SECTION 7.2

SWITCHING STATION AUTOMATION SYSTEM

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7.2 SWITCHING STATION AUTOMATION SYSTEM

7.2.1 Scope of Supply

This specification covers the design, manufacture, inspection, testing at the manufacturer's works and erection and commissioning of a Switching station Automation System described in the following sections, to control and operate the 33 kV GIS switching station.

This describes the facilities required to provide the control of plant and system within a switching station and outlines the facilities to be provided on site, interface requirements and performance criteria.

The Switching station Automation System (SAS) shall comprise full station and bay protection, control, monitoring and communication functions. It shall enable local station control via PC by means of a human machine interface (HMI) and control software package and perform the necessary system control and data acquisition functions. It shall include communication gateway to inter- bay-bus, intelligent electronic devices (IED) for bay control and protection as shown in the enclosed general system architecture drawing. In addition, all other signals from battery charger, multifunction meter, energy meter, MCCB status of ACDB & DCDB indications and other related signals should be incorporated to SAS through IEDs, Protection Relays and RTUs. If necessary, the contractor has to provide standard protocol converter or separate device to accommodate analogue or digital signals which are not in IEC 61850 Protocol. The protocol converter shall support digital, analog, alarm, event, and SOE data and shall be fully interoperable with the SAS. All configuration, integration, testing, and commissioning shall be in the Contractor's scope.

The communication gateways (or RTUs) shall secure control from and information flow to and from remote network control centers via IEC 60870-5-104. The inter-bay bus, configured as a star connection (via star couplers) shall provide independent station-to-bay and bay-to-bay data exchange. The bay level intelligent electronic devices (IED) for protection and control shall be directly connected to the instrument transformer without any interposing equipment and perform control, protection, and monitoring functions subject to a detail proposal approved by the Engineer.

The design and application shall conform to IEC 62351 and IEC 62443.

The system shall be capable of having its computing power increased in the future by the addition of additional computing systems.

The system design life shall be not less than 20 years.

The tenderer shall provide:

- IEC 61850 compliance report for the offered system with IEDs and
- Interoperability test report from any UCA approved system verification and validation center along with the bid document.

The capacity of the SAS system shall be sufficient for the ultimate development of the switching station as set out in the project requirements.

The SAS supplier shall demonstrate that the system proposed has been designed, installed and commissioned in accordance with relevant international standards.

The contractor shall provide the installation software of the switching station automation

system. Installation, testing and commissioning of switching station automation system shall be done by the automation Engineer(s) of the switching station automation manufacturer(s).

The software architecture and the database structure shall be finalized with the Purchaser. The facilities shall be incorporated in order to access the database from the backend by the authorized user of the Purchaser. Object oriented technology shall be used in the software development.

The standard database like Oracle, MySQL, SQL or Other shall be used. Cyber Security of this system shall be built in with the system. The objective of cyber security is to protect information and physical assets from damages caused by theft, corruption or natural disasters while allowing the information and assets to remain accessible and productive to employer. All potential causes of cyber attacks need to be considered when employing a defence in depth approach.

All electrical wiring from protection relays, RTUs, protocol converters, marshalling panels, ACDB, DCDB, battery chargers, meters, and other auxiliary devices up to the SAS panels shall be in the Contractor's scope. This includes supply of cables, termination, ferruling, labelling, testing, and commissioning.

For switching stations where only Switching station Automation System (SAS) shall be installed by this project and where the required Binary Input (BI) / Binary Output (BO) signals are not fully available from the existing Intelligent Electronic Devices (IEDs), the Contractor/EPC shall be responsible for accommodating all remaining digital and analogue signals of each 33 kV PCM panel etc. into the SAS and Gateway / RTU.

The scope of work shall include, but not be limited to, the supply, installation, routing, termination, ferruling, labelling, testing, and commissioning of all necessary electrical wiring from 33 kV GIS cubicle, 33 kV PCM panels, ACDB, DCDB, battery charger, energy meters, transformer marshalling panels, and other associated auxiliary devices up to the RTU in SAS panels.

All control cables, accessories, and related materials required for complete and reliable integration shall be provided by the Contractor. The entire work shall be executed in accordance with the applicable IEC standards, approved drawings, and the Employer's technical specifications, ensuring full functionality and operational readiness of the SAS. The supply of required control cables will be in the scope of works.

For all six (06) switching stations, during the Switching station Automation System (SAS) configuration and engineering phase, adequate provision shall be made to integrate all necessary monitoring, alarm and status signals related to the 48 V DC battery system. The 48 V DC battery system, although falling under a separate tender package scope, will be the primary DC power source required for reliable and continuous operation of the SCADA and SAS equipment. The SAS configuration shall therefore allow for seamless incorporation of these signals at a later stage, including but not limited to battery health, DC voltage levels, charger status, alarms, and fault indications. All required interfaces, I/O capacity, signal mapping, and communication arrangements shall be planned and reserved accordingly to ensure full SCADA visibility and uninterrupted system operation once the 48 V DC battery system is commissioned.

7.2.2 Compliance with standards

For design and type testing of the protection and control equipment, the following standards shall be applicable:

7.2.2.1 General List of Specifications

IEC 255:	Electrical Relays
IEC 60038:	IEC Standard voltages
IEC 68068:	Environmental testing
IEC 60664:	Insulation co-ordination for equipment within low-voltage systems
IEC 61850:	Standard for Substation integrated protection and control data communication
IEC 62443:	Cyber Security
IEC 62351:	Cyber Security

7.2.2.2 Detailed List of Specifications

IEC 255-6:	Measuring relays and protection equipment
IEC 255-7:	Test and measurement procedures for electromechanical all-or-nothing relays IEC 68-2-3: Test Ca: Damp heat steady state
IEC 68-2-30:	Test Db and guidance; Damp heat, cyclic
IEC 255-5:	Insulation tests for electrical relays
IEC 255-22:	Electrical disturbance tests for measuring relays and protection equipment:
IEC 255-22-1:	1 MHz burst disturbance test
IEC 255-22-2:	Electrostatic discharge test
IEC 255-22-3:	Radiated electromagnetic field disturbance test
IEC 255-22-4:	Fast transient disturbance test
IEC 255-11:	Interruptions to and alternating component (ripple) i n D.C. auxiliary energizing quantity to measuring relays
IEC 255-6:	Measuring relays and protection equipment
IEC 255-21:	Vibration, shock, bump and seismic tests on measuring relays and protection equipment:
IEC 255-21-1:	Vibration tests (sinusoidal)
IEC 255-21-2:	Shock and bump tests
IEC 255-21-3:	Seismic tests
IEC 255-0-20:	Contact performance of electrical relays IEC 870-3 class 2: Digital I/O, Analogue I/O dielectric tests
IEC 801-5/class 3:	Digital I/O Surge withstand test
IEC 870-3/class 2:	Radio interference test
IEC 801-4/4:	Transient fast burst test
IEC 801-2/4:	Static discharge
IEC 801-3/3:	Electromagnetic fields

7.2.3 Design and Operating Requirements

7.2.3.1 General

The SAS shall be suitable for operation and monitoring of the complete switching station including future extensions. The offered products shall be suitable for efficient and reliable operation and maintenance support of the switching stations.

The SAS system shall be state-of-the art design suitable for operation in high voltage switching station environment, follow the latest engineering practice, ensure long term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

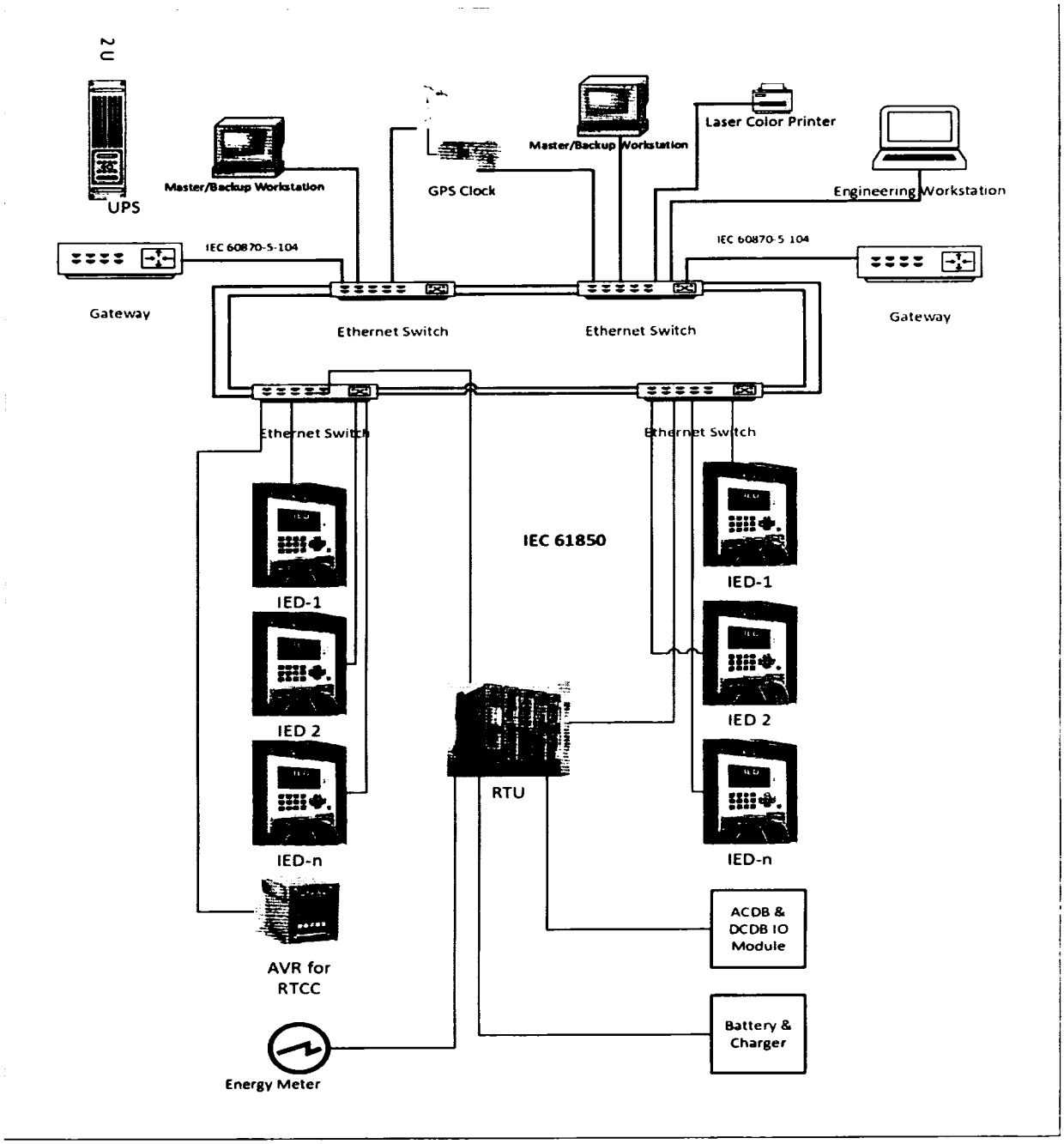
Protection is an integral part of the SA system and protective relays shall be directly connected to the inter-bay bus in order to provide unrestricted access to all data and information stored in the relays and for changing protection parameters from the remote-control location.

Failure behaviour of the hardware and software functions shall be addressed and related diagnostic and rectification working instructions shall be provided. The system performance, if failure of communication to main and redundant computer base workstations, central functions, data model, control and protection IED's, station and bay level communication shall also be clearly addressed (shall be provided by the manufacturer).

The switching station can also be controlled from Local Control Panel. The following modes of operation shall be possible:

- Emergency operation of breaker, disconnector, earthing switch etc. from the Local Panel.
- Emergency operation of breaker, disconnector, earthing switch etc. from the backup mimic panel located in the control room on the 1st floor/Ground floor. Both bay controller guided and unguided operation shall be possible from this panel.
- Normal operation of breaker, disconnector, earthing switch etc. from the Station Automation System HMI located in the 1st floor/Ground floor.
- Remote operation from the control centres.

SAS Architecture:



7.2.4 Modes of Operation

The operator stations and specified remote users shall have following operational modes, each password protected.

Monitoring Ability to select graphic displays and lists for viewing only. No capability to acknowledge alarms, complete controls or select items for inclusion in program functions.

Control: Selection of graphic display and lists. Able to acknowledge station and SA alarms, complete controls, dressing etc. associate with normal real time control of the switching station.

SA Engineering: Provides all the SA monitoring functions, together with online facilities for program/database/format modifications and checking

without the possibility of executing power system controls.

System Manager: Provides access to all system functions, including assignment of passwords and system maintenance activities.

In addition, a facility to provide access to the numerical Protection relays, change / modify relay settings & AVR parameters and Fault Recorder data shall be provided.

A series of passwords shall be personally assigned to operators in each of the above categories. It shall be possible for switching station operators to log on either of the switching station workstation and to be allocated the appropriate mode of operation relevant to the password. SA System Engineering work and access to the protection relay and disturbance recorder information shall generally be carried out at the Engineering workstation or remote master station.

All the workstation and the system database shall function as a system. It shall not be necessary for example to acknowledge an alarm at more than one workstation.

Similarly, an operator manual entry applied at a workstation shall be immediately displayed at other workstations where this data is presented.

7.2.4.1 Project Specifications

Specific functions required and boundary conditions of the SA are detailed elsewhere in this specification. The project specific drawings are attached:

- Overall single line diagram
- General system architecture
- Location of switching station buildings
- Control and operation principles
- Protection schemes

7.2.4.2 Vendor's Experience and Local Support

Only experienced and technically capable manufacturers in design and supply of control and protection systems for electricity transmission and distribution applications will be accepted. Preferred manufactures will be those who have experience in deliveries of the full scope of station automation systems and services.

. In order to assess the vendor's experience with similar projects, the vendor is required to submit the following with his Bid:

- Technical design specifications and description of SAS
- Catalogues and brochures of equipment and devices offered
- Reference list

The vendor shall assure for long-term maintenance and availability of spares.

7.2.5 General System Design

The system shall be so designed that personnel without any background in microprocessor-based technology can operate the system easily after they have been provided with some basic training.

System control from the switching station control room will be with the help of an Industrial Computer (PC) operated by a mouse. The following HMI (Human Machine Interface) functions shall be provided:

- Acquisition and plausibility check of switchgear status
- Control of switchgear
- Remote checking of device parameters and activation of alternative parameter sets in the connected protective relays
- Display of actual measured values (U, I, P, Q, f, PF)
- Display of Energy (kWh and kVarh export and import) from energy meter
- Display of events
- Display of alarms
- Display of trends
- Sequence control functions
- Disturbance records and fault location
- System self-supervision
- Display of Low voltage switchgear status and analog signals (ACDB, DCDB, Battery, Battery Charger, analogue parameter and signal monitoring etc.)
- Hard copy printing.
- Selection of Remote Control from the control centres.

Maintenance, modification or extension of components shall not require a shutdown of the whole station automation system. Self-monitoring of single components, modules and communication shall be incorporated to increase the availability of the equipment while minimizing maintenance time to repair.

The data exchange between the electronic devices shall take place via an inter-bay bus using IEC 61850 protocol. The high- speed bus shall permit peer-to-peer communication between the connected devices with democratic access. The entire station shall be controlled and supervised from the station level PC.

It shall also be possible to control, monitor and protect each individual bay from the respective bay level equipment for maintenance purposes or if the communication to a particular bay should fail. Clear control priorities shall prevent initiation of operation of a single switch at the same time from more than one of the various control levels viz., station level, bay level or switchgear (apparatus) level. The priority shall always be with the lowest enabled control level.

Each bay control and protection unit shall be independent of each other and its functioning shall not be affected by any fault occurring in any of the other bay control and protection units of the station.
The SAS shall contain the following main functional parts:

- Human Machine Interface (HMI) with process database
- Gateway / RTU function for remote control and monitoring via industrial grade hardware from two control centres simultaneously.
- Dial in facility / laptop workstation for protection relay parameterization, disturbance analysis and SA system fault analysis.
- Data exchange between the different system components via high-speed bus
- Bay and Station level devices for control, monitoring and protection
- Bay oriented local control and protection panels with mimic inserts
- Facility for emergency operation of all the switchgear, if IEDs fails. (Key/master key system.)
- Provision for future gateway for redundant remote supervisory control via SCADA.
- GPS Master Clock

The main process information of the station shall be stored in distributed databases. The system shall be based on a de-centralized concept with bay oriented distributed intelligence for safety and availability reasons. Functions shall be decentralized, object oriented and located as close as possible to the process.

The switching station monitoring/protection system shall supply data for maintenance, repair and remote parameter setting of protection and control devices in the switchyard.

In the event of a fault in the electrical network, the switching station monitoring shall provide a quick means for collecting the relevant and critical data of the fault.

The monitoring system shall be suitable for the supervision and monitoring of all the secondary (IED) and primary devices in a switching station including future extensions.

Maintenance, modification or extension of components shall not cause a shut-off of the whole station monitoring system. Self-monitoring of single components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.

It shall be possible to access all protection and control devices for reading the terminal parameters (settings). The setting of parameters or activation of parameter sets shall be restricted by password to the protection engineer.

7.2.6 Flexibility and Scalability

The offered SA system concept shall be flexible and shall permit future extensions to be realized easily. Preference will be given to those suppliers who are in a position to provide protection and control devices which can be freely adapted to the application functions required.

7.2.7 System Hardware

7.2.7.1 Operator Station

The main operator station shall be based on an industrial PC hardware and high-resolution full- graphics screen with manufacturers standard type tested software operating under the Windows environment(Windows 11). A Hard Copy printer shall be connected via a printer server and LAN to the operator station. The CPU shall be installed in the automation panel.

Dual station computers shall control the SA system and drive the work stations and other peripherals. One of the station computers shall operate the system in the "on line" state while the other acts as a "redundant hot standby". The standby computer shall be continuously updated and shall immediately take over the SA system duties without interruption or transfer mechanism should the on-line operator workstation fails.

Disturbance Records shall be analysed using the installed Disturbance Record Analysis programmes. The Disturbance Records will be collected, over the inter bay bus, from the connected IED's by the system software. All necessary facilities shall be provided to allow the system to perform spontaneous upload of Disturbance data or upload them in a pre-programmed manner.
Each uploaded data report file shall be reported on one line that shall contain:

- The event date and time
- The name of the event object
- A descriptive text
- The state or value of the object

The information fields above shall be structured in columns for maximum readability.

The hard copy printer shall permit printing of any picture (or part thereof) from the station

level PC's using easily accessible commands from the window menus.

The main Station PC's shall be supplied by the station DC battery or a UPS system with a supply duration of not less than 120 minutes shall be provided to supply the monitor and the printers.

7.2.7.2 Station Inter-bay Bus:

The LAN connecting the industrial computer-based operator workstations, printers shall be Ethernet 802.3 LAN, Protocol TCP/IP (10 M. bits/ sec or higher) and the physical medium shall be thin Ethernet or fibre optic bus, provided this LAN is kept within the confines of the control room.

The Contractor shall select, supply, and install all managed Ethernet switches compatible with copper (RJ-45) Ethernet interfaces, considering the port configuration, communication bandwidth, redundancy requirements, and IEC 61850 performance criteria of IEDs.

All protection and control units with serial communication facilities are connected in a star topology via glass fibre optics to the star coupler. Under no circumstances shall events from the protections be taken into the system via IEDs i.e., each protection device should have its own independent fibre optic communication channel to the star coupler. The star couplers shall be mounted in a separate communication cubicle.

All glass fibre optic and LAN Cables shall be armoured.

7.2.7.3 Protection and Control IED's on 33 kV Level:

The control IED's, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. They shall incorporate select-before-operate control principles as safety measures for operation via the HMI. They shall perform all bay related functions, such as protection, commands, bay interlocking, data acquisition, data storage and event recording and shall provide inputs for status indication and outputs for commands. They shall be mounted in the LV compartment of the switchgear and shall be directly connected to it without any need for separate interposing equipment or transducers.

The 33 kV protection IEDs shall have the following features depending on the requirement:

- Minimum of 8 analogue channels
- At least BI and BO as per PCM Panels requirements.
- Minimum 12 nos. programmable LED's on the front of the unit for indication
- Instantaneous Phase Over Current Protection
- Instantaneous Earth Fault Protection
- Inverse Time Phase Over Current Protection
- Inverse Time Earth Fault Over Current Protection
- Over voltage / under voltage Protection
- Synchro-check function
- Built-in mimic display with controls for operating the switchgear. In the event of failure of the bay unit a backup system for emergency operation should be provided.
- High speed bus serial communication port
- Sequence of Events Recorder with a buffer for 256 events and a resolution of 1 msec. The events that are to be recorded should be freely programmable. These could be alarm/trip signals, external signals connected to optocoupler inputs, internal signals, etc. Once events are defined, they are recorded in chronological order as they occur.
- Disturbance Recorder function which can record 9 analogue values, 16 Binary signals and 12

analogue channels for internal measurement values. It shall be possible for the Disturbance Recorder function to be triggered by any internal or external binary signal or internal protective function.

- Comprehensive self-supervision
- Battery-free memory back-up of Event and Disturbance Records
- Logic functions (AND, OR, bi-stable flip flop, etc.)
- Delay/Integrator function

The numerical IED's shall be mounted together with all the relevant bay protective relays in cubicles of Protection Class IP54 or better. Distributed back-up control mimics with associated switches meters and Indicating LEDs shall also be provided on these cubicles. These cubicles shall be installed in an air-conditioned room in the switching station.

The electronic system has to be provided with functions for self-supervision and testing. Each circuit board shall contain circuits for automatic testing of its own function.

Faults in the bay control IED shall be indicated on a front HMI and a message shall be sent to the station level HMI. The time for fault tracing and replacement of a faulty unit shall be reduced to a minimum. The supervision shall also cover the power supply system, the internal system bus and the ability of the central processing module to communicate with different printed circuit boards.

Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown. The n-1 criteria must be maintained in worst case scenarios also. Further, a single failure must not have any effect on the primary system, which is monitored and controlled.

7.2.7.4 Gateway / Remote Terminal Unit (RTU)

A total of six (6) switching stations are included under the scope of this project. All signals generated from protection relays installed at these switching stations shall be fully incorporated into the Switching station Automation System (SAS).

Signals that are not available directly from the protection relays shall be acquired and integrated into the SAS through suitable RTU modules, without any degradation or loss of SAS functionality. The number of required Binary Inputs (BI), Binary Outputs (BO), and Analog Inputs (AI) of the RTU shall be determined in accordance with the Guaranteed Technical Particulars (GTP) and the approved Signal List.

All **common switching station signals** that are not associated with individual bays are to be come through RTU modules to SAS. These signals shall include, but shall not be limited to, the following:

- AC Distribution Board (ACDB) status and alarms
- DC Distribution Board (DCDB) status and alarms
- Battery system and battery charger alarms
- MCCB auxiliary contact status
- Energy meter signals
- Any other non-bay-specific alarms, indications, measurements, or control signals required for complete switching station monitoring and operation

All protection relays installed at the 33 kV voltage levels shall be IEC 61850 compliant and shall act as the **primary source** of protection, control, measurements, event recording, and alarm information for the SAS. For these switching stations, a separate RTU panel shall **not** be required.

The I/O quantities specified in the GTP represent the **minimum installed capacity** only. In the event that the actual project signal requirements exceed the specified minimum BI, BO, or AI capacities, the Contractor shall supply, install, configure, and commission all additional I/O modules, expansion units, or accessories necessary to ensure full signal availability and complete SAS integration, **at no additional cost to the Employer.**

All RTUs provided under this project shall:

- Support Sequence of Events (SOE) recording with a time resolution of **1 millisecond or better**
- Be capable of accurate time synchronization using GPS, NTP, or IEC 61850 time-synchronization mechanisms
- Support communication protocols including IEC 61850, IEC 60870-5-104, and Modbus RTU/TCP
- Be fully interoperable with the SAS and remote SCADA systems

The RTUs shall be powered from the **110 V DC switching station power supply** and shall be suitable for installation within SAS panels or control panels, as applicable.

All activities related to engineering, system configuration, database preparation, signal definition, I/O mapping, testing, commissioning, and complete electrical wiring between SAS panels, RTUs, and interfaced equipment shall be deemed to be fully included within the Contractor's scope of work. No additional cost or variation shall be admissible on this account.

7.2.8 Software Structure

The software package shall be structured according to the SA architecture and strictly divided in various levels. It shall be possible to extend the station with the minimum possible effort. Maintenance, modification or extension of components of any feeder may not force a shut-down of the parts of the system which are not affected by the system adaptation.

Confirmation that the software programs will be supported for a minimum of 20 years is required to be submitted with the Bid.

It shall be the responsibility of the contractor to obtain any license required for the operation software. The contractor shall indemnify the client against all claims of infringement of any patent, registered design, copyright, trademark or trade name or other intellectual property right.

7.2.8.1 Station Level Software - Human Machine Interface (HMI)

The base HMI software package for the operator station shall include the main SA functions and it shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. The System shall contain a library with standard functions and applications.

7.2.8.2 Station Level Software - Operating System

Windows operating system shall be used for the operator station as it supports several standard system features, e.g., support for several Windows office applications, multitasking, security levels, data exchange mechanisms (DDE, OLE), open data base communication standards (ODBC) and a standardized, user-friendly look & feel HMI. The licensed copy of the operating system backup software shall be provided.

7.2.8.3 Bay Level Software - System Software

The system software shall be structured in various levels. This software shall be placed in a non- volatile memory. Its lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance engineer for modifications. The system shall support the generation of typical control macros and a process database for user specific data storage.

7.2.8.4 Bay Level Software - Application Software

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They shall form part of a library.

The application software within the control/protective devices shall be programmed in a functional block language.

7.2.9 System Testing

The supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval. For the individual bay level IED's, applicable Type Test certificates shall be submitted.

The manufacturing phase of the SA shall be concluded by a Factory Acceptance Test (FAT). The purpose is to ensure that the Contractor has interpreted the specified requirements correctly. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified with site conditions simulated to the extent possible in a test lab. If the FAT involves only a certain portion of the system for practical reasons, it has to be assured that this test configuration contains at least one unit of each and every type of equipment incorporated in the delivered system.

If the complete system consists of parts from various suppliers, the supplier shall arrange interoperability test at factory during stage inspection or FAT. The complete system test shall also be performed at site in the Site Acceptance Test (SAT).

7.2.10 System functions

7.2.10.1 Control Unit Functions

The different high voltage apparatuses within the station shall either be operated manually by the operator or automatically by programmed switching sequences.

The control function shall comprise:

- Commands from different operator places, e.g., from the station HMI, or local control panel according to the operating principle
- Select-before execute commands
- Operation from only one operator place at a time.
- Operation depending on conditions from other functions, such as interlocking, synchro-check, operator mode, or external status conditions.

The control function shall also include:

- Prevention of double operation
- Command supervision
- Selection of operator place

- Block/deblock of operation
- Block/deblock of updating of position indications
- Manual setting of position indications
- Overriding of the interlocking function (Second key switch.)
- Switchgear run time supervision
- Selection of remote control from the control centres.

7.2.10.2 Status Supervision

The position of each switchgear, e.g., circuit breaker, isolator, earthing switch, etc., shall be permanently supervised. Every detected change of position shall be immediately visible on the screen in the single-line diagram, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in cases when spontaneous position changes have taken place.

Each position of an apparatus shall be indicated using two binary auxiliaries normally closed (NC) and normally open (NO) contacts. An alarm shall be initiated if these position indications are inconsistent or indicate an excessive running time of the operating mechanism to change position.

7.2.10.3 Interlocking

The interlocking function prevents unsafe operation of apparatuses such as isolators and earthing switches within a bay or station wide. The operation of the switchgear shall only be possible when certain conditions are fulfilled. The interlocking function is required to be decentralized so that it does not depend on a central control device. Communication between the various bays for the station interlocking shall take place via bay communication system. An override function shall be provided, which can be enabled to by-pass the interlocking function via a key/password, in cases of maintenance or emergency situations.

7.2.10.4 Measurements:

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers.

The correlated values of active power (W), reactive power (VAr), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated.

7.2.10.5 Event and Alarm Handling:

Events and alarms shall be generated either by the switchgear, by the control devices and by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time tagged with a time resolution of 1ms. The time tagging shall be done at the lowest level where the event occurs and the information shall be distributed with the time tagging.

7.2.10.6 Time Synchronization:

The time within the SA shall be set via a GPS Clock Receiver connected directly to the Bay Level LAN. The time shall then be distributed to the control/protective devices via the high-speed optic fibre bus.

An accuracy of ±1 ms within the station is required.

7.2.10.7 Synchronism and Energizing Check

The synchronism and energizing check functions shall be distributed to the control and/or protective devices and shall have the following features:

- Adjustable voltage, phase angle, and frequency difference.
- Energizing for dead line - live bus, or live line - dead bus.
- Settings for manual close command and auto-reclose command shall be adaptable to the operating times of the specific switchgear.

7.2.10.8 Voltage Selection

The voltages, which are relevant for the synchro-check functions, depend on the station topology i.e., on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronizing and energizing is derived from the auxiliary switches of the circuit breakers, isolator, and earthing switch and shall be selected automatically by the control and protection IED.

7.2.10.9 HMI Functions

The operator station HMI shall provide basic functions for supervision and control of the switching station. The operator shall give commands to the switchgear via the station monitor with the help of mouse clicks on soft-keys.

The HMI shall provide the operator with access to alarms and events displayed on the screen. Besides these lists on the screen, there shall be a print out of hard copies of alarms or events in an event log.

The Alarm List shall indicate persisting and fleeting alarms separately.

An acoustic alarm shall indicate abnormalities and all unacknowledged alarms shall be accessible from any screen selected by the operator.

Following standard pictures shall be available from the HMI:

- Single line diagram showing the switching status and measured values
- Control dialogues
- Measurement dialogues
- Blocking dialogues
- Alarm list, station / bay oriented
- Event list, station / bay oriented
- System status
- Checking of parameter setting
- Supervisory control selection Local / Control Centre

7.2.10.10 HMI Design Principles

Consistent design principles shall be provided with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.

Object status shall be indicated using different status colours for:

- Selected object under command
- Selected on the screen
- Not updated, obsolete value, not in use or not sampled
- Alarm or faulty state
- Warning or blocked
- Update blocked or manually updated
- Control blocked
- Normal state

- Busbar colouring to show live & dead bus

7.2.10.11 Process Status Displays and Command Procedures

The process status of the switching station in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, isolators and transformer tap changers are displayed in the station single line diagram.

In order to ensure a high degree of security against unwanted operation, a special "select – before - execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognise the selected device on the screen and all other switchgear shall be blocked. After the "execution" of the command, the operated switch symbol shall blink until the switch has reached its final new position.

The system shall permit the operator to execute a command only if the selected object is not blocked and if no interlocking condition is going to be violated the interlocking conditions shall be checked by the interlocking scheme which is implemented on bay level.

After command execution, the operator shall receive a confirmation that the new switching position is reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

7.2.10.12 System Supervision Display

The SA system shall feature comprehensive self-supervision such that faults are immediately indicated to the operator before they possibly develop into serious situations. Such faults are recorded as faulty status in a system supervision display. This display shall cover the status of the entire switching station including all switchgear, IED's, communication links, and printers at the station level etc.

7.2.10.13 Reports

The SA shall generate reports that provide time related information on measured values and calculated values. The data displayed shall comprise:

- Trend reports:
  - Day (mean, peak)
  - Month (mean, peak)
  - Semi-annual (mean, peak)
  - Year (mean, peak)

- Historical reports:
  - Day
  - Week
  - Month
  - Year

It shall be possible to select displayed values from the database on-line in the process display.

Scrolling between e.g., days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory.

This report shall be printed automatically at pre-selected times. It shall also be possible to print this report on request.

7.2.10.14 Trend Display (Historical Data)

A trend is a time-related follow-up of process data. The analogue channels of all the connected bay level devices on the 33 kV level shall be illustrated as trends. The trends shall be displayed in graphical form as columns or curve diagrams with 10 trends per screen as maximum

It shall be possible to change the type of value logging (direct, mean, sum, or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.

7.2.10.15 Event List

The event list shall contain events, which are important for the control and monitoring of the switching station.

The time has to be displayed for each event.

The operator shall be able to call up the chronological event list on the monitor at any time for the whole switching station or sections of it.

A printout of each display shall be possible on the hard copy printer.

The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer. The information shall be obtainable also from printed event log.

The chronological event list shall contain:

- Position changes of circuit breakers, isolators and earthing devices
- Indication of protective relay operations
- Fault signals from the switchgear
- Violation of upper and lower limits of analogue measured value
- Loss of communication – local network
- Loss of communication with the control centres

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

- Date and time
- Bay
- Device
- Function
- Alarm class

7.2.10.16 Alarm List

Faults and errors occurring in the switching station shall be listed in an alarm list and shall be immediately transmitted to the control centre. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. Date and time of occurrence shall be indicated.

The alarm list consists of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

- The alarm date and time
- The name of the alarming object

- A descriptive text
- The acknowledgement states

The operators shall be able to acknowledge alarms, which shall be either audible or only displayed on the monitor. Acknowledged alarms shall be marked at the list.

Faults that appear and disappear without being acknowledged shall be specially presented in a separate list for fleeting alarms. For example, due to bad contacts or intermittent operation.

Filters for selection of a certain type or group of alarms shall be available as for events.

7.2.10.17 Object Picture

When selecting an object such as a circuit breaker or isolator in the single line diagram, first the associated bay picture shall be presented. In the selected object picture, all attributes such as-

- type of blocking,
- authority
- local / remote control
- SA control
- errors,
- etc., shall be displayed.

7.2.10.18 Control Dialogues

The operator shall give commands to the system by means of soft keys located on the single line diagram. It shall also be possible to use the keyboard for soft key activation. Data entry is performed with the keyboard.

7.2.10.19 User Authority Levels

It shall be possible to restrict the activation of the process pictures of each object (bays, apparatus, etc.) to a certain user authorisation group. Each user shall then be given access rights to each group of objects, e.g.:

- Display only
- Normal operation (e.g. open/close apparatus)
- Restricted operation (e.g. by-passed interlock)
- System administrator

For maintenance and engineering purposes of the station HMI, the following authorization levels shall be available:

- No engineering allowed
- Engineering/configuration allowed
- Entire system management allowed

The access rights shall be defined by passwords assigned during the log-in procedure. ly the system administrator shall be able to add/remove users and change access rights.

7.2.10.20 System Performance

The refresh/update times on the operator station PC under normal and calm conditions in the switching station shall be according to the levels specified below:

Functions	Typical values
Exchange of display (First reaction)	<2S
Presentation of a binary change in the Process display	<1S
Presentation of an analogue change in the process display	<1S
From order to process output	<1S
From order to updated of display	<1S

7.2.10.21 System Reliability

The SA system shall be designed to satisfy very high demands for reliability and availability concerning:

- Solid mechanical and electrical design
- Security against electrical interference (EMI)
- High quality components and boards
- Modular, well-tested hardware
- Thoroughly developed and tested modular software
- Easy-to-understand programming language for application programming
- Detailed graphical documentation, according to IEC 1131-3, of the application software
- Built-in supervision and diagnostic functions
- After sales service
- Security
- Experience of security requirements
- Process know-how
- Select before execute at operation
- Process status representation as double indications
- Distributed solution
- Independent units connected to the local area network
- Back-up functions
- Panel design appropriate to the harsh electrical environment and ambient conditions
- Panel grounding to provide immunity against transient ground potential rise
- The overall availability shall be equal to or better than 99.9%

7.2.10.22 Configuration Tools:

The configuration of the station HMI shall be made using the operator station working in Windows environment. The various functions shall be customized by easy-to-use interactive configuration tools. Configuration shall include the visual presentation of the object, adaptations needed in process database and adaptations of the communication configuration data.

A portable Personal Computer (PC) as a service unit shall be foreseen for on-site modifications of the control and protection devices. The service unit shall be used for documentation, test and commissioning.

The PC based service & support system shall be used for the following purposes:

- System configuration
- System testing
- Help functions
- Program documentation
- Down- and up-loading of programs
- System commissioning
- Data base management
- Changing peripheral parameters

The service & support system shall be able to monitor data in the running switching station control system and to present changing variables on the display screen in graphic representation.

All necessary configuration tools & software License should be supplied within the tender scope.

7.2.10.23 Information Required

The following documentation shall be provided for the system during the course of the project and they shall be consistent, CAD supported, and of similar look/feel:

- List of Drawings
- Control Room Lay-out
- Assembly Drawing
- Single Line Diagram
- Block Diagram
- Circuit Diagram
- List of Apparatus
- List of Labels
- Functional Design Specification (FDS)
- Test Specification for Factory Acceptance Test (FAT)
- Logic Diagram
- List of Signals
- Operator's Manual
- Product Manuals
- Calculation for uninterrupted power supply (UPS) dimensioning
- Licensed Copy of all software
- Third Party cyber security certification
- IP addressing scheme and actual IP addresses

SECTION 7.3

TECHNICAL SPECIFICATIONS OF 33/0.4 KV 200 KVA STATION AUXILIARY TRANSFORMER

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7.3 Technical Specification of 33/0.415KVA, 200KVA Auxiliary Transformer

7.3.1 GENERAL SPECIFICATION:

1.	Installation	Outdoor, Tropical, High Rainfall & Humidity
2.	Type	Core
3.	Coolant	Mineral oil
4.	Method of Cooling	ONAN
5.	Phases	3 (Three)
6.	Frequency	50 Hz.
7.	Winding	Two windings of high conductivity copper
8.	KVA Rating	200 KVA
9.	Rated Voltage at no-load	33/0.415 kV
10.	Vector Group	Dyn11
11.	Percentage Impedance at 75°C, %	5 %
12.	No Load Loss	Max 650 Watts
13.	Load loss at 75° C	Max 2910 Watts
14.	Maximum Temperature Rise at full load Over 40°C ambient temperature with tap changer in principal position.	a) 65°C for Winding measured by Resistance Method.
		b) 60°C for Top Oil measured by Thermometer Method.

7.3.2 Major Components

H.T WINDING :	
Nominal rated voltage	33 kV
Maximum system voltage	36 kV
Basic insulation level (minimum)	170 kV
Tap Changer	+1x 2.5%, 0, -3x2.5% of rated kV & all fully rated capacity. Tap Changer shall be off load type, manually operated from an external five-position mechanism.
Inter phase connection	Delta
Bushings	Porcelain, outdoors type with arcing horns of standard gap, mounted on top of tank. Quantity – 3 Nos.
Power frequency withstand voltage for one minute	70 kV
L.T WINDING :	
Nominal rated voltage	415 volts
Highest system voltage	457 volts
Inter phase connection	Y (Wye) with neutral brought out.
Bushings	Porcelain, outdoor type, mounted on the side of tank. (Longest side) Quantity – 4 nos.
Power frequency withstand voltage for one minute	3 kV
Transformer Oil :	
Application	Insulating mineral oil for Transformer. It will be free from PCB (Poly Chlorinated Biphenyl)

Grade of oil	Class-1
a) Physical Properties	
Appearance	Liquid and free from suspended matter or sediment
Density at 20° C	0.895 g/cm³ (Max^m.)
Flash point (Closed cup)	140° C (Min^m.)
Kinematics Viscosity at -15° C	800 cSt. (Max^m.)
Kinematics Viscosity at 20° C	40 cSt. (Max^m.)
Pour point	-30° C (Max^m.)
b) Electrical Properties	
Dielectric Strength at 50 Hz (with 2.5 mm standard gap and 40 mm standard depth)	New untreated oil, shall go through filtration treatment before the oils are introduced into the apparatus or equipment. The break down voltage of this oil shall be more than 50 kV.
Loss tangent/Dielectric dissipation factor at temp. 90° C, stress 500V/mm to 1000 V/mm and frequency 40 Hz to 62 Hz.	0.005 (Max^m.)
c) Chemical Properties	
Neutralization value	0.03 mg KOH/g (Max^m.)
Neutralization value after oxidation	0.40 mg KOH/g (Max^m.)
Total sludge after oxidation	0.10% weight (Max^m.)
PCB Content	Free from PCB (Poly Chlorinated Biphenyl)
d) Standards	Performance and testing of oil shall comply with the latest revision of the relevant standards BS 148 : 1972, IEC-60296 or latest revision there on.

7.3.3 Features and Accessories

a) All bolts and nuts connected with transformer tank, conservator, radiator etc. shall be of non-ferrous metal. If it is ferrous metal, it shall be hot dip galvanized as per standard ASTM A90/ BS EN ISO 1461:1999.

b) Lugs for lifting & towing complete unit.

c) Facilities for lifting core & coil assembly.

d) Base designed for platform mounting on poles.

e) First filling of new oil shall comply to the latest revision of IEC-60296 standard or other equivalent standards.

f) Each H.T. bushing shall have bolted type bimetallic connector suitable for accommodating ACSR conductor having Dia. range from 9mm to 14.5mm.

g) Each L.T. bushing shall have bolted type bimetallic connector for accommodating copper/AAC of area range 2x95mm² to 2x150mm².

h) The L.T. bushing shall be installed on the side/ top lengthwise of the transformer body. However radiator shall be avoided on this side on the body.

i) Dial thermometer for oil temperature mounted on L.T. side of the tank.

j) Earthing terminals at the bottom corners of Tank.

k) Name plate with transformer rating & winding diagram made of stainless steel shall have engraved letters filled with black enamel.

l) The tank & radiator or flanged radiator shall be painted with two coats of gray finishing

paint on suitable prime coats.

m) Transformer capacity with Sl. No. and WZPDCL Contract No. should be marked with emboss/ engrave on the transformer tank adjacent to name plate easily visible from ground.

n) HT and LT bushing shall be outdoor porcelain type

o) Set of sundries such as similar wiring terminals boards and glands for multi-core 0.415KV Power cables, 33KV terminal connectors suitable for ACSR etc.

For Conservator Type:

a) Transformer tank completes with covers, necessary openings & gaskets.
b) Complete oil preservation system consisting of an oil conservator with shut-off valve oil level gauge. The system shall have valve for filter press inlet & oil drain. The oil sampling valve & dehydrating breather shall be provided.

7.3.4 Information Required

The Bidder/ Manufacturer as per tender requirements shall provide all information. Besides these, the following information has to be submitted:

- Manufacturer's Printed Catalogue describing Specification and Technical Data for crucial components of offered 33/0.415KV, 200KVA, 3-Phase, Dyn11 stationary transformer.
- Detail dimensional drawings of offered 33/0.415KV, 200KVA, 3-Phase, Dyn11 stationary transformer.
- Manufacturer's valid ISO 9001 Certificate;

7.3.5 DOCUMENTATION

The following documents are to be submitted along with the Tender for the similar or higher KVA rating of same voltage class of offered 33/0.415KV stationary Transformer:

1) Guaranteed Technical Particulars (GTP) shall be properly filled up and signed by both Manufacturer & Tenderer;

2) Letter of authorization from the Manufacturers, in case, the Bidder is not the manufacturer, in prescribed Form;

3) 2 nos. of Manufacturer's Supply Record for similar or higher KVA rating of same voltage class of offered type Stationary Transformer within the last 5 (five) years from the date of opening in the following format (The supply record covering 25% of the tendered quantity in a single Contract will be considered only);

Sl. No.	Name, Address, Phone No., e-mail & Fax No. of the Purchaser	Contract No. & Date	Contract Value	Description of Material with Quantity	Date of Completion of Supply

4) At least 2 (two) Satisfactory Performance Certificate from for similar or higher KVA rating of same voltage class of offered type Stationary Transformer within the last 5 (five) years from the date of opening;

5) Type Test report for similar or higher KVA rating of same voltage class of offered type Stationary Transformer from an independent testing laboratory/Institute as per relevant standard (unless otherwise specified).

7.3.6 Test Reports

Tenderer's shall include in their offer the following routine tests, type tests and Short circuit withstands tests (or details calculations on the basis of design data) as prescribed in IEC- 60076/ BS-171 for 33/0.415KV, 200KVA , 3-Phase, Dyn11 Stationary Transformer or higher capacity.

ROUTINE TESTS

1) Measurement of turn ratio test.
2) Vector group test.
3) Measurement of winding resistance.
4) Measurement of insulation resistance.
5) Measurement of no-load loss & no-load current.
6) Measurement of impedance voltage & load loss.
7) Dielectric withstands Tests.
8) Transformer oil tests.

TYPE TESTS

1) Impulse Voltage withstands test.
2) Temperature rise test.

SPECIAL TESTS

1) Short circuit withstands tests or details calculations along with thermal & mechanical calculations on the basis of design data.

7.3.7 EVALUATION CRITERIA

a) Bidders declared/ guaranteed No-Load loss and Full load loss value shall be supported by type test reports, otherwise the bid will be rejected.

b) Bidders declared/ guaranteed percentage impedance value shall be within the specified value, otherwise the bid will be **rejected.**

7.3.8 ACCEPTANCE CRITERIA OF TRANSFORMER LOSS AND PERCENTAGE IMPEDANCE DURING FACTORY TEST WITNESS

Transformer will be tested during factory test witness and will be accepted if the measured transformer losses are within the specified value or within the following tolerance with deduction of money from the quoted/ contract price as below :

i) Each component loss (No load loss or Full load loss) may exceed up to 15% of the specified component loss, provided that the total losses cannot be exceeded 10% of the specified total losses.

ii) Percentage Impedance may vary up to ± 10 % of the specified value.

iii) The purchaser can carryout the testing of any no. of transformers during pre-delivery inspection. But, the testing of transformers during pre-delivery inspection will not be less than 10% at random basis of the transformer ready for inspection but in any case it will not be less than 3 nos. The manufacturer will provide all arrangements for the testing of transformers desired by the purchaser in his factory.

iv) If the test results of any transformer exceed the specified guaranteed losses or impedance, and any individual loss component exceeds the guaranteed value by more

than 15%, the transformer shall be deemed non-compliant with the specification or total loss exceeds more than 10% of the specified losses or percentage impedance exceeds 4±10% then the whole lot will be rejected or on request of the supplier/manufacturer every transformer may be tested (Transformer losses, percentage impedance, vector group test etc.) at his factory premises / CERS, BPDB by the WZPDCL inspection team. If the said transformers are tested by the WZPDCL inspection team at the manufacturers/suppliers premises, then the testing fees per transformer shall be paid by the supplier through invoice in advance. If the said transformers are tested at CERS, BPDB all the expenditure for carrying, loading/unloading and testing fees fixed by the CERS are to be borne by the supplier in advance. After completion of the test, the transformer passes the test will be properly sealed by the inspection team. The supplier will be liable to protect those seal up to delivery to the WZPDCL's designated Place(s).

The transformers which pass the tests will be accepted by WZPDCL subject to fulfillment of the other qualification criteria as per contract. The remaining transformers failed to qualify the tests will be rejected.

7.3.9 APPROVAL OF DRAWINGS

Calculation for the Max. Temp. Rise of Winding & Oil over 40°C ambient supported by Load Losses and Heat Dissipation by Radiator and also Short Circuit Calculation along with thermal & mechanical calculations on the basis of proposed Design Data.

7.3.10 TRANSFORMER CORE AND COILS

Transformers core and coils must be new, unused, and clean.

Supporting frames of the core and coils of transformers shall be designed to accommodate variations in tank height.

The core and coil assembly shall have the core and coils rigidly connected to the tank and suitably closed lugs shall be provided for removing the core and coil assembly from the tank.

Transformer Sl. no. should be marked with emboss on the Supporting frames of the core and coils of each transformers minimum in 2(two) places.

7.3.11 TRANSFORMER SEALING

A satisfactory lid-sealing gasket shall be provided on each of these transformers to maintain the seal at extremes of operating temperature. A cold oil level (COL) mark shall be provided inside each transformer marked COL.

7.3.12 FINISHES

a) Painting

Painting ferrous metal work is to be provided with an effective vapour sealing paint finish, applied generally in accordance with BS 5493 and /or other recognized international standard.

Paint shall be applied to produce a uniform film. Edges corners, crevices, welds, bolts, and rivets shall receive special attention to maintain the required thickness.

Before painting or filling with oil or compound, all un-galvanised parts shall be completely clean and free from rust, scale and grease and all external rough metal surfaces on the casting shall be filled.

The paint system shall be in accordance with best practice for hot and humid locations in a highly aggressive environment. A description of the paint system to be used and the proposed method of application shall be fully described in the Tender.

All external surfaces shall receive a minimum of three coats of paint. The primary coat shall contain an approved rust inhibitor and shall be applied as soon as possible after the completion of the surface preparation. The second coat shall be of oil and weather resisting nature and have a shade of colour easily distinguishable from the primary. The final coat shall be of oil and weather resisting and non-fading glossy paint of a colour agreed by the Engineer.

b) Non-ferrous parts and Bright Steel parts

All exposed metal liable iron corrosion during transport is to be appropriately protected by casting with an approved anti-rusting composition. Other non-ferrous parts shall be adequately protected against corrosion during shipment or in service.

c) Galvanizing

Galvanizing where applicable shall be applied by the hot dipped process generally in accordance with ASTM A90/ BS EN ISO 1461:1999 or equivalent standard of metal surface unless specified otherwise.

The zinc coating shall be smooth clean and of uniform thickness and free from defects. The preparation of galvanizing itself shall not adversely affect the mechanical properties of the coated material.

All drilling, punching, cutting, shaping and welding of parts shall be completed and all burrs shall be removed before the galvanizing process is applied.

Surfaces that are in contact with oil shall not be galvanized or cadmium plated.

7.3.13 RATING PLATE

A brass or stainless steel rating plate shall be fitted to each transformer. The information shall deeply etched including the diagram of the connections of the windings, the vector diagram showing the general phase relations of the transformer, and a diagrammatic plan of the transformer cover showing the terminal positions and marking and other essential particulars. The plate shall be mounted in an accessible position and preferably adjacent to the tapping switch if this is located on the side of the tank.

The rating plate shall be fitted below the LV terminals. Rating and diagram plates shall be attached by a 5 mm brass screw in each corner to 20 mm mild steel brackets welded horizontally approximately 20 mm from the tank side. The following information is to be provided on the rating and diagram plate in the English language - clearly and indelibly marked.

- Transformer type
- Manufacture's name
- Manufacturer's serial number
- Year of Manufacture
- Number of phases
- Rated power
- Rated frequency
- Rated voltages
- Rated currents
- Connection symbol
- Impedance voltage at rated current

- Type of cooling
- Total mass
- Mass of insulating oil
- Insulation levels
- Details regarding tapings

Each Transformer should be marked with emboss or welded on the body easily visible from the ground, with letters of size mentioned against each word(s)/ sentence(s) below:

WZPDCL (40 mm)
Contract No & Date: (20 mm)
Sl. No. :--------- of ----------KVA ---------- (20 mm)

Note :

a) Sl. No. .....of .....KVA ..... is meant for particular No. of the Transformer out of the contracted quantity under this contract.

b) The above marking on the body of the transformer shall be done in addition to the normal nameplate of the transformer. The nameplate shall be continuous welded on the body of the Transformer before Pre-delivery inspection.

7.3.14 TERMINAL MARKING

All transformers shall have the primary and secondary terminal markings plainly and indelibly marked on the transformer adjacent to the relevant terminal. These markings shall preferably be 25 mm in height. The terminal marking shall be embossed on the body of the Transformer with respective color code.

7.3.15 TERMINAL LEADS

Outgoing leads shall be brought out through bushings. The leads shall be such that the core and coils may be removed with the least possible interference with these leads and they shall be specially supported inside the transformer to withstand the effects of vibration and short circuits.

7.3.16 BUSHINGS

All bushings shall be porcelain clad and shall be of the highest quality. They shall be sealed in a manner to prevent ingress of moisture and to facilitate removal. The neutral bushings and stems shall be identical to those provided for phase terminations. Bushing stems, nuts and washers shall be made of brass.

7.3.17 EARTHING CONNECTIONS

Earthing connections shall be provided with connection facilities for 2x50 mm2 copper stranded conductor. The bolts shall be located on the lower side of the transformer and be of M12 size; each shall be clearly indicated with an engraved 'earth symbol'. Two earthing connections are required on each transformer.

7.3.18 GASKETS

Any gaskets provided with the transformers shall be suitable for making oil tight joints and there shall be no deleterious effects of either gaskets or oil when the gaskets are continuously in contact with hot oil. No gaskets shall be used in which the material of the material of the gasket is mounted on a textile backing. Exterior gaskets shall be weatherproof and shall not be affected by strong sunlight.

7.3.19 OIL

All transformers shall be filled to the required level with new, unused, clean, standard mineral oil after treatment in compliance with IEC 60296 & BS 148.

7.3.20 TAPINGS

Five voltage tapings shall be provided on the primary side of each transformer and shall give: + 2.5%, 0,- 2.5%, – 5% and –7.5% steps of the primary nominal voltage.

The tapings shall be selected by an 'off load' tapping switch with an external hand wheel with provision for looking onto a selected tapping. The switch shall have a positive action designed to eliminate the possibility of stopping in an intermediate position. The shaft shall be adequately sealed so that no seepage of oil occurs under all conditions of service. The voltage operating positions, together with tap change positions shall be clearly and indelibly marked.

SECTION 7.4

TECHNICAL SPECIFICATION OF CABLES & CONDUCTOR

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7.4 TECHNICAL SPECIFICATION OF CABLES & CONDUCTOR

7.4.1 General

Where a Manufacturer's Standard or a national Standard equal to or better than the appropriate specified standard has been issued and is acceptable to the Purchaser, any material or goods supplied shall be manufactured, installed and tested in accordance with the latest revision of the relevant standard unless otherwise specified.

Where any Standard referred to in this Specification has been superseded by a new standard prior to the date of the letter or invitation to Bid, the reference shall be deemed to be to such superseding standard.

Deviations from this Specification or standards referred to above shall be mentioned in the Bid and shall be taken into consideration by the Purchaser before contract placement.

The goods shall be designed to ensure continuity of service under all working condition at the site as the first consideration and to facilitate inspection, maintenance and repairs. All electrical components shall be adequately rated for their most onerous duty and the specified ambient temperature.

7.4.2 References

The recommendations and tests specified in the standards shall be adhered to. It shall be the responsibility of the Contractor to demonstrate to the Purchaser that any proposed Standard is equal to or superior to the equivalent IEC or BS. All costs for proving such equivalence are deemed included in the Contractors Bid Prices.

7.4.3 Climatic Condition

The offered XLPE U/G cables with jointing Kits must be suitable for working in the climate conditions of Bangladesh as described below:

•	Altitude	:	0-300 meters above the sea level
•	Maximum ambient temperature	:	45°C
•	Minimum ambient temperature	:	5°C
•	Humidity	:	98%
•	Mean annual rainfall	:	1500-3000 mm
•	No. of annual rainy days	:	80-120 days
•	Average isokeraunic level	:	80 days/year
•	Pollution of ambient air	:	dust, salt, chemical.
•			

7.4.4 Technical Requirements

Cross Link Polyethylene (XLPE) cables shall be suitable for operation at voltage of 33KV between phases at continuous maximum conductor temperatures of 90 deg. C. The cable shall be suitable in all respect for use on 33KV system with a nominal three-phase fault level of 31.5KA for 3 sec. The cables and associated fittings, joints and termination shall be so designed to prevent damage to the cable or fittings, except in the immediate vicinity of the fault, n the event of an insulation failure at any point which results in a fault current to earth of 31.5 KA for 3 sec.

The core of Power Cable shall comprise 800sq. mm, 500 sq. mm and 95 sq. mm Copper Conductor XLPE Insulated. Copper screen and shall comply with IEC 60502, except as modified or extended by the requirement of the specification. The length of cable on a drum shall be 500M continuous or as specified by the Purchaser and it shall be shipped on standard non-returnable steel drum, each drum having stenciled on its side; size, type and length of cable, together with its gross weight, net weight and contract number.

7.4.4.1 **Conductors**

All conductors shall be stranded, circular and compacted and comply with IEC 60228. Copper conductor cables shall be constructed with core of size. 1Cx 800sq. mm, 1Cx500 sq. mm, 1Cx 95 sq. mm

7.4.4.2 **Conductor Screening**

The conductor shall be screened with an extruded layer of semi-conducting compound, compatible in all respects with the conductor and insulation materials.

Conductor screen shall be bounded to the insulation such that no voids or discontinuities are present. The bound shall be adequate to withstand the normal electrical and mechanical stresses in service without degradation or separation.

Lapped semi-conducting tape shall not be used for conductor screens.

7.4.4.3 **Insulation**

The insulation shall consist of cross-linked polyethylene tightly extruded over the conductor screen. The insulation shall generally comply with IEC 60502-2.

The highest possible purity of insulation material is required. The Bider shall confirm that adequate precautions are taken to remove contaminants and to eliminate the introduction of particles of contaminants during material handling or extrusion process.

The Cable shall be manufactured through CCV/VCV process.

The insulation material shall be cross-linked by a dry process. A cross-linking process using steam curing will not be permitted.

7.4.4.4 **Insulation Thickness**

The thickness of insulation shall be determined by taking the average of number of

measurements and shall be not less than the values tabulated in IEC Publication 60502.

Insulation thickness shall not depart from the specified nominal value by an amount exceeding the tolerances specified in IEC Publication 60502.

The thickness at any point, however, is less than the specified value, provided the difference does not exceed 10 percent plus 0.1mm.

The thickness of the semi conducting screens on the conductors and over the insulation shall not be included in the measurement of insulation thickness.

7.4.4.5 **Insulation Screening**

The insulation screen shall comprise non-metallic semi-conducting polyethylene part in combination with a metallic part.

The non-metallic semi-conducting part shall be applied directly upon insulation of the core and shall comprise a layer of extruded semi-conducting polyethylene compound.

The conductor screen, insulation and semi-conducting part of insulation screen layer shall be applied to the conductor in common extrusion process with dry curing system.

The metallic part shall be stranded copper applied over the layer of semi conducting compound.

There shall be single layer of copper wires adequately spaced apart on the core of PowerCable. The non-metallic part shall be applied directly upon the insulation and shall be a layer of extruded semi-conducting compound. This screen shall be formed in such a way that it can be readily removed for jointing.

7.4.4.6 **Metallic Screen**

The metallic Screen shall consist of a concentric layer of copper wires or a combination of copper wires and helically applied copper tape(s) as per IEC Standard. The metallic Screen for 33 KV Cable shall be designed to carry the specified minimum earth fault current.

7.4.4.7 **Separation Sheath**

The Separation Sheath should be covering the whole surface area of the metallic screen as per IEC Standard

7.4.4.8 **Over sheath**

The cable shall be sheathed overall with a Medium Density Polyethylene (MDPE) outer sheath. The outer sheath shall be of smooth and uniform composition and free of holes, cracks, and bisectors.

As a protection against termite attack, the outer covering shall contain the termite repellent substance of Pb napthanate.

The outer sheath shall have adequate strength and thickness to withstand the test voltage

and mechanical tests and be suitable for ambient conditions at site.

The outer sheath material shall be capable of withstanding the highest temperature achieved with the cable at its rated current without damage or deformation at site ambient conditions.

The outer surface of the polyethylene outer sheath shall be as specified in IEC 60502.

7.4.4.9 **Armour**

The armour shall be Aluminium Alloy round wires or Corrugated Aluminum sheath as per IEC Standard.

The joints are brazed or welded and any wire shall be not less than 01 mm from the nearest joints in any other armour wire in the complete cable.

The metallic screen and armour combined short circuit withstand capacity should be 31.5 kA for 3 seconds.

7.4.4.10 **Continuous Current Rating**

The continuous current rating of the cable shall be calculated in accordance with the procedure described in IEC 60287 based on the site ambient condition, with the insulation parameters as specified. The Cable current ratings shall base on site ambient conditions, with the general methods of installation and bonding.

The maximum conductor temperature shall not exceed 90 deg. C when carrying the rated current under the most onerous site conditions.

7.4.4.11 **Short Circuit Rating**

The cable shall be capable of withstanding the specified maximum short circuit current for the specified times without damage or permanent distortion.

The temperature of the conductor at maximum fault current for the specified time shall not exceed 250 deg. C as specified in IEC 60502.

7.4.4.12 **Manufacturer Identification**

The external surface of the cable shall be marked by the following at an interval of 1000 mm with 10 mm high character throughout the length of the cable:

i) 33KV, XLPE, Core size"

ii) "WZPDCL", "Manufacturers Name"

7.4.4.13 **Information Required**

The Bidder/ Manufacturer as per tender requirements shall provide all information. Besides these, the following information has to be submitted:

a) Manufacturer's Printed Catalogue describing specification and technical data.
b) Outline and General Arrangement drawings.
c) The Bidder/ Manufacturer shall submit the list of available testing/ measuring equipment, meters, etc., along with valid Calibration Certificate(s) from competent authority used in manufacturer's laboratory for performing Routine Test as per IEC standard.
d) Copy of relevant IEC standards (to be submitted with design and drawing for approval after the contract).

7.4.4.14 APPROVAL OF DRAWINGS

Design, Drawing diagrams, Manufacturer's printed catalogue, Specification and Technical Particulars & Guarantees etc. of 33 KV cables shall be submitted to the Project, Director, Grid Power Evacuation System Development Project (GPESFDP), WZPDCL by the Bidder for approval, prior to the manufacturing of the goods. The Tenderer shall have to submit 3 (three) sets of the same for approval within 30 (thirty) days from the date of signing Contract. The submittal shall include detail design Calculation.

No work shall be performed in connection with the fabrication and manufacture of the Testing Equipment until the technical data and drawings have been approved. The cost of supplying drawings and specifications shall be borne by the supplier.

At the time of delivery of Equipment, the supplier shall supply three (3) sets of all approved technical data and drawings in bound book form along with manufacturer's original catalogue of the Equipment to the office of Project, Director, Grid Power Evacuation System Development Project (GPESFDP), WZPDCL. WZPDCL will approve the submitted design and drawings within 15 days from the date of submission if the submitted design and drawings meets the technical specification and GTP

7.4.5 Tests

7.4.5.1 General

The following tests shall be carried out to demonstrate the integrity of the cable. The frequency of the alternating current supply be between 48Hz and 52Hz.

7.4.5.2 Tests at Manufacturer's Establishment

Tests shall be carried out in accordance with the relevant British standards/IEC and the following type tests and routing tests shall be carried out at the Manufacturer's premises.

a) Type Tests

Type test for 33 KV cables shall be carried out in accordance with the IEC 540 and 502/1983 for suitable length of cable.

i) Electrical Tests

1. Insulation Resistance Measurement at room temperature
2. Partial Discharge test (S).
3. Bending test.

4. Power factor /High voltage test
5. Power factor / temperature test
6. Insulation Resistance measurement at max. rated temperature.
7. Heat cycle test
8. Impulse Voltage withstand test
9. High voltage Alternating current test

ii) **Non-Electrical Test**

1. Measurement of Insulation thickness
2. Determination of mechanical properties before and after ageing.
3. Test of Degree of cross-linked of insulation
4. Abrasion, Penetration, Bending and saline bath test on anti-corrosion serving.

iii) **Routine Test**

Routing tests shall be carried out by the manufacturer on all finished cables to demonstrate their individual integrity.

1. Measurement of Electrical Resistance of conducts.
2. High voltage test
3. Partial discharge test
4. Capacitance test
5. Voltage test on cable serving

7.4.6 General Requirement

The General requirements of 33KV, XLPE, 1Cx800 mm^2 Copper Cable, indoor & outdoor termination kits and straight-through joint box are stated below.

7.4.6.1 33KV, XLPE, 1Cx 800 mm^2 Copper Cable

The following table:

Item No.	Description of Items	Unit	Particulars
1	Nominal System Voltage	KV	33
2	Rated Voltage	KV	18/30 (36)
3	Cross sectional Area of Conductor	mm^2	800
4	Insulation thickness	mm	Average thickness shall not be less than 8.0 mm nominal value as per IEC 60502. However, thickness at any point may be less than nominal value

			provided that the difference does not exceed 0.1mm + 10% of nominal value.
5	Conductor Material	-	Copper, Grade compatible to IEC 60228
6	Shape of Conductor	-	Compact Circular
7	Type of Conductor Screen / Shield	-	Semi-conducting XLPE
8	Conductor Temperature	°C	250 (under short circuit conditions)

7.4.6.2 Indoor Termination Kits for 33KV XLPE, 1Cx800 mm² Copper cable

The following table:

Item	Description of Items	Particulars
i	Application	For 33KV, XLPE, 1Cx800 mm² Copper Conductors
ii	Installation	For Indoor switchgear terminations
iii	System	33KV, effectively earthed system
iv	Cable conductor	800 mm² Copper Conductors
v	Kit content	Heat shrinkable high voltage insulating and non-tracking tubing, Heat shrinkable stress control tubing, Stress relieving mastic strip, Track resistant sealant tape

7.4.6.3 Outdoor Termination Kits for 33KV XLPE, 1Cx800 mm² Copper cable

The following table:

Item	Description of Items	Particulars
i	Application	For 33KV, XLPE, 1Cx800 mm² Copper Conductors
ii	Installation	For Outdoor installation on poles/structures
iii	System	33KV, effectively earthed system
iv	Cable conductor	800 mm² Copper Conductors
v	Kit content	Heat shrinkable high voltage insulating and non-tracking tubing, Heat shrinkable stress control tubing, Stress relieving mastic strip, Track resistant sealant tape, Heat shrinkable track resistant rain skirt, Support insulator

7.4.6.4 Straight-through joint box for 33KV XLPE, 1Cx800 mm² Copper cable

The following table:

Item	Description of Items	Particulars
i	Application	For 33KV, XLPE, 1Cx800 mm² Copper Conductors

ii	Installation	For underground horizontal mounting
iii	System	33KV, effectively earthed system
iv	Cable conductor	800 mm^2 Copper Conductors
v	Construction	The joint shall be proof against ingress of moisture and water
vi	Kit content	Compression ferrules, Void filling tape, Heat shrinkable stress control tubing, Track resistant sealant tape, Heat shrinkable black/red dual wall, Elastomeric tube Roll spring, Heat shrinkable outer jacket tube, Cable preparation kit

7.4.6.5 Information Required

The Bidder/ Manufacturer as per tender requirements shall provide all information for 33KV Power Cable.

Besides these, the following information has to be submitted:

7.4.6.6 Documentation

The following Documents, shall be submitted with the Tender for the offered type 33KV Cables, otherwise the bid will be rejected:-

a) Letter of authorization from the Manufacturers (in case, the bidder is not the manufacturer), in prescribed Form.

b) Manufacturer's supply record for at least 3 years within the last 7 years specifically mentioning purchaser's name, address, telephone number, fax number, contract number with date, supply quantity with ratings, date of commencement & completion of supply, in format below. Supply record will be equipped with the same offered type 33KV Cable.

Sl. No.	Name, Address, Phone & Fax No. of the Consumer	Contract No. & Date	Contract Value	Description of Materials with Quantity	Date of completion of supply

d) Satisfactory Performance certificates (SPC) issued within the last 7 years from at least 2 End users depicting that the offered type equipment or higher Ampere rating of same voltage class, has been in service for at least 3 years.

e) Submission of Type Test Reports as stated in per relevant IEC from recognized independent laboratories.

7.4.6.7 APPROVAL OF DRAWINGS

Design, Drawing diagrams, Manufacturer's printed catalogue, Specification and Technical Particulars & Guarantees etc of 33 KV cables shall be submitted to the Engineer, Project Director, Grid Power Evacuation System Development Project (GPESFDP), WZPDCL by the Bidder for approval, prior to the manufacturing of the goods. The Tenderer shall have to submit 3 (three) sets of the same for approval within 30 (thirty) days from the date of signing Contract. The submittal shall include detail design Calculation.

No work shall be performed in connection with the fabrication and manufacture of the Testing Equipment until the technical data and drawings have been approved. The cost of supplying

drawings and specifications shall be borne by the supplier.

At the time of delivery of Equipment, the supplier shall supply three (5) sets of all approved technical data and drawings in bound book form along with manufacturer's original catalogue of the Equipment to the office of Project Director, Grid Power Evacuation System Development Project (GPESFDP), WZPDCL, Khulna. WZPDCL will approve the submitted design and drawings within 15 days from the date of submission if the submitted design and drawings meets the technical specification and GTP.

7.4.7 General Requirement

The General requirements of 33KV, XLPE, 1Cx500 mm2 Copper Cable, indoor & outdoor termination kits and straight-through joint box are stated below.

7.4.7.1 33KV, XLPE, 1Cx 500 mm2 Copper Cable

Item No.	Description of Items	Unit	Particulars
1	Nominal System Voltage	KV	33
2	Rated Voltage	KV	18/30 (36)
3	Cross sectional Area of	mm^2	500
4	Insulation thickness	mm	Average thickness shall not be less than 6.0 mm nominal value as per IEC 60502. However, thickness at any point may be less than nominal value provided that the difference does not exceed 0.1mm + 10% of nominal value.
5	Conductor Material		Copper, Grade compatible to IEC 60228
6	Shape of Conductor		Compact Circular
7	Type of Conductor		Semi-conducting XLPE
8	Conductor Temperature	°C	250

7.4.7.2 Indoor Termination Kits for 33KV XLPE, 1Cx500 mm2 Copper cable

Item	Description of Items	Particulars
i	Application	For 33KV, XLPE, 1Cx500 mm2 Copper Conductors
ii	Installation	For Indoor switchgear terminations
iii	System	33KV, effectively earthed system
iv	Cable conductor	300 mm2 Copper Conductors
v	Kit content	- Heat shrinkable high voltage insulating and non-tracking tubing - Heat shrinkable stress control tubing - Stress relieving mastic strip - Truck resistant sealant tape

7.4.7.3 Outdoor Termination Kits for 33KV XLPE, 1Cx500 mm2 Copper cable

Item	Description of Items	Particulars
i	Application	For 33KV, XLPE, 1Cx500 mm2 Copper Conductors
ii	Installation	For Outdoor installation on poles/structures
iii	System	33KV, effectively earthed system
iv	Cable conductor	500 mm2 Copper Conductors
v	Kit content	Heat shrinkable high voltage insulating and non- tracking tubing - Heat shrinkable stress control tubing - Stress relieving mastic strip - Truck resistant sealant tape - Heat shrinkable truck resistant rain skirt - Support insulator

7.4.7.4 Straight-through joint box for 33KV XLPE, 1Cx500 mm2 Copper cable

Item	Description of Items	Particulars
i	Application	For 33KV, XLPE, 1Cx500 mm2 Copper Conductors
ii	Installation	For underground horizontal mounting
iii	System	33KV, effectively earthed system
iv	Cable conductor	500 mm2 Copper Conductors
v	Construction	The joint shall be proof against ingress of moisture and water
vi	Kit content	- Compression ferrules - Valid filling tape - Heat shrinkable stress control tubing - Truck resistant sealant tape
		- Heat shrinkable black/red dual wall - Estomeric tube - Roll spring - Heat shrinkable outer jacket tube - Cable preparation kit

7.4.7.5 Information Required

The Bidder/ Manufacturer as per tender requirements shall provide all information for 33KV Power Cable.

Besides these, the following information has to be submitted:

a) Manufacturer's Printed Catalogue describing specification and technical data

b) Outline and General Arrangement drawings.

c) The Bidder/ Manufacturer shall submit the list of available testing/ measuring equipment, meters, etc., along with valid Calibration Certificate(s) from competent authority used in manufacturer's laboratory for performing Routine Test as per IEC standard.

d) Manufacturer's ISO 9001 Certificate.

7.4.7.6 **Documentation**

The following Documents, shall be submitted with the Tender for the offered type 33KV Cables, otherwise the bid will be rejected:-

a) Letter of authorization from the Manufacturers (in case, the bidder is not the manufacturer), in prescribed Form.
b) Manufacturer's supply record for at least 3 years within the last 7 years specifically mentioning purchaser's name, address, telephone number, fax number, contract number with date, supply quantity with ratings, date of commencement & completion of supply, in format below. Supply record will be equipped with the same offered type 33KV Cable.

Sl. No.	Name, Address, Phone & Fax No. of the Consumer	Contract No. & Date	Contract Value	Description of Materials with Quantity	Date of completion of supply

d) Satisfactory Performance certificates (SPC) issued within the last 7 years from at least 2 End users depicting that the offered type equipment or higher Ampere rating of same voltage class, has been in service for at least 3 years.

e) Submission of Type Test Reports as stated in per relevant IEC from recognized independent laboratories.

7.4.7.7 **APPROVAL OF DRAWINGS**

Design, Drawing diagrams, Manufacturer's printed catalogue, Specification and Technical Particulars & Guarantees etc of 33 KV cables shall be submitted to the Engineer, Project Director, Grid Power Evacuation System Development Project (GPESFDP), WZPDCL by the Bidder for approval, prior to the manufacturing of the goods. The Tenderer shall have to submit 3 (three) sets of the same for approval within 30 (thirty) days from the date of signing Contract. The submittal shall include detail design Calculation.

No work shall be performed in connection with the fabrication and manufacture of the Testing Equipment until the technical data and drawings have been approved. The cost of supplying drawings and specifications shall be borne by the supplier.

At the time of delivery of Equipment, the supplier shall supply three (5) sets of all approved technical data and drawings in bound book form along with manufacturer's original catalogue of the Equipment to the office of Project Director, Grid Power Evacuation System Development Project (GPESFDP), WZPDCL, Khulna. WZPDCL will approve the submitted design and drawings within 15 days from the date of submission if the submitted design and drawings meets the technical specification and GTP.

7.4.8 General Requirement

The General requirements of 33KV, XLPE, 1Cx95 mm^2 Copper Cable, indoor & outdoor termination kits and straight-through joint box are stated below.

7.4.8.1 33KV, XLPE, 1Cx 95 mm² Copper Cable

Item No.	Description of Items	Unit	Particulars
1	Nominal System Voltage	KV	33
2	Rated Voltage	KV	18/30 (36)
3	Cross sectional Area of Conductor	mm²	1x95
4	Insulation thickness	mm	Average thickness shall not be less than 8.0 mm nominal value as per IEC 60502-2. However, thickness at any point may be less than nominal value provided that the difference does not exceed 0.1mm + 10% of nominal value.
5	Conductor Material	-	Copper, Grade compatible to IEC 60228
6	Shape of Conductor	-	Compact Circular Stranded
7	Type of Conductor Screen / Shield	-	Semi-conducting XLPE
8	Conductor Temperature	°C	250 (under short circuit conditions)

7.4.8.2 Indoor Termination Kits for 33KV XLPE, 1Cx95 mm² Copper cable

Item	Description of Items	Particulars
i	Application	For 33KV, XLPE, 1Cx95 mm² Copper Conductors
ii	Installation	For Indoor switchgear terminations
iii	System	33KV, effectively earthed system
iv	Cable conductor	95 mm² 1-Core Copper Conductors
v	Kit content	Heat shrinkable high voltage insulating and non-tracking tubing Heat shrinkable stress control tubing Stress relieving mastic strip Track resistant sealant tape 3-Core Breakout boot

7.4.8.3 Outdoor Termination Kits for 33KV XLPE, 1Cx95 mm² Copper cable

Item	Description of Items	Particulars
i	Application	For 33KV, XLPE, 1Cx95 mm² Copper Conductors
ii	Installation	For Outdoor installation on poles/structures
iii	System	33KV, effectively earthed system
iv	Cable conductor	95 mm² 1-Core Copper Conductors
v	Kit content	Heat shrinkable high voltage insulating and non-tracking tubing Heat shrinkable stress control tubing Stress relieving mastic strip