guaranteed Technical Data

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
1	Rectifier			
2	Manufacturer		to be specified	
3	Type		Thyristor-controlled	
4	Input voltage	VAC	400	
5	Frequency	Hz	50+/- 10%	
6	Residual ripple		5 %	
7	Cooling		to be specified	

Annex A2-22 48VDC Batteries Rectifiers Guaranteed Technical Data

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
1	Rectifier			
2	Manufacturer		to be specified	
3	Type		Thyristor-controlled	
4	Input voltage	VAC	400	
5	Frequency	Hz	50+/- 10%	
6	Residual ripple		5 %	
7	Cooling		to be specified	

Annex A2-23 240 VAC Uninterruptible Power Supply Guaranteed Technical Data

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	Static Inverter			
1	Manufacturer			
2	Applicable standards		IEC62040	
3	Rated power at … °C ambient temperature (Minimum)	kVA/°C	3/ 40	
4	Active power(Minimum)	kW	2.4	
5	Type of cooling	-	AN	
6	Protection class of cubicle	IP	20	
7	Rated DC voltage, input	V	110	
8	Rated voltage, output	V	400/230	
9	Voltage control	%	<+/-1	
10	Frequency	Hz	50	
11	Frequency stability	Hz	+/-0,05	
12	Frequency stability with auto-pulsing	%	+/-0,1	
13	Overload capability		125 % - 10 min 150%- 60s	
14	Max. power loss at rated load	W		

15	Acousticlevelon100 % load	dB(A)	< 63 (in 1m)	
16	Efficiency at 75- 100% linear load	%	>95	
17	Efficiency at 75- 100% non linear load	%	>93	
18	Total Harmonic Distortion	%	<9	
19	Static transfer switch	yes/ no	yes	
20	Network card	yes/ no	yes	
21	Interfaces: RS-232, RJ 45,	yes/ no	yes	
22	Relays cards for operating and malfunction messages	yes/ no	yes	
23	Dimensions: - height	mm		
24	-width	mm		
25	- depth	mm		
26	Total weight	kg		
	Rectifie rdata			
1	Manufacturer	-	-	
2	Type	-	-	
3	Power supply	-	TN-S 400V± 10 % 50 Hz ± 2 %	

Annex A2-24 Substation Control and Monitoring System Guaranteed Technical Data

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	General			
1	Manufacturer			
2	Type / Designation			
3	Availability class according to IEC 61850	class	A3	
4	System availability	%	>99.95	
5	Reliability class according to IEC 60870-4	class	R3	
6	Automatic time synchronization at all nodes of the network		yes	
7	Time resolution events	ms	1	
8	Fault indication LEDs on modules		yes	
9	Spare function capacity	%	50	
10	Spare parts	%	20	
	Station Bus			
1	Protocol		61850	
2	Transmission medium		fiber	
3	Transmission rate	Mbit/s		
	Ethernet Switches			
1	Number of Ethernet switches		2	
2	Manufacturer			
3	Type			
4	Power supply	V DC	110	
	RTU			
1	Number of RTU		1	
2	Manufacturer			
3	Type			
4	Power Supply	V DC	110	
5	Communication protocol		IEC60870-5-104	
6	Input / output cards for common substation signals/commands		yes	
	Operator Works station			
1	Number of operator workstation		1	

2	Type			
3	Power supply	V AC	230	
4	CPU			
5	Working Memory		Min 8 GB	
6	Hard Disc		Min. 500 GB	
7	Operrting System		Windows 10	
8	Monitors for per operator workstation with corresponding accessories – KVM Extenders)	pcs	2	
9	Monitor size	inch	24	
10	Desk	pc	2	
11	Chair	pc	6	
	HMI			
1	Manufactures			
2	Type			

Annex A2-25 Protection Relays Guaranteed Technical Data

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	General			
1	Relays:	-	Digital	
2	Standard	-	IEC 60255	
3	Maximum ambient temperature for rated accuracy	ºC	55	
4	Maximum temperature by storage	ºC	60	
5	maximum humidity	%	80	
6	Electromagnetic compatibility tests	-	Per Specification	
7	Insulation tests	-	Per Specification	
8	Mechanical tests (vibration and shock stress)	-	Per Specification	
9	Switching capacity of output contacts	W	>1000W,110V-DC	
10	Manufacturer references	year	8	
	Panels:			
1	Standard	-	IEC 60529	
2	Protection class	-	IP 54	
3	Pre-wired	-	Yes	
4	Floor-mounted	-	Yes	
5	Steel sheet thickness	mm	2,5	
6	Maximum height	mm	2200	
7	Maximum width	mm	800	
8	Maximum depth	mm	800	
9	Front-door material	-	Glass	
10	Coloring	-	RAL 7035	
	69 kV line protection relay, Protection Main			
	Differential protection (ANSI: 87L, 87C)			
1	Relay Type	-		
2	Manufacturer	-		
3	Place of manufacture	-		
4	Type of line differential protection	-	Segregated phase	
5	Rated values:			
6	Frequency	Hz	45/55	
7	Rated current	A	1 and 5	
8	Rated voltage	V	110+/- 15%	
9	Number of phases	-	3	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
10	Measuring characteristics of distance elements (quadrilateral, Mho,___	-	Quadrilateral	
11	Range of auxiliary DC supply	V DC	110 + 20%	
12	Relay operating time	msec.	≤ 35	
13	Quantity of output relays or contacts		24	
14	Quantity of LEDs for indication		16	
15	Time synchronization signal	msec.	1	
16	Time tagging resolution	msec.	± 1	
17	Front serial interface communication:			
	Baud rate	kb/s	100 Mbit	
	Connection		RJ45-LAN	
18	System interface:			
	Connection		Ethernet (TCP/IP)	
	Protocol		IEC 61850	
	Communication speed	Mbps	100	
19	Point-to-point connection		Monomode fiber connection ITU-G685	
20	SDH Multimode fiber connection		IEEE C37.94 / or G703-E1/T1 through converter	
21	Settings:			
	Ranges of values of restrained protection	I/I_{nO}	5-100%	
	Ranges of values of unrestrained protection	I/I_{nO}	100-1000% I base	
	Ranges of times	sec	0.00-60.00sec	
22	Remote change of active group allowed (Yes / No)	yes	Yes	
23	Remote change of settings allowed (Yes / No)	yes	Yes	
	69kV line Autoreclosure relay			
1	Number of reclosures		1 pole / 3 poles (4Nos)	
2	Dead time range	sec	0.1- 15 Sec	
3	Reclaim time range	sec	0…600	
4	Operating mode with check synchronizing function		Yes	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	69kV line Back-up overcurrent protection relay (ANSI: 50/51, 50N/51N, 67 and 67N):			
1	Relay Type	-		
2	Manufacturer	-		
3	Place of manufacture	-		
4	Rated values			
5	Frequency	Hz	50	
6	Phase current	A	1	
7	Phase to phase voltage	V	110	
8	Auxiliary voltage	V DC	110	
9	Time synchronization signal	msec.	1	
10	Time tagging resolution	msec.	± 1	
11	Front serial interface communication:			
	Baud rate	kb/s	100 Mbit	
	Connection		RJ45-LAN	
12	System interface:			
	Connection		FO ST	
	Protocol		IEC 61850	
	Communication speed	Mbps	100	
13	High set overcurrent protection:			
14	Definite time overcurrent phase current setting range	A	0.10….40.00xIn	
15	Definite time overcurrent time setting range	Sec	0.05….15.00	
16	Dropout ratio			
17	Inverse time overcurrent phase current starting	A	0.05…5xIn	
18	Inverse time overcurrent time multiplier range		0.05…15.00	
19	Low set overcurrent protection: -			
20	Definite time overcurrent phase current setting range	A	0.05…5.00xIn	
21	Definite time overcurrent time setting range	Sec	0.05….15.00	
22	Dropout ratio			

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
23	Inverse time overcurrent phase current starting	A	0.05…5xIn	
24	Inverse time overcurrent time multiplier range	Sec	0.05…15.00	
25	High set earth fault protection:			
26	Definite time overcurrent earth fault setting range	A	0.10…40.00xIn	
27	Definite time overcurrent time delay setting range	Sec	0.05….15.00	
28	Inverse time overcurrent earth fault starting	A	1..40In	
29	Inverse time overcurrent time multiplier range		0.05….15.00	
30	Low set earth fault protection:			
31	Definite time overcurrent earth fault setting range	A	0.001…5.00xIn	
32	Inverse time overcurrent earth fault starting	A	0.05….15.00	
33	Inverse time overcurrent time multiplier range		0.05….15.00	
34	Direction detection for phase overcurrent:			
35	Forward range – Inductive angle	degree	-30….+30deg	
36	Forward range – Resistive angle	degree	-30….+30deg	
37	Forward range – Capacitive angle	degree	-30….+30deg	
38	Direction detection for earth faults: -		-30….+30deg	
39	Forward range – Inductive angle	degree	-30….+30deg	
40	Forward range – Resistive angle	degree	-30….+30deg	
41	Forward range – Capacitive angle	degree	-30….+30deg	
	Transformer Protection, Main			
	Differential protection (ANSI: 87T and 87R)			
1	Manufacturer			
2	Relay Type			
3	Ratings			

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
4	Secondary current	A	1	
5	Rated frequency	Hz	50	
6	DC supply	V	110	
7	Time synchronization signal	msec.	1	
8	Time tagging resolution	msec.	± 1	
9	Front serial interface communication:			
	Baud rate	kb/s	100 Mbit	
	Connection		RJ45-LAN	
10	System interface:			
	Connection		Ethernet (TCP/IP)	
	Protocol		IEC 61850	
11	Communication speed	Mbps	100	
12	Differential protection settings: -			
13	Pick-up values range of differential current		10%	
14	High current stage range		5000%	
15	Inrush restraint ratio (2^{nd} harmonic)		Yes	
16	Stabilization ratio further (n – th) harmonic		5th	
17	Dropout ratio		> 94%	
18	Built in CT ratio and vector group matching included (yes / no)	Transformer only	Yes	
19	Transformer star point conditioning (earthed, non – earthed)	Transformer only	earthed	
20	Restricted earth fault protection setting: -			
21	Differential current setting range		4%	
22	Time delay setting range		25ms…open	
23	Definite time three phase over current and earth fault protection setting: -			
24	High set phase current setting	A	500…250000%	
25	High set earth fault setting	A	100…250000%	
26	Low set phase current setting	A	500…250000%	
27	Low set earth fault current setting	A	100…250000%	
28	Time setting range for high set phase current setting (sec)	sec.	0…60 sec	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
29	Time setting range for low set phase current setting	sec.	0…60 sec	
30	Time setting range for high set earth fault setting	sec.	0…60 sec	
31	Time setting range for low set earth fault setting	sec.	0…60 sec	
32	Inverse time three phase over current and earth fault protection setting: -			
33	Phase starting current setting range		1%	
34	Time setting range for phase current		0…60 sec	
35	Earth fault starting current setting range		100…2500%	
36	Time setting range for earth fault current		0…60 sec	
37	Breaker failure protection time setting range	sec.	> 35 ms	
38	Breaker failure protection current setting range	A	5…200%	
	Transformer Back-up overcurrent protection (ANSI: 50/51):			
1	Relay Type	-		
2	Manufacturer	-		
3	Place of manufacture	-		
4	Rated values			
5	Frequency	Hz	50	
6	Phase current	A	1	
7	Phase to phase voltage	V	110	
8	Auxiliary voltage	V DC	110	
9	Time synchronization signal	msec.	1	
10	Time tagging resolution	msec.	± 1	
11	Front serial interface communication:			
	Baud rate	kb/s	100 Mbit	
	Connection		RJ45-LAN	
12	System interface:			
	Connection		FO ST	
	Protocol		IEC 61850	
	Communication speed	Mbps	100	
13	High set overcurrent protection:			

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
14	Definite time overcurrent phase current setting range	A	0.10….40.00xIn	
15	Definite time overcurrent time setting range	Sec	0.05….15.00	
16	Dropout ratio			
17	Inverse time overcurrent phase current starting	A	0.05…5xIn	
18	Inverse time overcurrent time multiplier range		0.05…15.00	
19	Low set overcurrent protection: -			
20	Definite time overcurrent phase current setting range	A	0.05…5.00xIn	
21	Definite time overcurrent time setting range	Sec	0.05….15.00	
22	Dropout ratio			
23	Inverse time overcurrent phase current starting	A	0.05…5xIn	
24	Inverse time overcurrent time multiplier range		0.05…15.00	
25	High set earth fault protection:			
26	Definite time overcurrent earth fault setting range	A	0.10…40.00xIn	
27	Definite time overcurrent time delay setting range	Sec	0.05….15.00	
28	Inverse time overcurrent earth fault starting	A	1..40In	
29	Inverse time overcurrent time multiplier range		0.05….15.00	
30	Low set earth fault protection:			
31	Definite time overcurrent earth fault setting range	A	0.001…5.00xIn	
32	Inverse time overcurrent earth fault starting	A	0.05….15.00	
33	Inverse time overcurrent time multiplier range		0.05….15.00	
	69kV Busbar protection, Main (different make one to each other) Fond Cole substation			
	Differential protection (ANSI: 87B):			
1	Relay Type	-		

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
2	Manufacturer	-		
3	Place of manufacture	-		
4	Rated values			
5	Frequency	Hz	50	
6	Phase current	A	1	
7	Auxiliary voltage	V DC	110	
8	Ranges of values of restrained protection	I/I_{nO}		
9	Ranges of values of unrestrained protection	I/I_{nO}		
10	Ranges of times	sec		
11	Time synchronization signal	msec.	IRIG-B / SNTP	
12	Time tagging resolution	msec.	1 ms	
13	Front serial interface communication:			
	Baud rate	kb/s	100 Mbit	
	Connection		RJ45-LAN	
14	System interface:			
	Connection		Ethernet (TCP/IP)	
	Protocol		IEC 61850	
	Communication speed	Mbps	100	
15	Time synchronization signal	msec	1	
16	Time tagging resolution	msec	± 1	
17	Bus bar protection:			
18	Over current setting range		yes	
19	Stabilizing factor setting range for bus bar		yes	
20	Selective protection		Yes	
21	Stabilizing factor K for check zone		yes	
22	Typical tripping time	msec	< 20 ms	
23	Differential current monitoring setting range		1…100000 A	
24	Breaker failure protection current setting range (Main1 relay only)		2 – 200%	
25	Breaker failure protection time setting range (Main1 relay only)		0 – 60 sec	
26	Isolator transition time setting range		0…6000 sec	
27	Over current protection in the bay unit		yes	
28	Definite time characteristics:			

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	High set over-current current setting range		1…2500%	
	High set over-current time setting range		0…60 sec	
	Low set over-current current setting range		1…2500%	
	Low set over-current time setting range		0…60 sec	
	High set earth fault current setting range		1…2500%	
	High set earth fault time setting range		0…60 sec	
	Low set earth fault current setting range		1…2500%	
	Low set earth fault time setting range		0…60 sec	
29	Inverse time over current characteristics:			
	Phase over current setting range		1…2500%	
	Earth fault setting range		1…2500%	
	Time delay for phase over current		0…60 sec	
	Time delay for earth fault		0…60 sec	
30	Setting range for over current release of trip command			
31	Operational measured values of central unit		Idiff&Ibias	
32	Operational measured values of bay units		n/a	
33	Number of events recorded in the central units		1000	
34	Number of events recorded in the bay units		n/a	
35	Number of faults recorded in the central unit		100	
36	Number of faults recorded in the bay units		n/a	
37	Number of equipped bays			
	Line overcurrent protection (ANSI: 50/51, ,50/50N, 67, 67N):			
1	Relay Type	-		
2	Manufacturer	-		
3	Place of manufacture	-		
4	Rated values			
5	Frequency	Hz	50	
6	Phase current	A	1	
7	Phase to phase voltage	V	110	
8	Auxiliary voltage	V DC	110	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
9	Time synchronization signal	msec.	1	
10	Time tagging resolution	msec.	± 1	
11	Front serial interface communication:			
	Baud rate	kb/s	100 Mbit	
	Connection		RJ45-LAN	
12	System interface:			
	Connection		FO ST	
	Protocol		IEC 61850	
	Communication speed	Mbps	100	
13	High set overcurrent protection:			
14	Definite time overcurrent phase current setting range	A	0.10….40.00xIn	
15	Definite time overcurrent time setting range	Sec	0.05….15.00	
16	Dropout ratio			
17	Inverse time overcurrent phase current starting	A	0.05…5xIn	
18	Inverse time overcurrent time multiplier range		0.05…15.00	
19	Low set overcurrent protection: -			
20	Definite time overcurrent phase current setting range	A	0.05…5.00xIn	
21	Definite time overcurrent time setting range	Sec	0.05….15.00	
22	Dropout ratio			
23	Inverse time overcurrent phase current starting	A	0.05…5xIn	
24	Inverse time overcurrent time multiplier range		0.05…15.00	
25	High set earth fault protection:			
26	Definite time overcurrent earth fault setting range	A	0.10…40.00xIn	
27	Definite time overcurrent time delay setting range	Sec	0.05….15.00	
28	Inverse time overcurrent earth fault starting	A	1..40In	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
29	Inverse time overcurrent time multiplier range		0.05….15.00	
30	Low set earth fault protection:			
31	Definite time overcurrent earth fault setting range	A	0.001…5.00xIn	
32	Inverse time overcurrent earth fault starting	A	0.05….15.00	
33	Inverse time overcurrent time multiplier range		0.05….15.00	
34	Direction detection for phase overcurrent:			
35	Forward range – Inductive angle	degree	-30….+30deg	
36	Forward range – Resistive angle	degree	-30….+30deg	
37	Forward range – Capacitive angle	degree	-30….+30deg	
38	Direction detection for earth faults: -		-30….+30deg	
39	Forward range – Inductive angle	degree	-30….+30deg	
40	Forward range – Resistive angle	degree	-30….+30deg	
41	Forward range – Capacitive angle	degree	-30….+30deg	
42	Autoreclosure:-			
43	Number of reclosures	$\geq$ 2 shots	2	
44	Dead time range (sec)		0…6000 sec	
45	Reclaim time range (sec)		0…6000 sec	
46	Breaker failure protection current setting range (A)		5…200%	
47	Breaker failure protection time setting range (Sec)		> 35 ms	
48	Sensitive earth fault protection function included	Yes	yes	
49	Phase discontinuity / broken conductor detection function included	Yes	yes	
50	Measured values ranges and display, please list: -		A,V,W,Var	
51	Disturbance recording setting: -			
52	Pre-fault time range (msec)		0.05---3.00sec	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
53	Post-fault time range (msec)		0.1…10.0	
54	Limit time range (msec)		340sec	
55	Number of recorded disturbances		100	

Annex A2-26 Measuring Instruments Guaranteed Technical Data

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	Measuring instruments for (Volt, Ampere, Watt, Var, cos phi etc.)			
1	**Size**	mm x mm	96 x 96	
2	**Accuracy class**	-	1.0	
3	**Operating principle**	-	Digital	
4	**Meters (internal)**			
4-1	Accuracy class	-	0.5	
5	**Meters (Billing)**			
5-1	Max. error	%	0.2	
5-2	Number of tariffs		4	
5-3	Selectable recording interval	min	1-60	
5-4	Accuracy class active/reactive		0.2S/1	
	Storage capacity for:			
1	15 minutes interval	Years	10 years	
2	And for No's channel	Nos.	4	
3	Battery capacity	Years	10years	
4	Optical port	-	Yes	
5	Serial port RS-232-C	-	Yes	
6	Internal clock: battery capacity	years	10 years	
7	Max. error per month	s	0.5	
8	Software			
9	Programmer/Retriever			
10	Type	-		
11	Batteries	-	rechargeable	
12	RS-232-C accessory module	-	yes	
13	Optical port accessory module	-	yes	

Annex A2-27 Telephone Communication Guaranteed Technical Data

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	PHONE AUTOMATIC PRIVATE BRANCH EXCHANGE			
1	*Manufacturer*			
2	Model			
3	Technology		modular digital VoIP technology	
4	Country of origin			
5	*Nominal characteristics*			
5-1	Common equipment			
	Central processing unit designation: - microprocessor type - data interface			
	Memory - ROM module designation - module capacity - RAM module designation - module capacity			
	Conference - number of simultaneous conferences - maximum number of simultaneous parties			
	Peripheral signaling module - designation - clock frequency - clock stability - tone and digit switch			

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	Network module designation - number of duplex loops - number of voice channels per loop -structure - data rate - coding		Non blocking	
	Mass storage - Hard disk - Other			
5-2	Peripheral equipment			
	Buffer module designation			
	Multi-frequency module designation - standard			
	4W E/M trunk interface: - module designation - number of ports per module - impedance - transmission level (min-max) - reception level (min-max) - standard - signaling - Pulse - Speed - make/break ratio - M lead idle state - E lead idle state - M lead seize state - E lead receival state - Private network trunk frequency limitation - Compatibility requirement with exchange (interface module)	- - Ohm dBm dBm - - - Pps %	- - 600 - - ITU-T Q E/M	
	PSTN central office trunk interface module designation - number of ports per module - impedance			

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	-transmission level (min-max) - reception level (min-max) - Signaling - pulse - loop current speed - make/break ratio - co trunk voltage - co ring - (volts/frequency) - Compatibility requirements: central office trunk	- - mA pps % V Hz	Loop start or ground start - 20 min. - - -48 Vdc - As per local telephone provider	
	Analogue Subscriber 2W extension interface : - module designation - number of ports per module - impedance - signal level max/min -off hook min-max loop current - signaling - maximum loop resistance - ringing voltage and frequency - signaling pulse characteristics: - speed - interdigital time - make/break ratio - signaling dual frequency (DTMF): - standard - speed - interdigital time - minimum duration	Ohm V Hz pps ms % - Digit/s ms ms	8-12 TYP 240 TYP 58-59 TYP ITU-T Q23 12.5 TYP 100 TYP 40 TYP	
	Digital Subscriber extension interface: - module designation - number of ports per module - Interface type - Bit rate - Power supply - Maximum line length - Standard	- - - kB/S - m -	- - - - - - ISDN	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	SIP Subscriber extension interface : - Module designation - Number of ports per module - Interface type - Bit rate - Power supply - Maximum line length - Standard	 - - - kB/S - m -		
	Attendant console module interface - module designation - number of ports per module - Interface type - Bit rate - power supply to console - dual frequency dialing: - standard - speed - interdigit time - maximum duration - provision for multi attendant consoles			
	Operator digital telephone interface - module designation - number of ports per module - Interface type - Bit rate - power supply to console - dual frequency dialing: - standard - speed - interdigit time - maximum duration - provision for multi operator telephones	 - - - kB/s - - - Digit/s ms ms -	 - - - - - - ITU-TQ23 12.5 TYP 100 TYP 40 TYP Yes	
	Digital PCM interface - module designation - Use - Number of ports per module	 - - -	 - Private or Public Network -	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	- Impedance - Signal level (min/max) - Data rate - Configuration - Digital trunk interface capability - Primary rate interface - Protocol designation - Standard	Ohms dBm Mbit/s - - - - -	- - 2048 30B+D - Yes Yes ITU – T, ISDN	
	Digital SDH Multiplexer interface module designation - Use - Number of ports per module - Impedance - Signal level (min/max) - Data rate - Configuration - Digital trunk interface capability - Primary rate interface - Protocol designation - Standard			
	Configuration of peripherals - 4 wires E/M trunks : required - 2 wires extension: required - PSTN trunks: required - Attendant consoles - required - ultimate - Operator phone interface: required - Digital or SIP phone interface - Digital PCM interface - Digital SDH Multiplexer interface		32 16 1 Various 4 50 4 8	
	Digital terminal and printer ports		Yes	
5-3	Performance			
	Traffic per line for ultimate configuration with blocking probability and maximum call delay			

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	Frequency response (-3 dB ref. 800 Hz)	Hz	300-2000 for PLC	
	Input impedance	ohms	600 (return loss 20 dB min)	
	Insertion losses: - line-trunk - line-line	 dB dB	 5 max 1	
	Idle noise	dB	29 dBrn (-90 dBm)	
	Crosstalk attenuation	dB	75 min	
	Harmonic distortion with respect to main signal			
	Power input: - voltage - voltage variation - load	 Vdc Vdc W	 48 positive grounded 43-58	
	Heat dissipation: - for actual configuration - for ultimate	 Ws Ws		
5-4	Software features and designation			
	Private switched network facilities		Yes	
	Priority for operator and specific users as programmed		Yes	
	Transfer of internal or external calls with third party consultation		Yes	
	Conference Int./Ext.		Yes	
	Night service to designated subscribers or general answering			
	Alternate station routing and hunting		Yes	
	Common link		Yes	
	Alarm ringing		Yes	
	Station routing to attendant upon no answer			
	Station outward signaling access restriction		Yes	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	Subscriber trunk selection		Yes	
	Pulse to multi-frequency conversion from trunk to subscribers			
	Incoming CO calls answered by attendant		Yes	
	Call on hold		Yes	
	Access to CO lines		Yes	
	Barge in for selected users		Yes	
	Call waiting tone		Yes	
	Speed dialing (abbreviated signaling)		Yes	
	Call forward		Yes	
	Call forward no answer		Yes	
	Direct inward system access		Yes	
	Intercept treatment		Yes	
	Line lockout		Yes	
	Call details recording CDR and automatic number identification			
	Charge account for CDR		Yes	
	Automatic call distribution		Yes	
	Last number redial		Yes	
	Other available features (enclose list of other features)			
5-5	Multi-terminal distributor - Designation - Number of terminals		- suitable for 200 lines (trunks or subscribers)	
	Terminal characteristics: - insulation level - current capacity - conductor size (min-max) - type of enclosure - list of components	V A mm² -		

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	- test facilities - connection	- -	Mechanical not soldering	
	Interconnection cables: - number of pairs - size - color coding - electrical insulation - equipment plug-in connector	- mm² - - -		
	Cross connect wire: - size - color coding - electrical insulation			
	Inside wiring cable: - size - color coding - electrical insulation	mm² - V		
	Enclosure - type - accessories		Steel wall mounted or free standing IP50 lockable hinged doors	
	Space provision			
	Overvoltage protection			
	CO Trunk transfer to designated extensions upon failure of PABX			
5-6	Console			
	Attendant console designation			
	Digital display		alphanumeric	
	Keyboard - functional keys with indication of activation - call indicators - features keys		Yes Yes	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	- trunk group busy indicators - dial pad		Yes 12 buttons	
	Impedance	ohm		
	Audio input/output			
	Signaling		Audible and visual	
	Dual tone dialing		DTMF ITU-T Q23	
	Head and handsets		Yes	
	Speech level		Adjustable	
	Power input: - voltage - consumption - heat dissipation			
6	Weight and dimensions			
	Weight			
	Main PABX unit - for service - for transport	kg kg		
	Distribution frame - for service - for transport	kg kg		
	Dimensions (H x W x D)			
	Main PABX unit - for service - for transport	mm mm		
	Distribution frame - for service - for transport	mm mm		
7	Standards - Manufacturing and design - Quality assurance		ITU-T ISO 9001	
8	Installation		Interior in Fond Cole Substation	

Annex A2-28 Optical Platform Guaranteed Technical Data

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	OPTICAL PLATFORM			
1	*Manufacturer*			
2	Type			
3	Model			
4	Country of origin			
5	*Nominal characteristics*			
5-1	General			
	Rate	Mbits/s	Minimum 100 Mbits/s	
	Configuration		Rings or Linear radial systems	
	Multiplexing structure			
	Cross-connect level			
	Redundancy configuration		Redundant common equipment	
	Alternative fiber path switching time	ms	3 max.	
	Error performance		ITU-T G.826	
	Jitter		ITU-T G.783, G.823, G.958	
	Diagnostics		ITU-T G.826, G.784	
	Indicators		Normal operation, malfunction detected, optical transmitting	
	Synchronization - bits reference signal type - drifting rate (1 second) without ref. signal			
	Orderwire channel		yes	
	Power supply	Vdc	-48	
	Power consumption	W		

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
5-2	Optical Aggregate Link			
	Physical level			
	Wavelength	nm		
	Rate	Mbps		
	Connector	-		
	Optical transmitter output	dBm	-3 dBm min.	
	Optical receiver sensitivity	dBm	-35 dBm max.	
5-3	Tributaries			
	Level	-		
	Physical level	-		
	Bit rate	Mbps		
	Line code			
5-4	Ethernet Unit			
	Interface		10 BASE-T/100 BASE-TX	
	VLAN compliant		IEEE 802.1	
5-5	Network management Software			
	designation		-	
	compatibility		PC Windows latest version	
	network configuration		Yes	
	node monitoring		Yes	
	alarm log and time stamping		Yes	
	trouble shooting and maintenance		Yes	
6	Weight and dimensions			
	Dimensions - cabinet for service - cabinet for shipment	 mm mm		
	Weight - cabinet for service	 kg		

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	- cabinet for shipment	kg		
7	Standards - manufacturing - quality assurance		ITU-T ISO 9001	
8	Installation		At substations and Powers Plant	
	Fiber Optic Cable			
1	Country of origin			
2	Characteristics			
2-1	**Optical Fiber**			
	Type of Fiber		Single mode	
	Core Diameter	Micro meter	10 +/-1	
	Core refractive Index Difference	%	0.3	
	Cladding Diameter	Micro meter	125 +/- 3	
	Cladding circularity tolerance	%	-	
	Primary coating material		Silicon or acrylate resin	
	Secondary coating material		-	
	Maximum attenuation at 1550nm	dB/Km	0.19	
	Fiber Dispersion at 1550 nm	ps / nm km	<= 18	
	Fiber splicing loss	dB	0.08	
2-2	**Cable**			
	Number of fiber/cable			
	Insulation materials shall be exclusively non-metallic			
	Type of moisture barrier			
	Type of rodent protection			
	Temperature cycling without damage	°C	-20 to + 90	
	Outer diameter	mm	-	
	Tensile load	N	2700	
	Minimum bending radius :	-	-	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	One time bending	mm	10 x OD	
	Repeated bending	mm	Max. between 200, 10 x OD	

Annex A2-29 Mobile Transformer Oil Purification Machine Guaranteed Technical Data

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
1	***Manufacturer***			
2	**Type**			
3	**Model**			
4	**Country of origin**			
5	***General***			
	Mounting		Trolley Mounted	
	Type of Service		Outdoor	
	Standard		IEC 60422	
	Environment friendly		weather proof	
	Break Down Voltage		>70 kV	
	Moisture Content		<3PPM	
	Gas content		<0.05% by volume	
	Filter rating		0.5 Micron	
	Processing Temperature		40-60 °C	
	Dissipation factor at 90 deg		0.05	
	Acidity		<0.08 mg KOH/gms of Oil	
6	**Magnetic Strainer**			
	Filter Rating/capability		All particles of sizes above 0.5mm and all magnetic particles	
	Flow		At least 4000 LPH	
7	**Oil Inlet Pump**			
	Type		Positive Displacement	
	Capacity		At least 4000 LPH	
	Features for pump protection against over pressure built up		Automatic	
	Motors Rating			
	Motor IP Rating		55	
	Motor Insulation class		Class “F”	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	Type of starters		Direct On Line Starter	
	Does the pump provided with interlocking arrangement in between the oil inlet pump and the heater?		Yes	
	Does interlocking arrangement provided in the filter plant between the inlet pump and the high level float switch to avoid excess rise of oil in the degassing column?		Yes	
8	**Heaters**			
	Type		Indirect with Tubular, Refectory former type	
	Full load heater rating in kW		<50 kW	
	Does the Selector switch provided?		Yes	
	Max. temperature of oil		80°C	
	Heater Vessel construction & Insulation		Mild Steel welded construction with glass/mineral wool insulation	
	Heater element		Nichrome/Kanthal wire filament	
	Does the Heaters arrangement interlocked with Gear Pump and not in ON position, unless the Inlet Pump is working?		Yes	
	Does Heater Tank is adequately thermally insulated to minimize loss of heat?		Yes	
	Specific Heat Load		Less or equal to 2W/cm2	
9	**Filtration System**			
	Preliminary Filter capability		All particles of sizes above 0.5 mm and all magnetic particles	
	Fine Filtration system: - Rated output			

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	- Type - Rating - Quantity		At least 4000LPH Non-hygroscopecartridge 0.5 micron 4 Nos	
10	**Degassing & Dehydration Chamber**			
	Number of stages		2	
	Pumps		Roots and Rotary Pumps	
	Vacuum Pressure		-0.06 to -0.099 MPa	
11	**Outlet Pump**			
	Rotary oil sealed pump			
	Type		Centrifugal glandless pump	
	Feature		Automatic pressure bypass arrangement	
12	**Gauges and Instruments**			
	Thermostat Digital			
	Thermometer			
	Pressure Gauge			
	Vacuum Gauge			
	Float switch			
	Digital Vacuum Gauge			
13	**Controller Panel (PLC Based)**			
	Supply		400 Volt, 3 Ph, 4 Wire, 50 Hz, A.C.	
	Control Circuit		230 V, Single phase AC	
	IP rating		55	
	Contactor Make, Overload Relay, Indicating lamps, Mimic Diagram, Main Switch, MCB, PLC, SMPS, Reverse Phase Indicator, Rotary Switch		To be available	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	with Illuminating Lamps, Twin luminous push buttons			
14	**Valves and Pipe Line**			
	Valves in Oil Line & Vacuum Line		Ball Type	
	Pipes welding		Electric Resistance Welding (ERW)	
	Joints in Oil & Vacuum Line		Flanged & 'O' Ring Sealing	
	O' Ring Material & Shape		Nitrile Rubber & Round Shape	
15	**Hose**			
	Material of Hoses		Oil Resistant Rubber Hose	
	Length		15 Meter long at least for each above	
16	**Others**			
	Independent Drives for		Oil discharge pump, Oil inlet pump & Vacuum pump	
	Manufacturer’s valid ISO 9001 certificate		To be submitted	
	Manufacturer’s authorization		To be submitted	
	End user’s Certificates showing that the manufacturer has successfully completed the Manufacturing & supply of at least 2 Sets of Transformer Oil Purification Plant		To be submitted	
	Functional/ Operational Test Certificate of Offered Transformer Oil Purification Machine		To be Provided	
	Operational Instruction Manual, Maintenance Instruction Manual with Troubleshooting		To be Provided	

A2-30 Diesel Generator Guaranteed Technical Data

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
1	***Manufacturer***			
2	**Type**		Outdoor, silenced and water proof	
3	**Model**			
4	**Country of origin**			
5	***General***			
	Governor, Mechanical (& Electronic)		Yes	
	Speed	rev/min	1500	
	Applicable standard		ISO 3046	
	Method of starting			
	Electrical system		12 Vdc	
	Capacity of fuel day-tank	L	Sufficient for full load continuous running period of 12 hours	
	Cooling system		Air and Water cooled	
	Noise level at full load (at 10m from the Diesel room)	dB(A)	Maximum 75	
6	**Generator**			
	Phases	-	3	
	Rated power	kVA	100 (Minimum)	
	Rated Voltage	V	230/400V, 3 phase	
	Type	-	Synchronous, brushless, self excited	
	Frequency	Hz	50	
	Stator		2/3 pitch	
	Rotor		Single bearing, flexible disc	
	Insulation System		Class H	
	Standard Temperature Rise		125 - 163°C Continuous	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
	Alternator Cooling		Direct drive centrifugal blower fan	
	AC Waveform Total Harmonic Distortion		No load <1.5% Non distorting balanced linear load < 5%	
	Protection degree		IP23	
7	**Control supervision and protection panel (as specified in DG Technical specification)**			
	mounted on the genset base frame		yes	
	Earth Fault, single set		yes	
	Power Outlet Terminal Board Mounted on the Gen-set Base Frame		yes	
8	**Accessories (as specified in DG Technical specification)**			
	Fuel-water separator filter		yes	
	Residential silencer		yes	
	Low fuel level alarm		yes	
	Sound proof canopy		yes	
	Tool kit for maintenance		To be provided	
9	**Dimensions and weight**			
	- Diesel generator set	m x m x m		
	- Fuel oil tank	m x m x m		
	- Weight of heaviest part or component	kg		

A2-31 Energy Meter Guaranteed Technical Data

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
1	***Manufacturer***			
2	**Type**		3Ph, 4Wire, direct connected, active & reactive energy, four quadrant measurements	
3	**Model**			
4	**Country of origin**			
5	***General***			
	Applicable standard		IEC 62052-11, IEC 62053-21, IEC 62053-23 and IEC 62056	
	Frequency	Hz	50Hz with + / - 5% variation	
	Class index		Class 0.5, Active Energy Class 0.2, Reactive Energy	
	Secondary Voltage		For VT - Suitable for operation from 110V Ph-Ph or 63.5V Ph-N	
	Base Current (Ib)	A	1	
	Starting Current		0.2% Ib	
	Maximum continuous current, Imax	A	100	
	Power factor range		-1 to +1	
	Number of Display Digits		8	
	Power consumption	VA	<1	
	Design		ASIC/Miccontroller based design factory calibration using high accuracy (0.05 class)	
	Power supply		110Vdc with voltage variation of 60% to 120 %	
	Measured parameters		Instantaneous parameters a. Voltage	

No.	Description	Unit	Minimum Required Data	Data Offered By The Bidder
			b. Current phases & Neutral channel c. Power factor d. Power in KW , KVA e. Frequency II. Cumulative Energies a. Active energy KWH b. Apparent energy KVAH c. Reactive energy KVARH III. Maximum Demand a. KW and KVA b. Integration time 15/30 minutes (programmable)	
	Load Survey data		Load survey for 60 power on days for 15/30 min integration: a. Active energy b. Reactive energy c. Apparent energy d. Average Voltage e. Average current f. Average Power factor g. Mid night cumulative KWH	
	Memory		Nonvolatile memory independent of battery backup, Data should be retained up to 10 years	
	Insulation		A meter shall withstand an insulation test of 4 KV and impulse test at 8 KV	
	Communication Protocols		RS232/RS485 and Ethernet TCP/IP	
	Routine and Type tests		To provide	

Annex 3: Drawings