PART 2 – EMPLOYER'S REQUIREMENTS

PART 2 - Employer's Requirements

VII-1

Project Description and Scope of Works

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List of Abbreviations

AC	Alternating Current
ADB	Asian Development Bank
AIS	Air Insulated Switchgear
AT	Autotransformer
BCPU	Bay Control and Protection Unit
BCU	Bay Control Unit
CD	Chromatic Dispersion
CT	Current Transformer
DC	Direct Current / Double Circuit
DGU	Diesel Generator Unit
EBRD	European Bank for Reconstruction
ECC	Emergency Control Center
EMTP	Electromagnetic Transients Program
EN	European Norm
ESMP	Environmental and Social Management Plan
EU	European Union
FAT	Factory Acceptance Test
FO	Fiber Optic
FOC	Fiber Optic Cable
GIB	Gas Insulated Busduct
GIS	Gas Insulated Switchgear
GPS	Global Positioning System
HMI	Huna Machine Interface
HPP	Hydro Power Plant
HV	High Voltage
HVAC	Heating Ventilation Airconditioning
HW	Hardware
IEC	International Electrotechnical Commission
IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronics Engineers
IGBT	Insulated-Gate Bipolar Transistor
IP	Ingress Protection
IPR	Intelligent Protection Relay
IT	Information Technology
ITU	International Telecommunication Union
LAN	Local Area Network
LDC	Load Dispatch Center
LED	Light Emission Diode
LILO	Line In Line Out
LV	Low Voltage
MCA	Millennium Challenge Account
MCC	Millennium Challenge Corporation
MPLS	Multiprotocol Label Switching

MV	Medium Voltage
MVA	Mega Volt Ampere
NEA	Nepal Electricity Authority
NLDC	National Load Dispatch Center
NOC	Non-Objection Certificate
ODF	Optical Distribution Frame
OHGW	Overhead Ground Wire
OHL	Overhead Line
OHTL	Overhead Transmission Line
OPGW	Optical Ground Wire
PBX	Private Branch Exchange
PMU	Synchrophasor Measurement Unit
PVC	Polyvinyl Chloride
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SCLR	Short Circuit Limiting Reactor
SCMS	Substation Control and Monitoring System
SDH	Synchronous Digital Hierarchy
SDR	Standard Dimensional Ratio
SER	Sequence Events Recording
SF6	Sulfur Hexafluoride
SFP	Small Form-factor Pluggable
SW	Software
TL	Transmission Line
TSO	Transmission System Operator
UGFO	Underground Fiber Optic Cable
UPS	Uninterruptible Power Supply
VT	Voltage Transformer
XLPE	Cross Linked Polyethylene

1 Introduction

This section details the main items of plant to be provided and works to be carried out under this Contract. The technical details of the items of plant to be provided shall comply with the requirements set out in the Technical Requirements, Technical Specifications and Technical Data Sheets.

2 Project Description

2.1 Background and Objective

The Ministry of Forest and Environment, GoN, under their Energy Policy, promoted the implementation of "Efficient Transmission of Electricity from Renewable Energy Sources in Nepal", which contributes to the overall development objective: "Contribute to the sustainable economic and social development of Nepal and to improve living conditions through a reliable, sustainable and climate-friendly power supply, and contribute to poverty reduction and the fight against climate change."

The efficient transmission of electricity from renewable energy sources is pursued by expanding the network infrastructure, which also implies the improvement of the line voltage, the reduction of the technical grid losses and the enhancement of the reliability of the electricity supply.

The "Lekhnath-Damauli 220 kV Transmission Line Project" is part of the mentioned Energy Policy and it aims at evacuating the climate-friendly electricity generated by hydropower plants (HPP) in the Seti-Madi River basin through a newly constructed 220 kV Transmission System comprising an approximately 45 km double-circuit transmission line between Lekhnath and Damauli, as well as two substations at the termination locations - one in Lekhnath and one in Damauli.

2.2 Overview

The overall project scope consists of two packages:

Package A - Transmission Lines

Package A comprises the following basic components:

- construction of the 220 kV Double Circuit Transmission Line from Substation Lekhnath to Substation Damauli
- tie in of loop-in-loop-out (LILO) connection of Tanahu Hydro 220 kV OHL into New Damauli Substation (OHL under-construction, separate financing)
- tie in of LILO connection of Old Damauli - Bharatpur 132 kV OHL into New Damauli Substation.

Package A has been awarded in first quarter of 2024.

Package B - Substations

Package B comprises the following basic components:

- extension of existing 132 kV Substation Lekhnath and construction of new 220 kV GIS
- construction of the new 220/132/33/11kV GIS Substation at Damauli

These Tender Documents refer to Package B - Substations.

Both Lekhnath and Damauli Substations are located in the Gandaki province, in the Kaski and Tanahun district respectively. The distance from the capital city Kathmandu is approximately 135km (Lekhnath) and 105km (Damauli) in northwest direction.

The existing 132/33/11 kV Lekhnath Substation is equipped with an air insulated 132 kV Bus and Transfer arrangement. A 220 kV extension shall be provided within the scope of this project. The 220 kV extension will be connected through two new air-insulated 132 kV bays to the existing Bus and Transfer system. The two new bays shall be located on the west side of the existing 132 kV switchyard and shall be connected to the 132/220 kV step up transformers via an overhead line connection.

The 220/132/33/11 kV new Damauli Substation shall be constructed on an empty plot of land in rural area. The substation shall be interconnected with the 400 kV new back-bone through the 400kV substation in new Damauli via 400/220kV intertie autotransformer banks. The 400 kV substation will be constructed by MCA Nepal, the construction contract is due to be awarded in 2024.

The new 400kV substation and 400/220kV intertie autotransformer banks will be built in close proximity of the new 220/132/33/11 kV Damauli Substation and the present project shall make provision for interfacing and interconnection with the 400 kV substation.

NEA currently is implementing as well the **NEA Grid Substation Automation System (SAS) Project-Phase 2**. The scope of this project includes the complete automation of 132 kV, 66 kV, 33 kV and 11 kV bays of substations under six Grid Division offices, including the construction of six Master Control Centers (MCCs) at various six grid locations and the integration of these substations into the Load Dispatch Center (LDC), NEA, Siuchatar and Backup Data Centre at Hetauda. The extension of the 132 kV switchyard in Lekhnath Substation, as well as the new 132/33/11 kV switchgear of New Damauli substation need to be interfaced with this project.

3 Scope of Supply and Services

3.1 General

3.1.1 General Supplies and Services

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

This section details the main items of plant to be provided and works to be carried out under this Contract. However, the Contractor is required to ascertain himself whether any additional plant or works are necessary so as to render the substations complete and 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 substations, are deemed to be included. Any quantities which may be set out shall be considered as minimum estimated quantities.

The technical details of the items of plant to be provided shall comply with the requirements set out in the Technical Requirements, Technical Specifications and Technical Data Sheets.

From the commencement date up to the signing of the provisional taking over certificate, the Contractor shall -at his own costs- 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.

All temporary works and equipment, necessary to keep the substations in operation during the execution of the works, are included in the scope of supply and services. The Contractor will be fully responsible for ensuring that all materials used in the works 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.

During the preparation of the project time schedule, the Contractor shall carefully consider that the monsoon period might slow down or hinder the on-site works.

In case discrepancies occur between the items of scope of supply and services stated hereby and the ones derived from the respective annexes and/or other contract documents, as well as in case certain items of scope of supply are identified hereby but not elsewhere in the contract documents (or vice versa), the Contractor is requested to interpret the Employer's requirements by considering this document and the annexes in conjunction. The most stringent requirements shall apply in case of deviations/discrepancies.

The paragraphs below specify key equipment and services to be provided.

All necessary connection and assembly material, such as cable lugs, ferrules, bolts, screws, rivets, nuts, washers and locking washers, including enough spare number of those, shall be included in the Contractor's scope of supply. The Contractor shall supply the net quantities plus 10% of all permanent bolts, screws, nuts and other similar parts and materials required for installation of the works at the site. Any such assembly material which is surplus after the installation of the equipment has been completed, shall become spare parts and shall be wrapped, marked and handed over to the Employer.

Any additional equipment or works required for proper operation of the substation, are deemed to be included in the contractual prices.

Coordination of all interfaces between individual sub-suppliers as well as coordination with existing systems, especially with remote end protection, communication and control systems with existing systems within the substation and with Contractors of other Lots and Projects are included in the scope.

The description below covers the scope of supplies and services in general terms. Particular configuration and quantities required for the individual substations are defined in subsequent paragraphs for each Substation.

3.1.2 Control and Protection System General

The scope of supply shall be based on state-of-the-art Intelligent Protection Relays (IPR), including:

- interfaces to local and remote communication equipment
- wired or fiber optic connections to SCMS, protection management, auxiliary supply, stand-alone event- and -disturbance recorders
- time tagging systems
- engineering, factory testing, installation, and site testing
- spare parts
- training on the job
- parametrizing and configuring software, manuals, special tools at each supply location.

Every power equipment shall be covered by redundant fast acting and overlapping protections, suitable for operation in an HV substation environment. The specified protection functions and the assignment to different IPR units must be basically considered as minimum requirements. The Contractor may propose additional functionality and devices, if required for higher dependability and security of the overall system.

For OHL bays, where the remote end substation is not included in the Project scope, the Contractor shall:

- provide the OHL protection terminal to be consistent with the existing scheme at the remote end and the protection relay manufacturer and type to be identical or, as a minimum requirement, fully compatible, with the remote end
- perform end-to-end commissioning tests in close cooperation with the Contractor and/or operator of the remote end
- perform from one end only commissioning tests of the distance and directional comparison signaling (echo signaling).

The scope of supply for the end-to-end line differential protection over fiber optics includes:

- all required protection terminal interfaces, dedicated optical/electrical communication converters, link integrity and end-to-end timing supervision, connectors, attenuators, accessories at both ends of the protected OHL (redundant dedicated monomode fiber optic pairs 9/125µm ITU-T G.652D supplied by others)
- for short direct optical fiber links (from switchgear protection cubicle up to general purpose multiplexer, supplied by others): redundant multimode optical fiber connection and all required protection terminal interfaces, optical/electrical communication converters, connectors, attenuators, accessories.

For the differential protection communication over general purpose multiplexer, the maximum communication delay shall follow the requirements of the IPR type, but not exceed 6 ms.

The end-to-end protection signaling requirements are as follows:

- distance protection: two (2) permissive duplex signals
- busbar and circuit breaker failure protection: one (1) direct trip duplex signal for each busbar section.

For each HV busbar section, a high accuracy Synchrophasor Measurement Unit (PMU) according to IEEE C37.118 shall be included, either integrated in the Bay Control Unit or as stand-alone device.

The preparation for transmission of the output to a Central Dispatching location, including SCMS protocol conversion and local and regional data concentrator are included in the scope of the Project.

All IPRs shall include transient disturbance recording functionality.

For other detailed functional requirements, refer to Section VII-5 Technical Specification.

3.1.3 Telecommunication System General

The Contractor shall provide a complete and functioning telecommunication system ready for use, even if equipment, services or quantities to be provided are not explicitly mentioned.

The new telecommunication system equipment will be subject to approval during the design stage.

The scope of supply and services shall be based on state-of-the-art Optical Line Terminal Equipment for Transport and Access, IP-PBX and underground fiber optic cables (UGFO) and accessories, including the provision of:

- Hybrid technology based SDH and MPLS - TP equipment designed for digital transmission using single mode optical fibers
- The present project does not include any Access Multiplex Equipment, as the fiber optic network shall be based on Hybrid technology which has the functionality of both Synchronous Digital Hierarchy (SDH) as well as Multiprotocol Label Switching – Transport Profile (MPLS – TP) technology. All the data, voice, video facilities will be communicated up to LDC, or regional control center via Ethernet ports of the Hybrid technology-based communication equipment. The number of ports of Ethernet cards should be sufficient to incorporate above facilities. At least 3 Nos. of ethernet cards (with minimum 8 ports on each card) will be required. Those ethernet cards should have L2 layer switching capability.
- a state-of-the-art IP-PBX in a reasonable size/capacity, providing reasonable features and with suitable telephone sets to be provided/installed at the related substations
- simultaneous data transfer for a more than enough telecommunication channels over the fiber optics communication network, each with ample bandwidth and quality
- all substations' communication requirements, data transfers, voice communication, video, access control, metering, SCADA etc.
- enough bandwidth, suitable ports, SFPs and interfaces (at least providing approx. 50% reserve)
- relevant data and cyber security
- proper communication of the concerned substations over the fiber optics communication network with the National Load Dispatch Center, as well as with the Emergency Control Center (ECC)

- Main & Back-up (NLDC/ECC) as well as with the telecommunication network management system TNMS.

All OPGW and UGFO shall incorporate the required number of single mode fibers of identical type and characteristics (according to ITU-T G.652D). No joints shall be allowed in any fiber in any drum length.

All new fiber optic links shall always and in any case be installed from ODF to ODF, ready for use.

In any case and at any place, always all available optical fibers that are hosted in an OPGW or UGFO shall be spliced, measured, tested and ODF-mounted completely and properly ready for use, even if they are not needed in the moment. No blind fibers will be accepted.

For any fiber, its attenuation always shall be measured along its course professionally and in both directions at the ODFs and clearly to be documented together with its associated deviations. Deviations in the course of curve to the normal shall be clearly/plausibly commented.

For optical connections from the joint box at the towers to the substation's building respectively to the ODF suitable underground FOCs shall be used. In general, UGFOs shall always be laid in suitable ducts that are suit DT able for the concerning particular environmental conditions.

All optical fibers of OPGW, UGFO, patch cords and pig tails shall be of the same type and shall have identical fiber optical characteristics like fibers of OPGWs and underground FOCs installed in this project.

Before installation on site, all UGFOs, fiber optic patch cords and pigtails shall be individually tailored so that there are no overlengths. They shall be documented and installed professionally and with respect to their permissible minimum bending radius.

All UGFOs, patch cords, pigtails and ODF ports shall be labelled suitable (if applicable, as per Employer's standards), professionally and consistently at both ends. All patch cords, pigtails or UGFOs fibers shall be terminated with one consistent plug/connector type as described.

As far as applicable, as per Employer's standards, Bidders shall investigate the type of optical connector (e.g., SC, LC, E2000, ...) that is predominantly installed/used at Employer's sites and shall as far as possible exclusively use this type of optical connector for the installations.

In telecommunication rooms ODFs can either be integrated as an all-in-one solution into the equipment's/routers'/switches' racks or as a separated solution in dedicated ODF cabinets. ODFs shall be capable to host all single mode fibers of the concerned FOC. The ODFs shall be protected against dust and humidity by IP64 or better.

In general, ODFs shall be planned/installed in a way so that one ODF is dedicated for one (1) optical line/cable that is related towards one (1) adjacent site/substation.

3.1.4 Engineering and Design

The Contractor shall provide the engineering and design for all components included in the scope. The engineering and design shall be in accordance with the respective requirements of the following Sections:

- Section VIII, Conditions of Contract
- Section IX, Particular Conditions of Contract
- Section VII-2 Project Procedures
- Section VII-3 General Technical Requirements
- Section VII-4 Particular Technical Requirements
- Section VII-5 Technical Specification
- Section VII-6 Technical Requirements Civil Works
- Section VII-7 Environmental and Social Management and Monitoring Plan (ESMMP)
- Section VII-8 Technical Data Sheets
- Section VII-9 Annexes.

3.1.5 Communication and Visibility

The Contractor shall ensure compliance with the project communication and visibility requirements and guidelines (including the EU guidelines) in placing Display Panels at defined locations.

The purpose of the display panel is to inform about the major features of the project and the work in progress. The display panel shall physically be connected to the place where the work is executed. A display panel shall be placed by preference at a spot were many people pass by e.g. near a road. Therefore, the panel must be readable from a distance, accounting for the speed of vehicles and people passing by.

Requirements

The panels shall contain (as a minimum) the following:

- the logos of the funding institutions displayed according to the specific requirements: German Cooperation, KfW and Government of Nepal (GoN)
- the name of the program
- the name of the Sub-project (to be defined)
- completion month/year
- name of the client, Logo and telephone number
- name of the contractor

- photography using the whole width of the panel can be used
- typography: a sans serif letter shall be used.

For each sub-project a minimum of 3 panels shall be placed on appropriate and approved locations.

The dimensions of the panels shall be 5.00 m x 3.00 m approx.

The panels shall be printed on an environmentally friendly material and be placed on a safe and solid frame and the whole construction shall be fully weather-resistant (wind, rain, snow) and on an appropriate support structure.

Procedure

For each sub-project the final number of display panels shall be established in consultation with the client.

- The contractor is responsible for producing and placing the panels.
- The marketing and communication company selected by the client shall provide the design (layout file - certified pdf, approved by the client) to the contractor.
- The contractor sends the certified panel layout (pdf-file) to the display supplier, selected by the contractor.
- The contractor has the construction boards produced according to the material specifications.
- The contractor pays the costs of the design and the production and placement of the display panels.

3.1.6 Environmental and Social Management Plan

In conjunction with the works and services described hereinabove, Contractor shall plan, execute and document construction works as prescribed in the Environmental and Social Management Plan (ESMP).

3.1.7 Spare Parts and Tools

3.1.7.1 General

Spare parts and tools are divided in two categories, i.e., the mandatory spare parts and tools and the recommended ones.

Tools and accessories shall include the following:

- special tools and equipment for maintenance, inspection and repair
- safety tools per voltage level

- all standard equipment and accessories necessary for the satisfactory operation of the system but which are not separately listed.

3.1.7.2 Mandatory spare parts and tools

For all substations, mandatory spare parts and tools are included in Contractor's scope. The type and quantity of these spare parts are listed in the Price Schedules.

3.1.7.3 Recommended spare parts and tools

In addition to the mandatory spare parts, the lists of recommended spare parts, equipment, tools and instruments for maintenance of each substation shall be filled in. This applies to all spare parts and tools which are not listed in the mandatory spare parts and tools but are considered as necessary by the Contractor.

It is noted that the cost of these recommended items of supply will be reviewed and considered during the bid evaluation process but shall not be part of the evaluated price. They will serve as basis of a potential order of the respective equipment and tools -or part thereof- that the Employer may decide to perform.

3.1.8 Factory Acceptance Tests

Employer's engineers shall participate in (FAT) for switchgear and other equipment included in the scope of supply.

The costs of conducting FAT at the manufacture premises or independent accredited test laboratory shall be borne by the Contractor and it shall be included in the equipment costs (Schedule I and II).

After receiving the prior information about the completion of manufacturing at the factory, the Employer will depute his personnel to the Contractor's factory to witness the fabrication, assembly and testing of any or all parts of major equipment. The number of the Employer's personnel and equipment to be witnessed will be as listed below. The duration of such visits shall be as per inspection/testing requirements.

Table 3-1 Scope of Factory Acceptance Tests

Equipment	Number of person x days	Number of FAT visits
HV Switchgear (220 and 132 kV GIS)	2 persons x 7 days	two (2)
HV Switchgear (132 kV AIS)	1 persons x 5 days	One (1)
Auto- Transformers	2 persons x 10 days	One (1)
Power Transformers	2 persons x 10 days	two (2)
LV Auxiliary Systems	1 person x 7 days	two (2)
MV Switchgear	2 persons x 7 days	two (2)
Protection system	2 persons x 7 days	two (2)
SCMS	2 persons x 10 days	two (2)
Telecommunication systems	2 persons x 7 days	One (1)
CCTV system,	1 person x 5 days	One (1)
Fire detection and firefighting system,	1 person x 5 days	One (1)

The arrival/departure of the Employer's personnel will be scheduled for one day before/after the respective test(s).

3.1.9 Training

The following training shall be provided from the Contractor to the Employer's personnel for the following category of equipment:

- high voltage switchgear
- medium voltage switchgear
- auto and power transformers
- LV auxiliary systems
- protection and control systems
- SCMS
- SCADA
- telecommunication systems
- CCTV System
- fire protection system.

The focus of all training items shall be on the general and basic structure of the systems, the configuration and setting of parameters, the maintenance and repair as well as the testing and troubleshooting in case of problems. Detailed training requirements for particular systems and equipment are provided in Section VII- 5 / Specifications.

Moreover, the Employer's personnel shall assist the Contractor during the pre-commissioning and commissioning periods as training on the job and they shall attend the site tests as well.

The Contractor shall provide the training schedule as per the General Requirements.

The table below describes the training and locations for training execution.

Table 3-2 Scope of Training

Training Abroad/ NEPAL	System/Training	No. of persons (Engineers)	Nos of Days	Total Mandays
Training at Manufacturer premises	High voltage GIS	4	7	28
	SCMS / SCADA /EMS and Telecommunication	4	5	20
	Protection and Control Systems	4	5	20
Training on site	High voltage GIS and Medium voltage switchgear	10	5	50
	Auto and power transformers and LV auxiliary systems	10	5	50
	SCMS/SCADA/EMS, Telecommunication and CCTV System	10	7	70
	Protection and control systems	10	5	50
	Fire protection system	10	5	50

The Contractor shall cover all costs related to the above-mentioned training, including air travel in economy class, hotel accommodation and local transportation and per diem in line with the corporate good governance procedures (50 USD/day) (when the training is not performed in the Employer's country).

All training sessions shall be conducted in English language. All training material shall be submitted in English.

3.1.10 Other Items of Supply and Services

3.1.10.1 Document Preparation and Submission for Permits

The Contractor shall prepare (and the Employer shall submit for approval to the relevant state building permit authorities) all necessary documents (including calculations, designs, drawings etc.) so as to obtain permits for the execution of works included in the Project.

The Contractor shall ensure that all documents for approval are prepared timely so as to allow sufficient time for examination by them, amendments to be made. Also, resubmission for approval is to be conducted without delay in the delivery and installation program or the guaranteed completion dates of the works.

All documents shall be prepared in accordance with the General Project Procedures, and all descriptive wording shall be in English.

3.1.10.2 Earthing Study

Soil electrical investigation for each substation affected by the Project is included in the scope of services. The soil electrical investigation shall be performed by the Contractor within 2 months from the Contract coming into force and shall be submitted to the Employer / Engineer for their approval. Soil electrical investigation shall be carried out in accordance with IEEE 80 Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Grounding System.

The earthing system shall be designed to minimize the dangers from step, touch and transferred potentials which can occur under maximum fault conditions. The Contractor shall design, furnish and install the substation grounding system in accordance with the provision on IEEE 80 “Guide for Safety in Substation Grounding”, and the provision included in these documents. The contractor shall submit calculations in support of his design. The Contractor shall submit for approval by the Employer / Engineer information on the software selected for the relevant calculations.

Furthermore, IEEE Publication 86 EH0253-5-PWR - Practical Applications of IEC/IEEE Standard 80-1986 and IEEE Guide for Safety shall be taken into consideration.

In addition to the aforementioned, the Contractor shall comply with applicable national and local laws, codes, regulations, statutes and ordinances and with the requirements for Earthing and Lightning Protection in section Technical Specification.

3.1.10.3 Insulation Coordination Study

The Contractor shall perform the insulation coordination study for the substations included in the scope.

Regarding to extension of existing substations, the insulation coordination study to be performed by the Contractor shall regard only for the extended/modified parts of the respective substations. The Contractor shall be responsible to make both a physical survey and a design verification of the existing system, so as to ensure the proper integration.

The studies shall be subject to approval by the Employer/Engineer.

The studies shall include the calculation of the voltage stresses, such as lightning or switching surges and temporary overvoltages, which may affect equipment duty. Remedies depend on the equipment capability and the type and magnitude of the stress. In general, stations with equipment operated at medium voltage and above, as well as all transformers and reactors, shall be protected against lightning and switching surges.

Typically, this includes station shielding against direct lightning strokes, surge arresters on all line terminals, transformers, reactors, and station entrance shielding with OHGW. The studies shall perform using adequate software such as e.g. EMTP or equivalent.

A proposed order of priorities for the insulation coordination policy is as follows:

1. ensure safety to public and operating personnel
2. avoid permanent damage to plant
3. minimize interruption of supplies to consumers
4. minimize circuit interruption.

The outcome of the study shall be mainly, but not limited to, the definition/confirmation of the lightning arresters' position, the selections of their characteristics and the conceptualization of the substation shielding protection against direct lightning strokes, etc.

The studies shall be performed keeping in consideration of all the sections of the grid system which may be involved in the Project and in compliance with IEC 60071 and all other relevant IEC standards.

In addition, attention shall be paid to the climatic conditions prevailing in each substation site.

All insulation-related values given -as minimum requirements- in the Technical Data Sheets (e.g. minimum unified specific creepage distance) are deemed to be indicative and shall be verified and adjusted accordingly (applying the appropriate correction factors) further to the findings of the insulation coordination studies.

3.1.10.4 Protection Settings Study and Adjustments

The Contractor shall carry out the Protection Coordination Study for all substations affected by the Project, highlighting the necessary changes of settings in the adjacent switchgears.

The data required for the protection settings report will be provided by the Employer, as far as available. These data shall be verified by the Contractor and the missing data have to be calculated or estimated. by the Contractor.

In addition:

- The adjustment of settings in the substations which are part of the scope of work under the Contract shall be performed by the Contractor.
- If, during preparing the coordination study, the Contractor identifies the necessity of adjustments in settings at substations not directly related to the Project, this adjustment will be done by the Employer, based on the proposals included in the Protection Settings Study by the Contractor.

The study shall have the following content but not limited to:

- CT/VT instrument transformer sizing
- fault current calculations
- protection setting principles and coordination with existing remote-end and adjacent equipment protections
- protection terminal configuration, communication interface and function settings
- selectivity diagrams for overcurrent earth/phase fault and distance protections.

The study shall be subject to review and approval by the Employer / Engineer.

3.1.10.5 Transport Study for large and heavy equipment

The Contractor shall perform and submit for information a transport study for large and heavy equipment included in the scope, such as e.g., Auto- and Power Transformers, GIS equipment, etc.

The transport study shall cover in particular the complete land transportation to the construction sites and shall address clearly any restrictions on the access route and mitigation measures to overcome these restrictions.

3.2 220/132 kV Lekhnath Substation

In Lekhnath, the new 220 kV substation will be connected to the existing 132 kV AIS outdoor switchyard by means of two 220/132/33 kV,315MVA autotransformer banks, and the existing 132 kV switchyard will be extended accordingly. For the new 220 kV substation, an indoor, double bus bar system SF_6 Gas Insulated Switchgear (GIS) type has been selected (refer to **Annex D5-3** - Substation Layout).

The following sections briefly describe the main substations features and scope of supply. Reference is made to the substation Single Line Diagrams (refer to **Annex D5-1**) and AC/DC Auxiliary System Scheme (refer to **Annex D 5-11**).

3.2.1 132 kV AIS Extension

The existing 132 kV AIS yard shall be extended with two additional bays (**E13** and **E14)** for the connection to 220/132 kV transformer units. The connection of the additional 132 kV bays (**E13** and **E14)** to the 315 MVA autotransformers will be through double circuit 132 kV overhead line conductors with earth wire via a lattice tower. The 132 kV gantries for the connection of the OHL conductors and earth wire to the additional 132kV bays (**E13** and **E14)** and to the 315 MVA autotransformers are included within the scope of this Substation Package B.

The lattice tower and the 132 kV OHL conductors and earth wire will be provided by the Contractor of the transmission line (Package A). The coordination of the related interfaces with the transmission line Contractor is included within the scope of this package.

The scope of supply and services related to the extension of the 132 kV outdoor switchyard is deemed to be complete to serve the purpose of the Project and therefore include supply, installation and commissioning of:

- busbars - extension of existing busbars, gantries
- primary high voltage equipment
- connections between equipment/equipment and equipment/busbars
- lattice-type steel structures for primary equipment
- all necessary insulators, support structures, clamps etc.
- cabling
- any other item considered necessary for the installation and successful operation of the works.

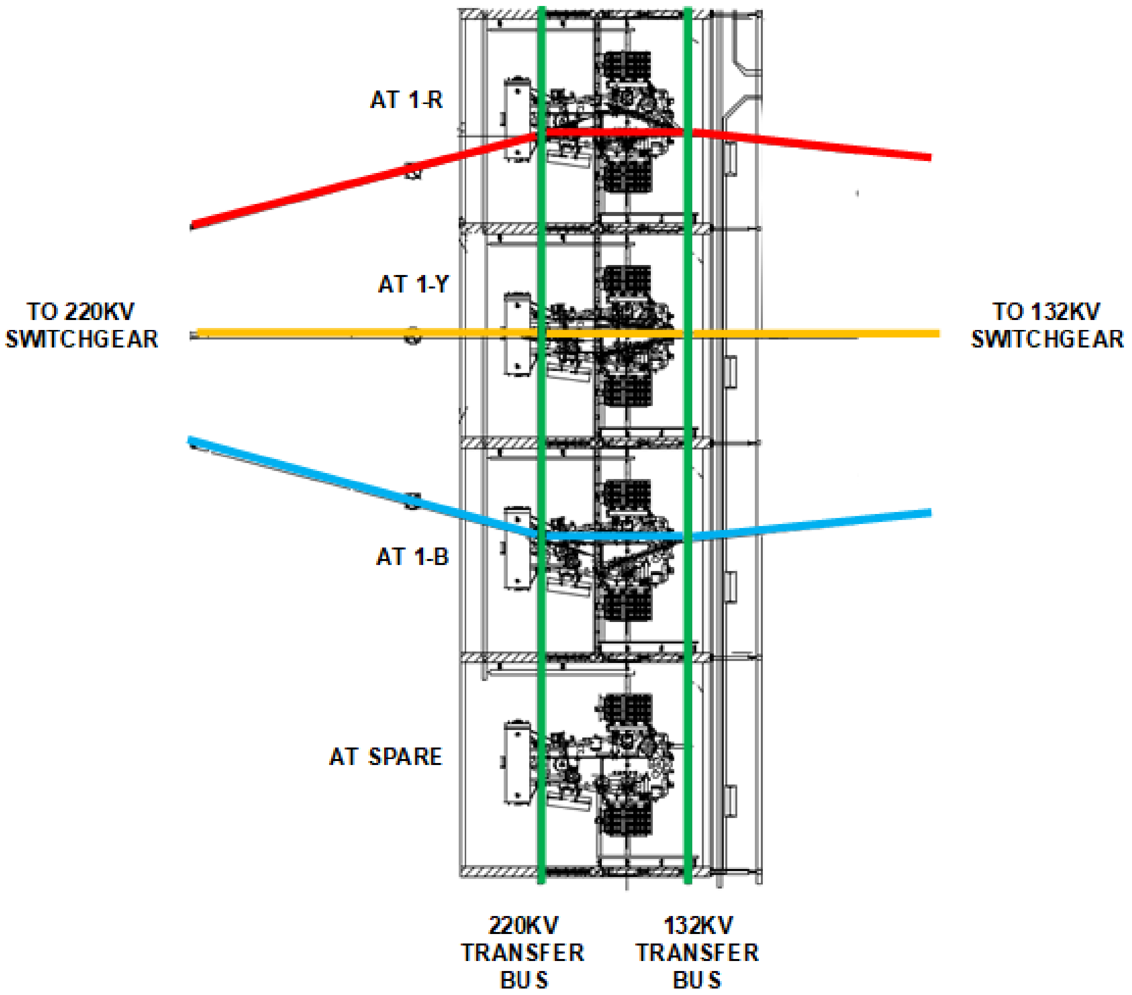
The 132 kV AIS extension shall include the following 132 kV outdoor AIS components:

Transformer Feeders (E13, E14), each with

- one (1) set of 3-pole circuit breaker
- two (2) sets of 3-pole disconnector with earthing switch
- one (1) set of 3-pole pantograph disconnector
- three (3) units of 1-pole current transformer
- three (3) units of 1-pole voltage transformer
- one (1) lot of gantries for busbar and feeders
- one (1) lot of busbar and feeder conductors
- one (1) lot of insulators and fittings.

Transformer AIS equipment and auxiliary system for fast reconnection of the spare transformer unit

The six 220kV GIS busducts are terminated with SF_6/air bushings to which overhead conductors are attached by means of clamps. During normal operation, the overhead conductors are connected to the 220kV bushings of the respective autotransformer (see Figure 3-1). In case of fault (or maintenance work) on one of the single-phase autotransformers, the conductor is manually disconnected from the faulty unit and reconnected to the 220kV transfer bus, via which power is transferred to the spare autotransformer unit. The operation has to be done by trained manpower using a crane basket and is repeated on the 132kV side (Figure 3-2).



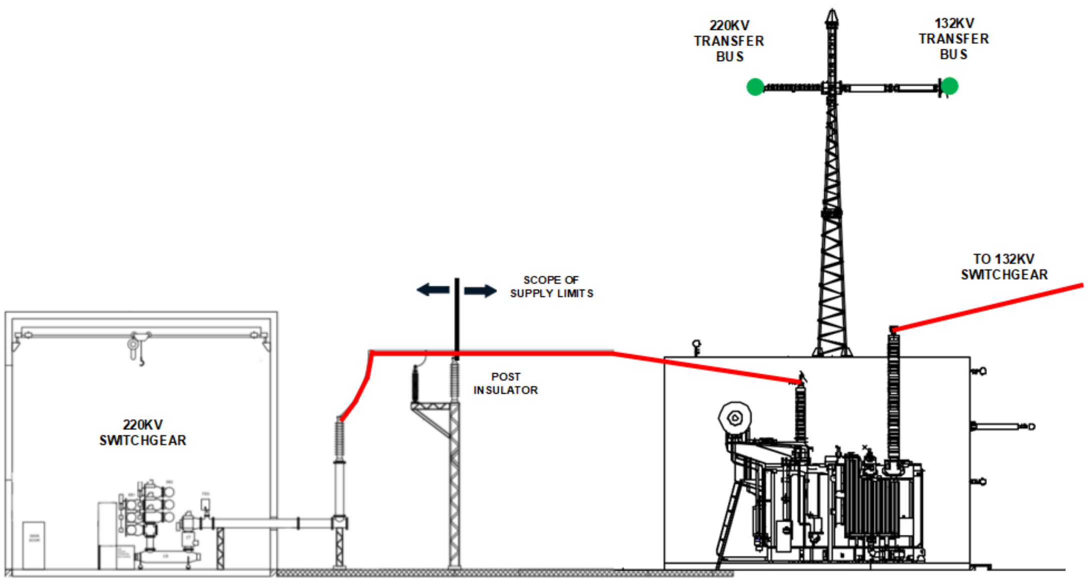


Figure 3-1 Schematic representation of the connection between 220kV switchgear and the autotransformers via overhead air-insulated conductors and transfer buses; normal operation (autotransformers 2-B, 2-Y and 2-R not shown)

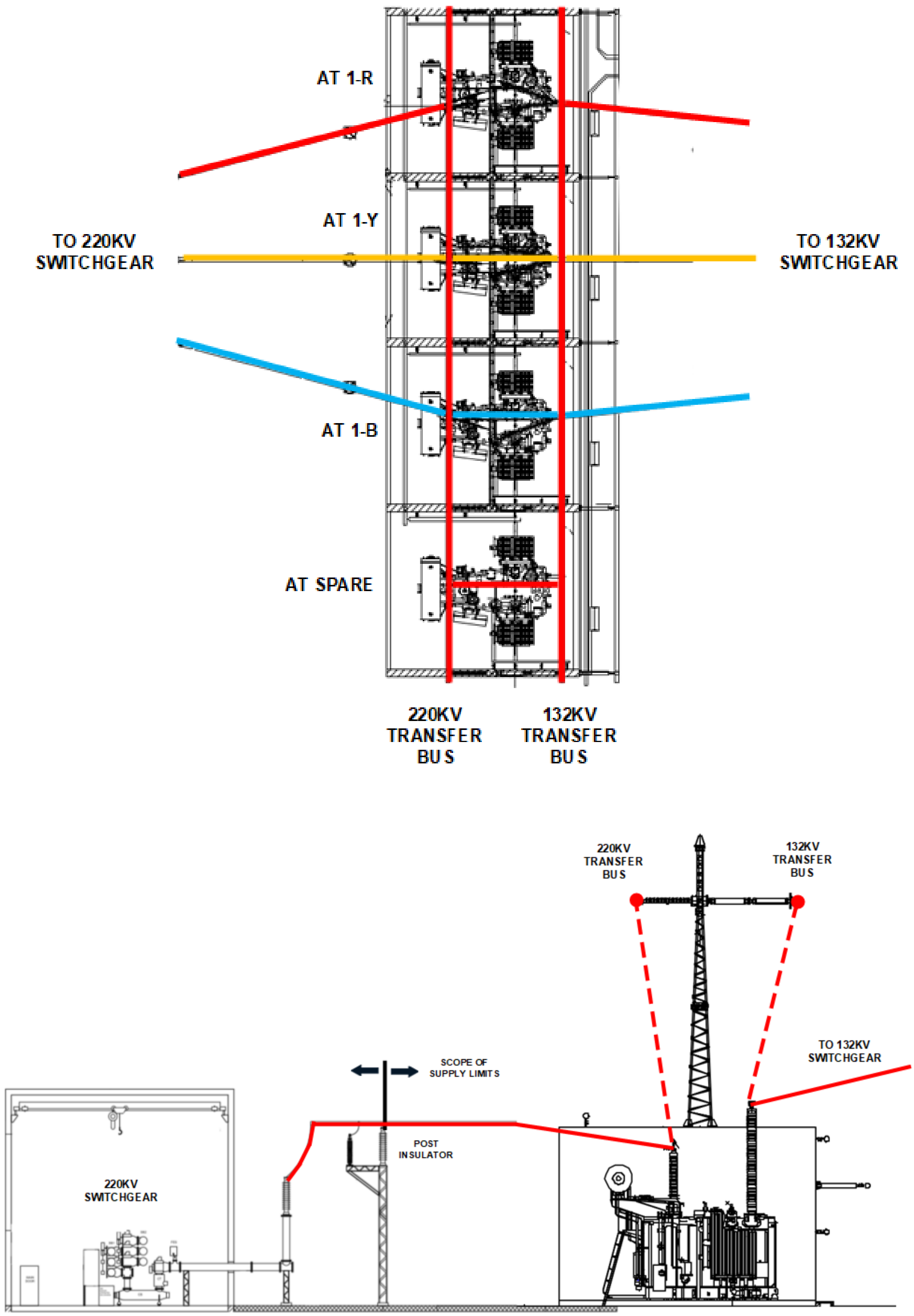


Figure 3-2 Schematic representation of the connection between 220kV switchgear and the autotransformers via overhead air-insulated conductors and transfer buses; fault condition (or maintenance works) on autotransformer 1-R

The transformer AIS equipment and auxiliary system for fast reconnection of the spare transformer unit shall include the following high voltage outdoor AIS components.

- seven (7) surge arresters for the 220 kV transformer side
- seven (7) surge arresters for the 132 kV transformer side
- fourteen (7) surge arresters for the tertiary (33 kV) side
- one (1) lot of gantries for 220 kV and 132 kV auxiliary busbar
- one (1) lot OHL conductors for 220 kV and 132 kV auxiliary busbar
- one (1) lot of 220 kV insulators and fittings
- one (1) lot of 132 kV insulators and fittings
- one (1) lot of materials for the interconnection of the auto-transformers tertiaries to delta connection and for connection with the 33 kV switchgear by means of busbar and cable including facility for fast reconnection of spare transformer.

Additional extension and relocation works

- relocation of existing lighting poles affected by the extension of the 132 kV switchyard
- relocation of two (2) existing lightning protection masts affected by the extension of the 132 kV switchyard

3.2.2 Auto Transformer 220/132 kV

The Auto Transformers shall be single-phase type, with a total installed power of 315 MVA. One additional single-phase unit shall be installed as spare, to cope with possible failures:

- seven (7) units of single-phase autotransformers 220/132/33 kV 105 MVA/phase
- two (2) set of automatic voltage regulator, including the relevant software and integration in the SCMS
- seven (7) online transformer condition monitoring system, including the relevant software and integration in the SCMS.

3.2.3 220 kV GIS

The 220 kV switchgear shall be arranged as double busbar and shall be fitted for the following connections:

- two (2) bays for the connection to 220/132kV transformers (D03 and D07)
- two (2) bays fort the connection to 220kV OHL to Damauli Substation (D04 and D06)
- one (1) Measuring Bay ((D05))
- one (1) Bus Coupler (D05).

Additionally, provision shall be made for the following future bays (to be included in GIS design for civil engineering):

- four (4) spare bays (D01, D02, D08 and D09) for GIB connections to OHLs
- provision for future installation of busbar surge arrestors with disconnector and maintenance earthing switch.

220 kV GIS equipment shall basically cover the following components for double bus bar scheme:

Two (2) Transformer Bays (D03, D07) including each

- two (2) three-phase bus bar modules
- two (2) three-phase bus bar disconnecting switches, motor operated
- two (2) three-phase maintenance earthing switches, motor operated
- one (1) three-phase circuit breaker, motor and spring operated
- three (3) single phase current transformers with five (5) cores
- one (1) three-phase feeder disconnecting switch, motor operated
- one (1) three-phase fast earthing switch motor and spring operated
- three (3) single phase SF6/Air bushing
- three (3) single phase gas insulated bus duct (GIB) for single phase transformer connection
- lot of sensors for partial discharge measurement
- lot of provision (light sensor) for future arc detection
- one (1) local control cubicle for local control and interlocking (bay control units are included in the protection cubicles)
- lot of steel structures for support the GIS
- lot of cables for control, measurement and protection
- lot of installation material (cable trays, cable bridges, earthing material etc.) to complete the bay in any respect.

Two (2) OHL Bays (D04, D06) including each

- two (2) three-phase bus bar modules
- two (2) three-phase bus bar disconnecting switches, motor operated
- two (2) three-phase maintenance earthing switches, motor operated
- one (1) three-phase circuit breaker, motor and spring operated
- three (3) single phase current transformers with five (5) cores
- one (1) three-phase feeder disconnecting switch, motor operated
- one (1) three-phase fast earthing switch motor and spring operated
- three (3) single phase SF6/Air bushing
- three (3) single phase gas insulated bus duct (GIB) for single phase OHL connection
- lot of sensors for partial discharge measurement
- lot of provision (light sensor) for future arc detection

- one (1) local control cubicle for local control and interlocking (bay control units are included in the protection cubicles)
- lot of steel structures for support the GIS, GIB and SF6/Air bushing
- lot of cables for control, measurement and protection
- lot of installation material (cable trays, cable bridges, earthing material etc.) to complete the bay in any respect.

One (1) Measuring Bay ((D05)) including

- two (2) three-phase bus bar modules
- six (6) single phase inductive voltage transformer
- two (2) three-phase disconnecting switches, motor operated
- two (2) three-phase maintenance earthing switches, motor operated
- two (2) three-phase fast earthing switch motor and spring operated
- lot of sensors for partial discharge measurement
- lot of provision (light sensor) for future arc detection
- lot of steel structures for support the GIS
- lot of cables for control, measurement and protection
- lot of installation material (cable trays, cable bridges, earthing material etc.) to complete the bay in any respect.

One (1) Bus Coupler Bay (D05) including

- two (2) three-phase bus bar modules
- two (2) three-phase bus bar disconnecting switches, motor operated
- two (2) three-phase maintenance earthing switches, motor operated
- one (1) three-phase circuit breaker, motor and spring operated
- (2) sets of three phase CTs each on the different side of the breaker. The first set shall have two (2) cores: one core for busbar protection and one core for main protection. The second set shall have three (3) cores as above plus one measuring core for BCU.
- lot of sensors for partial discharge measurement
- lot of provision (light sensor) for future arc detection
- one (1) local control cubicle for local control and interlocking (bay control units are included in the protection cubicles)
- lot of steel structures for support the GIS
- lot of cables for control, measurement and protection
- lot of installation material (cable trays, cable bridges, earthing material etc.) to complete the bay in any respect.

3.2.4 220 kV AIS Equipment

The two (2) 220 kV OHL feeders will be provided each with the following

- one (1) set of three single phase 220kV surge arresters
- one (1) set of three single phase 220kV capacitive voltage transformers.
- one (1) set of 220 kV OHL gantry.

3.2.5 33 kV Switchgear

The 33kV section shall comprise two (2) separate metal clad air-insulated switchgear assemblies, each one consisting of the following:

- one (1) outgoing feeder to auxiliary transformer (K02, K04), each of them provided with withdrawable circuit breaker, current transformer, capacitive indicator, earthing switch, surge arresters
- one (1) riser measurement panel (K01, K03) each of them provided with current transformer, earthing switch and withdrawable voltage transformer protected by fuse.

One set of accessories shall be provided for the medium voltage switchgear including as a minimum the following:

- one (1) set of keys, cranks, levers for operation of switchgear, including holder for wall mounting
- one (1) feeder trolley
- one (1) short circuiting device
- one (1) voltage tester
- one (1) cable testing plug.

3.2.6 Zig Zag Earthing Auxiliary Transformers

- two (2) three-phase zig zag earthing auxiliary transformers 33/0.4 kV, hermetically sealed type with off load tap changer, each of minimum 630 kVA, suitable for outdoor installation, provided with sunshade, shall be provided.
- two (2) set of three single phase tank mounted surge arresters for the primary (33 kV) side.

3.2.7 Auxiliary Power Supply System

At Lekhnath Substation, the auxiliary power supply system shall consist of the following equipment:

- one (1) set of LV AC metal-clad switchgear with two bus sections
- one (1) set of 220 V DC switchgear with two bus sections
- two (2) sets of 220 V battery chargers
- two (2) sets of 220 V battery Systems

- one (1) set of 48 V DC switchgear with two bus sections
- two (2) sets of 48 V battery chargers
- two (2) sets of 48 V Battery Systems
- two (2) sets of 230 V AC UPS System.

General arrangement

The system hereby described is pertaining to the 220 kV substation extension. The existing substation parts are already supplied -in terms of auxiliaries- by the relevant existing facilities.

The auxiliary supply for the extended part of the substation will be provided by two (2) auxiliary transformers 33/0.4 kV 630 kVA.

The basic design of the auxiliary AC & DC system shall consist of a single busbar 0.4 kV, including a sectionalizing circuit breaker.

In normal operation mode, one of the auxiliary transformer circuit breakers shall be in open position and the busbar sections shall be coupled to each other.

The 0.4kV busbar shall be split in two busbar sections, one feeding the essential loads and one feeding the non-essential ones. The 0.4 kV busbar shall be fed from the substation auxiliary transformers. The essential-loads section shall be fed by a diesel generator set in case of emergencies. A suitable control device (BCU, IED), providing interlocking conditions, shall be installed to implement the control of the auxiliary supply system and the in-feeding sources. The control device shall provide the possibility to define interlocking conditions in order to avoid that two sources feed the bus bar in parallel.

LV AC installations

The function of the LV AC station supply system is to feed the auxiliary equipment, as well as the lighting and other services, via the relevant AC distribution boards. Hereby, reference is made to the LV AC installations pertaining to the substation extension.

- one (1) 0.4 kV main switchgear, metal-clad type, suitable for indoor installation, with single-busbar and with bus-tie, for two incomers and connection of the diesel generator unit, with automatic transfer switching enabling also manual operation.

DC installations

The DC voltage level of the existing 132/11 kV substation is 110 V DC. Therefore, the equipment related to the extension of the 132 kV switchyard and related control and protection shall be provided for 110 V DC control voltage, supplied from the existing 110 V DC system. Extension of existing 110 V DC distribution cabinets / provision of additional sub distribution cabinets required for the two 132 kV bays to be extended are to be included in the scope of this package.

The equipment for the new 220 kV part shall be provided for 220 V DC control voltage, supplied from a new 220 V DC system as part of the auxiliaries of the new 220 kV substation part.

The function of the DC systems is to provide the DC supply for all auxiliary and substation DC dependent equipment (relevant to the extended part of the substation), through the DC distribution boards. This equipment comprises the protection relays, control systems and the communication systems in addition to the emergency lighting.

Batteries rated 220 V DC and 48 V DC shall be of valve-regulated Ni-Cd type. They shall be installed on the battery racks in separate battery rooms.

Each battery shall consist of two sections (in each room one 48 V DC and one 220 V DC).

The battery capacity shall be defined during the detailed design stage but shall not be less than stated below- Each section of the battery shall be capable of supplying 100% of the DC loads (including future extension). This requirement is applicable for both 220 V DC and 48 V DC batteries.

A complete 220 V DC supply system shall be provided for the substation extension, including:

- one (1) 220 V DC distribution board with DC control panel, comprising two busbars. Each busbar section will be connected to the relevant battery charger.
- two (2) 400/230 V rectifiers / battery chargers
- two (2) 220 V DC batteries of Ni-Cd type, each with a minimum capacity of 600 Ah (10h discharge rate).

In addition, for supply of 48 V DC, required for certain equipment of the SCMS and telecommunication system, the following shall be provided:

- one (1) 48 V DC distribution board with DC control panel, comprising two tied busbars
- two (2) 400/230 V rectifiers / battery chargers
- two (2) 48 V DC batteries of Ni-Cd type, each with a minimum capacity of 150 Ah.

The complete arrangement for DC installations shall be designed taking into consideration possible future extensions.

The substation control & monitoring system (SCMS), the telecommunication system, as well as the protection, control and emergency lighting systems will be fed from the 220 V DC or 48 V DC distribution boards, as necessary.

The batteries and rectifiers will be sized to supply the required DC loads, taking into considerations the present and future services in the substation final stage.

The DC distribution boards shall be provided with all hardware required for reliable operation and safe isolation, as well as with protection against short circuits.

Uninterruptible Power Supply (UPS) system

An UPS power supply system of adequate size shall be provided for all consumers which require un-interruptible supply (e.g. workstations).

The UPS system shall consist of two (2) independently operating units.

Each system shall be complete and include, among others, the following items:

- one (1) thyristor or IGBT controlled 220 V DC / 230 V AC inverters
- one (1) thyristor static transfer switches
- one (1) manual bypass switches
- one (1) distribution board with control devices
- monitoring system with three (3) contacts for each alarm of the 240 V AC UPS
- UPS enclosure, similar in characteristics with the enclosures of the AC and DC switchgear.

3.2.8 Diesel generator unit

A diesel generator unit (DGU) shall be installed and used as the emergency power supply source. Rated output voltage of the DGU shall be 400 V AC.

The rated power of the DGU shall be such that the DGU is capable to supply all the critical substation systems for 24 hours.

The final power ratings shall be defined during the detailed design stage but shall not be less than stated below.

The DGU shall be installed in a prefabricated container equipped with fire-detection system and exhaust gas evacuation system.

A fuel tank with diesel fuel for the DGU shall be installed in the substation area for emergency use. The volume of fuel stored shall be suitable for uninterrupted fuel supply of the DGU for 24 hours.

The DGU shall be connected to the intermediate bus of the LV AC switchgear via an automatic bus-tie circuit-breaker. The DGU shall be started automatically in case of voltage loss at busbars of 0.4 kV AC switchgear and stop automatically after normal auxiliary supply voltage restoration.

Parallel operation of auxiliary power supply system and DGU shall be avoided.

- One (1) diesel generator set, adequately sized but as a minimum of 50 kVA shall be provided, along with a fuel tank accommodating fuel for a continuous operation in line with the relevant Technical Data Sheets. The diesel generator set shall be housed in a thermal- and noise-insulated prefabricated cover.

3.2.9 Control and Protection System

220kV OHL and Busbar Protections

Minimum functional requirements for each IPR and the CT/VT connections are shown in **Annex D5.7.** For OHL Lekhnath - Damauli the remote end substation is part of the scope and the same type and manufacturer of protection relays as foreseen at the remote end shall be provided.

Two (2) 220 kV OHL Protection Terminals (D04, D06) including each:

- one (1) Multifunctional protection terminal including line differential protection over fiber optic, distance protection with PTT and DT signaling, overcurrent phase and earth back-up, directional overcurrent phase and earth fault with PTT signaling, switch on to fault, synchrocheck, auto-reclosing, thermal overload, out of step tripping, overvoltage/ undervoltage, fault locator (Main 1)
- one (1) Multifunctional protection terminal including, distance protection with PTT and DT signaling, overcurrent phase and earth back-up, directional overcurrent phase and earth fault with PTT signaling, switch on to fault, synchrocheck, auto-reclosing, thermal overload, out of step tripping, overvoltage/ undervoltage, fault locator (Main 2)
- one (1) Bay Control Unit including P, Q, U, I, f measurements, circuit breaker trip/close control, graphic display, Phasor Measurement Unit, synchrocheck
- one (1) low impedance busbar and circuit breaker failure protection, field unit
- two (2) trip coil supervision
- one (1) lot relay software, documentation
- one (1) lot Cubicles, accessories, auxiliary relays, etc.

One (1) 220kV Bus coupler (D05) and Busbar Protections (Annex D5-7) including each:

- one (1) multifunctional protection terminal with distance relay, back-up phase and earth overcurrent
- one (1) Bay Control Unit including P, Q, U, I, f measurements, circuit breaker trip/close, graphic HMI, synchrocheck, phasor measurement
- two (2) de-centralized low impedance busbar and circuit breaker failure protection, field units
- one (1) de-centralized low impedance busbar and circuit breaker failure protection, central unit
- two (2) trip coil supervision

- one (1) lot software, documentation
- one (1) lot cubicles, accessories, auxiliary relays.

220/132/33kV, 3x105MVA/20MVA Lekhnath Autotransformer Protection

Minimum functional requirements for each IPR and CT/VT connections are shown in **Annex D5-5.**

Two (2) 315MVA 220 kV side autotransformer protection (D03, D07) including each:

- one (1) multifunctional protection terminal with differential protection, distance protection, directional overcurrent phase and earth fault, overcurrent phase and earth back-up, circuit breaker failure, synchrocheck, thermal overload, restricted earth fault protection, overexcitation (Main 1)
- one (1) multifunctional protection terminal with differential protection, backup distance protection, overcurrent phase and earth back-up, circuit breaker failure, synchro check, thermal overload, restricted earth fault protection, overexcitation (Main 2)
- one (1) Bay Control Unit including P, Q, U, I, f measurements, trip/close HMI, synchrocheck
- one (1) low impedance busbar and breaker failure protection (field unit)
- two (2) trip coil supervision (two breakers)
- one (1) lot software, documentation
- one (1) lot cubicles, accessories, auxiliary relays.

Two (2) 315MVA 132kV side autotransformer protection (E13, E14) including each:

- two (2) duplicated multifunctional protection terminals with backup distance protection, directional overcurrent, back-up overcurrent phase and earth, circuit breaker failure, thermal overload, voltage unbalance, under/overvoltage protection (Main 1 and 2)
- one (1) Bay Control Unit including P, Q, U, I, f measurements, circuit breaker trip/close, graphic HMI, synchrocheck
- two (2) trip coil supervision (two breakers)
- one (1) lot software, documentation
- one (1) lot cubicles, accessories, auxiliary relays.
- **One (1) extension of the existing low impedance busbar and breaker failure protection**
  The existing 132kV bus configuration is single bus and transfer bus. Existing 87BB type is ABB REB670. The existing 87BB type ABB REB670 has spare capacity for two more channels, however, there are no spare terminals and peripheral devices. The contractor shall supply an extension panel with the required terminal blocks, auxiliary contactors and all other components that are required for the extension of the 132kV Busbar Protection and shall integrate the new bays (E13, E14) into the existing busbar protection system.

The busbar protection extension panel and the 315MVA 132kV side autotransformer protection panels shall be installed inside the existing control building and shall be interfaced with the new substation automation system for the 132 kV system, which is currently under implementation.

Two (2) 20MVA 33kV side autotransformer (K01, K03) protection including each:

- one (1) combined bay control unit and multifunctional protection terminal (BCPU) with two-stage phase and earth overcurrent protection
- two (2) trip coil supervision
- one (1) lot software, documentation
- one (1) lot cubicles, accessories, auxiliary relays.

Note:
Lekhnath 33 kV switchgear is fed from the AT tertiaries and low resistance earthed (NER 300A). The AT tertiary winding is included in the overall biased differential protection zone (**Annex D5-9A**).

Two (2) 33kV Auxiliary Transformer Feeder protection (K06, K10) (Annex D5-9A) including each:

- one (1) combined bay control and multifunctional protection terminal (BCPU), two-stage overcurrent phase and earth fault protection, sensitive earth fault protection, circuit breaker failure, over/undervoltage, including P, Q, U, I, f measurements, trip/close HMI, synchro check
- two (2) trip coil supervision
- one (1) lot software, documentation
- one (1) lot accessories, auxiliary relays.

3.2.10 Synchrophasor Measurement Unit

For each HV AC busbar at the Lekhnath and New Damauli 220kV S/S high accuracy Synchrophasor Measurement Unit (PMU) according to IEEE C37.118 shall be provided. Integration of the PMU in the Bay Control Unit or the Digital Fault Recorder shall be offered, subject to Employer's approval.

PMU measurement shall be integrated in a Wide Area Monitoring system to be gradually deployed over the entire NEA transmission system. Therefore, it shall comply with the P- class specification acc. to IEEE C37.118 and shall be synchronized to GPS or other low jitter time tagging system with accuracy of not less than 1 micro-second. For the present time, the proposed architecture shall be a stand-alone system for monitoring voltage and relevant currents monitoring of feeders as follows:

- voltages of the 220 kV busbars
- currents of the Damauli - Lekhnath 220 kV OHLs
- currents of Lekhnath 220/132 kV Autotransformers.

The PMU shall have a measurement capability of min 6 currents and 6 voltages on a constant time basis. The required total vector error shall be less than 1%; other performance requirements are:

- measurement magnitude ranges 0.1-2 In for current and 20- 140V for voltages
- off-frequency accuracy +/- 5 Hz
- harmonic distortion 10% (on individual harmonic)
- automatic change-over in case of bus VT unavailability.

The system shall have a proven interoperability and shall be prepared for future streaming to a central Synchrophasor Central Processor located at the NEA Dispatch Center.

Indoor Marshalling Panel for Transformer Control Circuits

To allow fast reconnection of the spare auto transformer, two indoor marshalling panels for the transformer control circuits shall be provided. The principle is indicated in **Annex D5-23**.

The marshalling panels shall have terminal block assemblies for each of the auto transformers and terminal block assemblies for the corresponding control and protection system. Patch wires with plug connectors shall permit to disconnect the control and protection circuits of a faulty autotransformer from the control and protection system and to connect the spare autotransformer control circuits instead.

3.2.11 SCADA and SCMS

3.2.11.1 General

The 132/33/11 kV Substation is already existing at Lekhnath Substation location, as already described in detail in the previous chapters.

Within the Project, a new SCMS system shall be provided (hardware and software, as necessary) to cover the new 220/132 kV Substation extension. Within the Contractor’s responsibility, the new system shall be tested and commissioned.

The new Lekhnath Substation Extensionshall be operated at the Substation level as an independent/separate new SCMS from the new HMI to be located in the new Substation Control Building. Necessary applicable interfacing & interconnection works between the new SCMS and the existing switchgear are included in the Contractor obligations.

The scope of supply and services associated with the Substation Control and Monitoring System comprises the design, manufacture, inspection, testing at manufacturer's work and at site, packing for export, shipment, insurance, transport and delivery to site, installation, commissioning and maintenance during guaranty period of a microcomputer-based digital substation control and monitoring system (SCMS/SCADA) suitable for proper and trouble free operation and support maintenance of the Project related 220 kV Substation at Lekhnath.

The scope of supply and services shall include all hardware, necessary works, accessories, patch cords, duct cables FO, terminals, strips, cabling, connection, software and parameterization (including data entry and display configuration-HMI mimic diagrams), Ethernet switches etc., so as to ensure the full establishment of new relays and circuits in the new SCMS and in order to fully cover the control and monitoring requirements of the Substation by the new SCMS. Compatibility and interoperability with NEA existing equipment and systems shall be ensured.

Compatibility and interoperability with the existing Substation related equipment and protocols shall be ensured.

New SCMS common BCU shall be provided.

The attached configuration under **Annex D5.14** "Principle System Architecture New Lekhnath 220/132/11 kV new Substation New SCMS" shall give an indicative example. Kindly refer for details regarding SCMS requirements at the Tender Documents, VII-5 "Technical Specifications".

For interfacing with the NEA NLDC/ECC (established already at Kathmandu Syuchathar and Hetauda) the new substation control and monitoring system shall be equipped with a set of two (2) redundant gateways for connection towards and from the NLDC /ECC via international standard protocols IEC 60870-5-104 (main and back-up gateways, each of them with minimum 2 channels).

The list of SCADA/SCMS signals and alarms, titles/designation etc., provided by the Contractor shall be subject to the Employer's/Engineer's approval.

The new Project related Substation shall be fully integrated into the existing SCADA/EMS System at NEA NLDC/ECC. The works shall consist in all respects required hardware, software and related associated works, necessary to make the new Project Substations an integral part of the overall SCADA/EMS system. Furthermore, any hardware/software required for this integration at the intermediate / end stations/NLDC/ECC shall be provided & implemented by the Contractor.

The relevant input data for parameterization, configuration, testing and putting in operation of SCMS/SCADA will be coordinated among the Contractor and the Employer/Engineer during the design stage of the project.

The SCMS/SCADA system shall cover control and supervision of all substation primary, secondary, control and protection, auxiliary equipment, etc. The architecture of the system shall consider and support bay level, substation level and gateway level-NLDC/ECC.

The new 220 kV bay control and protection cubicles shall be installed in the control building. For the new 33 kV switchgear, the bay control units shall be installed in the control compartment of the switchgear. The new 132 kV bay control and protection cubicles for the extension of the 132 kV switchgear shall be installed in the existing control building.

In the following paragraphs, the respective scope for the new SCMS to be established at the new extension 220/132/33 kV Substation of the new Lekhnath Substation is addressed.

3.2.11.2 Scope of Supply and Services (New Lekhnath)

A new State of the art digital full redundant Substation Control and Monitoring (SCMS) for the monitoring and control of the new extension (220 kV, 132 kV, 33 kV) with redundant scheme and possibility for future extension shall be implemented at the new LEKHNATH Substation.

The new 220/132/33 kV protection and control units shall be connected in separate double optical ring connection utilizing IEC 61850 standard. The design shall be subject to further approval by Employer/Employer’s representative.

The provided equipment and systems shall be compatible/interoperable in every respect both with the interconnected substations equipment and systems as well as with the relevant National NLDC/ECC (National Load Dispatch Centre/Emergency Control Centre) operated by the NEA Transmission System Operator.

For interfacing with the NEA NLDC/ECC, the substation control and monitoring system shall be equipped with a set of two (2) redundant gateways channels for connection towards and from the related existing NEA NLDC/ECC (National Load Dispatch Centre/Emergency Control Centre) via international standard protocols IEC 60870-5-104 (main and back-up). In this regard, the Contractor shall also take into consideration that the Nepal NEA Transmission network is operated on National Dispatch level by two (2) systems:

- main control system NLDC located at Kathmandu Syuchathar (SCADA/EMS System SINAUT SPECTRUM Power 7 from Siemens) and
- emergency control system ECC located at Hetauda (SCADA/EMS System SINAUT SPECTRUM Power 7 from Siemens).

The related existing SCADA/EMS is put in service very recently in 2020 by Siemens India.

The relevant National NLDC/ECC SCADA/EMS systems are already existing and already equipped with the with Telecommunication systems and related Software capabilities for interfacing via international standard protocols according to IEC60870-5-104 and IEC60870-5-101. The redundant gateways protocol shall be also according to IEC 60870-5-104 (main and backup medium).

As depicted in **Annex D5-14** New SCMS Principle System Architecture of the New Extension Lekhnath 220/132/33 kV for the SCMS systems to be established under the current project at the related substation extension shall be designed for connection with the NEA National Load Dispatch Centers LDC/ECC SCADA/EMS system.

Control and protection panels shall include as a minimum the following equipment:

- mimic diagram with position indicators (semaphores) for circuit breakers, isolating switches, earthing switches located in the local control cubicle of the equipment
- all alarms and indicators associated with protection tripping
- integration of state-of-the-art cyber security equipment
- all auxiliary relays, switches, contactors, MCBs with the necessary auxiliary contacts, fuses, etc., for the control, monitoring, remote control, protection and interlocking circuits.

The Contractor must ensure that after handing over, a minimum of 20% spare capacity in terminal strips for future extensions is available.

For the HV/MV NEA Transmission Network voltage levels, the Project related 220 kV and 132 kV control, the control and protection shall be accommodated in common control and protection panels and shall be equipped with BCUs (Bay Control Units). Control and protection panels shall have additional spare space for extensions.

For the Project related new 33 kV switchgear, the control and protection can be accommodated in the control compartment of the switchgear and shall be equipped with BCPUs (Bay Control and Protection Units). Control compartments shall have additional spare space for extensions.

The number of BCU/BCPUs and digital protection devices to be interfaced with the SCMS can be taken from the relevant chapters of the present document, where details on the various bays of the substation and the necessary equipment are indicated.

In addition, sufficient number of common BCUs, acquiring data from the substation auxiliaries and other common substation elements, shall be included in the scope.

For 220 kV and 132 kV BCUs measurements shall have at least 0.5 class accuracy.

The new Lekhnath SMCS equipment shall be fully integrated on Substation SCMS HMI and Substation Gateways level.

The following Project related 220 kV, 132 kV and 33 kV system control operations shall be possible:

1. local control: from the individual bay equipment at each 220 kV, 132 kV, 33 kV switchgear cubicles. The mimic scheme on the local control cubicles shall be provided only for indication (semaphores) related to HV/MV equipment positions.
2. remote control level 1: from BCU/BCPU on 220 kV, 132 kV, 33 kV. No analogue mimic control is required.
3. remote control level 2: from the SCMS local HMI in the substation control room (220 kV, 132 kV, 33 kV)
4. remote control level 3: from the responsible NLDC/ECC (National Load Dispatch Center/National Emergency Control Centre) SCADA/EMS System operated by NEA for 220 kV.

Remote control levels shall be interlocked against each other according to parameterizable interlocking rules as per the switching authority.

Integration of the new substation new SCMS installed under the project into the National Load Dispatch Centre& Emergency Control Centre (NLDC/ECC) SCADA/EMS System including related supply of hardware, software, accessories, database extension, display generation, point-to point tests etc. is included and shall be performed by the Contractor.

Integration works associated with the scope of the current project is as follows:

- for the NLDC/ECC side, Contractor will perform the work

and

- for SCMS Gateways side, the Contractor will perform the works

(including - but not limited to-commissioning protocols/tests to verify point by point all Substation extension signals and the required interfacing protocols).

Contractor is required to coordinate with NEA/NEA's Contractors for the interfacing works.

The 220 kV, 132 kV and 33 kV control panels shall be equipped with the following main equipment for each bay:

1. mimic diagram with position indicators (semaphores) for all circuit breakers, isolating switches, and working earth switches
2. bay control unit (BCU) for 220 kV & 132 kV and BCPU for 33 kV
3. 1-20 way alarm facia with accept/test/reset push button
4. Numerical automatic voltage regulator suitable for parallel operation for transformer bay.

Lock out relays (high burden fast operated trip relays) shall be included for all circuit breakers (HV and LV side) for all voltage levels.

The SCMS to be implemented under the Project at the new LEKHNATH 220 kV substation shall be equipped with the following:

- two (2) redundant servers (computers), with sequence events recording (SER)
- all related LAN and IT security equipment
- one (1) main GPS synchronized time system, including antenna, cabling and time synchronization equipment
- one (1) back-up GPS synchronized time system, including antenna, cabling and time synchronization equipment
- two (2) operator work stations HMI, equipped with two (2) LED flat monitors per work station
- one (1) emergency HMI and maintenance service laptop with interface connection for engineering/protection relay interrogation
- one (1) A4 and one (1) A3 color laser printers
- one (1) set of all necessary cubicles
- one (1) set of main Ethernet switches
- one (1) Engineering Workstation with interface connection for engineering/protection relay interrogation and equipped with two (2) LED flat monitors
- computers furniture (such as desks and chairs)
- redundant supply, UPS (included under Auxiliary Systems)
- 2 redundant gateways for interfacing NLDC/ECC
- 1 gateway for interfacing Existing Lekhnath 132 kV Substation RTU/SCADA
- weather station
- two (2) operator desks with four (4) chairs.

In addition, all necessary interfacing with the telecommunication systems is deemed to be included in the present scope of supply and services.

Within the Contractor's responsibility, the new system shall be tested and commissioned.

The list of SCMS signals and alarms, titles/designation etc., updated, prepared and provided by the Contractor shall be subject to the Employer's/Engineer's approval.

The Contractor shall ensure that the auxiliary power services are monitored from SCMS.

Engineering and parameterization as well as construction of mimic diagrams for display on the LED monitors shall be included in the services.

Design of the SCMS System and the HMI/ mimic diagrams shall be subject to further approval by the Employer/Engineer.

The SCMS/SCADA system shall cover control and supervision of all substation primary, secondary, control and protection, auxiliary equipment, etc. The architecture of the system shall consider and support bay level, substation level and gateway level-NLDC/ECC.

The new bay control and protection cubicles shall be installed in the control building.

The relevant input data for parameterization, configuration, testing and putting in operation of SCMS/SCADA will be coordinated among the Contractor and the Employer/Engineer during the design stage of the project.

Substation control and monitoring system (SCMS)

The substation control and monitoring system shall provide all control and signaling amenities required in the substation such that the status of the substation can be ascertained and all the necessary control and switching operations can be carried out from the control room.

Substation control and monitoring system shall fulfil the functions and amenities described in the Tender Documents Part II/ VII-5 Technical Specifications.

Substation control level

Central system for future substation control and supervision will be located in the control room. The substation control level equipment shall comprise the elements and functions as described in the Tender Documents Part II/ VII-5 Technical Specifications.

Bay control level

Distributed (bay oriented) microprocessor devices, hierarchically linked with central substation control unit, shall be foreseen for bay control. The bay control level is described in the Tender Documents Part II/ VII-5 Technical Specifications.

Interlocking system

Interlocking system on a 220/132/33 kV switchyard/switchgear-level shall be carried out by software using distributed (bay oriented) microprocessor devices. This interlocking system between bays should be independent of local SCADA/SCMS system running.

Interlocking system on a 220/132/33 kV bay-level, shall be also managed through conventional (hard wire) interlocking, in parallel in all times with the software interlocking.

Miscellaneous

Single Line diagram should be agreed with National NEA NLDC.

All monitoring and control actions on station level as well as on remote level (from NLDC/ECC) shall be managed from the SCMS central system to be established at the new Substation.

Full compatibility and interoperability with the existing NEA SCADA/EMS systems, SCMS system, Telecommunication Networks shall be ensured by the Contractor on the new Lekhnath Substation side.

New Lekhnath Substation shall be provided with a weather station to monitor environmental climatic indicators (as a minimum Temperature, Humidity. Luminosity (Lightness), Wind Speed, Wind Direction, Rainfall shall be measured). This information shall be integrated in SCADA HMI and Gateways.

The above-mentioned requirements are preliminary only and the final list of equipment and final technical data are subject to design approval.

3.2.11.3 Interfacing with the existing Lekhnath Substation

The Contractor shall coordinate his works at the interfaces with NEA/NEA Contractors related works in the existing Substation.

NEA currently is implementing the **NEA Grid Substation Automation System (SAS) Project-Phase 2**. The scope of this project includes the complete automation of 132 kV, 66 kV, 33 kV and 11 kV bays of substations under six Grid Division offices, including the construction of six Master Control Centers (MCCs) at various six grid locations and the integration of these substations into the Load Dispatch Center (LDC), NEA, Siuchatar and Backup Data Centre at Hetauda.

As part of this project, a new substation automation system will be provided for the existing 132 /33 / 11 kV Lekhnath Substation, including integration of this substations into the Master Control Centers (MCC) Pokhara and Load Dispatch Center (LDC), NEA, Siuchatar and Backup Data Centre at Hetauda.

For the additional 132 kV transformer bays included in the Lekhnath Damauli 220 kV Transmission Line Project Package B, the split of responsibilities shall be as follows:

- Package B includes provision of control and protection panel with bay control unit for the two extended 132 kV bays and Ethernet switch to allow integration to the automation system
- SAS Project-Phase 2 undertakes to increase the capacity of the Lekhnath substation automation system at Lekhnath to allow integration of the two additional bays for LD 220 kV TLP
- Integration of the two additional bays for LD 220 kV TLP and adaption of HMI displays will be done by into SAS Project-Phase 2 / NEA with support of Package B Contractor
- Integration of 220 kV switchgear into NLDC and Backup LDC is in scope of Package B

3.2.11.4 Integration of the new LEKHNATH Substation SCMS into the existing SCADA/EMS System at NLDC/ECC

The new SCMS installed under the project for the new 220/132/33 kV extension of Lekhnath Substation shall be fully integrated into the existing National Load Dispatch Centre Main & Back-up (NLDC/ECC) SCADA/EMS System.

Integration of the new substation new SCMS installed under the project into the National Load Dispatch Centre& Emergency Control Centre (NLDC/ECC) SCADA/EMS System including related supply of hardware, software, accessories, database extension, display generation, point-to point tests etc. is included in the scope.

Integration works associated with the scope of the current project is as follows:

- for the NLDC/ECC side, Nominated Subcontractor shall perform the work and
- for SCMS Gateways side, the Contractor shall perform the works

(including - but not limited to-commissioning protocols/tests to verify point by point all Substation extension signals and the required interfacing protocols).

Contractor is required to coordinate with NEA/NEA Contractors for the interfacing/interconnection works.

The required works envisage advanced Vendor specifics, complexity and need for authorization access rights into the existing system, also eventual required NOC (non-objection certificate if the existing system is still under warranty at the construction period) for the Project related extension of the existing Sinaut Spectrum Power 7 SCADA system at NLDC/ECC. Therefore, in order to achieve a smooth and timely implementation of the related works, such works are required to be performed by the original Vendor/Supplier (Siemens) of the relevant existing SCADA/EMS System at NEA National NLDC/ECC. The Contractor is required to subcontract the related works accordingly to this Nominated Subcontractor.

Furthermore, under the Project scope, the NEA staff operating and maintaining the National NLDC/ECC SCADA/EMS Systems, shall be well trained and acquainted to perform such operation & maintenance work.

In order to safeguard that the selected NEA staff at NLDC/ECC will be sufficiently skilled and trained for such data engineering works, a series of Training sessions, in a mixture of abroad and local Training in NEPAL, shall be performed by the Contractor under the present scope.

For training requirements please refer to Chapter 3.1.9 and Section VII-5 Technical Specifications/ chapter 13. SCADA and SCMS /13.4 Other Requirements/13.4.6 Training.

For interfacing with the super-ordinate NLDC/ECC, the substation control and monitoring system shall be equipped with a set of two (2) redundant gateways channels for connection towards and from the NLDC/ECC of NEA TSO Nepal via international standard protocols IEC 60870-5-104 (main) and IEC 60870-5-104 (fallback).

The list of signals, operations, IP addresses etc. for integration up to the NLDC/ECC shall be submitted by the Contractor and shall be subject to the Employer's/Engineer's approval.

The relevant input data for parameterization, configuration, testing and putting in operation of SCMS/SCADA shall be coordinated among the Contractor and the Employer/Engineer during the design stage of the project.

3.2.12 Telecommunication

3.2.12.1 Optical Line Terminal Equipment for SDH and MPLS – TP (Hybrid technology)

New state-of-the-art Hybrid technology based Optical Line Terminal Equipment for SDH and MPLS - TP shall be provided and installed at the new 220 kV GIS Lekhnath Substation and shall be integrated as a new Hybrid technology based SDH node into the existing NEA SDH network.

The Hybrid technology based SDH node shall provide FOC connections to the new 220/132/33/11kV GIS Damauli Substation and to the existing 132/33/11kV Lekhnath Substation.

3.2.12.2 Fiber Optical Cables

All FOCs shall incorporate 48 single-mode fibers, which shall comply with IEC 60793 and IEC 60794 standards and with ITU-T G.652D.

OPGW

The new 220kV DC OHTL Lekhnath - Damauli of Package A – TL will provide an OPGW with 48 optical fibers to be connected to the new Lekhnath SDH node.

UGFO

An UGFO cable with 48 optical fibers shall be provided and installed between the Gantry of the 220kV DC OHTL Lekhnath – Damauli and telecommunications room in the substation control building.

The 48 optical fibers of the OPGW shall be spliced to the 48 optical fibers of the UGFO cable providing the connection between the new Hybrid technology based SDH node at 220 kV GIS Lekhnath Substation and new the SDH node at the 220/132/11kV GIS Damauli Substation.

An UGFO cable with 48 optical fibers shall be provided and installed between the new 220 kV GIS Lekhnath Substation and the existing 132/33/11kV Lekhnath Substation. The 48 optical fibers of the UGFO cable shall provide the connections between the new Hybrid technology based SDH node at 220 kV GIS Lekhnath Substation and the SDH node at the existing 132/33/11kV Lekhnath Substation.

Patch cords

A sufficient number of patch cords shall be provided to establish the connections between

- the optical fibers terminated in the ODFs and the SFP ports of the SDH equipment
- the optical fibers terminated in different ODFs.

3.2.12.3 Fiber optical cables accessories

Optical distribution frame

Optical distribution frames (ODF) shall be provided and installed in the telecommunication rooms of both substations:

- new 220 kV GIS Lekhnath Substation
  - one ODF with 96 connectors/ports for fiber optic cables
    - to terminate the UGFO cable running to the Gantry of the 220kV DC OHTL Lekhnath – Damauli
    - to terminate the UGFO cable running to the existing 132/33/11kV Lekhnath Substation
- existing 132/33/11kV Lekhnath Substation
  - one ODF with 48 connectors/ports for fiber optic cables to terminate the UGFO cable running to the new 220 kV GIS Lekhnath Substation.

Connectors and plugs

A sufficient number of appropriate state-of-art optical plug/connector type shall be provided for new installations in the Project.

3.2.12.4 Telephony

A new state-of-the-art IP-PBX and appropriate telephone sets shall be installed, ready for use.

3.2.13 Metering system

The existing metering system of the substation shall be extended to accommodate the necessary three-phase meters, further to the switchyard modifications.

Electricity metering shall be installed for the following:

- two (2) 220 kV OHL feeders to Damauli
- four (4) 220/132/33 kV autotransformers (220 kV side and 132 kV side)
- two (2) auxiliary transformers.

Meters shall be connected to the class 0.2S metering cores of the relevant instrument transformers by independent wiring systems. The meters shall be remotely accessible through existing automated meter reading software of the Employer.

The scope of supply related to the metering system is deemed to be complete and therefore inclusive of:

- high accuracy three-phase electricity meters
- metering panels, connection terminals and LV protection equipment
- wiring and (fiber optic) cabling system
- convertors and/or switches, as necessary to allow the aforementioned communication between the meters and the automated meter reading system of the Employer
- notebook PC including related software for local access for meter reading.

3.2.14 Cable System

3.2.14.1 Medium and Low Voltage Cable System

The scope of supply and services related to power and control cables shall include the complete cabling systems required for an operational substation. Therefore, on top of the required cables, the scope includes all necessary sealing ends, steel structure supports, clamps, accessories, cable trenches, cable containment, cable canals, bus ducts etc., as necessary.

- one (1) lot of MV cable systems comprising 33 kV XLPE cables shall be provided for the connection between tertiary windings of 220/132/33 kV transformers and 33 kV switchgear
- one (1) lot of MV cable systems comprising 33 kV XLPE cables shall be provided for the connection between 33 kV switchgear and auxiliary transformers
- one (1) lot of low voltage AC&DC power and control cables and cable support systems, as defined in the Technical Specification shall be provided for interconnection of all equipment included in the scope.

3.2.15 Earthing and Lightning Protection system

Earthing and lightning protection systems shall include:

- underground earth grid for new HV installations including earthing grid of OHL tower for interconnection between 132 kV switchyard and autotransformers
- extension of existing earth grid of 132 kV switchyard for new bays E13 / E14

- interconnection of new earth grids with earth grid of existing switchyard
- embedded and surface mounted earthing systems of buildings
- lightning protection systems for switchyards and buildings.

3.2.16 Lighting and Small Power

A lighting and small power system, complete in every respect and suitable for satisfactory operation, shall be provided for the extension of the substation. It shall include the following items:

- 400/230 V distribution boards for lighting system and small power
- complete indoor and outdoor normal and emergency lighting systems, including all required luminaires, lighting poles, external lighting control systems etc.
- cabling system, including cable trunking and cable containment systems
- socket outlets and plugs (3-ph and 1-ph sockets)
- power outlet combinations (with 3-ph and 1-ph socket outlets)
- power connection points for autotransformer bays
- all standard equipment and accessories necessary for the satisfactory operation of the system but which are not separately listed.

3.2.17 Fire protection system

A fire detection, alarm and firefighting system shall be provided for the complete 220/132 kV substation, i.e. including the existing control building and switchyard. The system shall cover the existing and new building, transformer bays and outdoor switchyard.

The system shall be such that, in case of fire detection, an alarm shall be able to be signaled to the local firefighting emergency service. Fire alarms shall be wired to the Common Bay Unit in order to be signaled to the substation control and monitoring system (SCMS). The fire detection system shall include the following items:

- one (1) central fire alarm panel
- one (1) fire alarm repeater panel
- one (1) lot of fire detectors
- one (1) lot of manual alarm pushbuttons
- one (1) lot of audible and visual alarm devices
- fire detection cabling system, including cable trunking and cable containment systems
- all accessories necessary for the satisfactory operation of the system but which are not separately listed.

Portable fire extinguishers shall be provided inside the buildings and at strategic outdoor locations, such as e.g. transformer bays and other locations with risk of fire. They shall include the following items:

- one (1) lot of handheld fire extinguishers including the following types:
  - dry chemical powder type
  - carbon dioxide type
- one (1) lot of wheel/trolley mounted fire extinguishers mechanical foam type.

A firefighting system shall be provided and shall include the following items:

- one (1) prefabricated containerized fire pump unit including
  - electric jockey pumps (1 set - 2x100%),
  - electric driven main pumps (1x100%),
  - diesel engine driven main pump (1x100%),
  - expansion tank arrangement,
  - control panel.
- one firefighting water tank
- one firefighting water supply pump with well and all accessories
- seven (7) transformer deluge systems for autotransformers
- one (1) lot of fire hydrant network and interconnection piping
- one lot of cabling system, including cable trunking and cable containment systems
- all accessories necessary for the satisfactory operation of the system but which are not separately listed.

3.2.18 CCTV system

A new VMS (visual monitoring system), internationally also referred to as Closed Circuit Television (CCTV) systems shall be provided for visual monitoring of the substation premises. The main observation objects are as follows:

- switchyard
- transformer bays
- GIS hall
- switchgear and control equipment rooms
- control room
- stores
- main gate.

The scope of supply and services related to the technological video surveillance system shall include supply, installation, and commissioning of:

- central unit comprising:
  - video server
  - matrix switch
  - redundant UPS
  - interface for transmission to RDC
- system control panel, located close to the SCMS workstations
- monitors located close to the SCMS workstations
- indoor and outdoor pan tilt zoom (PTZ) cameras (minimum forty (40) sets) with remote control including
  - high-speed swivel platform with a protective cover
  - receiver for control commands
  - power supply
  - highly sensitive color camera with motorized lens.

The following supplies and services shall be included in the items above:

- base frames, steel works, supports and foundations required for installation
- all control and auxiliary supply cabling for interconnection and for power supply
- any other item considered necessary for the installation and successful operation of the works.

3.3 220/132 kV Damauli Substation

In Damauli, a new 220 /132/33/11 kV substation shall be constructed. An indoor, double bus bar system SF6 Gas Insulated Switchgear (GIS) type has been selected for the 220 kV and 132 kV switchgear (refer to **Annex D5-4** - Substation Layout).

The following sections briefly describe the main substations features and scope of supply. Reference is made to the substation Single Line Diagrams (refer to **Annex D5-2**) and AC/DC Auxiliary System Scheme (refer to **Annex D 5-10**).

3.3.1 220 kV GIS

The 220 kV switchgear shall be arranged as double busbar and shall be fitted for the following connections:

- six (6) bays for the connection to 220kV OHL to Lekhnath Substation, Tanahu power station and Bharatpur Substation (D06, D07, D08, D13, D14, and D15)
- two (2) bays for the connection to 220/132kV power transformer (D09 and D12)
- two (2) Measuring Bays ((D10) and (D11))
- two (2) Bus Couplers (D05, D16)
- two (2) Busbar Sectionalizers (D10 and D11).

Additionally, space provision shall be made for the following future bays (to be included in GIS design for civil engineering):

- two (2) bays for cable connection to 400/220kV autotransformers (D04 and D17)
- one (1) auxiliary gas-insulated bus duct for the fast reconnection of the spare units
- one (1) bay for cable connection a third additional 400/220kV autotransformer (D18)
- five (5) future bays (D01, D02, D03, D19 and D20) for cable connection
- provision for future installation of busbar surge arrestors with disconnector and maintenance earthing switch.

The detailed scope of supply shall be as follows:

Six (6) OHL Bays (D06, D07, D08, D13, D14, D15) including each

- two (2) three-phase bus bar modules
- two (2) three-phase bus bar disconnecting switches, motor operated
- two (2) three-phase maintenance earthing switches, motor operated
- one (1) three-phase circuit breaker, motor and spring operated
- three (3) single phase current transformers with five (5) cores
- one (1) three-phase feeder disconnecting switch, motor operated
- one (1) three-phase fast earthing switch motor and spring operated
- three (3) single phase SF6/Air bushing
- three (3) single phase gas insulated busducts (GIB) for single phase OHL connection
- lot of sensors for partial discharge measurement
- lot of provision (light sensor) for future arc detection
- one (1) local control cubicle for local control and interlocking (bay control units are included in the protection cubicles)
- lot of steel structures for support the GIS
- lot of cables for control, measurement and protection
- lot of installation material (cable trays, cable bridges, earthing material etc.) to complete the bay in any respect.

Two (2) 220/132kV Transformer Bay (D09 and D12)

- two (2) three-phase bus bar modules
- two (2) three-phase bus bar disconnecting switches, motor operated
- two (2) three-phase maintenance earthing switches, motor operated
- one (1) three-phase circuit breaker, motor and spring operated
- three (3) single phase current transformers with five (5) cores
- one (1) three-phase feeder disconnecting switch, motor operated
- one (1) three-phase fast earthing switch motor and spring operated
- three (3) single phase SF6/Air bushing

- three (3) single phase gas insulated busducts (GIB) for single phase AIS transformer connection
- lot of sensors for partial discharge measurement
- lot of provision (light sensor) for future arc detection
- one (1) local control cubicle for local control and interlocking (bay control units are included in the protection cubicles)
- lot of steel structures for support the GIS
- lot of cables for control, measurement and protection
- lot of installation material (cable trays, cable bridges, earthing material etc.) to complete the bay in any respect.

Two (2) Measuring Bays ((D10) and (D11)) including each

- two (2) three-phase bus bar modules
- six (6) single phase inductive voltage transformer
- two (2) three-phase disconnecting switches, motor operated
- two (2) three-phase maintenance earthing switches, motor operated
- two (2) three-phase fast earthing switch motor and spring operated
- lot of sensors for partial discharge measurement
- lot of provision (light sensor) for future arc detection
- one (1) local control cubicle for local control and interlocking (bay control units are included in the protection cubicles)
- lot of steel structures for support the GIS
- lot of cables for control, measurement and protection
- lot of installation material (cable trays, cable bridges, earthing material etc.) to complete the bay in any respect.

Two (2) Bus Coupler Bays (D05, D16) including each

- two (2) three-phase bus bar modules
- two (2) three-phase bus bar disconnecting switches, motor operated
- two (2) three-phase maintenance earthing switches, motor operated
- one (1) three-phase circuit breaker, motor and spring operated
- (2) sets of three phase CTs each on the different side of the breaker. The first set shall have two (2) cores: one core for busbar protection and one core for main protection. The second set shall have three (3) cores as above plus one measuring core for BCU.
- lot of sensors for partial discharge measurement
- lot of provision (light sensor) for future arc detection
- one (1) local control cubicle for local control and interlocking (bay control units are included in the protection cubicles)
- lot of steel structures for support the GIS
- lot of cables for control, measurement and protection

- lot of installation material (cable trays, cable bridges, earthing material etc.) to complete the bay in any respect.

Two (2) Busbar Sectionalizers (D10, D11) including each

- two (2) three-phase bus bar modules
- two (2) three-phase bus bar disconnecting switches, motor operated
- two (2) three-phase maintenance earthing switches, motor operated
- one (1) three-phase circuit breaker, motor and spring operated
- (2) sets of three phase CTs each on the different side of the breaker. The first set shall have two (2) cores: one core for busbar protection and one core for main protection. The second set shall have three (3) cores as above plus one measuring core for BCU.
- lot of sensors for partial discharge measurement
- lot of provision (light sensor) for future arc detection
- one (1) local control cubicle for local control and interlocking (bay control units are included in the protection cubicles)
- lot of steel structures for support the GIS
- lot of cables for control, measurement and protection
- lot of installation material (cable trays, cable bridges, earthing material etc.) to complete the bay in any respect.

3.3.2 220 kV AIS equipment

The six (6) 220 kV OHL feeders will be provided each with the following

- one (1) set of three single phase 220 kV surge arresters
- one (1) set of three single phase 220 kV capacitive voltage transformers.
- one (1) set of 220 kV OHL gantry.

3.3.3 132 kV GIS

The 132 kV switchgear shall be arranged as double busbar and shall be fitted for the following connections:

- two (2) bays for the connection to 220/132 kV transformer (E02 and E06)
- two (2) bays fort the connection to 132 kV OHL to Damauli and Bharaptur Substations (E03 and E07)
- two (2) bays for the connection to 132/33 kV transformer (E01 and E05)
- one (1) Measuring Bay ((E04))
- one (1) Bus Coupler (E04).

Additionally, space provision shall be made for the following future bays (to be included in GIS design for civil engineering):

- one (1) future bay (E08) for cable connection.

The detailed scope of supply shall be as follows:

Two (2) 220/132kV Transformer Bays (E02 and E06) including

- two (2) three-phase bus bar modules
- two (2) three-phase three position bus bar disconnecting switches with maintenance earthing switch, motor operated
- one (1) three-phase circuit breaker, motor and spring operated
- one (1) three phase current transformers with five (5) cores
- one (1) three phase three position feeder disconnector with maintenance earthing switch, motor operated
- one (1) three-phase fast earthing switch motor and spring operated
- one (1) three phase cable end unit for cable connection to transformer
- lot of sensors for partial discharge measurement
- lot of provision (light sensor) for future arc detection
- one (1) local control cubicle for local control and interlocking (bay control units are included in the protection cubicles)
- lot of steel structures for support the GIS
- lot of cables for control, measurement and protection
- lot of installation material (cable trays, cable bridges, earthing material etc.) to complete the bay in any respect.

Two (2) OHL Bays (E03, E07) including each

- two (2) three-phase three position bus bar disconnecting switches with maintenance earthing switch, motor operated
- one (1) three-phase circuit breaker, motor and spring operated
- one (1) three phase current transformers with five (5) cores
- one (1) three phase three position feeder disconnector with maintenance earthing switch, motor operated
- one (1) three-phase fast earthing switch motor and spring operated
- three (3) single phase SF6/Air bushing
- one (1) three phase gas insulated busducts (GIB) for OHL connection
- lot of sensors for partial discharge measurement
- lot of provision (light sensor) for future arc detection
- one (1) local control cubicle for local control and interlocking (bay control units are included in the protection cubicles)

- lot of steel structures for support the GIS
- lot of cables for control, measurement and protection
- lot of installation material (cable trays, cable bridges, earthing material etc.) to complete the bay in any respect.

Two (2) 132/33kV Transformer Bay (E01 and E05) including

- two (2) three-phase three position bus bar disconnecting switches with maintenance earthing switch, motor operated
- one (1) three-phase circuit breaker, motor and spring operated
- one (1) three phase current transformers with five (5) cores
- one (1) three phase three position feeder disconnector with maintenance earthing switch, motor operated
- one (1) three-phase fast earthing switch motor and spring operated
- three (3) single phase SF6/Air bushing
- one (1) three phase gas insulated busducts (GIB) for AIS transformer connection
- lot of sensors for partial discharge measurement
- lot of provision (light sensor) for future arc detection
- one (1) local control cubicle for local control and interlocking (bay control units are included in the protection cubicles)
- lot of steel structures for support the GIS
- lot of cables for control, measurement and protection
- lot of installation material (cable trays, cable bridges, earthing material etc.) to complete the bay in any respect.

One (1) Measuring Bay ((E04)) including

- two (2) three-phase three position bus bar disconnecting switches with maintenance earthing switch, motor operated
- two (2) three phase inductive voltage transformers
- two (2) three-phase fast earthing switch motor and spring operated
- lot of sensors for partial discharge measurement
- lot of provision (light sensor) for future arc detection
- one (1) local control cubicle for local control and interlocking (bay control units are included in the protection cubicles)
- lot of steel structures for support the GIS
- lot of cables for control, measurement and protection
- lot of installation material (cable trays, cable bridges, earthing material etc.) to complete the bay in any respect.

One (1) Bus Coupler (E04) including

- two (2) three-phase three position bus bar disconnecting switches with fast earthing switch, motor operated
- two (2) three-phase fast earthing switch motor and spring operated
- one (1) three-phase circuit breaker, motor and spring operated
- (2) sets of three phase CTs each on the different side of the breaker. The first set shall have two (2) cores: one core for busbar protection and one core for main protection. The second set shall have three (3) cores as above plus one measuring core for BCU.
- lot of sensors for partial discharge measurement
- lot of provision (light sensor) for future arc detection
- one (1) local control cubicle for local control and interlocking (bay control units are included in the protection cubicles)
- lot of steel structures for support the GIS
- lot of cables for control, measurement and protection
- lot of installation material (cable trays, cable bridges, earthing material etc.) to complete the bay in any respect.

3.3.4 132 kV AIS equipment

The two (2) 132 kV OHL feeders shall be provided each with the following

- one (1) set of three single phase 132 kV surge arresters
- one (1) set of three single phase 132 kV capacitive voltage transformers.
- one (1) set of 132 kV OHL gantry.

3.3.5 Power Transformers

3.3.5.1 Power Transformer 220/132 kV

The Power Transformers shall be three-phase type, with a tertiary winding which is intended to be used only for stabilization purposes, with a total power of 50/63 MVA:

- two (2) unit of three-phase power transformer 220/132 kV 50/63 MVA, equipped with on-load tap changer
- two (2) set of three single phase line surge arresters for the primary (220 kV) side
- two (2) set of three single phase line surge arresters for the secondary (132 kV) side
- two (2) set of automatic voltage regulator, including the relevant software and integration in the SCMS.

3.3.5.2 Power Transformer 132/33 kV

The Power Transformers shall be three-phase type, with a tertiary winding which is intended to be used only for stabilization purposes, with a total power of 24/30 MVA:

- two (2) unit of three-phase power transformer 132/33kV 24/30 MVA, equipped with on-load tap changer
- two (2) set of three single phase line surge arresters for the primary (132 kV) side
- two (2) set of three single phase surge arresters for the secondary (33 kV) side (tank mounted)
- two (2) set of automatic voltage regulator, including the relevant software and integration in the SCMS.

3.3.5.3 Power Transformer 33/11 kV

The Power Transformers shall be three-phase type, with a total power of 6/8 MVA:

- two (2) unit of three-phase power transformer 33/11kV 6/8 MVA, equipped with on-load tap changer
- two (2) set of three single phase surge arresters for the primary (33 kV) side (tank mounted)
- two (2) set of three single phase surge arresters for the secondary (11 kV) side (tank mounted)
- two (2) set of automatic voltage regulator, including the relevant software and integration in the SCMS.

3.3.6 Medium Voltage (MV) Metal Clad Switchgear

3.3.6.1 33 kV Switchgear

The 33kV air-insulated metal clad switchgear shall be arranged as single busbar and shall be fitted for the following connections:

- two (2) incomers for 132/33kV transformer connection (J02, J11), each of them provided with withdrawable circuit breaker, current transformer, capacitive indicator, earthing switch, surge arresters and withdrawable voltage transformer protected by fuse
- two (2) outgoing feeders (J04, J10), each of them provided with withdrawable circuit breaker, current transformer, capacitive indicator, earthing switch, surge arresters and voltage transformer
- two (2) outgoing feeder 33/11 kV transformer (J03, J12), each of them provided with withdrawable circuit breaker, current transformer, capacitive indicator, earthing switch, surge arresters
- two (2) outgoing feeders to auxiliary transformer (J05, J09), each of them provided with withdrawable circuit breaker, current transformer, capacitive indicator, earthing switch, surge arresters

- one (1) bus tie (J07), each of them provided with withdrawable circuit breaker, current transformer, earthing switch
- one (1) riser measurement panel (J08), each of them provided with earthing switch and withdrawable voltage transformer protected by fuse
- one (1) measurement panel (J06), each of them provided with earthing switch and withdrawable voltage transformer protected by fuse
- one set of accessories shall be provided for the medium voltage switchgear including as a minimum the following:
  - one (1) set of keys, cranks, levers for operation of switchgear, including holder for wall mounting
  - one (1) feeder trolley
  - one (1) short circuiting device
  - one (1) voltage tester
  - one (1) cable testing plug

Additionally, space provision shall be made for the following connections:

- two (2) future outgoing feeders (J01, J13)

3.3.6.2 11 kV Switchgear

The 11kV metal clad air-insulated switchgear shall be arranged as single busbar and shall be fitted for the following connections:

- two (2) incomers for 33/11kV transformer connection (K03, K08), each of them provided with withdrawable circuit breaker, current transformer, capacitive indicator, earthing switch, surge arresters and withdrawable voltage transformer protected by fuse
- five (5) outgoing feeders (K04, K05, K09, K11, K12), each of them provided with withdrawable circuit breaker, current transformer, capacitive indicator, earthing switch, surge arresters
- one (1) bus tie (K07), each of them provided with withdrawable circuit breaker, current transformer, earthing switch
- one (1) riser measurement panel (K06) , each of them provided with earthing switch and withdrawable voltage transformer protected by fuse
- one (1) measurement panel (K10), each of them provided with earthing switch and withdrawable voltage transformer protected by fuse
- one set of accessories shall be provided for the medium voltage switchgear including as a minimum the following:
  - one (1) set of keys, cranks, levers for operation of switchgear, including holder for wall mounting
  - one (1) feeder trolley
  - one (1) short circuiting device

- one (1) voltage tester
- one (1) cable testing plug.

Additionally, space provision shall be made for the following connections:

- four (4) future outgoing feeders (K01, K02, K13, K14)

3.3.7 Auxiliary Transformers

- Two (2) three-phase auxiliary transformers 33/0.4 kV, hermetically sealed type with off load tap changer, each of minimum 1250 kVA, suitable for outdoor installation, provided with sunshade, shall be provided
- two (2) set of three single phase tank mounted surge arresters for the secondary (33 kV) side.

3.3.8 Auxiliary Power Supply System

The auxiliary power supply system shall consist of the following equipment:

- one (1) set of LV AC metal-clad switchgear with two bus sections
- one (1) set of 220V DC switchgear with two bus sections
- two (2) sets of 220 V battery chargers
- two (2) sets of 220 V Battery Systems
- one (1) set of 48 V DC switchgear with two bus sections
- two (2) sets of 48 V battery chargers
- two (2) sets of 48 V Battery Systems
- two (2) sets of UPS System.

General arrangement

The system hereby described is pertaining to the 220 kV substation extension. The existing substation parts are already supplied -in terms of auxiliaries- by the relevant existing facilities.

The auxiliary supply for the extended part of the substation will be provided by two (2) auxiliary transformers 33/0.4 kV 1250 kVA.

The basic design of the auxiliary AC & DC system shall consist of a single busbar 0.4 kV, including a sectionalizing circuit breaker.

In normal operation mode, one of the auxiliary transformer circuit breakers shall be in open position and the busbar sections shall be coupled to each other.

The 0.4kV busbar shall be split in two busbar sections, one feeding the essential loads and one feeding the non-essential ones. The 0.4 kV busbar shall be fed from the substation auxiliary transformers. The essential-loads section shall be fed by a diesel generator set in case of emergencies. A suitable control device (BCU, IED), providing interlocking conditions, shall be installed to implement the control of the auxiliary supply system and the in-feeding sources. The control device shall provide the possibility to define interlocking conditions in order to avoid that two sources feed the bus bar in parallel.

LV AC installations

The function of the LV AC station supply system is to feed the auxiliary equipment, as well as the lighting and other services, via the relevant AC distribution boards for the complete substation.

- One (1) 0.4 kV main switchgear, metal-clad type, suitable for indoor installation, with single-busbar and with bus-tie, for two incomers and connection of the diesel generator unit, with automatic transfer switching enabling also manual operation.

DC installations

The function of the DC system is to provide the DC supply for all auxiliary and substation DC dependent equipment (relevant to the extended part of the substation), through the DC distribution boards. This equipment comprises the protection relays, control systems and the communication systems in addition to the emergency lighting.

Batteries rated 220 V DC and 48 V DC shall be of valve-regulated Ni-Cd type. They shall be installed on the battery racks in separate battery rooms.

Each battery shall consist of two sections (in each room one 48 V DC and one 220 V DC).

The battery capacity shall be defined during the detailed design stage but shall not be less than stated below Each section of the battery shall be capable of supplying 100% of the DC loads (including future extension). This requirement is applicable for both 220 V DC and 48 V DC batteries.

A complete 220 V DC supply system shall be provided for the substation extension, including:

- one (1) 220 V DC distribution board with DC control panel, comprising two busbars. Each busbar section will be connected to the relevant battery charger. Two (2) 400/230 V rectifiers / battery chargers
- two (2) 220 V DC batteries of Ni-Cd type, each with a minimum capacity of 600 Ah (10h discharge rate).

In addition, for supply of 48 V DC, required for certain equipment of the SCMS and telecommunication system, the following shall be provided:

- one (1) 48 V DC distribution board with DC control panel, comprising two tied busbars
- two (2) 400/230 V rectifiers / battery chargers
- two (2) 48 V DC batteries of Ni-Cd type, each with a minimum capacity of 150 Ah.

The complete arrangement for DC installations shall be designed taking into consideration possible future extensions.

The substation control & monitoring system (SCMS), the telecommunication system, as well as the protection, control and emergency lighting systems will be fed from the 220 V DC or 48 V DC distribution boards, as necessary.

The batteries and rectifiers will be sized to supply the required DC loads, taking into considerations the present and future services in the substation final stage.

The DC distribution boards shall be provided with all hardware required for reliable operation and safe isolation, as well as with protection against short circuits.

Uninterruptible Power Supply (UPS) system

An UPS power supply system of adequate size and autonomy shall be provided for all consumers which require un-interruptible supply (e.g. workstations).

The UPS system shall consist of two (2) independently operating units.

Each system shall be complete and include, among others, the following items:

- one (1) thyristor or IGBT controlled 220 V DC / 230 V AC inverters
- one (1) thyristor static transfer switches
- one (1) manual bypass switches
- one (1) distribution boards with control devices
- monitoring system with three (3) contacts for each alarm of the 240 V AC UPS
- UPS enclosure, similar in characteristics with the enclosures of the AC and DC switchgear.

3.3.9 Diesel generator unit

A diesel generator unit (DGU) shall be installed and used as the emergency power supply source. Rated output voltage of the DGU shall be 400 V AC.

The rated power of the DGU shall be such that the DGU is capable to supply all the critical substation systems for 24 hours.

The final power ratings shall be defined during the detailed design stage but shall not be less than stated below.

The DGU shall be installed in a prefabricated container equipped with fire-detection system and exhaust gas evacuation system.

A fuel tank with diesel fuel for the DGU shall be installed in the substation area for emergency use. The volume of fuel stored shall be suitable for uninterrupted fuel supply of the DGU for 24 hours.

The DGU shall be connected to the intermediate bus of the LV AC switchgear via an automatic bus-tie circuit-breaker. The DGU shall be started automatically in case of voltage loss at busbars of 0.4 kV AC switchgear and stop automatically after normal auxiliary supply voltage restoration.

Parallel operation of auxiliary power supply system and DGU shall be avoided.

- One (1) diesel generator set, adequately sized but as a minimum of 100 kVA shall be provided, along with a fuel tank accommodating fuel for a continuous operation in line with the relevant Technical Data Sheets. The diesel generator set shall be housed in a thermal- and noise-insulated prefabricated cover.

3.3.10 Control & Protection System

220kV OHL Protection

Minimum functional requirements for each IPR and CT/VT connections are shown in **Annex D5.7.** For OHL Lekhnath - Damauli the remote end substation is part of the scope and the same type and manufacturer of protection relays as foreseen at the remote end. shall be provided.
For OHLs to Tanahu and Bharatpur HPPs, the contractor shall provide the same type and manufacturer of the existing protection relays at the remote ends.

Six (6) 220 kV OHL Protection Terminals (D06, D07, D08, D13, D14, D15) including each:

- one (1) Multifunctional protection terminal including line differential protection over fiber optic, distance protection with PTT and DT signaling, overcurrent phase and earth back-up, directional overcurrent phase and earth fault with PTT signaling, switch on to fault, synchrocheck, auto-reclosing, thermal overload, negative sequence overcurrent, out of step tripping, overvoltage/ undervoltage, fault locator (Main 1)
- one (1) Multifunctional protection terminal including, distance protection with PTT and DT signaling, overcurrent phase and earth back-up, directional overcurrent phase and earth fault with PTT signaling, switch on to fault, synchrocheck, auto-reclosing, thermal overload, negative sequence overcurrent, out of step tripping, overvoltage/ undervoltage, fault locator (Main 2)
- one (1) Bay Control Unit including P, Q, U, I, f measurements, circuit breaker trip/close control, graphic display, Phasor Measurement Unit, synchrocheck
- one (1) Low impedance busbar and circuit breaker failure protection, field unit
- two (2) Trip coil supervision
- one (1) lot Relay software, documentation
- one (1) lot Cubicles, accessories, auxiliary relays, etc.

Two (2) 220kV Bus- Sectionalizer and Busbar protection (D10, D11) including each:

- one (1) Multifunctional protection terminal with distance relay, back-up phase and earth overcurrent
- one (1) Bay Control Unit including P, Q, U, I, f measurements, circuit breaker trip/close, graphic HMI, synchrocheck, phasor measurement
- two (1) De-centralized low impedance busbar and circuit breaker failure protection, central unit
- two (2) Low impedance busbar and circuit breaker failure protection, field unit
- two (2) Trip Coil Supervision (two breakers)
- one (1) lot Software, documentation
- one (1) lot Cubicles, accessories, auxiliary relays.

Two (2) 220kV Bus-coupler protection (D05, D16) including each:

- one (1) multifunctional protection terminal with distance relay, back-up phase and earth overcurrent
- one (1) Bay Control Unit including P, Q, U, I, f measurements, circuit breaker trip/close, graphic HMI, synchrocheck, phasor measurement
- two (2) low impedance busbar and circuit breaker failure protection, field unit
- two (2) trip coil supervision (two breakers)
- one (1) lot software, documentation
- one (1) lot cubicles, accessories, auxiliary relays.

220/132 kV 50/63 MVA power transformer protection

Minimum functional requirements for each IPR and CT/VT connections are shown in Annex D5.6.

Two (2) 50/63 MVA 220/132 kV Transformer 220 kV side protection (D09, D12) including each:

- one (1) multifunctional protection terminal with differential protection, distance protection, directional overcurrent phase and earth fault, overcurrent phase and earth back-up, circuit breaker failure, synchrocheck, thermal overload, restricted earth fault protection, overexcitation (Main 1)
- one (1) multifunctional protection terminal with differential protection, backup distance protection, overcurrent phase and earth back-up, circuit breaker failure, synchro check, thermal overload, restricted earth fault protection, overexcitation (Main 2)
- one (1) Bay Control Unit including P, Q, U, I, f measurements, trip/close HMI, synchrocheck
- one (1) low impedance busbar and breaker failure protection (field unit)
- two (2) trip coil supervision (two breakers)

- one (1) lot software, documentation
- one (1) lot cubicles, accessories, auxiliary relays.

Two (2) 50/63 MVA 220/132 kV Transformer 132 kV side protection (E02, E06) including each:

- one (1) multifunctional protection terminal with distance protection, overcurrent phase and earth back-up, thermal overload, current unbalance, circuit breaker failure, over/undervoltage (Main 1)
- one (1) multifunctional protection terminal with overcurrent phase and earth back-up, directional overcurrent phase and earth, thermal overload, current unbalance circuit breaker failure, under/overvoltage (Main 2)
- one (1) Bay Control Unit including P, Q, U, I, f measurements, trip/close HMI, synchrocheck
- one (1) low impedance busbar and breaker failure protection (field unit)
- two (2) trip coil supervision (two breakers)
- one (1) lot software, documentation
- one (1) lot cubicles, accessories, auxiliary relays.

132kV OHL protection

Minimum functional requirements for each IPR and CT/VT connections are shown in **Annex D5.8**. The two OHL feeders are LILO of the New Damauli 132 kV S/S towards the existing Old Damauli S/S and Bharatpur S/S. These OHLs currently are not provided with OPGW or any other type of end-to-end signaling facility, however, NEA is installing the OPGW in this section.

The contractor shall provide protection relays to be compatible with the existing protection relays at the remote ends, including a complete distance protection device ready for operation.

Depending on the availability of the OPGW scheme and / or distance protection functionality of protection relays at the remote ends at the time of project execution, the protection relays at New Damauli Substation shall be configured for either for standalone operation or including end-to-end testing of the communication schemes.

In case the OPGW scheme and / or distance protection functionality of protection relays at the remote ends are not available at the time of project execution, end-to-end testing of the communication schemes will be executed later by the Employer after the OPGW installation is completed.

Two (2) 132 kV OHL Protection Terminals (E03, E07) including each:

- one (1) multifunctional protection terminal with distance protection, overcurrent phase and earth back-up, thermal overload, negative sequence overcurrent, circuit breaker failure, under/overvoltage, auto reclosing, synchrocheck (Main 1)

- one (1) multifunctional protection terminal with overcurrent phase and earth back-up, directional overcurrent phase and earth, negative sequence overcurrent, circuit breaker failure, under/overvoltage, synchrocheck, auto-reclosing (Main 2)
- one (1) Bay Control Unit including P, Q, U, I, f measurements, trip/close HMI, synchrocheck
- one (1) low impedance busbar and breaker failure protection (field unit)
- two (2) trip coil supervision
- one (1) lot software, documentation
- one (1) lot cubicles, accessories, auxiliary relays.

One (1) 132kV Bus-coupler and Busbar protections (E04) including each:

- one (1) multifunctional protection terminal with distance relay, back-up phase and earth overcurrent
- one (1) Bay Control Unit including P, Q, U, I, f measurements, circuit breaker trip/close, graphic HMI, synchrocheck, phasor measurement
- one (1) de-centralized low impedance busbar and circuit breaker failure protection, central unit
- two (2) low impedance busbar and breaker failure protection (field unit)
- two (2) trip coil supervision
- one (1) lot software, documentation
- one (1) lot cubicles, accessories, auxiliary relays.

Two (2) 132/33kV 24/30 MVA Transformer feeder protection 132 kV side (E01, E05) (Annex D5-8) including each:

- two (2) multifunctional protection terminal with differential and restricted earth fault protection, overcurrent phase and earth back-up, neutral overcurrent, circuit breaker failure, over/undervoltage, voltage unbalance synchrocheck,
- one (1) Bay Control Unit including P, Q, U, I, f measurements, trip/close HMI, synchrocheck
- one (1) low impedance busbar and breaker failure protection (field unit)
- two (2) trip coil supervision
- one (1) lot software, documentation
- one (1) lot cubicles, accessories, auxiliary relays.

Two (2) 132/33kV 24/30 MVA Transformer feeder protection 33 kV side (J02, J11) (Annex D5-8) including each:

- one (1) combined multifunctional protection and control terminal (BCPU), with neutral overcurrent protection, two-stage overcurrent phase and earth fault protection, circuit breaker failure, over/undervoltage, including P, Q, U, I, f measurements, trip/close HMI, synchrocheck
- one (1) multifunctional protection terminal with neutral overcurrent protection, two-stage overcurrent phase and earth fault protection

- two (2) trip coil supervision
- one (1) lot software, documentation
- one (1) lot accessories, auxiliary relays.

One (1) 33kV Bus-coupler protections (J07) (Annex D5-8) including each:

- one (1) combined multifunctional protection and control terminal (BCPU), with neutral overcurrent protection, two-stage overcurrent phase and earth fault protection, circuit breaker failure, over/undervoltage, including P, Q, U, I, f measurements, circuit breaker trip/close, graphic HMI, synchrocheck, phasor measurement
- one (1) multifunctional protection terminal with neutral overcurrent protection, two-stage overcurrent phase and earth fault protection, circuit breaker failure, over/undervoltage
- two (2) high impedance busbar and circuit breaker failure protection
- two (2) trip coil supervision (two breakers)
- one (1) lot software, documentation
- one (1) lot accessories, auxiliary relays.

Two (2) 33kV Feeder protection (J04, J10) including each:

- one (1) combined multifunctional protection and control terminal (BCPU), two-stage overcurrent phase and earth fault protection, sensitive earth fault protection, circuit breaker failure, over/undervoltage, including P, Q, U, I, f measurements, trip/close HMI, synchro check
- two (2) trip coil supervision
- one (1) lot software, documentation
- one (1) lot accessories, auxiliary relays.

Two (2) 33kV Auxiliary Transformer Feeder protection (J05, J09) (Annex D5-9B) including each:

- one (1) combined multifunctional protection terminal and BCU, two-stage overcurrent phase and earth fault protection, sensitive earth fault protection, circuit breaker failure, over/undervoltage, including P, Q, U, I, f measurements, trip/close HMI, synchro check
- two (2) trip coil supervision
- one (1) lot software, documentation
- one (1) lot accessories, auxiliary relays.

Two (2) 33/11kV 6/8MVA Transformer feeder protection 33 kV side (J03, J12) (Annex D5-9B) including each:

- one (1) multifunctional protection terminal with transformer differential fault protection
- one (1) combined multifunctional protection and control terminal (BCPU), with neutral overcurrent protection, two-stage overcurrent phase and earth fault protection, circuit breaker failure, over/undervoltage, including P, Q, U, I, f measurements, trip/close HMI, synchrocheck

- two (2) trip coil supervision
- one (1) lot software, documentation
- one (1) lot accessories, auxiliary relays.

Two (2) 33/11kV 6/8 MVA Transformer feeder protection 11 kV side (K03, K08) (Annex D5-9B) including each:

- one (1) combined multifunctional protection and control terminal (BCPU), with neutral overcurrent protection, two-stage overcurrent phase and earth fault protection, circuit breaker failure, over/undervoltage, including P, Q, U, I, f measurements, trip/close HMI, synchrocheck
- two (2) trip coil supervision
- one (1) lot software, documentation
- one (1) lot accessories, auxiliary relays.

Five (5) 11kV Feeder protection (K04, K05, K09, K12, K13) (Annex D5-9B) including each:

- one (1) combined multifunctional protection terminal and BCU, two-stage overcurrent phase and earth fault protection, sensitive earth fault protection, circuit breaker failure, over/undervoltage, including P, Q, U, I, f measurements, trip/close HMI, synchro check
- two (2) trip coil supervision
- one (1) lot software, documentation
- one (1) lot accessories, auxiliary relays.

One (1) 11kV Bus-coupler protection (K07) (Annex D5-9B) including each:

- one (1) combined multifunctional protection and control terminal (BCPU), two-stage overcurrent phase and earth fault protection, sensitive earth fault protection, circuit breaker failure, over/undervoltage, including P, Q, U, I, f measurements, trip/close HMI, synchrocheck
- two (2) trip coil supervision
- one (1) software, documentation
- one (1) accessories, auxiliary relays.

3.3.11 Synchrophasor Measurement Unit

For each HV AC busbar at the Lekhnath and New Damauli 220kV S/S high accuracy Synchrophasor Measurement Unit (PMU) according to IEEE C37.118 shall be provided. Integration of the PMU in the Bay Control Unit or the Digital Fault Recorder shall be offered, subject to Employer´s approval.

PMU measurement shall be integrated in a Wide Area Monitoring system to be gradually deployed over the entire NEA transmission system; therefore, it shall comply with the P- class specification acc. to IEEE C37.118 and shall be synchronized to GPS or other low jitter time tagging system with accuracy of not less than 1 micro-second. For the present time, the proposed architecture shall be a stand-alone system for monitoring voltage and relevant currents of feeders evolving from the 220kV and 132 kV buses installed withing the Project.

The PMU shall have a measurement capability of min 6 currents and 6 voltages on a constant time basis. The required total vector error shall be less than 1%; other performance requirements are:

- measurement magnitude ranges 0.1-2 In for current and 20- 140V for voltages
- off-frequency accuracy +/- 5 Hz
- harmonic distortion 10% (on individual harmonic)
- automatic change-over in case of bus VT unavailability.

The system shall have a proven interoperability and be prepared for future streaming to a central Synchrophasor Central Processor located at the NEA Dispatch Center.

3.3.12 SCADA and SCMS

3.3.12.1 General

Within the Project, a new SCMS system shall be provided (hardware and software, as necessary) to cover the new 220/132/33/11 kV Damauli Substation. Furthermore, the new Damauli 220 kV Substation SCMS shall be capable to be connected to the future Damauli 400 kV RTU/SCMS/SCADA. Within the Contractor’s responsibility, the new system shall be tested and commissioned.

The new DAMAULI 220 kV Substation shall be operated at the Substation level as an independent/separate new SCMS from the new HMI, to be located in the new Substation Control Building. Necessary preparation for future interfacing & interconnection works of the new Damauli 220kV SCMS to the new Damauli 400 kV are included in the Contractor obligations.

The scope of supply and services associated with the Substation Control and Monitoring System comprises the design, manufacture, inspection, testing at manufacturer’s work and at site, packing for export, shipment, insurance, transport and delivery to site, installation, commissioning and maintenance during guaranty period of a microcomputer-based digital substation control and monitoring system (SCMS/SCADA) suitable for proper and trouble free operation and support maintenance of the Project related 220/132/33/11 kV DAMAULI Substation.

The scope of supply and services shall include all hardware, necessary works, accessories, patch cords, duct cables FO, terminals, strips, cabling, connection, software and parameterization (including data entry and display configuration-HMI mimic diagrams), Ethernet switches etc., so as to ensure the full establishment of new relays and circuits in the new SCMS and in order to fully cover the control and monitoring requirements of the Substation by the new SCMS. Compatibility and interoperability with NEA existing equipment and systems shall be ensured.

Compatibility and interoperability with the existing Substation related equipments and protocols shall be ensured.

New SCMS common BCU shall be provided.

The attached configuration under **Annex D5-15** "Principle System Architecture_New DAMAULI 220/132/33/11 kV new Substation New SCMS" shall give an indicative example. Kindly refer for details regarding SCMS requirements at the Tender Documents, VII-5 "Technical Specifications".

The 220 kV part of the substation shall be interfaced with the already existing NLDC/ECC (established already at Kathmandu Syuchathar and Hetauda). The 132/33/11 kV part shall be interfaced with the Master Control Center (MCC) Pokhara currently under implementation and with the existing NLDC/ECC (established already at Kathmandu Syuchathar and Hetauda).

For interfacing with the NLDC/ECC (established already at Kathmandu Syuchathar and Hetauda) the new substation control and monitoring system shall be equipped with a set of two (2) redundant gateways channels for connection towards and from the NLDC /ECC via international standard protocols IEC 60870-5-104 (main and back-up gateways, each of them with minimum 2 channels).

For interfacing with the Master Control Center (MCC) Pokhara and to LDC and Backup LDC separate gateways with sufficient number of ports shall be provided.

The list of SCADA/SCMS signals and alarms, titles/designation etc., provided by the Contractor shall be subject to the Employer's/Engineer's approval.

The new Project related Substation shall be fully integrated into the existing SCADA/EMS System at NEA NLDC/ECC. The works shall consist in all respects required hardware, software and related associated works, necessary to make the new Project Substations an integral part of the overall SCADA/EMS system. Furthermore, any hardware/software required for this integration at the intermediate / end stations/NLDC/ECC shall be provided & implemented by the Contractor.

The relevant input data for parameterization, configuration, testing and putting in operation of SCMS/SCADA will be coordinated among the Contractor and the Employer/Engineer during the design stage of the project.

The SCMS/SCADA system shall cover control and supervision of all substation primary, secondary, control and protection, auxiliary equipment, etc. The architecture of the system shall consider and support bay level, substation level and gateway level-NLDC/ECC.

The new 220 kV and 132 kV bay control and protection cubicles shall be installed in the respective control buildings. For the 33 kV and 11 kV switchgear, the bay control units shall be installed in the control compartment of the switchgear.

In the following paragraphs, the respective scope for the new SCMS to be established at the new DAMAULI 220/132/33/11 kV Substation is addressed.

3.3.12.2 Scope of Supply and Services (New DAMAULI)

A new State of the art digital full redundant Substation Control and Monitoring (SCMS) for the monitoring and control of the new extension (220 kV, 132 kV, 33 kV, 11 kV) with redundant scheme and possibility for future extension shall be implemented at the new DAMAULI Substation.

The new 220/132/33/11 kV protection and control units shall be connected in separate double optical ring connection utilizing IEC 61850 standard. The design shall be subject to further approval by Employer/Employer's representative.

The provided equipment and systems shall be compatible/interoperable in every respect both with the interconnected substations equipment and systems as well as with the relevant National LDC/ECC (National Load Dispatch Centre/Emergency Control Centre) operated by NEA.

For interfacing of the 220 kV part with the NEA NLDC/ECC, the substation control and monitoring system shall be equipped with a set of two (2) redundant gateways channels for connection towards and from the related existing NLDC/ECC (National Load Dispatch Centre/Emergency Control Centre) via international standard protocols IEC 60870-5-104 (main and back-up). In this regard, the Contractor shall also take into consideration that the Nepal NEA Transmission network is operated on National Dispatch level by two (2) systems:

- main control system NLDC located at Kathmandu Syuchathar (SCADA/EMS System SINAUT SPECTRUM Power 7 from Siemens)

and

- emergency control system ECC located at Hetauda (SCADA/EMS System SINAUT SPECTRUM Power 7 from Siemens).

The related existing SCADA/EMS is put in service very recently in 2020 by Siemens India.

The relevant National NLDC/ECC SCADA/EMS systems are already existing and already equipped with the Telecommunication systems and related Software capabilities for interfacing via international standard protocols according to IEC60870-5-104 and IEC60870-5-101. The redundant gateways protocol shall be according to IEC 60870-5-104 (main and backup medium).

For interfacing of the 132/33/11 kV part with the Master Control Center (MCC) Pokhara and to LDC and Backup LDC separate gateways with sufficient number of ports shall be provided.

As depicted in **Annex D5-13**: "New SCMS Principle System Architecture of the New Damauli 220/132/33/11 kV" for the SCMS systems to be established under the current project at the New Damauli 220 kV Substation shall be designed for connection with the NEA National Load Dispatch Centers NLDC/ECC SCADA/EMS system.

Control and protection panels shall include as a minimum the following equipment:

- mimic diagram with position indicators (semaphores) for circuit breakers, isolating switches, earthing switches located in the local control cubicle of the equipment.
- all alarms and indicators associated with protection tripping.
- integration of state-of-the-art cyber security equipment
- all auxiliary relays, switches, contactors, MCBs with the necessary auxiliary contacts, fuses, etc., for the control, monitoring, remote control, protection and interlocking circuits.

The Contractor must ensure that after handing over, a minimum of 20% spare capacity in terminal strips for future extensions is available.

For the HV/MV Transmission Network voltage levels, the Project related 220 kV and 132 kV control, the control and protection shall be accommodated in common control and panels and shall be equipped with BCUs (Bay Control Units). Control (BCU and mimic panels) shall have additional spare space for extensions.

For the 33 kV and 11 kV switchgear, the control and protection can be accommodated in the control compartment of the switchgear and shall be equipped with BCPUs (Bay Control and Protection Units). Control compartments shall have additional spare space for extensions.

The number of BCU/BCPUs and digital protection devices to be interfaced with the SCMS can be taken from the relevant chapters of the present document, where details on the various bays of the substation and the necessary equipment are indicated.

In addition, a sufficient number of common BCUs, acquiring data from the substation auxiliaries and other common substation elements, shall be included in the scope.

For 220 kV and 132 kV BCUs measurements shall have at least 0.5 class accuracy.

The new Damauli SMCS equipment shall be fully integrated on Substation SCMS HMI and Substation Gateways level.

The following 220 kV, 132 kV, 33 kV and 11 kV system control operations shall be possible:

1. local control: from the individual bay equipment at each 220 kV, 132 kV, 33 kV 11 kV switchgear cubicles. The mimic scheme on the local control cubicles shall be provided only for indication (semaphores) related to HV/MV equipment positions
2. remote control level 1: from BCU/BCPU on 220 kV, 132 kV, 33 kV, 11 kV. No analogue mimic control is required.
3. remote control level 2: from the SCMS local HMI in the substation control room (220 kV, 132 kV, 33 kV, 11 kV)
4. remote control level 3: from the responsible NLDC/ECC (National Load Dispatch Centre/National Emergency Control Centre) SCADA/EMS System operated by NEA, for 220 kV and from the Master Control Center (MCC) Pokhara for 132/33/11 kV.

Remote control levels shall be interlocked against each other according to parameterizable interlocking rules as per the switching authority.

Integration of the new substation new SCMS installed under the project into the National Load Dispatch Centre& Emergency Control Centre (NLDC/ECC) SCADA/EMS System including related supply of hardware, software, accessories, database extension, display generation, point-to point tests etc. is included and shall be performed by the Contractor.

Integration works associated with the scope of the current project is as follows:

- for the NLDC/ECC side, Contractor will perform the work; and
- for SCMS Gateways side, the Contractor will perform the works

(including - but not limited to-commissioning protocols/tests to verify point by point all Substation signals and the required interfacing protocols).

Contractor is required to coordinate with NEA/NEA Contractors for the interfacing works.

The 220 kV, 132 kV, 33 kV and 11 kV control panels shall be equipped with the following main equipment for each bay:

1. mimic diagram with position indicators (semaphores) for all circuit breakers, isolating switches, and working earth switches
2. bay control unit (BCU) for 220 kV & 132 kV and BCPU for 33kV and 11 kV
3. 1-20 way alarm facia with accept/test/reset push button
4. Numerical automatic voltage regulator suitable for parallel operation for transformer bay.

Lock out relays (high burden fast operated trip relays) shall be included for all transformer breakers (HV and LV side) for all voltage levels.

The SCMS to be implemented at each new Project related DAMAULI Substation shall be equipped with the following:

- two (2) redundant servers (computers), with sequence events recording (SER)
- all related LAN and IT security equipment
- one (1) main GPS synchronized time system, including antenna, cabling and time synchronization equipment
- one (1) back-up GPS synchronized time system, including antenna, cabling and time synchronization equipment
- two (2) operator work stations HMI, equipped with two (2) LED flat monitors per work station
- one (1) emergency HMI and maintenance service laptop with interface connection for engineering/protection relay interrogation
- one (1) A4 and one (1) A3 color laser printers
- one (1) set of all necessary cubicles
- one (1) set of main Ethernet switches
- one (1) Engineering Work Station with interface connection for engineering/protection relay interrogation and equipped with two (2) LED flat monitors
- computers furniture (such as desks and chairs)
- redundant supply, UPS (included under Auxiliary Systems)
- 2 redundant gateways for interfacing NLDC/ECC
- 1 gateway for interfacing future New Damauli 400 kV Substation RTU/SCADA/SCMS
- weather station
- two (2) operator desks with four (4) chairs.

In addition, all necessary interfacing with the telecommunication systems is deemed to be included in the present scope of supply and services.

Within the Contractor's responsibility, the new system shall be tested and commissioned.

The list of SCMS signals and alarms, titles/designation etc., updated, prepared and provided by the Contractor shall be subject to the Employer's/Engineer's approval.

The Contractor shall ensure that the auxiliary power services are monitored from SCMS.

Engineering and parameterization as well as construction of mimic diagrams for display on the LED monitors shall be included in the services.

Design of the SCMS System and the HMI/ mimic diagrams shall be subject to further approval by the Employer/Engineer.

The SCMS/SCADA system shall cover control and supervision of all substation primary, secondary, control and protection, auxiliary equipment, etc. The architecture of the system shall consider and support bay level, substation level and gateway level-NLDC/ECC.

The new bay control and protection cubicles shall be installed in the respective control building.

The relevant input data for parameterization, configuration, testing and putting in operation of SCMS/SCADA will be coordinated among the Contractor and the Employer/Engineer during the design stage of the project.

Substation control and monitoring system (SCMS)

The substation control and monitoring system shall provide all control and signaling amenities required in the substation such that the status of the substation can be ascertained and all the necessary control and switching operations can be carried out from the control room.

Substation control and monitoring system shall fulfil the functions and amenities described in the Tender Documents/Part II/ VII-5 Technical Specifications.

Substation control level

Central system for future substation control and supervision will be located in the control room.

The substation control level equipment shall comprise the elements and functions as described in Tender Documents/Part II/ VII-5 Technical Specifications.

Bay control level

Distributed (bay oriented) microprocessor devices, hierarchically linked with central substation control unit, shall be foreseen for bay control.

The bay control level is described in the Tender Documents Part II/ VII-5 Technical Specifications.

Interlocking system

Interlocking system on a 220/132/33/11 kV switchyard/switchgear-level shall be carried out by software using distributed (bay oriented) microprocessor devices. This interlocking system between bays should be independent of local SCADA/SCMS system running.

Interlocking system on a 220/132/3311 kV bay-level, shall be also managed through conventional (hard wire) interlocking, in parallel in all times with the software interlocking.

Miscellaneous

Single Line diagram shall be agreed with National NEA NLDC.

All monitoring and control actions on station level as well as on remote level (from NLDC/ECC) shall be managed from the SCMS central system to be established at the new Substation.

Full compatibility and interoperability with the existing NEA SCADA/EMS systems, SCMS system, Telecommunication Networks shall be ensured by the Contractor on the new Damauli Substation side.

New Damauli Substation shall be provided with a weather station to monitor environmental climatic indicators (as a minimum Temperature, Humidity. Luminosity (Lightness shall be measured), Wind Speed, Wind Direction, Rainfall). This information shall be integrated in SCADA HMI and Gateways.

The above-mentioned requirements are preliminary only and the final list of equipments and final technical data are subject to design approval.

3.3.12.3 Interconnection with the separate Damauli 400 kV Substation

Since the New Damauli 400 kV Substation is currently under implementation through the separate MCA/MCC project, some specifics shall be highlighted and further considered in the design of the new SCMS system at New Damauli 220 kV to be established under the current Project.

The Contractor shall provide under the current Project the new separate SCMS at the New Damauli 220 kV Substation and shall make provision for interconnection with the new future DAMAULI 400 kV Substation SCMS/RTU/SCADA RTU.

Local SCADA/SCMS/RTU for the future New Damauli 400 kV Substation will be located in a separate Building than the new Damauli 220 kV Substation to be established via the current Project.

Boundaries of area of responsibility shall be the gateway towards the 400 kV substation.

The SCMS system of the current Project New Damauli 220 kV Substation SCMS shall be capable to be interfaced with the new SCMS/RTU/SCADA of the separate MCA/MCC Project so as to make monitoring of the 220 kV part of the substation available to the operators dealing with the 400 kV New Damauli Substation on substation level as well as for signals exchange.

Interfacing shall be realized by an additional gateway (i.e. a third one) to be included in the 220 kV SCMS system which shall transmit all 220 kV New Damauli Substation related information points (double point indications of 220/132/33/11 kV switchgear, single point indications, alarms, measurements as well as information originating from the 220/132/33/11 kV related protection relays) to the New Damauli 400 kV SCMS system utilizing international standard protocol IEC60870-5-104. The additional gateway shall include full parameterization for transmission of all information as mentioned above and shall consider interoperability list as per **Annex 8** of the related IEC standard. Project related works will be limited at the mentioned third gateway of the

New Damauli 220 kV Substation. MCA/MCC Project shall ensure the necessary compatible interfacing Telecom links and gateway/equipment on their side.

The 400 kV RTU/SCMS/Local Substation SCADA system shall hereby take the role of the master, while the 220 kV SCMS system shall take over the role of the slave in this interfacing connection. MCA Project shall adapt to our Project related SCADA/SCMS & associated systems Design ref. to the New Damauli 220/132 kV Project Substation.

The 220 kV SCMS system as part of the KfW Project - in addition to the dual port connectivity towards existing SCADA Control Centers as specified in the previous chapters - shall therefore be equipped with a third communication interface for interconnection with the 400 kV New DAMAULI Substation SCMS.

3.3.12.4 Integration 220 kV into the existing SCADA/EMS System at NLDC/ECC

The 220 kV part of the new SCMS to be installed under the project for the new 220/132/33/11 kV DAMAULI Substation shall be fully integrated into the existing National Load Dispatch Centre Main& Emergency (NLDC/ECC) SCADA/EMS System.

Integration of the new substation new SCMS installed under the project into the National Load Dispatch Centre& Emergency Control Centre (NLDC/ECC) SCADA/EMS System including related supply of hardware, software, accessories, database extension, display generation, point-to point tests etc. is included in the scope.

Integration works associated with the scope of the current project is as follows:

- for the NLDC/ECC side, nominated Subcontractor shall perform the work and
- for SCMS Gateways side, the Contractor shall perform the works

(including - but not limited to-commissioning protocols/tests to verify point by point all Substation extension signals and the required interfacing protocols).

Contractor is required to coordinate with NEA/NEA Contractors for the interfacing works.

The required works envisage advanced Vendor specifics, complexity and need for authorization access rights into the existing system, also eventual required NOC (non-objection certificate if the existing system is still under warranty at the construction period) for the Project related extension of the existing Sinaut Spectrum Power 7 SCADA system at NLDC/ECC. Therefore, in order to achieve a smooth and timely implementation of the related works, such works are required to be performed by the original Supplier/Vendor (Siemens) of the relevant existing SCADA/EMS System at NEA National NLDC/ECC. The Contractor is required to subcontract the related works accordingly to this Nominated Subcontractor.

Furthermore, under the Project scope, the staff at the NEA TSO operating and maintaining the National NLDC/ECC SCADA/EMS Systems, shall be well trained and acquainted to perform such operation & maintenance work.

In order to safeguard that the selected NEA staff at NLDC/ECC will be sufficiently skilled and trained for such data engineering works, a series of Training sessions, in a mixture of abroad& local Training in NEPAL, shall be performed by the Contractor under the present scope. For training requirements please refer to Chapter 3.1.9 and Section VII-5 Technical Specifications/ chapter 13. SCADA and SCMS /13.4 Other Requirements/13.4.6 Training.

For interfacing with the super-ordinate NLDC/ECC, the substation control and monitoring system shall be equipped with a set of two (2) redundant gateways channels for connection towards and from the NEA NLDC/ECC via international standard protocols IEC 60870-5-104 (main) and IEC 60870-5-104 (fallback).

The list of signals, operations, IP addresses etc. for integration up to the NLDC/ECC shall be submitted by the Contractor and shall be subject to the Employer's/Engineer's approval.

The relevant input data for parameterization, configuration, testing and putting in operation of SCMS/SCADA shall be coordinated among the Contractor and the Employer/Engineer during the design stage of the project.

3.3.12.5 Integration 132 kV/33kV/11kV into the new Master Control Center (MCC) Pokhara

For the 132 kV/33kV/11kV part of the substation provision shall be made for integration into the new Master Control Center (MCC) Pokhara. The split of responsibilities shall be as follows:

- for 132 kV/33kV/11kV part of the substation separate gateways with sufficient number of ports for connection to the Master Control Center (MCC) Pokhara and to LDC and Backup LDC to be included
- Integration of the 132/33/11 kV part into the Master Control Center (MCC) Pokhara and to LDC and Backup LDC will be done by SAS Project-Phase 2 / NEA

3.3.13 Telecommunication

3.3.13.1 Optical Line Terminal Equipment for SDH and MPLS – TP (Hybrid technology)

New state-of-the-art Hybrid technology based Optical Line Terminal Equipment for SDH and MPLS - TP shall be provided and installed at the new 220/132/33/11kV GIS Damauli Substation and shall be integrated as a new Hybrid technology based SDH node into the existing NEA SDH network.

The SDH node shall provide FOC connections

- to the new 220 kV GIS Lekhnath Substation,
- to the Tanahu HPP and
- to the existing new 220 kV Bharatpur Substation.

3.3.13.2 Fiber Optical Cables

Two different types of FOCs shall be provided

- two (2) FOCs incorporating 48 single-mode fibers each and
- two (2) FOCs incorporating 24 single-mode fibers each.

Both types of FOCs shall comply with IEC 60793 and IEC 60794 standards and with ITU-T G.652D.

OPGW

The new 220kV DC OHTL Lekhnath - Damauli of Package A – TL will provide an OPGW with 48 optical fibers to be connected to the new 220/132/33/11kV GIS Damauli Substation SDH node.

The new LILO from the 132kV S/C OHTL Old Damauli Substation – old Bharatpur Substation will provide two (2) OPGWs with 48 optical fibers each to be connected to the 220/132/33/11kV GIS Damauli Substation the SDH node.

The new LILO from the ADB 220kV D/C OHTL Tanahu HPP – new 220kV Bharaptur Substation will provide two (2) OPGWs with 24 optical fibers each to be connected to the 220/132/33/11kV GIS Damauli Substation the SDH node.

UGFO

An UGFO cable with 48 optical fibers shall be provided and installed between the Gantry of the 220kV DC OHTL Lekhnath – Damauli and the telecommunications room in the substation control building.

The 48 optical fibers of the OPGW shall be spliced to the 48 optical fibers of the UGFO cable providing the connection between the new Hybrid technology based SDH node at 220 kV GIS Lekhnath Substation and the new Hybrid technology based SDH node at the 220/132/33/11kV GIS Damauli Substation.

Two (2) UGFO cable with 24 optical fibers each shall be provided and installed between the Gantry of the new LILO from the ADB 220kV D/C OHTL Tanahu HPP – new 220kV Bharaptur Substation and the telecommunications room in the substation control building.

The 24 optical fibers of the 220kV D/C OHTL Tanahu HPP OPGW shall be spliced to the 24 optical fibers of one dedicated UGFO cable providing the connection between the new Hybrid technology based SDH node at the new 220/132/33/11kV GIS Damauli Substation and the SDH node at the Tanahu HPP.

The 24 optical fibers of the 220kV D/C OHTL new 220kV Bharaptur Substation OPGW shall be spliced to the 24 optical fibers of one dedicated UGFO cable providing the connection between the new Hybrid technology based SDH node at the new 220/132/33/11kV GIS Damauli Substation and the SDH node at the new 220kV Bharaptur Substation.

Two (2) UGFO cable with 48 optical fibers each shall be provided and installed between the Gantry of the new LILO from the 132kV S/C OHTL Old Damauli Substation – Old Bharatpur Substation and the telecommunications room in the substation control building.

The 48 optical fibers from the LILO of the 132kV S/C OHTL Old Damauli OPGW shall be spliced to the 48 optical fibers of the first UGFO cable providing the connection between the new Hybrid technology based SDH node at 220/132/33/11kV GIS Damauli Substation and the existing SDH node at the Old Damauli Substation. Moreover, the future OPGW on the OHTL towards the old Damauli Substation will be installed by NEA.

The 48 optical fibers from the LILO of the 132kV S/C OHTL Old Bharatpur OPGW shall be spliced to the 48 optical fibers of the second UGFO cable providing the connection between the new Hybrid technology based SDH node at 220/132/33/11kV GIS Damauli Substation and the existing SDH node at the Old Bharatpur Substation. Moreover, the future OPGW on the OHTL towards the old Bharatpur Substation will be installed by NEA.

Patch cords

A sufficient number of patch cords shall be provided to establish the connections between

- the optical fibers terminated in the ODFs and the SFP ports of the SDH equipment
- the optical fibers terminated in different ODFs.

3.3.13.3 Fiber optical cables accessories

Optical distribution frame

Optical distribution frames (ODF) shall be provided and installed in the telecommunication room of the substation:

- one ODF with 96 connectors/ports for fiber optic cables
  - to terminate the 48 optical fibers of the UGFO cable running to the Gantry of the 220kV DC OHTL Lekhnath – Damauli
  - to terminate the 24 optical fibers of the UGFO cable running to the Gantry of the new LILO from the 220kV D/C OHTL Tanahu HPP

  - to terminate the 24 optical fibers of the UGFO cable running to the Gantry of the new LILO from the ADB 220kV D/C OHTL new 220kV Bharatpur Substation
- one ODF with 96 connectors/ports for fiber optic cables
  - to terminate the 48 optical fibers of the UGFO cable running to the Gantry of the new LILO from the 132kV S/C OHTL Old Damauli
  - to terminate the 48 optical fibers of the UGFO cable running to the Gantry of the new LILO from the 132kV S/C OHTL Old Bharatpur.

Connectors and plugs

A sufficient number of appropriate state-of-art optical plug/connector type shall be provided for new installations in the Project.

3.3.13.4 Telephony

A new state-of-the-art IP-PBX and appropriate telephone sets shall be installed, ready for use.

3.3.14 Metering system

A metering system for the substation shall be provided to accommodate the necessary three-phase meters.

Electricity metering shall be installed for the following:

- six (6) 220 kV OHL feeders
- two (2) 132 kV OHL feeders
- four (4) 220/132 kV transformers (220 kV side and 132 kV side)
- four (4) 132/33 kV transformers (132 kV side and 33 kV side)
- four (4) 33/11 kV transformers (33 kV side and 11 kV side)
- two (2) 33 kV feeders
- five (5) 11 kV feeders
- two (2) auxiliary transformers.

Meters shall be connected to the class 0.2S metering cores of the relevant instrument transformers by independent wiring systems.

The scope of supply related to the metering system is deemed to be complete and therefore inclusive of:

- high accuracy three-phase electricity meters
- metering panels, connection terminals and LV protection equipment
- wiring and (fiber optic) cabling system
- convertors and/or switches, as necessary to allow the aforementioned communication between the meters and the automated meter reading system of the Employer

- notebook PC including related software for local access for meter reading.

3.3.15 Cable System

3.3.15.1 132 kV Cable System

3.3.15.1.1 Scope of Supply - 132 kV Cable System

General

The 132 kV Cable System is required for a fully operational and reliable connection between the 220/132 kV Power Transformers and the 132 kV GIS.

The 132 kV cable technology shall be based on a Cross-Linked Polyethylene (XLPE) insulation designed for a maximum operating voltage of 132 kV.

The Bidders shall note that the adequacy of the proposed Cable System shall be duly supported by type tests carried out in accordance with IEC 60840 prior to the award of the Contract.

In his scope the Contractor shall include the complete construction activities required to provide a robust external protection to the 132 kV Cable System.

132 kV Cable System

The 132 / 33 kV Power Transformers shall be connected to the GIS via a 132 kV Cable System. Each individual three-phase circuit of the Cable System shall be capable of delivering continuously 30 MVA at the receiving end without any degradation of the respective physical and electric characteristics along the required service lifetime.

As a minimum the 132 kV Cable System shall include:

- the required 132 kV cables to connect the 132 kV GIS to the two 132 / 33 kV Power Transformers.
- 6 GIS terminations
- 6 outdoor terminations
- steel supports for the outdoor terminations and a suitable cable supports for the cable trajectory in the approach to the GIS
- the required number of link boxes - to be determined by the Detailed Engineering
- parallel earth cable (if required following the Detailed Engineering)
- cable clamps/cleats and respective fixation.

Documentation

The Contractor shall provide all relevant documentation required to demonstrate the proper engineering of the Cable System design, manufacture, installation, repair and testing. All engineering documents shall be submitted to the Employer for review and comments.

The Contractor shall supply documentation as outlined in VII-5 Technical Specification, 132 kV Cable System.

132 kV Cable System Studies

As a minimum the scope of studies required for design and verification of the 132 kV Cable System shall contain the following:

- insulation coordination
- maximum allowable electric stress levels in the insulation layer calculated for the most onerous situations at the expected ambient conditions
- short circuit currents
- sheath bonding scheme
- current carrying capacity in full load permanent operation considering the most onerous ambient conditions expected throughout the Cable System lifetime service.
- confirmation of the mechanical features of the Cable Systems, namely: maximum tension, maximum bending under tension, minimum bending radius, maximum sidewall pressure.

All studies shall be subject to the Employer's review.

Cable System - Testing

The Contractor shall submit for the Employer's approval all the type tests required to demonstrate the adequacy of the proposed Cable System for the intended application and lifetime service.

To confirm that all components of the Cable System, meet the specified requirements, the Contractor shall carry out all the necessary routine, sample and factory acceptance tests.

3.3.15.1.2 Scope of Construction

General

The Contractor shall carry out all necessary site investigations and any other complementary analysis to confirm the reliability and accuracy of all the data required for a robust Detailed Engineering of the Cable System aiming at a fully functional and reliable 132 kV Cable System. Moreover, the Contractor shall confirm all the required data for a safe and efficient completion of the Cable Works.

132 kV Cable Routing

The Contractor shall optimize the cable routing between the GIS and the two 132 / 33 kV Power Transformers, aiming a smooth installation of the 132 kV Cable System and a robust external protection capable of avoiding any physical degradation of the 132 kV Cable System throughout the respective lifetime service.

The pre-cast concrete troughs used to establish a Cable System route between the GIS and the two 132 / 33 kV Power Transformers, shall be adequately designed, manufactured and installed to avoid any physical degradation of the Cable System during the respective lifetime service. The covers shall be sufficient strong to cope with the most onerous loads and shall include provisions to allow the respective lifting and provide safe and practical access for any maintenance activities.

Any crossings of roads or other obstacles shall be carried via PVC or PE ducts embedded in a reinforced concrete bank. The concrete bank shall be designed and constructed to cope with the mechanical loads due to the heavy traffic crossing the duct bank. Moreover, the design of the duct bank shall not introduce any derating of the 132 kV Cable System electric current rating capability.

The inner surface of the end-to-end duct system along the crossing shall be smooth and free of any elements that may endanger the 132 kV Cable System integrity. The PVC or PE ducts shall have a minimum Standard Dimensional Ratio (SDR) which ensures the required robustness and avoids any deformation during the construction of the crossing.

Cable System - Testing

Following the completion of the installation of the Cable System, the Contractor shall carry out tests to confirm the compliance with the contractual obligations relating to the performance, reliability and safety of the Cable System.

Cable System - Single Lengths and Spare Parts

Given the short distance between the GIS and two 132 / 33 kV Power Transformers, it is expected that the manufacturer of the 132 kV cables imposes a minimum deliverable/sellable length to justify the respective production. The Contractor may procure other alternatives that may prove valuable in terms of delivery time and cost. Any alternative solution shall exceed the performance requirements of the 132 kV Cable System prescribed in the documents: VII-5 Technical Specification 132 kV Cable System and VII-8 Data Sheets 132 kV Cable System.

The Contractor shall submit for the Employer’s approval any potential alternative solution for the required 132 kV Cable System. Moreover, any potential alternative solution shall be duly substantiated with studies, routine and type tests that confirm the respective adequacy and robustness.

The time elapsed between the manufacturing date of the 132 kV cables proposed as an alternative solution and the Commencement Date shall not exceed 6 months. Moreover, the 132 kV cables proposed as alternative, shall be in pristine conditions and evidence shall be provided to confirm the adequacy of the packing and storage conditions since the manufacturing date.

If the Contractor procures the required 132 kV cables from a new production batch, the delivery lengths shall be provided in sound steel drums. The reasoning being that the remaining length in the drum(s) to be used as spare cable. In this case the lagging shall be suitable to cope with long storage periods without degradation.

3.3.15.2 Medium and Low Voltage Cable System

The scope of supply and services related to power and control cables shall include the complete cabling systems required for an operational substation. Therefore, on top of the required cables, the scope includes all necessary sealing ends, steel structure supports, clamps, accessories, cable trenches, cable containment, cable canals, bus ducts etc., as necessary.

- One (1) lot of MV cable systems comprising 33 kV XLPE cables shall be provided for the connection between secondary windings of 132/33 kV transformers and 33 kV switchgear.
- One (1) lot of MV cable systems comprising 33 kV XLPE cables shall be provided for the connection between 33 kV switchgear and 33/11 kV transformers.
- One (1) lot of MV cable systems comprising 33 kV XLPE cables shall be provided for the connection between 33 kV switchgear and auxiliary transformers.
- One (1) lot of MV cable systems comprising 11 kV XLPE cables shall be provided for the connection between secondary windings of 33/11 kV transformers and 11 kV switchgear.
- One (1) lot of MV cable systems comprising 11 kV XLPE cables shall be provided for the connection between 11 kV switchgear and distribution OHL pole location on the north side of the substation towards the river.
- One (1) lot of low voltage AC&DC power and control cables and cable support systems, as defined in the Technical Specification shall be provided for interconnection of all equipment included in the scope.

3.3.16 Earthing and Lightning Protection system

Earthing and lightning protection systems shall include:

- underground earth grid
- provision for interconnection of earth grid with grid of future 400 kV switchyard
- embedded and surface mounted earthing systems of buildings
- lightning protection systems for switchyards and buildings.

3.3.17 Lighting and Small Power

A lighting and small power system, complete in every respect and suitable for satisfactory operation, shall be provided for the extension of the substation. It shall include the following items:

- 400/230 V distribution boards for lighting system and small power
- complete indoor and outdoor normal and emergency lighting systems, including all required luminaires, lighting poles, external lighting control systems etc.
- cabling system, including cable trunking and cable containment systems
- socket outlets and plugs (3-ph and 1-ph sockets)
- power connection points for autotransformer bays
- all standard equipment and accessories necessary for the satisfactory operation of the system but which are not separately listed.

3.3.18 Fire protection system

A fire detection, alarm and firefighting system shall be provided for the complete 220/132/33/11 kV substation. The system shall cover the new switchgear and control buildings, transformer bays and outdoor switchyards.

The system shall be such that, in case of fire detection, an alarm shall be able to be signaled to the local firefighting emergency service. Fire alarms shall be wired to the Common Bay Unit in order to be signaled to the substation control and monitoring system (SCMS). The fire detection system shall include the following items:

- one (1) central fire alarm panel
- one (1) fire alarm repeater panel
- one (1) lot of fire detectors
- one (1) lot of manual alarm pushbuttons
- one (1) lot of audible and visual alarm devices
- fire detection cabling system, including cable trunking and cable containment systems
- all accessories necessary for the satisfactory operation of the system but which are not separately listed.

Portable fire extinguishers shall be provided inside the new buildings in all electrical equipment rooms, in call corridors and at strategic outdoor locations, such as e.g. transformer bays and other locations with risk of fire. They shall include the following items:

- one (1) lot of handheld fire extinguishers including the following types:
  - dry chemical powder ABC rated type
  - carbon dioxide type
- one (1) lot of wheel/trolley mounted fire extinguishers mechanical foam type.

A firefighting system shall be provided and shall include the following items:

- one (1) prefabricated containerized fire pump unit including
    - electric jockey pumps (1 set - 2x100%),
    - electric driven main pumps (1x100%),
    - diesel engine driven main pump (1x100%),
    - expansion tank arrangement,
    - control panel.
- one firefighting water tank
- one firefighting water supply pump with well and all accessories
- seven (7) transformer deluge systems for autotransformers
- one (1) lot of fire hydrant network
- one lot of cabling system, including cable trunking and cable containment systems
- all accessories necessary for the satisfactory operation of the system but which are not separately listed.

3.3.19 CCTV system

A new VMS (visual monitoring system), internationally also referred to as Closed Circuit Television (CCTV) systems shall be provided for visual monitoring of the substation premises. The main observation objects are as follows:

- switchyard
- transformer bays
- GIS hall
- switchgear and control equipment rooms
- control room
- stores
- main gate.

The scope of supply and services related to the technological video surveillance system shall include supply, installation, and commissioning of:

- central unit comprising:
    - video server
    - matrix switch
    - redundant UPS
    - interface for transmission to RDC
- system control panel, located close to the SCMS workstations
- monitors located close to the SCMS workstations
- indoor and outdoor pan tilt zoom (PTZ) cameras (minimum forty (40) sets) with remote control including

- high-speed swivel platform with a protective cover
- receiver for control commands
- power supply
- highly sensitive color camera with motorized lens.

The following supplies and services shall be included in the items above:

- base frames, steel works, supports and foundations required for installation
- all control and auxiliary supply cabling for interconnection and for power supply
- any other item considered necessary for the installation and successful operation of the works.

3.4 Civil Works

3.4.1 General

This section includes the design, supply of materials and all civil works for the substations.

The equipment foundations, GIS and control building, and all other structures of the substations shall be designed and constructed with due regard to the need for operation, inspection, maintenance, cleaning and repair and shall be constructed in order to operate for long-term periods with the minimum of inspection, adjustment and repair works.

The services to be provided within the framework of this specification comprise the planning, design, supply, and execution in every respect, including all the necessary calculations and documentation, prefabrication, delivery, erection and acceptance of all civil works and belonging installation works required for the faultless operation of the new substations.

This part of the specification shall be read in conjunction with all relevant Annexes, i.e. with the proposed layout plans, building plans and open-air switchgear areas.

The civil works generally consist of, but shall not be limited to, the following services:

- site related investigations, such as surveying, and soil investigation works
- if necessary, piling and / or soil improvement works
- all necessary site preparatory and infrastructural works including demolishing, excavation, levelling, grading, filling, compacting etc.
- temporary site installation works
- detailed design and engineering
- supply of labor, materials, equipment, temporary works, tools, etc. necessary for the execution of works
- establishment of a substation platform at a level which shall ensure that the substation will be protected from flood levels resulting from a 1 in 200-year flood event (including required soil improvement, fill with suitable material, etc.)

- necessary river training and flood prevention works to protect the substation site from a 1 in 200-year flood event on the Chabdi river.
- foundation works for substation buildings, equipment supports, gantries, etc.
- structural and non-structural steel works for substation buildings, equipment supporting structures etc.
- building works
- civil works for new and rehabilitation of existing damaged cable routing, ducts, channels, road crossings etc.
- rehabilitation and refurbishing works in existing buildings and of existing structures, which will be used also after the extension works
- fire protection works
- lightning protection and grounding system as described in Section "VII-5 Technical Specifications"
- outdoor and indoor lighting systems as per section "Technical Specification"
- levelling and grading works
- surfacing and landscaping
- heating, ventilation and air-conditioning (HVAC) works
- cleaning of the site and reinstatement of the area affected by the rehabilitation and construction works to the fully satisfaction of the Employer/Engineer.

All other works not described in the specification, but necessary for the completion of works, such as temporary works, transport and storage of materials etc., in order to serve the purpose of the Project.

3.4.2 Instructions

While the civil works are in progress, the Contractor shall provide sufficient suitably qualified competent civil engineers to be available on site in order to supervise and verify the work quality, and progress to the approved schedule of the work undertaken by the Contractor and any approved subcontractors.

The design and degree of detailing of building, structures and roads within the site shall comply with -and satisfy- the fundamental technical and operational requirements of the electrical equipment to be accommodated therein.

Ducts, trenches and/or tunnels shall be provided with suitable sump pits to enable the quick removal of water spillages collected in these areas.

If culvert(s) and /or tunnel(s), trench(s), any other underground services are crossing roads, these shall be constructed as bridges calculated for heavy truck loading.

Where sizes and/or dimensions are given in throughout of this document, these shall be considered as informative and for guidance only. The Contractor shall be responsible to verify and finalize all such sizes and dimensions during his detailed engineering in order to fulfill all functional and specified requirements.

3.4.3 Design and engineering

The Contractor shall prepare and submit for approval to the Employer/Engineer all design calculations and construction drawings for:

- excavation plans
- levelling plans
- piling calculations (if any)
- structural calculations for buildings, structures and foundations
- general arrangement and reinforcement drawings for concrete works, including bar bending schedules
- architectural arrangement and detailed drawings for the substation buildings
- layout with details of outdoor facilities
- general arrangement and manufacturing drawings for steel structures
- preparation and submission of drawings for statutory approvals of local authorities and of the agencies
- calculations and drawings associated with supplements to the existing lighting and small power
- conceptual and execution drawings and calculations for HVAC works
- fire protection works (if required).

3.4.4 Site related surveys

Topographical surveys shall be made by the Contractor for the site of the Project and access roads before and after the completion of the civil works in order to:

- obtain initial and final topographic survey maps
- ensure that the position and elevation of all works are in accordance with the drawings and documents and coordinated with adjacent works and installations
- Existing benchmarks, where available, shall be considered in the surveying works.

3.4.5 Soil investigations

Before starting with the design of the Contractor shall execute soil investigations. The extent of the investigations to be performed by the Contractor shall be such as to permit the satisfactory determination of all necessary subsoil characteristics, to exclude any unacceptable settlement and to determine reliable type, size and execution of foundations in all untouched, cut and filled areas of the site.

Detailed soil investigation is defined in the Technical Requirements Civil Works.

The detailed extent of the investigation, as well as the report with recommendations for the type of foundations to be used, are subject to the approval of the Employer/Engineer.

3.4.6 Site development works

The site development works shall include in general:

- site clearance including diversion of existing services, for areas affected by the works
- levelling and grading works
- temporary accesses and making good of any affected site internal roads, drains, surfacing, paving etc.
- temporary constructions, services and works, as necessary for the execution of the Project
- temporary fencing for storage and demarcation of working areas etc.

The Contractor shall be responsible for temporary and permanent protection of the works from groundwater and river flow. The Contractor shall construct any necessary diversion or temporary drainage systems to ensure that the area of the substation site remains unaffected by groundwater and river flow, during the earthworks required to establish the substation platform.

3.4.6.1 Site Development Works New Damauli

In addition to the general Site Development Works described above, additional development works as detailed below are required for New Damauli Substation:

Site Access

The new bridge over the Chabdi river serves as access for both, the 400 kV and the 220 kV substation.

As construction for both substations is expected to take place in parallel, close coordination of transport activities and traffic to the site will be required. This is especially important during site preparation works, which are expected to require intensive truck traffic for transportation of fill material during extended periods.

The permanent and main access to the 220 kV substation shall be via an access road bypassing the 400 kV substation road from the new bridge over the Chabdi river to the 220 kV substation.

Site Preparation, leveling and compacting

The Contractor shall be responsible for the establishment of an earthworks platform for the 220kV substation, which has a final level set with respect to the 200-year flood line of the River Chabdi, incorporating any necessary freeboard. The platform for the 400kV MCA substation is not part of the scope of works, and it will be established under a separate contract. The Contractor shall make any necessary measures to protect and reinforce any sections of the substation platform which may be exposed to flood waters.

The Contractor shall coordinate the design details of the 220 kV platform (i.e. coordinates, levels, embankment, drainage, etc.) with the 400 kV substation Contractor. Before starting with the main civil works for the substations, the Contractor shall execute all necessary levelling, soil replacement, filling, and grading works on the substation site. This includes provision and transport of suitable fill material from approved borrows to the construction site. The +/-0.00 level is subject for the approval of the Employer/Engineer and shall be fixed by means of a marking/fixing control point. These marks shall be always visible and accessible during the construction period.

The Contractor shall clear all materials, debris, etc. from the areas required for the temporary and permanent works and accesses and, shall take all reasonable precautions to prevent damage to existing roads and paved areas.

All trees and vegetation and objectionable materials not designated to remain, shall be felled, stumped, stacked and disposed of. Unless otherwise stated, holes and cavities resulting from the clearing, grubbing, and uprooting shall be filled with acceptable materials and compacted to the density of the adjacent areas. The first earthworks operation shall be the removal of topsoil, to a depth as agreed with the Employer. The topsoil shall be kept separate from other material and stock-piled for re-use on the site in the landscaped areas, if required. If not, it shall be disposed by the Contractor to the approved location.

Flood Protection

The proposed site for the 220kV Damauli substation is bounded to the north by the Chabdi river, and the substation platform will be established in an area prone to flooding by the river. The river flows passed the site in a west to east direction. Adjacent to the eastern boundary of the site, is the area allocated for the development of the 400kV extension which is foreseen to be developed under separate Contract.

The 220kV substation platform shall be provided with flood protection from the 1 in 200-year flood event.

The flood protection works shall be provided as outlined in VII-6 Particular Technical Requirements Civil Works and **Annex D5-22** and shall be compliant with the requirements of the relevant planning authorities.

The Employer has developed a hydraulic model of the river Chabdi which is attached as **Annex D5-16** so that the 200-year flood levels can be obtained, and the required height of the river training works can be determined for the extent of the flood protection works.

The site development and flood protection works for Damauli Substation are split in two Phases, as outlined in **Annexes D5-24** and **D5-22** and shall include the following:

Phase 1:

- development of the external drainage collector 1 (hill side south of substation)
- development of the external drainage collector 2 (400 kV side east of substation)
- development of the 220kV substation platform (excavation, filling and compaction, flood protection works).
- permanent access road, including dedicated drainage
- inner fencing surrounding the substation area with main access gate and maintenance access gates to area between the 220kV substation platform and the riverbed
- access road (3 m wide) from maintenance access gates to area between the 220kV substation platform and the riverbed
- external drainage collector on south side
- external drainage collector on east side of substation platform

Phase 2

- levelling of the area between the 220kV substation platform and the riverbed (no filling required for the area between the 220kV substation platform and the riverbed) and development of a drainage system to drain water from this area
- development of flood retaining wall and external chain link fence:
  - flood retaining wall north-west, adjacent to the riverbed, with chain link fence and three personnel gates for inspection purpose, with steps on both sides of the retaining wall at the gate locations
  - low wall along external drainage collector on south side with chain link fence
  - low wall along east side of substation platform (towards future 400 kV substation with chain link fence

General

During the construction works, the Contractor shall adopt all temporary mitigation measures to avoid that heavy rains / monsoon may affect the works already performed, providing for instance temporary drainage systems and protection earthworks to avoid the ingress of water in the site.

3.4.7 Site installation and temporary works

3.4.7.1 General

The Contractor shall supply all temporary offices, laboratories, sanitary conveniences, stores, equipment, workshops, compounds, parking areas etc., necessary for the completion of the works. The treatment of soil, as well as the transport of excess earth material, rocks etc. to an approved disposal area, are deemed to be included in the Contractor's scope.

Site installation and temporary works shall include:

- clearing, grubbing, stripping, excavation, levelling, draining, dumping of excavated materials etc. for the areas required for the site installation
- distribution of electrical power to each individual required location in accordance with the applicable standards for temporary site supplies, including earthing system
- supply and distribution of potable and industrial water, as required through the execution of the work
- sewer system and sewage disposal if required
- execution of all mechanical and electrical installation, foundation works for the temporary equipment, machinery, storage and site facilities etc.
- hard standing for vehicles as required
- waste disposal
- movable fire-fighting equipment
- watching, lighting and fencing of camp and working areas if required.

3.4.7.2 Temporary Storage Facility at Site

A designated temporary storage and laydown area shall be levelled and finished with a compacted gravel surface suitable for unloading and storing of heavy duty equipment.

For Damauli Substation, this surface shall be elevated to the design flood level of > 335 m a.s.l. and sufficiently graded to drain away intensive monsoon rain.

All costs required for the temporary construction, shelter roofs, container supports, storage maintenance, security fencing and reinstatement of original terrain before completion of the project shall be deemed included in the Mobilization and Site Preparation Lump Sum.

The location of the temporary storage and laydown area is subject to approval by the Employer.

3.4.7.3 Temporary Site Facilities

The Contractor shall provide and maintain for each site the temporary site facilities and accommodations, including office containers, sanitary containers, rest rooms, etc., for Contractor's own staff, in sufficient size and quantity.

In addition to the facilities and accommodations for Contractor's own staff described above, the Contractor shall provide, separate accommodation facilities on each site for the Employer and the Engineer.

Therefore, the below mentioned items of supply shall be provided:

- one (1) office container for Employer / Engineer.

These containers shall be installed at locations to be indicated by the Employer/Engineer. The Contractor shall maintain them throughout the Project period and shall remove them after the completion of works and subject to the approval of the Employer.

The afore-mentioned temporary site facilities shall be structurally sound and compatible with the weather conditions on the site, including at least the following rooms:

Office containers

- two (2) main (office) rooms, each equipped for 2-3 persons
- two (2) toilet rooms, one for men and one for ladies
- one (1) small kitchen.

All the above-mentioned containers shall be provided with the respective furniture so as to fulfill their purpose. In addition, they shall be equipped with heating and air-conditioning systems.

All containers shall be provided with an internet connection and a telephone system, which shall be connected to the public telephone system for international and local calls. The contractor shall ensure the availability of internet connection. If it is a problem to have internet connection in the site, the contractor shall provide internet via mobile connection in the site.

The Contractor shall install a communication system to the Employer's/Engineer's containers independent of the one that he has installed for his own containers. All the relevant costs, except for telephone bills, throughout the Project implementation shall be covered by the Contractor.

The facilities shall be provided along with the services necessary for their operation including (maintenance and cleaning to the Employers satisfaction and shall include electrical energy, potable water supply, sewers, drainage system, fire extinguishing system, A3 printing etc. All the relevant costs throughout the Project implementation shall be covered by the Contractor.

3.4.8 Main civil works

Based on the draft layout plans, the Contractor shall propose detailed arrangements of the various components for the final configuration of the substations. Adequate safety clearances, fire compartments, favorable layout of the substation components for monitoring and maintenance, possibility for extension and any other requirements of up-to-date substation construction shall be taken into account by the Contractor.

Dimensions indicated in drawings included in the Contract shall be perceived as indicative. However, the number and purpose of rooms and room dimensions indicated in drawings constitute minimum requirements and shall not be reduced.

The Contractor shall be responsible for fitting all items of Plant in the respective planned locations, respective all relevant technical requirements, derived from the Contract and/or the applicable technical standards, regulations etc. All equipment rooms must be adequately sized to allow future extension of the substation, as a minimum to accommodate spare feeders as indicated in the single line diagram (**Annex D5-1 / Annex D5-2**).

The design of the overall layout must include space provision for installation of cable channels for spare feeders as indicated in the single line diagram (**Annex D5-1 / Annex D5-2**) in the future and corresponding tentative arrangement and routing shall be indicated in the design drawings.

Where fencing system is foreseen, this shall be installed on the border of the respective property.

Main Civil Works shall comprise the following:

3.4.8.1 Lekhnath Substation

In Lekhnath, the existing 132 kV switchyard shall be extended, and a new 220/132kV Substation shall be established. The relevant civil works shall include, without being limited to, the following:

Buildings

- one (1) 220 kV GIS building
- one (1) control building, including furniture as required to fulfill the function of the respective room
- one (1) storage shelter as replacement for the existing storage shelter to be demolished, with similar size. The storage shelter shall comprise a metal clad steel construction with transport door of 3 m width and personnel access doors. The storage shelter shall be provided with ventilation louvers to allow air circulation, but no mechanical ventilation systems. The storage shelter shall be provided with adequate electric lighting.

Transformer Foundations

Transformer reinforced concrete foundations with oil catch and collection pits and fire separation walls shall be foreseen

- seven (7) 220/132/33 kV 105 MVA single phase autotransformer foundations with oil catch and pits and fire separation walls

- two (2) auxiliary transformer bays (outdoor) with sunshade and oil catch and pits
- one (1) common oil collection pit with oil separator.

Outdoor foundations - HV equipment

- One (1) lot Foundations for the outdoor switchyard equipment, supports and gantries shall be provided, including but not limited to:
  - 220 kV gantry foundations
  - 220 kV AIS equipment foundations for voltage transformers and surge arrestors
  - 220 kV GIB and SF_6/air termination foundations
  - 132 kV gantry foundations
  - 132 kV AIS equipment foundations for switchgear extension
  - 132 kV GIB and SF_6/air termination foundations.

Foundation for Diesel generator

- one (1) foundation for the diesel generator and fuel storage shall be provided.

Foundation for Fire Fighting Pump Container and Fire Water Tank

- one (1) foundation for the containerized firefighting pump system
- one (1) foundation for the fire water tank

Channels, ducts etc. for cables

- One (1) lot reinforced concrete channels and ducts, as required, shall be provided for the connection of the new equipment to be installed, including but not limited to:
  - 33 kV power cables from 220/132/33 kV autotransformers to 33 kV switchgear
  - 33 kV power cables from 33 kV switchgear to auxiliary transformers
  - LV power and control cables from 220 kV GIS building to autotransformers and outdoor equipment
  - LV power and control cables from extended132 kV switchyard to existing control building
  - LV power and control cables from 220 kV GIS building to existing132 kV switchyard and control building.

Roads, pavings and gravel bed surfacing

Roads, pavings and gravel bed surfacing shall be provided for the 220/132/33 kV substation extension and its connection to the existing parts as defined in the drawings and described in the Technical Requirements Civil Works.

The access road connections between the relevant external main roads and the substation are deemed to be included in the scope of the Contractor. These access roads shall be suitable for the transportation of all equipment foreseen under the Contract.

The existing 132kV switchyard internal and external service roads have to be extended to suit the switchyard extension.

The Contractor's scope shall also include any rehabilitation or improvement of existing infrastructure (e.g. roads, bridges etc.) so as to allow the access to site, as well as the transport of all foreseen equipment.

Site Preparation, leveling and compacting

Before starting with the main civil works for the substations, the Contractor shall execute all necessary levelling and grading works on the substation site. The +/-0.00 level is subject for the approval of the Employer/Engineer and shall be fixed by means of a marking/fixing control point. These marks shall be always visible and accessible during the construction period.

The Contractor shall clear all materials, debris, etc. from the areas required for the temporary and permanent works and accesses and, shall take all reasonable precautions to prevent damage to existing roads and paved areas. This includes breaking down and removing of the existing storehouse, if required to accommodate the new substation.

All trees and vegetation and objectionable materials not designated to remain, shall be felled, stumped, stacked and disposed of. Unless otherwise stated, holes and cavities resulting from the clearing, grubbing, and uprooting shall be filled with acceptable materials and compacted to the density of the adjacent areas. The first earthworks operation shall be the removal of topsoil, to a depth as agreed with the Employer. The topsoil shall be kept separate from other material and stock-piled for re-use on the site in the landscaped areas, if required. If not, it shall be disposed by the Contractor to an approved location.

Water supply system

The 220kV Extension in Lekhnath shall be provided with the following:

One (1) water treatment plant including the following main components

- one (1) pump with capacity of 0.5 liter/s
- one (1) storage tank of 10m^3
- one (1) well
- one (1) filter unit
- one (1) pressurizer unit
- one (1) lot of pipes, valves, etc.

One (1) Internal water supply system (including water pipes, pumping stations etc.)

Drainage and sewage systems

Storm water drainage system

Complete storm water drainage system shall be provided for the extended substation and the Contractor shall carry out any possible modifications/upgrades in the existing system so as to ensure the proper storm water drainage of the complete, extended substation.

The storm water drainage system shall collect only clean storm water which shall be discharged into the storm water system of the zone (if any existing, or in agreement with the Employer). The system shall be substantially maintenance-free, and the installation shall be operationally safe. The surface water drainage shall include all necessary gutters, down pipes, gullies, traps, catch pits, manholes etc.

The existing 132kV switchyard drainage channel has to be relocated and reconnected with the existing system to suit the switchyard extension.

The storm water drainage system shall include three distinct parts

- the drainage system not permitting the entrance of external stormwater to the substation site
- the internal drainage system, which shall collect and discharge the water collected in the substation site; and
- the external drainage system, which shall convey the water collected in the substation to an adequate collector system.

Sanitary sewage drainage system

Complete sanitary sewage drainage system shall be provided for all new facilities. The sanitary water from the WC, urinals, wash basins etc. shall be discharged on the substation site to a three-chamber treatment made of reinforced concrete. The pre-cleaned water shall be led to a soak-away pit.

Landscaping

The free area inside the extended substation, where no roads or gravel is provided, shall be landscaped using low to medium-high growing plants and grass. Plantations shall be provided along the main roads and buildings, as indicated on the layout drawings, subject to the approval of the Employer.

Fencing and gates

Substation fencing system shall be provided for the substation extension. The Contractor shall also carry out all works necessary towards the connection of the existing fencing system with the new one (corresponding to the substation extension). The fencing system shall comprise robust fences of rigid steel type, with a height of 2.5 m above the concrete foundation. An adequately dimensioned entrance gate, along with a separate personnel entrance, shall be provided for the substation extension.

Air-conditioning, ventilation and heating systems

Air conditioning, ventilation and electrical heating system shall be provided as follows:

- one lot of independent ventilation system for the GIS hall, with air inlet filters, in accordance with the requirements of the GIS manufacturer to keep slight overpressure within the hall (about 20 - 30 Pa above ambient pressure
- one lot of independent ventilation system for each battery room designed in accordance with the requirements of IEC 62485 (redundant fans are required)
- one lot of independent ventilation system for corridors and toilets
- one lot of air-conditioning system for each switchgear room and control / protection / telecommunication and metering cabinet rooms
- one lot of air-conditioning system for the control rooms.
- one lot of air-conditioning system for each office

Overhead Traveling Crane

- one (1) set of overhead traveling crane, 6 t lifting capacity, for 220 kV GIS building, minimum height of crane shall be 8.0 meters or as per actual requirement whichever is higher.

Other works

- cleaning of the site from gravel or other type of surfacing
- execution of backfilling works
- execution of grouting layers between foundations and steel base plates
- execution of all necessary earthing works
- final surfacing works.

3.4.8.2 Damauli Substation

In Damauli, a new 220/132/33/11 kV Substation shall be established. The relevant civil works shall include, without being limited to, the following:

Buildings

- one (1) 220 kV GIS building
- one (1) 132 kV GIS building
- one (1) control building, including furniture as required to fulfill the function of the respective room
- one (1) storage building
- One (1) guard house adjacent to the gate of the 220 kV Substation area shall be provided. The guard house shall be a simple, one-level construction with a service room, and sanitary facilities.

Transformer Foundations

Transformer reinforced concrete foundations with oil catch and collection pits and fire separation walls shall be foreseen:

- two (2) 220/132 kV 50/63 MVA power transformer foundations with oil catch and pits and fire separation walls
- two (2) 132/33 kV 24/30 MVA power transformer foundations with oil catch and pits and fire separation walls
- two (2) 33/11 kV 6/8 MVA power transformer foundations with oil catch and pits and fire separation walls
- two (2) 33/0.4 kV 1250 kVA auxiliary transformer foundations with sunshade and oil catch pit
- one (1) common oil collection pit with oil separator.

Outdoor foundations - HV equipment

- one (1) lot foundations for the outdoor switchyard equipment, supports and gantries shall be provided, including but not limited to:
  - 220 kV gantry foundations
  - 220 kV AIS equipment foundations for voltage transformers and surge arrestors
  - 220 kV GIB and SF_6/air termination foundations
  - 132 kV gantry foundations
  - 132 kV AIS equipment foundations for voltage transformers and surge arrestors
  - 132 kV GIB and SF_6/air termination foundations.

Foundation for Diesel generator

- One (1) foundation for the diesel generator and fuel storage shall be provided.

Foundation for Fire Fighting Pump Container and Fire Water Tank

- one (1) foundation for the containerized firefighting pump system
- one (1) foundation for the fire water tank

Channels, ducts etc. for cables

Suitable cable routes shall be constructed as tentatively indicated in the layout drawings with pre-cast concrete troughs with robust concrete covers. Road crossings shall be provided via PVC or PE ducts embedded in reinforced concrete (if required following the Detailed Engineering).

- One (1) lot reinforced concrete channels and ducts, as required, shall be provided for the connection of the new equipment to be installed, including but not limited to:
  - 220 kV cables from the 220 kV GIS up to the fence towards the future 400 kV Substation
  - 220 kV cables from the 220 kV GIS up to the fence towards the future 220 kV gantries
  - 132 kV cables from the 220/132 kV transformers to the 132 kV switchgear
  - 33 kV cables from 132/33 kV transformers to 33 kV switchgear and from 33 kV switchgear to 33/11 kV transformers
  - 33 kV cables from 33 kV switchgear to auxiliary 33/0.4 kV transformer
  - 11 kV power cables from 33/11 kV transformers to 11 kV switchgear
  - 11 kV outgoing feeder cables between 11 kV switchgear and distribution OHL pole location on the north side of the substation towards the river
  - 33 kV outgoing feeder cables between 33 kV switchgear and distribution OHL pole location on the north side of the substation towards the river
  - LV power and control cables from 220 kV GIS building to autotransformer and outdoor equipment
  - LV power and control cables from 132 kV GIS building to power transformer and outdoor equipment
  - LV power and control cables from 220 kV GIS building to 132 kV building.

Roads, paving and gravel bed surfacing

Roads, paving and gravel bed surfacing shall be provided for the 220/132/33/11 kV Substation and its connection to the existing parts as defined in the drawings and described in the Technical Requirements Civil Works, subject to the approval of the Employer. The access road connections between the relevant external main roads and the substation are deemed to be included in the scope of the Contractor. These access roads shall be suitable for the transportation of all equipment foreseen under the Contract.

Water supply system

The 220kV Substation in New Damauli shall be provided with the following:

- one (1) water treatment plant including the following main components:
  - one (1) pump with capacity of 0.3 liter/s
  - one (1) storage tank of 10m^3
  - one (1) well
  - one (1) filter unit
  - one (1) pressurizer unit
  - one (1) lot of pipes, valves, etc.
- one (1) internal water supply system (including water tanks, pumping stations etc.),

Drainage and sewage systems

<u>Storm water drainage system</u>

Complete storm water drainage system shall be provided for the extended substation and the Contractor shall carry out any possible modifications/upgrades in the existing system so as to ensure the proper storm water drainage of the complete, extended substation. The storm water drainage system shall collect only clean storm water which shall be discharged into the storm water system of the zone (if any existing, or in agreement with the Employer). The system shall be substantially maintenance-free, and the installation shall be operationally safe. The surface water drainage shall include all necessary gutters, down pipes, gullies, traps, catch pits, manholes etc.

The storm water drainage system shall include three distinct parts

- the drainage system not permitting the entrance of external stormwater to the substation site
- the internal drainage system, which shall collect and discharge the water collected in the substation site; and
- the external drainage system, which shall convey the water collected in the substation to an adequate collector system.

Sanitary sewage drainage system

Complete sanitary sewage drainage system shall be provided for all new facilities. The sanitary water from the WC, urinals, wash basins etc. shall be discharged on the substation site to a three-chamber treatment made of reinforced concrete. The pre-cleaned water shall be led to a soak-away pit.

Landscaping

The free area inside the extended substation, where no roads or gravel is provided, shall be landscaped using low to medium-high growing plants and grass. Plantations shall be provided along the main roads and buildings, as indicated on the layout drawings, subject to the approval of the Employer.

Fencing and gates

Substation fencing system shall be provided for the substation extension. The Contractor shall also carry out all works necessary towards the connection of the existing fencing system with the new one (corresponding to the substation extension). The fencing system shall comprise robust fences of rigid steel type, with a height of 2.5 m above the concrete foundation.

An adequately dimensioned entrance gate, along with a separate personnel entrance, shall be provided for the substation extension. These shall be operable from the adjacent gate house.

Air-conditioning, ventilation and heating systems

Air conditioning, ventilation and electrical heating system shall be provided as follows:

- one lot of 3 x 50% independent ventilation and air conditioning systems for each GIS hall, with air inlet filters and cooling units, in accordance with the requirements of the GIS manufacturer to keep slight overpressure within the halls (about 20 - 30 Pa above ambient pressure) and to maintain temperatures within specified limits as defined in VII-6 Technical Requirements Civil Works
- one lot of independent ventilation system for each battery room designed in accordance with the requirements of IEC 62485 (redundant fans are required)
- one lot of independent ventilation system for corridors and toilets
- one lot of air-conditioning system for each switchgear room and control / protection / telecommunication and metering cabinet rooms
- one lot of air-conditioning system for the control rooms.
- one lot of air-conditioning system for each office.

Overhead Traveling Crane

- one (1) set of overhead traveling crane, 6 t lifting capacity, for 220 kV GIS building, minimum height of crane shall be 8.0 meters or as per actual requirement whichever is higher
- one (1) set of overhead traveling crane, 6 t lifting capacity, for 132 kV GIS building, minimum height of crane shall be 8.0 meters or as per actual requirement whichever is higher
- one (1) set of monorail crane, 1 t lifting capacity, for storage room in control building.

Other works

- cleaning of the site from gravel or other type of surfacing
- execution of backfilling works
- execution of grouting layers between foundations and steel base plates
- execution of all necessary earthing works
- final surfacing works.

4 Limits of Supply and Interfaces

4.1 Interfaces between Packages

In general terms, the interface between Package A (OHL) and Package B (Substation) shall be the substation's take-off gantries (see Figure 4-1).

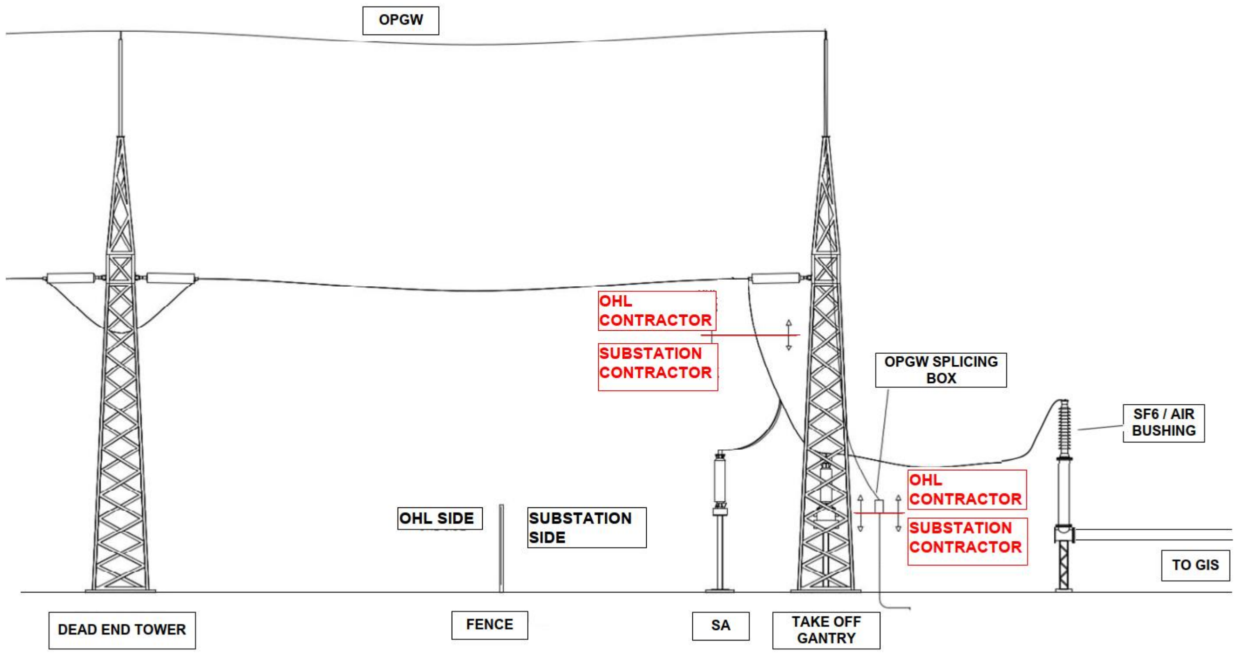


Figure 4-1 Schematic representation of scope of supply limit

The scope of supply limits for the Package A contractor shall include the supply and installation of:

- phase conductor droppers to the air-insulated surge arresters and voltage transformers
- OPGW and its connection to the take-off gantry
- dropper to the OPGW splicing box at the bottom of the take-off gantry
- OPGW splicing box
- all required splicing works and testing.

The internal links between splice boxes and Control Building shall be within the Package B contractor's scope. The number of splice boxes, the splicing arrangements, the termination in ODF, the numbers of OPUG in the substation facilities etc. shall be defined at following stages.

The Package A contractor shall leave sufficient spare free conductor after installing the final insulator string on the take-off gantry so to enable the Package B contractor to connect the substation equipment (surge arresters).

The two contractors shall coordinate and agree on the locations and heights of the respective gantries, as well as on “end to end” protection and telecommunication tests.

The *Internal OHL Connection at Lekhnath Substation* between the 132 kV bays and the 315 MVA autotransformers shall follow similar principles as above: The OHL interconnection is within Package A (OHL). The 132 kV gantries for the connection to the additional 132kV bays (**E13** and **E14)** and the gantries for the connection of 315 MVA autotransformers are included within the scope of Package B (Substation). The stringing will be the responsibility of the Contractor of Package A (OHL). The coordination of the related interfaces with the transmission line Contractor is included within the scope of this package. The Contractor of the Substation Package B shall give access to the Package A contractor for construction of the OHL interconnection as required.

4.2 Interfaces with Other Projects

4.2.1 Existing 132kV Lekhnath Substation

132 kV Switchyard

The present project includes the extension of the existing 132/33/11 kV Lekhnath Substation. The existing substation is equipped with an air insulated 132 kV Bus and Transfer arrangement. The 220 kV extension will be connected through two new air-insulated 132 kV bays to the existing Bus and Transfer system and the two bays are located west side of the existing 132 kV switchyard. The two new bays will be provided with two sets of air-insulated capacitive voltage transformers to be used for the voltage control of the new 220/132/33 kV auto transformers.

132 kV busbar differential protection

Currently, the existing Busbar Differential relay is going to be replaced by Lahachowk 132 kV double circuit transmission line project’s substation contractor ABB, India with a new phase wise model REB670 of ABB 12 channel Bus Bar protection relay. The new protection relay has spare capacity for two more channels, but no peripheral devices for connection. The contractor shall supply an extension panel with the required terminal blocks, auxiliary contactors and all other components that are required for the extension of the 132kV Busbar Protection. The interface point to the existing busbar protection system shall be the relay terminals of the REB670.

NEA Grid Substation Automation System (SAS) Project-Phase 2

NEA currently is implementing the **NEA Grid Substation Automation System (SAS) Project-Phase 2**. The scope of this project includes the complete automation of 132 kV, 66 kV, 33 kV and 11 kV bays of substations under six Grid Division offices, including the construction of six Master Control Centers (MCCs) at various six grid locations and the integration of these substations into the Load Dispatch Center (LDC), NEA, Siuchatar and Backup Data Centre at Hetauda.

As part of this project, a new substation automation system will be provided for the existing 132 /33 / 11 kV Lekhnath Substation, including integration of this substations into the Master Control Centers (MCC) Pokhara and Load Dispatch Center (LDC), NEA, Siuchatar and Backup Data Centre at Hetauda.

For the additional 132 kV transformer bays included in the Lekhnath Damauli 220 kV Transmission Line Project Package B, the split of responsibilities shall be as follows:

- Package B includes provision of control and protection panel with bay control unit for the two extended 132 kV bays and Ethernet switch to allow integration to the automation system
- SAS Project-Phase 2 undertakes to increase the capacity of the Lekhnath substation automation system at Lekhnath to allow integration of the two additional bays for LD 220 kV TLP
- Integration of the two additional bays for LD 220 kV TLP and adaption of HMI displays will be done by into SAS Project-Phase 2 / NEA with support of Package B Contractor
- Integration of 220 kV switchgear into NLDC and Backup LDC is in scope of Package B

Integration 220 kV into the existing SCADA/EMS System at NLDC/ECC

The 220 kV part of the new SCMS to be installed under the project for the new 220/132/11 kV Lekhnath Substation shall be fully integrated into the existing National Load Dispatch Centre Main& Emergency (NLDC/ECC) SCADA/EMS System, as described in detail in Clause 3.2.11.4.

4.2.2 New Damauli Substation

400 kV Substation

The 220/132/33/11 kV new Damauli Substation will be connected with the 400 kV new backbone through the 400kV switchgear in new Damauli and 400/220kV intertie autotransformer banks, which are under implementation by MCA..

The new 400kV switchgear and 400/220kV intertie autotransformer banks will be built in proximity of 220/132/33/11 kV new Damauli Substation. No primary equipment for interconnection with the 400kV switchgear shall be provided as part of this project, however, provision for future extension shall be made, including the following:

- Space in the 220 kV GIS building for later installation and connection of additional four (4) autotransformer feeders shall be provided.
- The Contractor shall make provision for future extension of the 220 kV GIS with additional bays for connection to the future 400/220kV intertie autotransformers. To facilitate future extension of the GIS with minimum interruption of service, the primary connection points of the GIS shall be provided as separate gas compartments, to avoid gas works on the main

busbar of the GIS. The interface point for extension shall be flanges of these gas compartments.

- Space inside the GIS room for a fast transfer system with GIB and GIS disconnectors for the spare autotransformer shall be provided.
- The connection from the future bays to the future 400/220kV intertie autotransformers is anticipated to be by means of 220 kV GIB to female SF6/cable terminations located at the outside wall of the GIS building and from there onwards via 220kV XLPE cables. The wall transitions for future GIB connection from GIS room to the outside shall be included.
- For SCMS integration the interface point shall be the gateway towards the 400 kV substation.

NEA Grid Substation Automation System (SAS) Project-Phase 2

For the 132 kV/33kV/11kV part of the substation provision shall be made for integration into the new Master Control Center (MCC) Pokhara. The split of responsibilities shall be as follows:

- for 132 kV/33kV/11kV part of the substation separate gateways with sufficient number of ports for connection to the Master Control Center (MCC) Pokhara and to LDC and Backup LDC to be included
- Integration of the 132/33/11 kV part into the Master Control Center (MCC) Pokhara and to LDC and Backup LDC will be done by SAS Project-Phase 2 / NEA

Integration 220 kV into the existing SCADA/EMS System at NLDC/ECC

The 220 kV part of the new SCMS to be installed under the project for the new 220/132/33/11 kV DAMAULI Substation shall be fully integrated into the existing National Load Dispatch Centre Main& Emergency (NLDC/ECC) SCADA/EMS System, as described in detail in Clause 3.3.12.

VII-2

Project Procedures

Table of Contents

List of Abbreviations

AC	Approved on Condition
AP	Approved
CAE	Computer Aided Engineering
CESMP	Contractor's Environmental & Social Management Plan
DC	Direct Current
DTS	Document Transmittal Schedule
EHS	Environment Health Safety
ESHS	Environment Social Health Safety
ESM	Environmental & Social Management
ESMP	Environmental & Social Management Plan
FA	For Approval
FAT	Factory Acceptance Tests
FI	For Information
HSE	Health Safety Environmental
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
NA	Not Approved / Not Applicable
PC	Particular Conditions of Contract
PDF	Portable Document Format
OHS	Operational Health and Safety
QA	Quality Assurance
QC	Quality Control
PDF	Portable Document Format
SCMS	Substation Control and Monitoring System

1 Project Organization and Administration

1.1 Project Organization Chart

The Project Organization Chart shall clearly identify the Contractor's Project team, their responsibilities, communication and reporting lines. The Chart is meant to be reflective of both the home office and the on-site organization of the Contractor, as well as all communication between the two.

1.2 Correspondence and Document Submission

The Contractor shall address all formal correspondence (letters etc.) to the Employer and / or to the Engineer in accordance with the Contract.

Each correspondence shall carry the Project title, Project number, date, correspondence number, the reference number of the funding institution (if applicable) etc.

The Contractor shall track all correspondence in a Correspondence Log, which shall be added to the Monthly Progress Reports (the latter are addressed in Paragraph 2.3).

Documents shall be submitted using Document Transmittal Sheets (DTS), as outlined in this document, in Chapter 4.

2 Reporting

2.1 General

The reporting activities shall cover the following:

- monthly progress reporting
- special reporting as defined in Paragraph 2.4
- project completion reporting
- environmental and social performance reporting
- other reports as might be required by the Engineer, in accordance with the Contract.

In addition, the Contractor shall introduce a Site Diary, specific to each construction site, which shall be maintained on daily basis.

2.2 Site Diary

The Site Diary shall be developed in accordance with the QA/QC procedures of the Contractor but shall, as a minimum, contain the following information:

- number of reports
- date
- name of the project
- weather conditions, temperature
- Contractor's personnel on site
- Subcontractors' personnel on site
- other attendees on site (Employer, Engineer, other visitors)
- machinery and equipment on site
- civil materials delivered to site
- equipment for permanent Works delivered to site
- activities performed
- special occurrences / incidents
- activities scheduled for next day.

One site diary will be kept at all times for each construction site (e.g. substation).

The Contractor shall be responsible to maintain/update this document on daily basis and the Employer/Engineer reserve the right to inspect the document at any time.

2.3 Monthly Progress Reports

Monthly Progress Reports shall be prepared by the Contractor and submitted to the Employer and to the Engineer the latest 5 days after the reporting period's (month's) end.

The structure of the monthly progress report shall be subject to approval.

As far as the contents of the reports are concerned, in addition to the items referred to in Part III, Paragraph 4.21, the following shall be included:

- executive summary
- financial summary and details, detailed cash flow estimates of all payments to which the Contractor will be entitled under the Contract, as well as updated Disbursement Schedule (including an S-graph reflecting planned/actual disbursement)
- main issues of concern and events
- updated Programme - the Contractor shall describe major adjustments and deviations between the updated Programme and the Baseline Programme, i.e. the Programme submitted in accordance with Part III, Paragraph 8.3
- updated FAT schedule
- updated Correspondence and DTS Logs
- subjects related to coordination/interfacing with other lots etc.
- ESIA/ESMP and HSE aspects, implementation of Contractor's ESMP (performance and progress).

Outline and structure of the monthly report are subject to approval.

2.4 Special reports

Throughout the Project, the Contractor shall prepare special reports covering (but without being limited to) the following:

- test reports (FAT and other type test and routine test reports)
- transport of (main) equipment like transformers etc.
- equipment failures, damages, during transport, testing, trial operation, defects notification period etc.
- inspections and tests during installation
- incident reports
- pre-commissioning tests
- site tests
- commissioning tests
- trial operation.

These reports shall be submitted to the Employer/Engineer as reasonably possible. If not otherwise specified in the Contract, these shall be submitted the latest within 28 days following the occurrence of the relevant event or circumstance, completion of the test etc.

Specifically for the events/circumstances set out below, the Contractor shall provide promptly, but the latest within 2 workdays, after the occurrence of the event, the following:

1. Details of

(a) any incident of an environmental or occupational health and safety nature, including -without limitation- any explosion, spill or workplace accident, which results in death, serious or multiple injuries or material environmental contamination; or

(b) any incident of a social nature, including -without limitation- any labor strike or violent labor unrest or dispute with local communities/community protests, occurring on or nearby any site, plant, equipment or facility of the Employer which has or is reasonably likely to have a material negative impact on the environment, the health, safety and security situation, or on the social and cultural context. Such details shall be provided along with a specification of the nature of the incident or accident and the on-site and off-site effects; or

(c) any actions by any relevant competent authorities of the Country, leading to partial or complete stop of project activities

2. Details of

any action the Contractor proposes to take in order to remedy the effects of these events. The Contractor shall keep the Employer/Engineer informed on the progress in relation to such remedial action(s).

2.5 Project Completion Report

The Contractor shall prepare and submit the Project Completion Report not later than 1 month after the Taking-over Certificate for the Works has been issued. In case the Works are divided into Sections, then one (1) Completion Report shall be issued per Section (within 1 month after the taking-over of such Section) and one (1) comprehensive report shall serve as a Project Completion Report (to be issued within 1 month after the taking-over of the last Section), covering all Sections, i.e. the whole Works.

The report shall contain (as a minimum):

- project definition, objectives etc.
- Contractor's scope of work
- financial summary (including all amendments and change orders)
- schedule comparison, i.e. comparison between the Baseline Programme (as per Part III, S-C 8.3) and the Programme at completion

- summary of incidents occurred during the implementation of the Contract, including description of mitigation measures and their effect
- Contractor's Organization Chart
- installation and commissioning report
- test certificates and reports
- inspection certificates
- acceptance certificates
- analysis of environmental and social compliance
- analysis of health and safety performance.

Details and requirements regarding the layout and content of above report will be coordinated between the Contractor and the Employer/Engineer in due course during the implementation of the Contract. The Completion Report(s) and the Project Completion Report shall be subject to approval.

3 Meetings

Following a sustainable approach to reduce project-related CO2 emissions, face-to-face meetings may be partially reduced and replaced by videoconferences, when possible and as jointly agreed. To this effect, the Contractor shall maintain reliable and state-of-the art videoconference tools and communication/collaboration platforms, allowing the stakeholders to connect to each other as required.

3.1 Kick-off Meeting

A kick-off meeting will be held at the Employer's offices to discuss the Contract framework, Programme, administrative aspects, organization and other project specifics.

The meeting shall be organized as soon as practical following the Commencement Date.

3.2 Progress Meetings

Progress meetings shall take place at the Contractor's site office, if not advised differently by the Employer/Engineer, on a regular (usually monthly) basis following the Commencement Date.

The main topics of these meetings shall be:

- work progress review (previous month)
- Programme review
- work forecasted for the upcoming period
- open topics, unresolved issues etc.
- review of Correspondence and Document Transmittal Sheet (DTS) Logs
- review of project finances
- discussion on any other topics, on the basis of the Monthly Progress Report of the Contractor (ahead of the progress meeting).

The relevant Minutes of Meetings shall be signed by all parties.

3.3 Site Meetings

During construction, installation and commissioning, site meetings shall be held on a regular basis (at least weekly) and/or as needed, in accordance with the progress and situation at the construction site(s).

The meetings shall take place at the sites, if not advised differently by the Employer/Engineer.

The main topics of these meetings shall be:

- progress review and forecast
- construction schedule review
- equipment and material delivery status
- ESHS aspects
- review of QA/QC
- other administrational matters.

Design-related topics might also be discussed but such discussions shall not be deemed to comprise design approval.

The relevant Minutes of Meetings shall be signed by all parties.

3.4 Other Meetings

Each Party may request a meeting at any time required.

Such request shall be in writing (accompanied by an agenda) and shall be submitted at least 5 working days prior to the meeting.

During Factory Acceptance Testing (FAT), inspections and commissioning tests, meetings shall be held as follows:

- a kick-off meeting at the beginning of each session, to discuss the scope, procedures, criteria, environment, expected results etc.
- a meeting at the end of each test session, to discuss the results and potential mitigation measures (if required).

The relevant Minutes of Meetings shall be signed by all parties.

4 Project Documentation, Review/Approval Procedure

4.1 General

For all documents issued by the Contractor, the latest applicable IEC and ISO standards shall be observed. Revisions and amendments shall be easily identifiable and traceable in accordance with such standards.

Documents (studies, specifications, reports, drawings etc.) shall be submitted in accordance with the Document Schedule.

All documentation (except if stated otherwise) shall be in the ruling language, as defined in Part III, Particular Conditions of Contract (PC).

4.2 Document Identification

All documents, including those of subcontractors and manufacturers, shall have a title block in accordance with ISO 7200.

In addition to the mandatory information, as per ISO 7200, the title block shall contain:

- the name and logo of the Employer in one box
- the title of the project
- the name and logo of the Engineer in one box
- the name and logo of the Contractor
- in case of manufacturers or subcontractor's documents additionally their name and logo
- Contractor's document number.

The title block shall be subject to approval.

The Contractor's document number shall be unique for each document and shall be assigned by the Contractor, unless otherwise specified elsewhere in the Contract and/or unless otherwise instructed by the Employer/Engineer.

Documents comprising several pages shall be provided with a cover page and with a table of contents. All pages shall be numbered and provided with revision index.

All documents shall reserve a free space of adequate size above the title block for an approval stamp.

4.3 Document Format

Documents shall be prepared in a format in accordance with ISO 216, unless specified differently in the Particular Technical Requirements.

Documents in electronic format shall be submitted in searchable Portable Document Format (PDF), preferably generated directly from the native document (scans from hardcopy shall be avoided as far as possible). Documents with more than one page shall be submitted as one data file only and shall be provided with thumbnails (e.g. for the main chapters of the document) to enable navigation within the document. All pages shall be orientated properly (so that main text is horizontally). Documents without proper structure and/or with misaligned pages and/or with inadequate resolution shall be subject to rejection.

Documents prepared electronically shall be submitted, upon request, additionally as native documents. Such native documents shall be provided in an electronic format compatible with the current version of commonly recognized and used application software packages (e.g. docx, xlsx, dwg, dxf, mpp, shp, etc.), as far as possible.

4.4 Document Structure, Reference Designation and Symbols

The document classes, the content of the documents and their basic document structure shall comply with IEC 61355. The designation of the documents shall be indicated as given therein, the build-up shall be carried out according to the basic rules for the management of technical documents, stipulated in ISO 11442.

If not specified differently in the Particular Technical Requirements, the systematic of equipment classification, designation and identification shall follow IEC 81346.

The schematic layout of circuit diagrams and function diagrams shall have the layout and the top-down structure as described in IEC 61082 and IEC 62023. References to control room, protection and other panels shall be included. The symbols in the drawings shall follow IEC 60617 and ISO IEC 81714.

In preparation of and during the kick-off meeting, the Contractor shall introduce its documentation/document management system (structure, document tree etc.).

4.5 Document Schedule

4.5.1 General

The Contractor shall prepare and submit a Document Schedule (in accordance with the Programme) which shall list all project documents, including (without being limited to):

- Project Organization Chart
- method statements for the various portions of the Works
- inventory
- spare parts
- system studies
- design studies
- equipment specifications
- design calculations
- drawings
- manuals
- inspection and test plans, test programs
- test protocols
- Quality Management System
- HSE management/OHS Management Plan (final version to be completed prior to start of construction activities)
- Environmental and Social Management Plan (final version to be completed prior to start of construction activities)
- environmental and social permits/approvals.

The Contractor shall include other documents, reports etc., as necessary to execute the Contract, as well as to meet all performance criteria and other obligations in compliance with the Contract requirements.

The Document Schedule shall indicate the dates the Contractor intends to submit the documents for information, approval and the as-built versions.

The Document Schedule shall be submitted as defined in Paragraph 4.13.1.

4.5.2 Documents for Approval

Documents for approval shall be submitted by means of Document Transmittal Sheets (DTSs). For more information in this regard, reference is made to Paragraph 4.15.2.

As a minimum, the Contractor shall submit the following documents (as far as applicable to the scope of the Works) for approval:

- Programme
- Project Organization Chart
- method statement for civil construction
- method statement for electrical installations, primary and secondary works
- geotechnical study

- topographical survey
- single line diagrams
- substation layouts
- system studies
- design studies
- equipment specifications
- design calculations
- list of manufacturers and subcontractors
- equipment outlines drawings
- substation and building layout drawings
- earthing system drawings and calculation
- lightning protection system drawings and calculation
- SCMS topology and functional description
- protection and control block diagrams and tripping matrix
- LV switchgear and AC/DC supply main single line diagrams
- general structure and layout for surveillance, fire detection alarm systems, etc.
- civil layout and section drawings
- cable routing plans
- steel work drawings
- inspection and test plans
- reports of factory acceptance tests (FATs)
- pre-commissioning tests report
- commissioning tests report
- earthing system test reports, including e.g. touch and step voltage measurements, etc.
- trial operation report
- training program and schedule
- operation & maintenance manuals
- spare parts list
- as built documentation
- CESMP and OHS Plan.

4.5.3 Documents for Information

As a minimum, the Contractor shall submit the following documents for information, through DTSs:

- wiring and connection diagrams, schematics
- cabling plans and schedules
- monthly progress reports
- training manuals.

4.6 Design Drawings

4.6.1 General

Design drawings shall show the equipment and structures to be provided as part of the Works, together with any existing equipment and facilities, as applicable. Existing equipment and facilities shall be clearly distinguished from the equipment and facilities to be provided with the Works (e.g. by using different line style, shading, etc.).

Design drawings shall also show the internal and external connections of all equipment, their designations, terminal numbers, color codes etc. and shall accommodate cross-references to other drawings, as applicable.

Design drawings shall be commonly used for manufacturing, installation and operation of equipment and systems and shall be revised and updated throughout the Contract, as necessary.

Duplication of equipment and systems shall be avoided to prevent contradictions. Drawings with duplications are subject to rejection. For equipment or systems with multiple use, a set of "General Drawings" shall be provided.

4.6.2 Layout Drawings

Layout drawings shall be prepared to-scale, with a scaling factor in accordance with ISO 5455, and shall be provided with scale bar and with a north arrow indicating geographical north and plant north.

Plant layout drawings shall be provided with corner coordinates with clear identification of the coordinates system used.

Layout drawings shall be provided with grid lines and all necessary dimensions shall be indicated with clear reference to facilities, structures, walls, etc. and to corner coordinates, in case of plant layout drawings.

4.6.3 Single line diagram

The single line diagram shall show the essential electrical equipment and connections. All circuits are represented by a single line only. The single line diagram shall contain all required key technical data of the equipment represented, including but not being limited to the following:

- rated voltage and frequency
- rated current of busbars and feeders
- short circuit current and short circuit time
- current – and voltage transformer arrangement with rated transfer ratio, accuracy class, and burden
- clear demarcation of scope, limit of scope, existing equipment (as applicable).

4.6.4 Schematics

Schematics for switchgear, control and protection systems, etc. shall be generated with recognized, CAE tools to ensure consistency between, for instance, circuit diagrams, terminal connection diagrams etc. Unless specified otherwise in the Particular Technical Requirements, the Contractor's or Subcontractors' proven CAE tools shall be used.

External connections and cross-references (external terminals, cable connections etc.) shall be coordinated and shall be included in the master file of the CAE-generated schematics during the design stage. They shall be updated throughout the Contract implementation, through to the as-built stage.

External connections and cross-references shall not be entered in converted documents or files (such as dwg or dxf files), to avoid several versions of the schematics, accommodating contradicting contents.

4.7 Method Statements

Prior to commencing any part of the Works, the Contractor shall submit method statements. This applies to all major works, e.g. survey, piling, earthworks such as excavation and backfilling, de-watering, electro-mechanical works, site tests etc. or any other portion of the Works for which a method statement is requested by the Engineer.

Each method statement shall include a detailed description of the proposed procedure for carrying out the corresponding works, calculations associated with any proposed temporary works, sketches, checklists, equipment and tools to be used, precautions to be taken and other necessary information/descriptions that might be reasonably requested by the Engineer. Special focus shall be given on safety aspects, task risk assessment and risk mitigation measures.

Works carried out without prior submission of a method statement and without obtaining the Engineer's approval of the same shall be at the Contractor's own risk and might be subject to rejection.

4.8 Calculations, Drawings and Tests Requested for Permitting

If not otherwise required in the Particular Conditions of Contract, the Contractor shall prepare all necessary documents (including calculations, designs, drawings etc.) so that permits for the execution of the permanent Works can be obtained.

The Contractor shall ensure that documents are submitted early enough to allow amendments to be made and that resubmission for approval is conducted without delay in the delivery and installation program or the guaranteed completion dates of the Works.

If not otherwise specified in the Particular Technical Requirements, all drawings shall be plotted and shall show the scales of the metric system, and all descriptive wording shall be in both English and in the language of the Country, as defined in the Particular Conditions of Contract (PC) (if different).

4.9 Acceptance Test Procedures and Schedules

The Contractor shall notify any tests to be performed (such as Factory Acceptance Tests, Tests on Completion etc.) and shall submit relevant acceptance test procedures and schedules for approval, not less than 28 days in advance of an acceptance test. The test schedules shall include the following:

- test values
- specified values and
- acceptance criteria
- appropriate tolerances.

In case the Employer and/or the Engineer do not confirm their intention to attend the test within 14 days from the notification, the Contractor may consider that their presence is waived.

During acceptance tests, the test records of previous routine test and/or other acceptance test of the equipment shall be available and ready to be checked for reference.

4.10 Operation and Maintenance Manuals

The Contractor shall provide the following documents in both English and the language of the Country, as defined in the Particular Conditions of Contract (PC):

- equipment operation & maintenance manuals for all equipment and auxiliary systems
- health & safety manual
- environmental and social management manual
- training manuals
- maintenance plan/schedule for recommended (preventive) maintenance
- spare parts list (incl. ordering and delivery specific information) and storage plan.

4.10.1 Equipment operation and maintenance manuals

The equipment operation and maintenance manuals shall contain the following:

- general description of the equipment
- main technical data and characteristics
- interfaces to other systems

- health, safety and environmental instructions, including reference to important rules, regulations and standards
- manufacturer's contact information
- component and material descriptions
- outline and assembly drawings
- connection and wiring diagrams
- installation (assembly) instructions
- operation instructions
- maintenance instructions
- maintenance schedule
- troubleshooting instructions
- spare parts list
- list of tools and consumables.

The maintenance instructions shall be divided into sections describing in detail the preventive maintenance and the trouble shooting procedures (instructions and recommendations).

The Operation and Maintenance Manual shall serve as a comprehensive document and shall include all information, as well as log sheets, required by the operating staff of the Employer to operate the plant safely, and effectively. To this effect, the Operation and Maintenance Manual shall be written clearly and in an easy-to-understand manner. During the Defects Notification Period, the Contractor shall revise and / or update the Operation and Maintenance Manual if and as necessary, should a defect be identified in this context.

The Operation and Maintenance Manual shall be properly bound in booklet form, suitable for day-to-day use.

4.10.2 ESHS Requirements and Health and safety manual

The Contractor shall prepare an Environmental & Social Management Plan (ESMP) including a Project specific Occupational Health and Safety (OHS) Management Plan and health & safety manual and shall submit for review and approval.

The OHS Management Plan and - manual and the procedures etc. described shall comply with applicable national codes and standards as well as with international Environmental, Social, Health and Safety (ESHS) standards, including the fundamental conventions of the International Labour Organisation (ILO) and international environmental treaties, as well as with any additional specifics outlined in the Contracts. In particular, the requirements outlined in Section VII-7 ESHS Specification shall be observed.

The preliminary ESMP and OHS Management Plan shall be submitted as part of the bid.

4.10.3 Training manuals

The Contractor shall provide training manuals for all equipment, auxiliary systems, services etc. included in the scope and in accordance with the Contract requirements.

Along with the manuals, the Contractor shall provide a training schedule, in principle including classroom training and training during factory testing, installation and commissioning.

4.10.4 Maintenance plan/schedule

The Contractor shall provide a maintenance plan/schedule, describing scheduled and preventive maintenance.

It shall include requirements and instructions regarding health & safety, shut down of systems and equipment, shut down periods and other information required to effectively plan, schedule and perform preventive maintenance.

4.10.5 Spare parts list and storage plan

The Contractor shall provide the Spare Parts List and Storage Plan including the following information:

- list of all spare parts including storage locations
- list of all consumables including storage information
- list of (special) tools
- ordering and delivery specific information regarding all spare parts and consumables.

4.11 As-Built Documents

As-built documents shall be prepared and submitted by the Contractor, for the documents agreed in the latest version of the Document Schedule. As a minimum, the document types listed below shall be revised to the as-built status:

- single line diagrams
- substation layouts
- building layouts
- schematics (e.g. for switchgear, protection and control, telecommunication, auxiliary systems, etc.).

Others might be included to the above mentioned, as per the relevant instructions of the Engineer and/or the Employer.

During the preparation of the as-built versions, the Contractor shall keep one original of "red-lines" available on site.

4.12 Final Documentation

The Contractor shall prepare and submit complete Final Documentation of the Works. This documentation shall include all design drawings, calculations, test results, etc. for all delivered and erected parts of the Works. The documents shall be in as-built status, to the extend defined in Paragraph 4.11.

The hardcopies shall be compiled in folders of adequate quality. Each folder shall be properly labelled and numbered and shall be provided with cover sheet and table of contents.

In addition to the hardcopies, electronic copies of the Final Documentation shall be provided in both, portable data format (pdf) and in native format. The files of the electronic copies shall be stored in folders, with a folder structure similar to the structure / table of contents used for the hardcopies.

4.13 Document Submission

Documents and information shall be provided by the Contractor at the times detailed below.

4.13.1 Documentation following Letter of Acceptance

Documentation following Letter of Acceptance or Contract Clarifications	**Preliminary**	**Final**
Programme	before kick-off meeting	as per Contract
Document Schedule	4 weeks	monthly updated
HSE/OHS Policy & Plan	4 weeks	8 weeks
Contract Documents	-	4 weeks
Contract Documents (A5)	-	8 weeks

4.13.2 Documentation following Commencement date

Documentation following Commencement date	**Preliminary**	**Final**
Monthly Progress Reports	-	5 days after the end of the reporting period (month)
Programme	before kick-off meeting	as per Contract

Documentation following Commencement date	**Preliminary**	**Final**
Factory Acceptance Test Program	6 months	monthly updated
Method statements	4 months before scheduled start of activity	before scheduled start of activity
H&S Management Plan	4 weeks	12 weeks
Quality Management Plan	4 weeks	12 weeks
Contractual Environmental Social Management Plant CESMP	4 weeks	12 weeks
Commissioning Test Program	4 months before scheduled start of activity	before scheduled start of activity
Training Program/Schedule	4 months before scheduled start of activity	before scheduled start of activity
Training Material	N/A	at Training
Operation & Maintenance Manuals	4 months before scheduled start of Tests on Comple-tion	4 weeks after Tests on Completion
Final documentation including As-built Documents	-	prior to Taking Over
Completion Report	1 month after Tak-ing Over	prior to Perfor-mance Certificate

All other documents shall be submitted in accordance with the Document Schedule.

4.14 Document Distribution and transmission

The Contractor shall submit/distribute documents as follows, if not advised differently:

Item	Employer		Engineer		Total
	H.O.	Site	H.O.	Site	
Contract Documents	3	2	1	2	8
Contract Documents (A5)	3	2	1	2	8
Correspondence	1	-	1	-	2
Documents for Approval	2	-	0	1	3
Progress Reports	1	-	1	-	2
Special Reports	1	-	1	-	2
Operation & Maintenance Manuals	1	2	1	1	5
Final Documentation	1	2	1	1	5
Other Reports and Submittals	1	-	1	-	2
Completion Report	1	-	1	-	2

The original submission, including the hardcopies, shall be sent to the Employer/Engineer. In parallel, an electronic copy of the entire submission shall be transferred electronically, e.g. via a secure transfer server, portal, cloud etc. to be arranged by the Contractor, subject to approval by the Engineer. The Contractor shall be responsible for the administration and troubleshooting of the system. The Employer/Engineer shall be informed by email when a new submission is uploaded. Unless agreed otherwise, Documents (other than correspondence or DTS) shall not be sent by email and shall not be exchanged via unsecure exchange platforms.

4.15 Document Review and Approval

4.15.1 General

The timing of the submissions shall be in accordance with the updated version of the Document Schedule.

Documents shall be submitted in a logical sequence, starting with documents of general/basic/high level nature, before submitting documents of more specific detailed and lower-level nature. Detail documents submitted out of context and without the related base documents available shall be subject to rejection.

Submissions shall be accompanied by a Document Transmittal Sheet (DTS), clearly marked and as outlined further below.

The Engineer reserves the number of days stipulated in the Contract to review/approve/comment on the submissions.

Should it be found at any time after approval has been given to any documents submitted by the Contractor that the said documents do not comply with the terms and conditions of the Contract or that any details do not comply with any documents submitted previously, then alternations and additions, as may be deemed necessary by the Engineer, shall be made therein by the Contractor and the work shall be carried out accordingly. In such cases, the Contractor shall not be entitled to any time extension or payment.

4.15.2 Document Transmittal Sheet (DTS)

Each formal submission of documents shall be accompanied by a DTS clearly indicating the purpose of the submission:

- for information (FI)
- for approval (FA).

Each DTS shall be clearly identifiable by a DTS number, date and title.

The DTS shall list all documents, drawings etc. included in the submission and it shall include the following information:

- Document/Drawing title
- document/drawing number
- revision number.

A DTS Log shall be kept by the Contractor. This shall be used to track the current status of all DTSs.

4.15.3 Submission & Response Procedure

Each submittal shall contain the following:

- DTS
- hardcopies of the documents (report, drawings, specifications etc.) included in the submission, in the quantities indicated in Paragraph 4.14).

The Engineer will keep a record of all incoming original submissions and the exact date each original submission was received (i.e. the controlling date for the review period). Upon request of the Contractor, the Engineer will be informing the Contractor on those dates of receipt of any submission.

The Engineer's response to any specific DTS will be given by an electronic copy of a relevant letter, or comment sheet, detailing the status, conditions and comments applicable for each document submitted.

4.15.4 Approval Categories

Approval categories shall be as follows:

- "Approved" - AP
- "Approved on Condition" - AC
- "Not Approved" – NA.

"Approved" authorizes the Contractor to commence manufacturing or to proceed with further activities in accordance with the time schedule related to the approved scope.

"Approved on Condition" authorizes the Contractor to commence manufacturing or to proceed with further activities, in accordance with the time schedule related to the approved scope, and based on the conditions detailed.

In cases of "Not Approved", "Approved on Condition", the Contractor shall re-submit revised versions of the concerned documents, addressing and/or incorporating the comments raised by the Engineer. The resubmission shall be performed by means of a DTS and it shall be accompanied by a Comments Compliance Sheet, indicating each comment of the Engineer and how it has been addressed in the context of the resubmission.

The Contractor shall re-submit the entire submission (including the corrected documents) within 28 days for review.

The Contractor is required to implement the approval procedure in the Programme, as required. No impact/delay to the Programme shall be accepted due to Not Approved documents.

5 Quality Assurance

5.1 General

The Contractor, any subcontractor, supplier and manufacturer, shall comply with and meet the quality standards of ISO 9001, ISO 14001, as well as Health and Safety certificate OHSAS 18001 or ISO 45001. Documentary evidence therefore shall be submitted to the Engineer on request.

The Contractor shall prepare and submit a project-specific Quality Plan and a Quality Manual based on ISO 9001, describing the quality-related activities, procedures, steps and measures (including project organization, qualifications and expertise, documents control, quality audits, testing procedures etc.) implemented in the context of the implementation of the Works.

5.2 Quality Plan

The Quality Plan shall specify the relevant quality standards, practices, resources, specifications etc. and the sequence of activities relevant to the particular equipment, deliverables etc., in accordance with the scope of the Works.

The Quality Plan shall define:

- objectives to be attained (characteristics or specifications, uniformity, cycle time, cost, natural resources, utilization, yield etc.)
- process steps that constitute the operating practice or procedures of the organization
- allocation of responsibilities, authority, and resources during the different phases of the process and the Works
- specific documented standards, practices, procedures, and instructions to be applied
- suitable testing, inspection, examination, and audit programs, at appropriate stages
- documented procedure for changes and modifications to the Quality Plan, when a process is improved
- methodology for measuring the achievement of the quality objectives
- other actions necessary to meet the objectives.

The Contractor's Quality Plan shall be submitted for approval and shall, as a major section, address:

- type tests
- routine tests
- special tests
- tests during installation
- Tests on Completion and commissioning.

5.3 Quality Monitoring and Inspection

The Employer/Engineer reserve the right to inspect the facilities of the Contractor, including facilities of subcontractors, manufacturers, suppliers and sub-suppliers, at any time throughout the Works, for the purposes of inspecting and obtaining information on the progress of work.

The Contractor shall provide all reasonable assistance, as might be necessary, regarding visa application, traveling and lodging reservations, in order to enable the Employer/Engineer to visit the facilities and to participate in the tests and inspections, as required.

Before any delivery to site, the Contractor shall submit for review/approval a detailed Inspection and Test Plan (ITP), scheduling the inspections and tests to be performed at the various manufacturers' premises and on site, for each major equipment, plant and the overall Works.

The ITP shall cover all:

- type tests
- routine tests
- special tests
- other factory acceptance tests
- tests during construction and civil works
- Tests on Completion, comprising installation & pre-commissioning tests, commissioning tests and trial operation.

The ITP shall include:

- a schedule or flow chart indicating each inspection and the stages in the manufacturing and erection process where the Contractor proposes inspection shall be carried out
- a short-written description of the method for each inspection
- standards of acceptance, with references to International Standards or Codes where applicable. Where the Contractor's acceptance standards are proposed, copies of such standards shall be provided.

The ITP shall cover all items of equipment and plant to be provided under the Contract, through the manufacturing and erection stages, and shall indicate the salient points of manufacture and/or erection at which the Employer's/Engineer's attendance is foreseen ("Witness/Hold" points in the process).

Formal written notification shall be given 28 days prior to any Witness/Hold point inspection to be performed. This shall be provided along with a test program, enveloping a detailed test procedure, specifying in detail the tests to be performed.

Detailed documentation (e.g. circuit diagrams, flow charts) of the tested equipment/plant shall also be made available, along with formats of the test report which are intended to be used. This detailed test program, and its contents, shall be subject to approval.

If the Employer and/or the Engineer intend to attend any particular test/inspection, they shall provide a notice at least 24 hours prior to the test/inspection itself. The Employer/Engineer may also request an alternative date to be proposed.

Should the Employer/Engineer not request an alternative date, and should they not confirm their attendance, then they might issue a waiver of attendance. In any case, the Contractor may, in such a case, proceed with the concerned test/inspection.

A detailed record of the results of all tests and inspection (including all test records, test certificates, test performance curves etc.) shall be maintained by the Contractor and copies provided to the Employer within a reasonable time after the tests, irrespectively of whether these tests were witness by the Employer/Engineer. Information given on such test certificates and curves shall be sufficient to identify the equipment and software to which the certificates refer and shall also bear the Contractors' reference and heading.

All test reports shall indicate the tests performed, Contract references, the results obtained, instruments used, names of test personnel, and shall accommodate witnesses' signatures. They shall also be numbered and dated.

The Contractor shall also include other tests, inspections and quality arrangements the Contractor deems necessary based on its scope, design and other project specifics, to demonstrate compliance with the requirements of the Contract.

6 Safety Requirements

At any time, the Contractor shall ensure the safety of his own employees, sub-contractors and third parties/public.

The Contractor shall strictly comply with the applicable Occupational Safety and Health (OSH) requirements, and all other applicable international, federal, state and local laws, ordinances, regulations, and other site-specific permits.

In due time and prior to the commencement of any works, the Contractor shall develop a project specific OHS Management Plan

As minimum the OHS Management Plan shall fully address the following aspects:

- scope of work
- roles and responsibilities
- for each task a hazard identification and risk assessment of the hazards
- for each task hazard mitigation procedures and respective work methods
- incident investigation
- reporting, compliance and monitoring.

In due time and prior to the commencement of any works, the Contractor shall develop and implement extended health and safety induction programs for all employees and sub-contractors, on which the OHS Management Plan is thoroughly reviewed.

To mitigate any risks and hazards, the Contractor shall ensure that all his employees and sub-contractors fully understand and adhere to the OHS Management Plan.

During the implementation/construction, the Contractor shall carry out daily job health and safety briefs, involving all the Contractor employees and sub-contractors. These daily job health and safety briefs shall address in detail the risk mitigation steps for the tasks/activities to be undertaken in the following days. The Contractor shall ensure that all his employees and sub-contractors fully understand the risk mitigation steps.

7 Programme

The Contractor shall prepare and submit the Programme (project time schedule) which shall be developed and maintained using recognized standard scheduling tool/software. If not otherwise instructed or allowed by the Engineer, the Programme shall be developed and maintained with e.g. Microsoft Project.

The Programme shall be developed as a Level II schedule (as a minimum), clearly identifying the critical path, 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.

Monthly Progress Reports shall accommodate updates of the Programme. These updates shall be presented with Tracking Gant.

Submission of documents, as outlined in the Document Schedule, shall be in accordance with the Programme.

The Contractor shall be prepared to reasonably coordinate his Programme with the one of the Contractors of other lots and/or interfacing projects, as far as necessary and applicable.

Specifically with regard to the required availability of the connected transmission lines, shut-downs, outages of plant and energization requirements, coordination and early planning with the Employer/Engineer as well as with the Contractors of other lots and/or interfacing projects are required as early as possible. This shall be a major coordination topic during the Monthly Progress Meetings and Programme updates.

It is the entire responsibility of the Contractor to plan and coordinate the necessary commissioning activities and requirements as early as possible, in order to avoid any delays and impact on its own Programme and the schedule of other contractors.

VII-3

General Technical Requirements

Table of Contents

List of Abbreviations

AC	Alternating Current
ASTM	American Society for Testing and Materials
BS	British Standards
CAE	Computer Aided Engineering
CB	Circuit Breaker
DC	Direct Current
DIN	German Institute of Standardization
EN	European Norm
FAT	Factory Acceptance Tests
HV	High Voltage
ID	Identification
IEC	International Electrotechnical Commission
ILAC	International Laboratory Accreditation
ISO	International Organization for Standardization
ITP	Inspection and Test Plan
LV	Low Voltage
MV	Medium Voltage
OHL	Overhead line
OLTC	On Load Tap changer
OPGW	Optical Ground Wire
SI	Système International d'Unités
VT	Voltage Transformer

1 Introduction

The present sub-section provides the General Technical Requirements that apply to the Contract.

These requirements are deemed to be applicable for all aspects of the Works, except for where different, additional and/or special requirements are introduced in the Particular Technical Requirements, the Technical Specifications and/or within the Technical Data Sheets forming part of the Contract.

2 Units of Measurement

The design of the Works, all calculations and measurements, technical schedules, drawings and instrument scales etc. shall be based on the SI (Système International d'Unités) system of units, in accordance with the provisions of ISO 80000.

3 Standards and Codes

All materials and equipment supplied, and all Works performed by the Contractor shall comply in every respect with the relevant codes, standards, accident prevention regulations and legal regulations, especially with those specified in the Particular Requirements and in the Technical Specifications. As a general rule, and unless specified otherwise in the Particular Technical Requirements and/or the Technical Specifications, the technical codes of the International Organization for Standardization (ISO) shall apply. IEC Standards shall apply to the electrical equipment.

As a general requirement, the following IEC standards shall be considered for the electrical system design, equipment arrangement and layout of switchyards, buildings and equipment's rooms:

ISO/IEC 17020	Conformity assessment -- Requirements for the operation of various types of bodies performing inspection"
ISO/IEC 17025	General requirements for the competence of testing and calibration laboratories
IEC 61936-1	Power installations exceeding 1 kV AC and 1,5 kV DC - Part 1: AC
IEC 60364	Low-voltage electrical installations - All Relevant Parts
IEC 60364-7-729	Low-voltage electrical installations - Part 7-729: Requirements for special installations or locations - Operating or maintenance gangways
IEC 62485-1	Safety requirements for secondary batteries and battery installations - Part 1: General safety information
IEC 62485-2	Safety requirements for secondary batteries and battery installations - Part 2: Stationary batteries
IEC 62305	Protection against lightning -All Parts
IEC 60909	Short-circuit currents in three-phase a.c. systems - All Parts

The following IEE standard shall apply as a basic requirement:

IEEE 693	IEEE Recommended Practice for Seismic Design of Substations
IEEE 980	IEEE Guide for Containment and Control of Oil Spills in Substations.

Further ISO and IEC standards related to specific systems and equipment are outlined in the Particular Technical Requirements and in the Technical Specifications.

Other internationally accepted standards may be accepted only if the Contractor provides sufficient evidence that these alternative standards proposed ensure a quality equal to or higher than the standards mentioned above and such alternative standards are subject to approval by the Engineer.

The order of prevalence among standards/codes is presented below:

1. ISO & IEC
2. EN
3. DIN
4. BS
5. ASTM
6. Other internationally accepted standards (as might be accepted).

For all relevant codes, standards, accident prevention regulations and legal regulations, the latest versions, including amendments and corrections, as available at the time the Contractor's Bid was submitted, shall apply.

It is the Contractor's responsibility to ensure that all relevant standards are available and accessible within its organization. For National Codes and Standards, which are available only in the language of the Employers Country, the Contractor is responsible to arrange for translation to the extent necessary to ensure compliance.

4 Plant and Equipment Identification

4.1 Identification System

Each plant and/or equipment shall be identified by an identification number. Designation (description) shall be provided in addition to the identification number where appropriate and/or required, e.g. for feeder designation of electrical panels etc. If not specified differently in the Particular Technical Requirements, the systematic of equipment classification, designation and identification shall follow IEC 81346.

Operating elements (e.g. control switches, circuit breakers etc.), indicating and measuring devices (e.g. signal lamps, voltmeters, ammeters etc.), protection relays etc., shall be identified by their circuit designation number and description. The description shall be precise and shall convey complete and specific information regarding the function of the element (e.g. “Busbar Voltage” instead of “Voltmeter”, “Line Disconnector” instead of “Disconnector”, etc.).

For each item of the plant, there shall be only one description, used consistently for plant, electrical and instrumentation designations.

The classification numbers shall appear in all drawings, lists, documents prepared by the Contractor for the Works, right from the initial stage of the Contract execution.

4.2 Nameplates, Labels

The Contractor shall supply all labels, nameplates and instruction and warning plates, necessary for the identification and safe operation of the plant. If not otherwise instructed in the Particular Technical Requirements, their inscriptions shall be in the ruling language of the Contract and (if different) in the language of the Country.

All labels, nameplates and instruction and warning plates shall be securely fixed to the various items of plant and equipment with stainless steel rivets, plated self-tapping screws or other approved means. The use of adhesives shall not be permitted.

Nameplates for plant/equipment identification and record purposes shall be manufactured from stainless steel with a mat or satin finish and shall be engraved with black lettering of a size which is legible from the working position.

All equipment within panels and desks shall be individually identified by durable labels, subject to approval.

Each switchgear panel, electrical control panel, relay panel, etc. shall have a circuit designation label on the front, as well as on the rear.

For equipment installed in non-accessible positions (e.g. outdoor switchyard equipment mounted elevated on pedestal, CTs and VTs installed in metal clad switchgear etc., additional nameplates shall be provided in an appropriate position so as to be easily legible, e.g. on the equipment frame, on the compartment door, etc.

4.3 Cable Route Markers

The routing of underground pipes and cables shall be indicated by cable route markers showing the relevant information.

Cable route markers shall be provided to identify start, end and any deviation of the cable route, as well as at straight sections of the cable route, as a minimum, every 50 m.

5 Safety and Information Signs

5.1 General

Safety colors, safety symbols and safety signs must comply in construction, geometrical form, color etc. with the latest version of ISO 3864-1.

The signs shall be of a weather-resistant material, of sufficient durability for the conditions prevailing on site.

5.2 Mounting and installation

The positions for the signs shall be chosen so that they are within the field of vision of the concerned persons.

The signs shall be permanently attached. Temporarily dangerous areas (e.g. construction sites, assembly areas) may also be marked by movable signs.

The safety signs must be mounted or installed in such a manner that there is no possibility of misunderstanding.

5.3 Information and emergency signs

Information signs shall convey the necessary information to acquaint the personnel with the physical arrangement and structure of site, buildings and equipment, e.g. floor numbers, load-carrying capacities including marking of floor areas, working loads of cranes, lifting gear and lifts, room identification etc.

Adequate numbers of emergency signs of appropriate size shall be accommodated at escape routes (including marking of floor areas), emergency exits etc. In addition, signs shall indicate the locations of fire alarms and fire extinguishers, locations of first aid equipment and first aid points etc.

In situations not covered by ISO, the possibility of using pictograms shall be considered. Pictograms are particularly suitable for the identification of rooms, areas and buildings in the non-technical parts of the plant (e.g. kitchen, sanitary etc.)

5.4 Mandatory signs

Signs indicating obligatory actions -e.g. do not obstruct the entrance; keep right etc.- shall be provided and installed wherever certain actions are necessary.

Signs shall also indicate when the wearing of protective clothing and equipment is necessary and obligatory.

5.5 Warning signs

Warning signs shall be installed as required, referring to the existence or possible existence of danger, for instance general danger, width/height restriction, steps, risk of trapping, slipping, falling etc.

In addition to warning signs, appropriate black-yellow strip markings shall also be used where necessary.

5.6 Prohibition signs

Prohibition signs, such as no smoking, no fires, no naked lights, no entry to pedestrians, no entry etc., shall be installed as required.

5.7 Signs at electrical operation rooms

Electrical operation rooms (e.g. switchgear rooms, battery rooms etc.) and their access doors must be provided with the necessary warning signs and instructions, as required by IEC 61936-1 and other applicable IEC standards and by the applicable national accident prevention regulations. As a minimum requirement, these shall include the following:

- hazard warning notices
- electric shock first aid treatment procedures and
- the contact number for the nearest hospital.

6 Packing and Marking for Shipment, Transportation

6.1 Preparation for Shipment, Packing and Marking

6.1.1 Preparation and Packing

The Contractor shall prepare all equipment and materials for shipment in such a manner to protect them from damage in transit. In addition, the Contractor shall be responsible for and make good any damage due to improper preparation or loading for shipment.

All parts of the plant shall be packed at the place of manufacture. The packing shall be suitable for shipment by sea and for all special requirements of the transportation to the site. Where necessary, double packing shall be used in order to prevent damage and corrosion during transportation, unloading, reloading and during intermediate storage.

The packing shall be enough to withstand, without limitation, rough handling during transit and exposure to extreme temperatures, salt, and moisture during transit and storage. Packing type and quality shall be adjusted to the remoteness of the goods' destination and the possible absence of suitable handling equipment at all points of transit.

Packing shall be done in convenient sections, so that the weight and size of sections are suitable for transport to the site and for handling at the site, under the special conditions applicable there. Material or equipment for different sites shall not be packed in the same case or package.

All identical members shall be packed together, if reasonably possible, in a form convenient for shipment and handling.

Loose steel structures (or steel structure parts) inside a container shall not be accepted. When container is used for shipping, this shall be of the open-top type. Parts packed together shall be bound by wrap wire of adequate strength so as to withstand lifting. All assembly components, bolts, nuts, washers etc., shall be delivered packed separately inside wooden boxes bearing appropriate marking.

Small items shall be packed in boxes and large items shall be protected, where necessary, by timber, straw and sacking.

Drums shall be used for cables and similar materials. All parts shall be suitably protected against corrosion, water, sand, heat, any adverse atmospheric conditions, shocks, impact, vibrations etc. for later transport and storage.

Tube ends, and other similar open ends shall be protected against external damage and ingress of dirt and moisture during transit and while awaiting erection at site.

Flanged pipes shall have their open ends protected by adhesive tape or jointing and then be covered with a wooden blind flange.

Spare parts shall be packed for long duration storage. Items such as gaskets and seals must be vacuum-sealed packed.

The contents of the cases shall be bolted securely to the case or fastened in position with struts or cross battens. They shall not be wedged in place with wooden shocks, unless these are fastened firmly in place. All struts or cross battens are preferably to be supported by cleats fixed to the case above and below to form ledges on which the batten may rest.

Where parts are required to be bolted to the sides of the case, large washers shall be strengthened by means of a pad.

Where practicable, all equipment intended for indoor use, such as switch- and control-gear, instruments and panels, matching components etc. shall be "cocooned" or covered in polyethylene sheeting, sealed at the joints and the interior provided with an approved desiccant.

Equipment sensitive to mechanical shock (e.g. switchgear panels, transformers) and/or tilting and/or onerous temperatures (e.g. batteries) shall be provided with impact indicators and/or tilting indicators and/or temperature indicators. Such indicators shall be removed only after the equipment is installed in its final position and its removal shall be witnessed by the Engineer.

6.1.2 Marking

Before being packed for shipment to the site, all items of the equipment shall be carefully numbered and marked so that they can be readily assembled and erected in the correct relative positions at the site. Wherever applicable, these numbers and markings shall be punched or painted so that they shall be clearly visible.

In case of several sites, the packing shall be marked accordingly.

In order to facilitate custom examination, all packages and transport documents shall be clearly and indelibly marked, regardless of other markings.

All individual pieces shall be marked with the plant identification number and the correct designation shown on the Contractor's detailed drawings and on other documents, such as packing lists, spare parts lists, operation and maintenance instructions etc.

Marking shall be done identically on labels and by stamping the marks into the metal before painting, galvanizing etc. and shall be clearly readable thereafter.

Each crate or package shall contain a packing list placed in a waterproof envelope. All items of the crate or package shall be clearly marked for easy identification against the packing list.

All cases, packages, etc. shall be clearly marked on the outside to indicate the total weight, the position of the center of gravity and the correct position of the slings and shall bear an identification mark relating them to the appropriate shipping documents.

All stencil marks on the outside of cases shall be either of a waterproof material or protected by shellac or varnish.

6.2 Shipment

Shipment by sea freight shall be made to the designated port of destination. Airfreight shall be made to the destination airport, as agreed with the Employer. Shipments shall be performed as laid down in the Particular Conditions of Contract, especially with regard to shipping documents.

6.3 Unloading, Handling and Storage on Site

The Contractor shall ensure that adequate handling equipment is available to unload the heaviest pieces of equipment.

All equipment shall be properly and neatly stored in designated storage areas and shall be protected to prevent damage or deterioration of any type. Equipment sensitive to solar radiation and/or excessive temperature shall be stored in storage areas taking account of these requirements (e.g. under sunshade, inside shelter, inside air-conditioned rooms, as may be appropriate). Packing of equipment sensitive to dust and / or humidity shall be removed only indoor, at the destination, prior to installation.

The packing materials shall be disposed by the Contractor, unless required otherwise by the Employer.

7 Standardization and Interchangeability

Corresponding parts throughout shall be made to gauge and shall be interchangeable wherever possible.

All equipment performing similar functions shall be of the same type and manufacture to limit the stock of spare parts required and maintain uniformity of plant and equipment to be installed.

The Employer reserves the right to ask for coordination of standardization to the extent reasonably possible.

8 Fire Protection Provisions for Materials and for Building Elements

All equipment, connections and cabling shall be designed and arranged to minimize the risk of fire and any damage which might be caused in the event of fire. Where equipment is normally energized, corresponding precautions, such overvoltage or overcurrent protection, shall be provided to avoid risk of fire in the event of excessive current due to a fault on one of the components in the circuit. This is particularly important where voltages are derived from voltage dropping circuits in which failure of a component could lead to the full supply voltage being applied across other components.

Unless otherwise specified in the Particular Technical Requirements and/or in the Technical Specifications, or unless otherwise agreed with the Employer, the following design principles shall be observed as the minimum fire prevention design requirements:

- Wall penetrations of cables shall be sealed with incombustible material with, as a minimum, the same fire resistance classification as the wall.
- Cable ducts and conduits shall be arranged to avoid the risk that they will be flooded with flammable liquid.
- Covered floor ducts shall be easily accessible for inspection and cleaning.
- All parts of plant and equipment shall be arranged so that no corners or pits difficult to inspect and clean are formed, where flammable matter could collect.
- For the paneling of walls and ceilings, for floor covering, as well as for cubicles and cabinets, incombustible materials shall be used.

Fire escape paths shall comply with IEC 61936 and all applicable local laws and standards.

9 Assembly Material

9.1 General

"Steel structures" are understood within these General Technical Requirements as all substation gantries and equipment supporting structures, including the foundation stubs and the stub setting templates.

"Assembly material" refers to all bolts, screws, rivets, nuts, washers, locking devices etc. which are necessary for the assembly of the steel structures and their accessories, as well as, for the assembling and mounting of the line equipment like insulator sets, conductor and earthwire/OPGW accessories etc.

9.2 Assembly Material

Members of lattice steel, structures including stub-setting templates shall be secured by means of bolts and nuts with approved spring washers and lock washers.

All bolts and nuts shall conform to ISO 898, ISO 4759 and/or to DIN 267, their quality shall not be less than 5.6, and they shall have metric screwed threads. Nuts and the heads of bolts shall be of the hexagonal type. Nuts – except lock nuts – shall be full bearing on one side.

Minimum size of bolts for all structural connections shall be 16 mm diameter in mild steel or 12 mm in high tensile steel.

All bolts and screwed rods shall be galvanized, including the threaded portions. All nuts shall be galvanized except for the threads, which shall be oiled.

Where high tensile steel bolts are used, these shall bear a mark on their head to allow identification of grades.

The nuts of all bolts shall be locked in an appropriate manner. Locking devices and anti-vibration arrangements shall be subject to the approval of the Employer/Engineer. Taper washers shall be fitted where necessary/when so requested by the Employer/Engineer.

Nuts shall be finger tight on the bolt and will be rejected if they, in the opinion of the Employer/Engineer, have an excessively loose or tight fit. Bolts with threads re-dyed after galvanizing will be rejected. Nuts and bolts of the same type shall be interchangeable and supplied from the same manufacturer.

When in position, all bolts or screwed rods shall project through the corresponding nuts, but this projection shall not exceed three threads, unless more length is required for adjustment.

10 Corrosion Protection and Coatings

10.1 General

These technical requirements define the surface preparation, protective coatings and paint systems to be applied by the Contractor on equipment and structures, unless otherwise specified within the Particular Technical Requirements.

All materials and equipment, including paints and thinners, shall be of reputed manufacturers, with international experience and world-wide available products.

All plant and material supplied under the Contract shall be suitably protected by an adequate painting system to withstand any deteriorating impacts caused by the climatic conditions specified in the Particular Technical Requirements.

The general guides for the relevant work, on top of the hereby stated technical requirements, shall be:

- ISO 12944 (all relevant parts) or equivalent standards
- the paint manufacturer's product data sheets with the related instructions.

The Employer shall have the right to choose the color from a color code that shall be prepared by the Contractor.

10.2 Inspection

The materials and equipment used, the methods of application and the quality of work shall always be subject to the inspection and approval of the Employer/Engineer.

The Contractor and, if necessary, the paint supplier or subcontractor shall assist the Employer/Engineer in making any test or inspection when, in the latter’s opinion, such test or inspection is necessary.

At commencement of painting up to a stage ensuring permanent high quality of application and thereafter upon request of the Employer, the paint supplier/subcontractor shall be present at the job site to supervise the application, preparing test patches and to cover questions and problems which might arise.

No consecutive coats of paint, except in the case of white, shall be of the same shade.

To provide proof of quality, various identified and recorded test patches shall be applied. Should any defect arise during the defects’ notification period, which is not reflected in the test patches, the reason will be assumed to be the inadequate workmanship of application.

Should the defect be reproduced similarly in the test patches and the total coated surface, the reason will normally be assumed to be the inadequate quality of the coating material.

For all coating work, samples shall be taken and retained at the job site for possible reference in the event of coating failure. Retained samples shall be kept at least until the defects' notification period has expired.

All paint film thickness quoted in the attached table "Paint Systems" refer to the dry film condition. For final acceptance, a surface area of 10 m^2 per 100 m^2 will be measured. Five (5) measurements of dry film thickness (dft) per m^2 will be taken. Of the fifty (50) single dft-measurements only five (5) may be below 10% of the specified dft.

If results do not meet technical requirements, additional coats shall be applied until the specified thickness is reached.

For measuring the dry film thickness, a non-destructive dry film thickness gauge shall be used.

Usually, the required minimum dry film thickness has to be checked for the complete coating system. In specific cases it is necessary to measure the wet film thickness per coat, for example the prime coats.

After coating work is completed, a general final check of the coating application shall be made. In certain cases (e.g. tar epoxy linings) the finished coating system shall be carefully inspected for pinholes in the paint film by commercial high voltage spark testers.

10.3 Weather Conditions

Painting shall only be done when no condensation occurs on the surface. Therefore, relative humidity shall be checked.

Painting of outdoor parts is not allowed immediately prior and during storms, heavy winds and rain.

In hot weather precautions shall be taken to ensure that the specified dry film thickness of priming or finish coats is obtained.

Any prime coat exposed to excess humidity, rain, etc., before drying shall be permitted to dry and the damaged area of primer removed and the surface prepared and primed again.

10.4 Protective Coatings and Paint Systems

A color scheme has to be established by the Contractor in co-operation with the Employer/Engineer. In this context, the type and number of protective coats for any item requiring painting shall be subject to approval.

Generally, all parts shall receive the specified prime coat(s) at the supplier's works to guarantee that no corrosion occurs during transport to the site and storage at the site. Parts, which cannot be damaged during transport, shall receive the full number of coats in the factory.

10.5 Galvanizing

Galvanizing work shall generally conform in all respects to internationally recognized standards, e.g. EN ISO 12944-5, EN ISO 1461 or equivalent standards and shall be performed by the hot dip process, unless otherwise specified.

Careful cleaning of welds is necessary before welded assemblies are dipped. The welds and the surrounding metal shall be cleaned separately, preferably by sand blasting.

All defects of the steel surface including cracks, surface laminations, laps and folds shall be removed.

All drilling, cutting, welding, forming and final fabrication of individual members and assemblies shall be completed before the structures are galvanized. The surface of the steelwork to be galvanized shall be free from paint, oil, grease and similar contaminants.

Except where specified to the contrary, all iron and steel used in the construction shall be galvanized. Galvanizing shall be applied by the hot dip process. The minimum weight of galvanizing coat shall be as follows:

- 900 g/m^2 (126 µm) on steel sections 5 mm thick and over
- 600 g/m^2 (84 µm) on steel sections 2–5 mm thick
- 500 g/m^2 (70 µm) on bolts and nuts including the threaded portion.

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

All drilling, punching, cutting and bending of parts shall be completed before the galvanizing process is applied.

On removal from the galvanizing bath, the resultant coating shall be smooth, continuous, and free from gross surface imperfections such as bare spots, lumps, blisters and inclusions of flux, ash or dross.

Galvanized contact surfaces to be joined by high tensile friction-grip bolts shall be roughened before assembly so that the required slip factor is achieved. Care shall be taken to ensure that the roughening is confined to the area of the mating faces.

Bolts, nuts and washers, including general grade high tensile friction-grip bolts shall be hot-dip galvanized and subsequently centrifuged. Nuts shall be tapped up to 0.4 mm oversize after galvanizing and the threads oiled to permit the nuts to be finger-turned on the bolt for the full depth of the nut.

No lubricant, applied to the projecting threads of a galvanized high-tensile friction-grip bolt after the bolt has been inserted through the steelwork, must be allowed to meet the mating faces of the steelwork.

Protecting slings shall be used for off-loading and erection.

Galvanized steelwork, which is to be stored during sea transport or at the works on site, shall be stacked so as to provide adequate ventilation to all surfaces to avoid wet storage staining (white rust).

Small areas of the galvanized coating damaged in any way shall be restored by:

- cleaning the area of any weld slag and thorough wire brushing to give a clean metallic surface
- the application of two coats of zinc powder rich paint, or the application of a low melting point zinc alloy repair rod or powder to the damaged area, which is heated to 300°C.

After fixing, bolt heads, washers and nuts shall receive two coats of zinc rich paint. Connections between galvanized surfaces and copper, copper alloy or aluminum surfaces shall be protected by suitable tape wrappings.

10.6 Sprayed Metal Coatings

Solely for repair purposes, corrosion protection can also be achieved by spraying aluminum, zinc, tin, copper, lead or other suitable metals on the surfaces of structures. Composition of coating metals, methods of surface preparation and application of coatings, requirements for thickness and adhesion and subsequent treatment shall conform, e. g. to EN ISO 2063 or equivalent.

10.7 Weathering Steels

The requirements of Standards ASTM-A 242, ASTM-A 588 and EN 10025, EN ISO 12944 or equivalent standards shall be observed in the use of structural steel which is corrosion-inhibited, so-called weathering steels.

11 Quality Control, Inspection and Testing

11.1 General

Hereby, general requirements are prescribed, in relation to inspections and tests of material, parts, equipment and workmanship of the plant during manufacture, assembling and erection and upon completion to demonstrate compliance with the General and Particular Technical Requirements, the Technical Specifications, as well as the applicable codes and standards. The objective is to ensure the overall reliability of plant operation and performance.

Quality Control, Inspection and Testing shall be carried out in accordance with the applicable standards, as defined in the Particular Technical Requirements and Technical Specifications. If no appropriate standards exist, inspection and testing shall be made in accordance with the Manufacturer's/Contractor's standard practice, subject to the approval of the Employer/Engineer. In such cases, the Contractor shall submit to the Employer a complete set of the relevant data and a suggested procedure for the testing to be performed, before manufacture commences.

The Contractor's attention is drawn to the climatic conditions in the site area and at the testing location. De-rating factors are to be in accordance with the relevant IEC codes and standards or an approved equivalent.

Failure on the part of the Employer/Engineer to discover or reject materials or work which do not meet specified requirements shall not be deemed to be an acceptance thereof nor a waiver of defects therein.

11.2 Inspection and testing requirements

Under the Contract, testing requirements are deemed to comprise all testing mentioned here below:

- type tests
- routine tests
- special tests
- other factory acceptance tests
- tests during construction and civil works
- tests on Completion.

The Contractor shall submit, before any delivery to site, an Inspection and Test Plan (ITP), in accordance with the relevant provisions of Project Procedures. Detailed test programs, containing also all relevant documentation prescribing the test procedures, shall also be submitted, again in accordance with the provisions of Project Procedures.

When preparing the ITP and the detailed programs for each and every test/ inspection, the Contractor shall pay due attention to the Employer's Requirements.

11.2.1 Type Test Requirements

All major equipment and components shall be type tested, in accordance with the applicable international standards (their latest versions, including all amendments), by an internationally accredited independent testing laboratory, not associated with the respective manufacturer. Type tests performed at a manufacturer's laboratory and witnessed by an accredited independent third party are also acceptable. Accreditation to the testing laboratory/ third party shall be given by a signatory member of International Laboratory Accreditation Cooperation (ILAC). For high voltage electrical transmission and distribution power equipment (i.e. above 1000V AC and 1200V DC) for which the type tests specified in standards include short-circuit and dielectric verification tests the testing laboratory shall be additional member of Short-Circuit Testing Liaison (STL).

Type test certificates shall be explicitly issued to the manufacturer, shall regard equipment manufactured at an explicit manufacturer's factory location, and shall clearly identify the tested equipment and the standards according to which the type tests have been conducted. The standards in question shall be the same as the ones called for in the Technical Specifications.

Type tests which are issued to the parent company are also acceptable.

The Bidder shall submit a declaration issued by parent company stating that manufacturer's standards, design, quality assurance and manufacturing processes are equivalent to the parent company with respect to the type tests performed.

If the type test certificates are issued in a language other than the ruling language of the Contract, then the Contractor shall provide translations from that other language to the ruling language.

Where compilations of multiple type test certificates and reports are provided, these shall be covered by a comprehensive table of contents, clearly structured by equipment designation, the relevant standards, their sub-clauses and designation of the relevant test.

During the tendering stage, the Contractor shall have already submitted with his Bid type test certificates for all major equipment. During the implementation of the Contract, should the Contractor be willing to make use of other equipment than the one proposed in the context of his Bid, then this other equipment shall also be type-tested and corresponding type test certificates must be submitted along with the proposal of change of equipment.

11.2.2 Factory acceptance tests

All equipment shall be subject to Factory Acceptance Tests (FATs). These shall comprise type tests (if this requirement is not waived in accordance with the previous paragraph), special tests (as required in the Particular Technical Requirements and the Technical Specifications) and routine tests (also including sample tests, as might be required in the Particular Technical Requirements and the Technical Specifications).

The passing of the inspection or test will not, however, prejudice the right of the Employer to reject the equipment components if they do not comply with the technical requirements when erected, or give complete satisfaction in service.

Where the Contractor desires to use stock material, not manufactured specially for the Works, satisfactory evidence that such material conforms to the requirements of the Contract shall be submitted. In this case tests on these materials may be waived, but certificates are to be submitted.

Arrangements shall be made for expediting the shop inspection by having all shop assemblies or pieces covering a single shipment ready at one time. Any packing work as well as transport to the site of the equipment concerned shall not be started before the approval of the Employer/Engineer has been obtained and all certificates due at this time for the equipment concerned have been received and reviewed by the Employer/Engineer.

11.2.3 Inspections and tests during erection and installation

The Contractor is responsible for all safety measures such as barriers, warning signs etc. required for inspection and testing while erection is in progress.

The Contractor is responsible for ensuring that safe procedures are adopted for the use, handling and storage of radioactive sources and an inventory of all sources supplied to the site shall be maintained.

All instruments and apparatus used for site inspection and testing shall be calibrated to an agreed standard at a laboratory of an international standing.

The following checks and tests measurements shall be made during erection, unless otherwise specified in the Particular Technical Requirements, and in accordance with agreed standards:

- checking for complete delivery
- cable route and laying depth inspection
- verification of galvanizing thickness
- torque testing of all screwed and bolted connections
- verification of terminals and terminal connections for correct assembly and compliance with approved for construction drawings and hook-up drawings/lists

- checking of earthing connections and testing of earthing resistance between the equipment and the ground grid, and overall ground grid resistance
- measurement of insulation resistance values on all cables, and continuity and polarity tests on all cables
- verification of fireproof partitioning
- verification of appropriate marking, inscription, and provision of all designation plates
- checking safety signs and warning signs
- checking settings on indicators
- checks on wiring and cabling for compliance with the approved-for-construction circuit-drawings and plans.

11.2.3.1 Earthing system resistance measurement

The earthing system resistance shall be measured during initial installation and immediately before commissioning, but at least once during the dry season, under reasonably dry soil conditions.

The measurements shall be carried out by means of a high frequency earth resistance measuring instrument, in order to allow readings of the impulse resistance value of the earthing system.

The stand-alone grid measurement shall be performed with the earth wires from OHLs disconnected.

The measurements shall be recorded in schedules containing, in addition to the measured ohmic values, details of the surface soil and underground data at the time of tests, the soil resistivity values, and the climatic conditions at the time of the test. Tests shall not be undertaken within 24 hours after any rainfall.

11.2.3.2 Galvanizing thickness

The galvanizing thickness shall be tested on site after receiving the galvanized components, as well as during erection. The zinc coatings shall comply with the thickness requirements defined in the Employer's Requirements.

The Contractor shall have available on site for the Employer's / Engineer's use an instrument suitable for the accurate checking of galvanizing thickness. The measuring instrument shall be available from the time of arrival of the first consignment of steelworks until the issue of the taking over certificate.

If evidence of white rust is apparent upon receipt at site of bundled steel section, the Contractor shall be obliged to undertake all necessary tests to determine the extent of damage, if any, and the necessary remedial measures.

11.2.4 Tests on Completion

11.2.4.1 General

The Tests on Completion shall be carried out by the Contractor, in accordance with the relevant International and national Standards.

The latest by the date/period specified in the Particular Conditions of Contract, or -if no such period/date is thereby stipulated- the latest 3 months before the date at which the Contractor intends to carry out the Tests on Completion, the Contractor shall submit to the Employer/Engineer a comprehensive list of all Tests on Completion. The latter shall be subject to approval.

The latest by the date/period specified in the Particular Conditions of Contract, or -if no such period/date is thereby stipulated- the latest 21 days prior to the date the Contractor intends to carry out the Tests on Completion, the Contractor shall issue a relevant notice, providing confirmation of his readiness to proceed with the tests at the scheduled date.

The Tests on Completion comprise:

- pre-commissioning tests, which demonstrate that each item of Plant can safely undertake the next stage
- commissioning tests, including cold and hot commissioning tests, which shall demonstrate that the Works or Section thereof can be operated safely and as specified, under all available operating conditions
- trial operation, which shall demonstrate that the Works or Section perform reliably and in accordance with the Contract.

As soon as the Works or a Section thereof, have passed all Tests on Completion, the Contractor shall submit a report of the results of these Tests to the Employer/Engineer.

11.2.4.2 Pre-commissioning tests

The pre-commissioning tests comprise the tests to be performed as site tests for the individual primary equipment items.

The pre-commissioning tests include:

- the loop checks to be performed on all circuits for the control and monitoring equipment
- primary and secondary injection tests to verify polarity and compliance with design performance requirements
- transformer winding tests
- AC & DC voltage withstand tests
- completed ground grid resistance tests

- digital low reading ohmmeter tests across all HV conductor joints, HV equipment connections, and MV busbar joints.

Some of the above mentioned may require sections of the control and/or LV system voltages to be available and in operation.

11.2.4.3 Commissioning tests

Commissioning tests comprise cold and hot commissioning tests.

The **cold commissioning tests** consist of, mainly, the tests of subsystems and systems to be performed on each individual item of Plant with the control voltages in operation and may also require a temporary LV voltage source to be available.

Such tests consist of automatic changeover testing, OLTC operation testing, transformer cooling fan sequencing and operation, all interlocking, battery charger performance testing, function and trip testing of all circuit breakers etc. Examples of typical requirements are:

- establishing the AC and DC control voltages and the relevant tests
- verification of local control of the HV and MV equipment, interlocking, sequencing
- startup of the substation control system, remote control of all equipment, inter trip send and receive testing to connected Substations, point-to-point tests with the dispatch center for all data-points
- tests of the protection relays (including tele-protection tests with remote ends)
- tests of the communication equipment (point-to-point tests)
- checking correctness of measurements
- verification of proper performance of the air conditioning system.

The **hot commissioning tests** are conducted during and after energization from the permanent source and typically comprise tests during and after energization, as follows:

Tests during energization:

- energization of all HV, MV, LV equipment
- verification of correct voltage levels and current measurements
- checking and verification of correct phase rotation and sequence
- synchronization tests of CBs (including point of wave device tests)
- checking the operation of the voltage regulators of the power transformer and cooling fan sequencing
- testing the functionality of the protection relays.

Tests after energization:

- performance and load testing
- stability tests of the protection system.

11.2.4.4 Trial operation

The trial operation shall be conducted only after the successful completion of the hot commissioning tests, and it is prescribed in the Particular Technical Requirements.

11.2.5 Facilities for inspections and tests

The Contractor shall provide all the test equipment and test sets required for carrying out the inspection and tests.

All equipment shall have current calibration certification.

Inspection and testing may be performed by an independent testing agency on behalf of the Contractor, following prior approval by the Employer/Engineer.

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Particular Technical Requirements

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List of Abbreviations

AC	Alternating Current
AT	Autotransformer
CT	Current Transformer
DC	Direct Current
EA	Emergency Automation
IEC	International Electrotechnical Commission
LIWL	Lightning Impulse Withstand Level
LV	Low Voltage
OHL	Overhead Line
PE	Protective Earth
SCMS	Substation Control and Monitoring System
SWIL	Switching Impulse Level
TN	Earthed Neutral
USCD	Unified Specific Creepage Distance
VT	Voltage Transformer

1 Introduction

This section details the particular requirements to be considered for the works.

The information provided in this section does not release the Contractor from his obligation to perform all necessary surveys, studies and investigations regarding the locations, the environmental conditions, site access and transportation facilities and local laws and requirements.

2 Location, Environmental and Climatic Data

2.1 Location

Both Lekhnath and Damauli Substations are located in the Gandaki province, in the Kaski and Tanahun district respectively. The distance from the capital city Kathmandu is approximately 135km (Lekhnath) and 105km (Damauli) in northwest direction.

Table 2-1: Substations Locations

Coordinate System **WGS 1984 UTM Zone 45N**	**Lekhnath SS**	**Damauli SS**
Coordinates (approx.)	Easting (m): 210900 Northing (m): 3120600	Easting (m) : 233750 Northing (m) : 3096550
Province	Gandaki	Gandaki
District	Kaski	Tanahun
Nearest city or village	Pokhara	Damauli
Linear distance from Kathmandu	135 km Northwest	105 km Northwest

2.2 Climate Conditions and Environmental Data

2.2.1 Climatic Conditions

Key environmental and climatic data are summarized in Tab 2-2 below. The information provided shall be considered on a purely informative basis.

Electrical equipment shall be designed in accordance with the environmental conditions as defined in IEC 60071-1 and in accordance with the environmental data in Table 3-1 (whichever is the more onerous requirement).

The following table summarizes the basic location, environmental and climatic parameters for the Substations:

Table 2-2 Basic location, environmental and climatic parameters

		Lekhnath SS	**Damauli SS**
Climate type		Sub-tropical	Tropical
Altitude above sea level	m	745	381
Air temperature, max.	°C	40	50

		Lekhnath SS	**Damauli SS**
Air temperature, min.	°C	0	0
Annual average temperature	°C	22	32
Maximum relative air humidity	%	100	100
Average relative air humidity	%	80.9	83.8
Annual average precipitation	mm	3665.66	1459.67
Max. wind speed	m/s	50	50
Max. snow cover	cm	N/A	N/A
Design snow load	kPa	N/A	N/A
Thickness of ice	mm	N/A	N/A
Number of foggy days	days/year	40	40
Isokeraunic level / thunderstorm days	days/year	60	60
Atmospheric pollution	light, medium, heavy, very heavy	Light	Light
Earthquake factor, g	g	0.48	0.48
Earthquake magnitude (Richter scale)	ML	4-6 (light to strong)	4-6 (light to strong)

2.2.2 Seismic Design Requirements

Being located at the boundary between Indian and Tibetan tectonic plates, Nepal lies in a seismically active region.

In particular, both substations fall into a highly active area, where very high earthquake intensity value are likely to be recorded in the coming decades.

All pieces of equipment shall therefore be suitable to such seismic hazard (according to IEEE 693 Figure A.1 - 0.5g). The civil works shall be designed considering an earthquake factor of 0.48g.

2.2.3 Animal Deterrents and Security

Since the two substations will be built in rural, scarcely developed areas, the issue of wild animals entering the substations site should be considered.

When getting in contact with live parts, animals can lead to bridging between phase and ground, causing outages and affecting the reliability and availability of the substation.

The risk of animal bridging usually exists at the low voltage side or distribution portion of the substation, but it can also affect higher voltage equipment (e.g. transformers).

It is therefore recommended that mitigation methods such as barriers (fences, meshes, climbing guards) or deterrents (ultrasonic devices, chemical repellents, sticky gels, predator urine, poisons, spined perching deterrents) be used to minimize the entry of animals inside the substation area.

The risk of bridging, along with wiring and cable deterioration, also exist inside control cubicles, in which small rodents can easily enter if they are not properly sealed. The use of insulation systems such as insulating tapes, heat-shrinkable tubes, insulating covers is therefore recommended.

3 Basic System Values

The basic system values considered throughout these specifications take into consideration the recommendations of IEC 60038, IEC 60071-1, IEC 60071-2 and other relevant IEC publications.

Table 3-1 Basic system values

Parameter	**Unit**				
Nominal voltage of system	kV	220	132	33	11
Rated voltage	kV	245	145	36	12
Rated frequency	Hz	50			
Neutral earthing		Solid grounded			
Installation		Indoor			
Rated Switching impulse withstand voltage: ▪ phase-to-earth ▪ across the isolating distance	kV kV	Not applicable for rated voltages up to 245kV acc. to IEC60071-1			
Rated lightning impulse withstand voltage phase-to-earth	kV	1050	650	170	75
Rated short-duration power-frequency withstand voltage phase-to-earth (1 min)	kV	460	275	75	28
Creepage distance	mm	6125	3625	N/A	N/A
Rated busbar / buscoupler, bus section current Lekhnath SS Damauli SS	A	3150 4000	2500 (existing) 2500	2000 2000	- 1250
Rated feeder current Lekhnath SS Damauli SS	A	2500 3150	2500 (existing) 2500	800 800	- 800
Rated short-circuit withstand current Lekhnath SS Damauli SS	kA	40 40	40 40	25 25	- 25
Duration of short-circuit current	s	3			
Rated peak withstand current Lekhnath SS Damauli SS	kA	100 100	100 100	62.5 62.5	62.5

4 Standards and Codes

In addition to the international standards and codes defined in the VII-3 General Technical Requirements and in VII-5 Technical Specifications, the applicable local laws, standards and codes shall apply.

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Technical Specifications

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List of Abbreviations

AC	Alternating Current
ACB	Air Circuit Breakers
ACSI	Abstract Communication Services
ACSR	Aluminum Conductor Steel-Reinforced Cable
ADB	Asian Development Bank
ADM	Add-and-Drop Multiplexer
ADSL	Asymmetric Digital Subscriber Line
AIS	Air Insulated Switchgear
ALC	Automatic Line Coloring
ANSI	American National Standards Institute
AR	Auto Reclose
ASTM	American Society for Testing and Materials
AT	Autotransformer
AVR	Automatic Voltage Regulator
AWA	Aluminum Wire Armor
BCD	Binary Coded Decimal
BCPU	Bay Control and Protection Unit
BCU	Bay Control Unit
BF	Breaker Failure
BMZ	German Ministry for Economic Cooperation
BS	British Standard
CB	Circuit Breaker
CCR	Central Control Room
CCTV	Closed Circuit Television
CCVT	Coupling Capacitor Voltage Transformer
CD	Chromatic Dispersion
CE	Conformité Européenne
CIP	Carriage and Insurance Paid
CISPR	Comité International Spécial des Perturbations Radioélectriques
CT	Current Transformer
CVT	Capacitor Voltage Transformer
dB	Decibel
dBm	dBmW or decibel-milliwatt
DC	Direct Current / Double Circuit
DC	Direct Current
DGA	Dissolved Gas Analysis
DGU	Diesel Generator Unit

List of Abbreviations

DIN	German national organization for standardization
DMZ	De-Militarized Zone
DS	Disconnector
EBRD	European Bank for Reconstruction
ECC	Emergency Control Center
EHV	Extra High Voltage
ELV	Extra low voltage
EMC	Electromagnetic compatibility
EMF	Electromotive force
EMI	Electromagnetic interference
EN	European Norm
ES	Earthing switch
EU	European Union
EWS	Engineering workstations
FAT	Factory Acceptance Test
FDS	Functional Design Specification
FLR	Front Lateral Rear
FO	Fiber Optic
GIB	Gas Insulated Busduct
GIS	Gas Insulated Switchgear
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HDPE	High Density Polyethylene
HF	High Frequency
HMI	Huna Machine Interface
HPP	Hydro Power Plant
HSE	Health Safety and Environmental
HSES	High Speed Earthing Switch
HV	High Voltage
HVAC	Heating Ventilation Airconditioning
HW	Hardware
IAC	International Arc Classification
ICD	IED capability description
ID	Identification
IDC	Insulation Displacement Connections
IEC	International Electrotechnical Commission

List of Abbreviations

IED	Intelligent Electronic Device
IEEE	Institute of Electrical and Electronics Engineers
IP	Ingress Protection
IP	Internet Protocol
IPR	Intelligent Protection Relay
ISO	International Organization for Standardization
IT	Information Technology
ITU	International Telecommunication Union
LAN	Local Area Network
LCD	Liquid Chrystal Display
LDC	Load Dispatch Center
LED	Light Emission Diode
LILO	Line In Line Out
LSZH	Low Smoke Zero Halogen
LV	Low Voltage
LVAC	Low Voltage Alternating Current
MCB	Miniature Circuit Breakers
MCC	Motor Control Center
MCCB	Molded Case Circuit Breakers
MDF	Main Distribution Frame
MPLS	Multiprotocol Label Switching
MTBF	Mean Time Between Failure
MTTR	Mean Time to Repair
MV	Medium Voltage
MVA	Mega Volt Ampere
NC	Normally Closed
NCC	National Control Center
NEA	Nepal Electricity Authority
NLDC	National Load Dispatch Center
NO	Normally Open
ODAF	Oil Directed Air Forced cooling
ODF	Optical Distribution Frame
OHL	Overhead Line
OHTL	Overhead Transmission Line
OLTC	On-load tap changer
ONAF	Oil Natural Air Forced cooling

List of Abbreviations

ONAN	Oil Natural Air natural cooling
OPGW	Optical Ground Wire
OWS	Operator Workstation
PABX	Private Automatic Branch Exchange
PBX	Private Branch Exchange; currently also usual: IP- PBX
PC	Personal Computer
PD	Partial Discharge
PE	Protective Earth
PEN	Protective Earth Neutral
PIR	Passive Infra-Red detector
PLC	Power Line Carrier / Communication
PMD	Polarization Mode Dispersion
PMU	Synchrophasor Measurement Unit
PTC	Positive Temperature Coefficient Thermistor
PVC	Polyvinyl Chloride
RCD	Residual Current Device
RDC	Regional dispatching center
RIV	Radio Interference Voltage
RMR	Remote Meter Reading System
RMS	Root Mean Square
RTU	Remote Terminal Unit
SA	Surge Arrestor
SAT	Site Acceptance Tests
SCADA	Supervisory Control and Data Acquisition
SCD	System Configuration Description
SCL	Substation Configuration Description Language
SCMS	Substation Control and Monitoring System
SDH	Synchronous Digital Hierarchy
SER	Sequence Events Recording
SF6	Sulfur Hexafluoride
SFP	Small Form-factor Pluggable
SFRA	Sweep Frequency Response Analysis
SI	International System of Units
SLD	Single Line Diagram
SOE	Sequence of Events
SOTF	Switch On to Fault

List of Abbreviations

STM	Synchronous Transport Module
SVL	Sheath Voltage Limiters
SW	Software
SWA	Steel Wire Armor
TCP	Transmission Control Protocol
TCS	Trip Coil Supervision
TDM	Time Division Multiplexing
TL	Transmission Line
TNMS	Telecommunication Network Management System
TRV	Transient Recovery Voltage
TSO	Transmission System Operator
UGFO	Underground Fiber Optic Cable
UHF	Ultra-High Frequency
UMTS	Universal Mobile Telecommunications System
UPS	Uninterruptible Power Supply
USCD	Unified Specific Creepage Distance
UV	Ultraviolet
VA	Volt Ampere
VC	Virtual Container
VDE	German Association for Electrical, Electronic & Information Technologies
VDU	Visual Display Unit
VFTO	Very Fast Transient Overvoltages
VT	Voltage Transformer
XLPE	Cross Linked Poly Ethylene

1 General

All materials and equipment offered and installed shall be brand new, from the manufacturer's normal and standard construction, designed and manufactured according to the latest technological methods, suitable for operation under the specified ambient conditions.

The Contractor will be responsible for ensuring that all relevant safety requirements are observed closely during manufacturing, transportation, assembling, erection, tests and trial operation until final handing over.

2 High Voltage Air Insulated Switchgear (AIS)

2.1 General

The below mentioned paragraphs deal with the high voltage outdoor switchyard equipment for the voltage levels as defined in the Particular Technical Requirements and Technical Data Sheets.

The interlocking system shall include hardware interlocking for local operation directly in primary apparatus.

2.1.1 Standards

In addition to the international standards and codes defined in the VII-3 General Technical Requirements, in VII-4 Particular Technical Requirements and in the Sections below, high voltage switchgear shall comply with the latest editions of the following standards as a general requirement:

IEC 60071-1	Insulation coordination Part 1: Definitions, principles and rules
IEC 60071-2	Insulation coordination Part 2: Application guidelines
IEC 62271-1	High voltage switchgear and control gear - Common specifications
IEC 60273	Characteristic of indoor and outdoor post insulators for systems with nominal voltages greater than 1000 V
IEC 60529	Classification of degree of protection provided by enclosures
IEC 60376	Specification of technical grade sulfur hexafluoride (SF6) for use in electrical equipment
IEC 60296	Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear.
IEC 60815	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions.

2.1.2 Corona and Radio Interference Voltage (RIV)

Neither visible nor audible corona must occur on the equipment at the rated operating voltage. In case of disconnectors, the requirement is valid for the open and closed positions.

All equipment shall be designed and constructed so as not to cause interference with radio reception or telephone communication circuits in accordance with most modern practice, and as generally defined in IEC 62271-1 and CISPR 18-1, CISPR 18-2 and CISPR 18-3. Limits of Radio Interference Voltage are 500 µV for each piece of equipment, measured in accordance with IEC 62271-1.

2.1.3 Primary Terminals and Earth Connections

Primary terminals shall be in accordance with IEC TR 6227-301 and shall be compatible with hardware connections made of aluminum alloy.

For the earthing of the voltage exposed parts, Terminals compatible with copper leads up to 150 mm^2 marked with appropriate graphical symbol, shall be provided. Enclosures shall also be provided with earthing terminal (min. 25 mm^2 Cu).

2.1.4 Mechanical Requirements

Weather exposed metal parts shall be hot dip galvanized or stainless steel or aluminum.

2.1.5 Operating Mechanisms, Cubicles and Junction Boxes

Drive mechanisms, closing and opening actuators, local cubicles and junction boxes shall be located between 0.4 m and 2 m above servicing level.

Cubicles and Junction Boxes shall comply with the requirements for Electrical Cubicles and as detailed below:

Auxiliary switches, which are operated in conjunction with the main contacts, shall be positively driven in both directions; they shall be of class 1 acc. to IEC 62271-1 Table 8. They shall be provided in sufficient quantity as required for control, interlocking and monitoring. As a minimum, fifteen NO and fifteen NC contacts shall be provided and a minimum of three spare NO and three spare NC contacts shall remain available for future.

Motors of the operating mechanisms shall be protected by MCB equipped with alarm contacts for remote indication of trip. Operating mechanisms shall be provided with a padlock with two duplicate keys and LOCAL-REMOTE control selector switch with contacts for control and indication.

2.1.6 Interlocking

All circuit breakers and disconnectors shall be electrically interlocked as required by the switchyard configuration and operational procedures. Furthermore, disconnectors shall be interlocked with their associated earthing switches in such a manner as to allow the disconnectors to be closed only if the earthing switches are open and to allow the earthing switch to be closed only if the disconnectors are open.

In addition, the line earthing switches shall be allowed to close only if no-volt relays, connected to the line voltage transformers, signalize a dead OHL (the relays shall be connected to the same VT core as the distance protection in order to make use of the fuse failure relay).

2.2 Circuit Breakers

2.2.1 Standards

Circuit breakers shall comply with the latest editions of the following standards:

IEC 62271-100	High-voltage switchgear and control gear - Alternating current circuit breakers
IEC 62271-110	High-voltage switchgear and control gear - Part 110: Inductive load switching
IEC TR 62271-300	Seismic qualification of alternating current circuit-breakers
IEC TR 62271-302	High-voltage switchgear and controlgear - Part 302: Alternating current circuit-breakers with intentionally non-simultaneous pole operation
IEC 62271-310	High-voltage switchgear and control gear - Part 310: Electrical endurance testing for circuit-breakers above a rated voltage of 52 kV

2.2.2 Technical requirements

Circuit breakers shall be SF6 circuit breakers of the outdoor type.

Circuit breakers for rated voltages of 400 kV and above shall be of single pole, double or single break per pole type.

Circuit breakers for rated voltages below 400 kV shall be of single pole, single break per pole type. Circuit breakers installed in OHL bays shall be provided with three independent motor operating mechanisms (i.e., one mechanism each pole) or one common mechanism with three separate actuators, whereas the breakers installed in transformer and bus coupler bays can be provided with one motor operating mechanism for three poles.

Circuit breakers for line feeders shall be suitable for single- and three-phase multiple and rapid auto-reclosing.

The three poles of the circuit breakers shall be mounted on a common base frame/support and shall be single-phase operated by separate operating mechanisms, appropriately accommodated on the steel support structure.

2.2.2.1 Operating mechanism

Each circuit breaker shall be equipped with a local control cubicle. The cubicle shall enclose the operating mechanism, the auxiliary contacts, the shunt trip coils for "ON" and "OFF" operation, the terminal blocks and control device for electrical or mechanical local operation of the breaker.

The local control cubicle shall comply with the requirements as outlined und General above and for Electrical Cubicles.

The operating mechanism shall be of motor charged spring type. In addition, it shall be possible to charge the spring manually. The trip signals from the protection relays shall be effective in both positions, LOCAL and REMOTE.

Fail-safe lockouts by direct and mechanically driven contacts shall be incorporated in each circuit-breaker to prevent operation whenever gas density, or driving mechanism hydraulic/ spring pressure, etc. are less than the set values for satisfactory operation of the circuit-breaker, or in case of any endangering irregularity. Corresponding alarm signals shall be provided on terminals for connection to the substation control system.

Each pole of the breaker shall have a mechanical position indicator. The device shall be labeled "ON" and "OFF" and shall be clearly visible.

After failure of power supply to the motor and when fully charged at least one open - 0,3s - close/ open operation shall be possible with the energy normally stored in the operating mechanism.

The maintenance intervals of the driving mechanism shall not be shorter than that of the circuit breaker itself.

The circuit-breaker operating mechanism shall be equipped with a manual closing and tripping device for maintenance purpose only. It shall be effective only in LOCAL operation mode.

The circuit breaker must not be fitted with protective spark gaps.

The circuit breaker shall be fitted with two (2) separate tripping magnets connected to completely independent trip circuits as described under Protection Equipment.

The circuit breaker shall be fitted with an operation counter (one operation corresponding to an operating sequence CO), local control push buttons and selector switch. In case of single pole operation, one counter per pole shall be provided. Operation counters shall be preferably electromechanical and shall be immune against EMF resulting from switching operations.

The circuit breakers shall have either a mechanical interconnection or a control scheme of pole discrepancy in accordance with IEC 62271-100 Clause 5.4 shall be part of the circuit breaker. In the case of the pole discrepancy all circuit breaker poles shall be tripped, and an alarm shall be given.

The circuit breakers shall be fitted with an anti-pumping device in accordance with IEC 62271-100 Clause 5.4, which shall act on each control circuit.

Please refer to the Technical Data Sheets for the full presentation of the required technical characteristics of the circuit breakers.

2.2.2.2 SF6-monitoring

The breaker shall be provided with a two-stage gas monitoring system. The first stage shall give an alarm while the second stage shall block the circuit breaker in the position in which the circuit breaker was at the moment when the gas pressure decreased below the level in question. All devices required for fail-safe operating during conditions of low gas pressure shall be provided.

Replenishing of gas shall be also possible while the circuit breaker is in service.

For refilling purposes, portable SF_6 gas bottles including all required accessories shall be furnished. Sufficient extra gas shall be included for compensation of possible losses during transport and installation. The SF6 valve shall be suitable for taking sample.

2.2.2.3 Point-on-wave controllers

The controllers shall not be installed in the local control cubicle, directly attached to the circuit breaker frame, but in the closest control and protection cubicle.

2.2.3 Test requirements

2.2.3.1 Type test

All type tests for each type of circuit breaker and type tests to be performed depending upon the application, rating or design shall be as per the relevant standard IEC 62271, parts 1, 100, 101, 110, 301, 302 and 310.

In addition, it is required the Type Test for seismic qualification performed in accordance with IEC Standard 62271-300.

2.2.3.2 Factory Acceptance Test

All routine tests, as per IEC 62271 100, shall be performed.

Following tests shall be executed in addition to the applicable standards during Factory Acceptance Test (FAT):

- speed and timing tests for circuit-breakers
- dynamic resistance measurement for circuit-breakers in dependence on IEC 62271-1 clause 7.3, where resistance is recorded during switching operation
- functional tests of all major components

- visual inspection.

During FAT all routine test protocols of the equipment shall be available and ready to be checked for reference.

2.2.3.3 Site Acceptance Test

The following shall be performed in particular:

- visual inspection
- speed and timing tests for circuit-breakers
- functional/ interlocking tests
- voltage drop tests during commissioning
- humidity and purity tests of SF_6 gas in accordance with IEC 60376 and IEC 60480 during commissioning, three months after that, before issuance of Final Acceptance Certificate, and at each refill operation. Critical dew points are subject to the approval of the Engineer.
- gas leakage test on gas insulated equipment with handheld gas leakage detector on all seals.

During SAT all routine test/ FAT protocols of the equipment shall be available and ready to be checked for reference.

2.3 Disconnectors and Earthing Switches

2.3.1 Standards

Disconnectors and earthing switches shall be constructed and tested according to the latest editions of the following standards:

IEC 62271-102	High-voltage switchgear and control gear - Alternating current disconnectors and earthing switches

2.3.2 Technical requirements

The disconnectors shall be suitable for outdoor operation and shall be - if not otherwise stated in the Technical Data Sheets equipped with motorized drives for both, phase contacts and earthing blades. Manual operation shall be possible for maintenance.

Up to the 220 kV voltage level, three single-phase disconnector poles shall be mounted on a common support and shall be operated on a three-phase basis by common operating mechanisms, unless specified differently in the data sheet.

Subject to their position in the respective substation feeder the isolators shall be equipped with one, two or none earthing switches.

The disconnectors' poles shall be coupled mechanically as far as possible, or other measures have to be taken so as to ensure synchronism of the switching motions under all conditions. The disconnectors shall be designed for the specified rated currents.

In case of multiple busbar systems, as e.g. double busbar systems, the maximum possible values of bus-transfer voltages have to be determined. In case the maximum possible values of bus-transfer voltages exceed the values specified in IEC 62271-102 the suitability of the proposed disconnectors has to be proven by the test certificate as an additional type test (or a disconnector with a suitable, higher insulation level has to be selected).

2.3.3 Operating mechanism

The motor operating mechanism shall be equipped with a manual operating device (e.g., handle or crank). During manual operation, the motor operation must be prevented.

The motor operating system must be pulse operated (i.e. once initiated, the motor mechanism shall complete an open or close operation without requiring the initiating contact to be held closed). There must be separate electrical circuits for motor drive, control and interlocking. An actuated control pulse must not affect any operation (neither later) when the motor circuit is non-energized.

2.3.4 Test requirements

2.3.4.1 Type test

All type tests for each type of disconnector shall be as per the relevant standard IEC 62271-102.

In addition to the mandatory type tests, the disconnectors and earthing switches shall have successfully passed the following optional type tests according to IEC 62271-102:

- tests to prove satisfactory operation at temperature limits, sub-clause 6.104
- tests to prove the bus-transfer current switching capability of disconnectors, sub-clause 6.106 and Annex B
- tests to prove the induced current-switching capability of earthing switches, sub-clause 6.107 and Annex C.

2.3.4.2 Factory Acceptance Test

All routine tests, as per IEC 62271 102, shall be performed.

Following tests shall be executed in addition to the applicable standards during Factory Acceptance Test (FAT):

- timing tests for disconnectors and earthing switches
- functional tests of all major components

- visual inspection.

During FAT all routine test protocols of the equipment shall be available and ready to be checked for reference.

2.3.4.3 Site Acceptance Test

The following shall be performed in particular:

- visual inspection
- timing tests for disconnectors and earthing switches
- functional/ interlocking tests.

2.4 Instrument Transformers

2.4.1 General

High Voltage instrument transformers shall be single-phase, designed according to IEC 61869, including all the latest versions of all amendments (in specific IEC 61869-2 for current transformers and IEC 61869-5 for capacitive voltage transformers). The transformation ratio shall be labeled clearly, and the secondaries shall be easily accessible. The characteristics of the Instrument transformers shall be in accordance with Instrument Transformer requirements in chapter Control and Protection Systems and Metering. Cabling shall be in accordance with the requirements in chapter Metering and Protection Cables.

2.4.2 Voltage transformers

2.4.2.1 Standards

All voltage transformers shall be constructed and tested in accordance with the latest editions of the below mentioned standards:

- IEC 61869-1 Instrument transformers - General Requirements for Instrument Transformers
- IEC 61869-3 Additional requirements for inductive voltage transformers
- IEC 61869-5 Additional requirements for capacitive voltage transformers
- IEC 60358-1 Coupling capacitor and capacitor dividers - Part 1 General rules.

2.4.2.2 Technical requirements

Unless specified in particular in the technical data sheets, voltage transformers, for line feeders and busbars, shall be of the any kind of voltage transformer type (Coupling Capacitor Voltage Transformer (CCVT), Capacitor Voltage Transformer (CVT) or Inductive Voltage Transformer, VT).

In case of CVT or CCVT), the capacitor elements shall be enclosed in containers of silicon or brown glazed porcelain, which are assembled to set up the capacitor forming one uniform self-supporting stack. The voltage transformer shall form an integral assembly with the capacitor.

The voltage transformers shall be single-phase, with one end of the primary winding directly earthed. The seal shall be of metallic diaphragm.

The single-phase voltage transformers shall be installed on separate steel support structures.

The secondary windings shall be provided with a miniature circuit breaker (MCB) with auxiliary contacts located in a sheet steel cabinet. Rating and tripping characteristic of the MCB shall be selected adequately to ensure protection of the VT. The connection terminals shall be split in two sections respectively for measuring and for protection. The connection terminal and the MCB of the high accuracy class coil for measuring shall have transparent cover which shall be sealable. The cover shall prevent any unauthorized access to the bolts of the terminals and connections between cables and terminals. The MCB for protection of measuring core shall be also sealable.

In addition to the secondary terminal box at each voltage transformer's base, one weatherproof terminal marshalling cabinet, for each three-phase group of voltage transformers shall be foreseen. This marshalling cabinet shall be mounted on one of the support structures, in a position accessible from ground level. The box and the marshalling cabinet shall ensure adequate prevention of any accidental or voluntary influence on the measurement equipment.

The marshalling cabinets shall contain all necessary terminals to terminate each voltage transformer secondary winding, three-phase and neutral circuit.

Please refer to the Technical Data Sheets for the full presentation of the required technical characteristics of capacitor voltage transformers.

2.4.3 Current transformers

2.4.3.1 Standards

All CTs shall be constructed and tested in accordance with the latest editions of the below mentioned standards:

- IEC 61869-1 Instrument transformers
  - General Requirements for Instrument Transformers
- IEC 61869 2 Instrument transformers
  - Additional requirements for current transformers

2.4.3.2 Technical requirements

The current transformers shall be single-phase, oil type, installed on separate steel support structures. For measuring and protection purposes, the same transformer type, with multiple secondary cores shall be used.

The current transformer shall be completely oil-tight and hermetically sealed by means of bellows, a membrane or an inert gas cushion so that the variations in ambient temperature and loading do not cause severe changes in the internal pressure. The expansion space shall be amply dimensioned to allow for, in addition to temperature fluctuations, oil leakage and filling error. In the case of bellows or a membrane there must be neither air nor inert gas space inside them. There must be neither gaskets nor valves, in the inert-gas cushion space.

The changing of the rated primary current must be obtained without opening the hermetically sealed space.

A bellows or membrane position indicator shall be provided in a current transformer fitted with bellows or a membrane.

A current transformer provided with an inert gas cushion shall be fitted with a liquid level indicator.

There shall be an earthed metallic shield between the primary and secondary winding in order to prevent the high voltage entering into the secondary winding in the case of internal flashover and to reduce the interference voltages transferring to the secondary.

A suitable terminal for earthing of the voltage exposed parts, marked with the appropriate graphical symbol shall be provided.

The connection boxes for the current transformers shall house adequately sized terminals for connection of the secondary windings and outgoing cables. The terminals shall be provided with shorting links. The box shall be sealable for prevention of any accidental or voluntary influence on the measurement circuit. The enclosure of the boxes shall have a class of protection of IP55 W.

The terminals of the windings shall be marked according to IEC standard requirements. The connection terminals shall be split in two sections respectively for measuring and for protection. The connection terminal of the high accuracy class coil for metering shall have transparent cover which shall be sealable. The cover shall prevent any unauthorized access to the bolts of the terminals and connections between cables and terminals.

Suitable metallic cable glands shall be provided in order to enable fixation of cables and cables run through.

2.4.3.3 Test requirements

Type test

All type tests for each type of instrument transformer shall be as per the relevant standard IEC 61869-1.

The CTs and VTs shall have successfully passed the following tests:

- chopped impulse voltage withstand test on primary terminals according to IEC 61869-1 Clause 7.4.1
- multiple chopped impulse test on primary terminals according to IEC 61869-1 Clause 7.4.2
- transmitted overvoltage test according to IEC 61869-1 Clause 7.4.4
- mechanical tests according to IEC 61869-1 Clause 7.4.5
- internal arc fault test according to IEC 61869-1 Clause 7.4.6
- enclosure tightness tests at low and high temperatures according to IEC 61869-1 Clause 7.4.7.

Only type tested instrument transformers are accepted.

Factory Acceptance Test

All routine tests, as per IEC 61869-1, shall be performed.

Site Acceptance Test

The following shall be performed in particular:

- visual inspection
- primary injection test
- power frequency voltage test for auxiliary circuits.

During SAT all routine test/ FAT protocols of the equipment shall be available and ready to be checked for reference.

2.5 Surge Arresters

2.5.1 Standards

High voltage surge arresters shall comply, as a minimum, with the following standards:

- IEC 60099-4 Surge Arresters - Metal-oxide surge arresters without gaps for AC systems
- IEC 60099-5 Surge Arresters - Selection and application recommendations

2.5.2 Technical requirements

The surge arresters shall be of gapless, zinc-oxide, heavy duty type, designed for a nominal discharge current as indicated in the data sheet and shall be equipped with a pressure relief device. For each surge arrester, a surge counter for monitoring the number of operations shall be provided.

The surge arresters shall be hermetically sealed, ensuring a permanently reliable performance of the arresters, irrespectively of the ambient atmosphere.

The impulse spark overvoltage shall be higher than the power frequency spark overvoltage to discharge overvoltage due to earlier switching. However, it must be lower than the impulse test voltage of the switchgear. The arrester shall be capable of diverting the impulse voltage caused by lightning strikes and over voltages due to switching.

The housing of the counter shall be of enclosure type IP55W (dust-tight and hose waterproof). It shall further be installed in the earth conductor of the arrester to make it possible to determine how many times the arrester has sparked over.

Each single-phase surge arrester shall be installed on separate steel structure support, close to the incoming and outgoing lines and close to the transformer bushings.

Please refer to the Technical Data Sheets for the full presentation of the required technical characteristics of the arresters. The values presented thereby must be considered as a rough guide. The Contractor, during engineering stage, shall design and size them in accordance with the insulation coordination study, subject to the Employer’s approval.

2.5.3 Test requirements

2.5.3.1 Type test

All type tests for each type of surge arrester shall be as per the relevant standard IEC 60099-4.

The surge arrester shall have successfully passed the following tests in addition to the standard tests:

Only type tested surge arresters are accepted.

2.5.3.2 Factory Acceptance Tests

All routine tests, as per IEC 60099-4, sub-clause 9.1, shall be performed.

2.5.3.3 Site Acceptance Tests

The Site Acceptance Tests shall be performed in accordance with IEC 60099-4.

During SAT all routine test/ FAT protocols of the equipment shall be available and ready to be checked for reference.

2.6 Coupling Capacitors

2.6.1 Standards

- IEC 60358-1 Coupling capacitors and capacitor dividers - Part 1: general rules
- IEC 60358-2 Coupling capacitors and capacitor dividers - Part 2: AC or DC single-phase coupling capacitor connected between line and ground for power line carrier frequency (PLC) application
- IEC 60481 Coupling devices for power line carrier systems

2.6.2 Technical Requirements

Coupling capacitors shall be oil immersed. The capacitor elements shall be enclosed in containers of silicone or brown glazed porcelain, which are assembled to set up the capacitor forming one uniform self-supporting stack.

The coupling capacitor shall be completely oil tight, and hermetically sealed by means of bellows or an inert gas cushion, so that variations in ambient temperature and loading do not cause severe changes in the internal pressure. The expansion space shall be amply dimensioned to allow for, in addition to temperature fluctuations, oil leakage and filling error. In the case of bellows there must be neither air nor inert gas space inside them. There must be neither gaskets nor valves, etc. in the inert gas cushion space.

An electromagnetic unit shall be equipped with a liquid level indicator.

A local control cubicle shall be provided for the PLC coupling device.

2.6.3 Test Requirements

2.6.3.1 Type test

All type tests shall be as per the relevant standard IEC 60358-1 and IEC 60358-2.

2.6.3.2 Factory Acceptance Test

All routine tests, as per IEC 60358-1 and IEC 60358-2 shall be performed.

2.6.3.3 Site Acceptance Test

The following shall be performed in particular:

- visual inspection
- functional tests.

2.7 Steel Structures

2.7.1 Introduction

This specification covers the design requirements, technical characteristics, manufacturing and testing of steel structures used in the switchyards of outdoor substations to support high voltage equipment, as well as gantry structures.

2.7.2 Standards

The latest editions of the following standards shall be observed and apply, in all relevant respects, for the steel structures and the corresponding fastening material:

EN 10025	Hot rolled products of structural steels
EN 10027	Designation systems for steels
EN 1090	Execution of steel structures and aluminum structures
EN 1993	Eurocode 3: Design of Steel Structures
EN 1994	Eurocode 4: Design of Composite Steel and Concrete Structures
DIN 78	Protrusions of bolt ends
DIN 267	Fasteners
DIN 434	Square taper washers for U-sections
DIN 7989	Washers for steel structures - Part 2: Product grade A
DIN 7990	Hexagon head bolts with hexagon nut for steel structures
ISO 4032	Hexagon regular nuts (style 1) - Product grades A and B
ISO 10721-1	Steel structures - Part 1: Materials and design
ISO 10721-2	Steel structures - Part 2: Fabrication and erection
ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
ISO 7438	Metallic materials - bend test
ISO 148	Metallic materials - Charpy pendulum impact test
ISO 6892	Metallic materials - Tensile testing

2.7.3 Design Requirements

The steel structures shall be of lattice type and the design shall be carried out in accordance with the above-mentioned Eurocode 3 and Eurocode 4. In addition to those, the following requirements shall be met:

- The preparation of design calculations shall include the computation of stresses in all structural components and shall show how all loads are transferred to the foundations.
- Consideration shall be made in sizing members to eliminate excessive deflection or vibration during service. The vertical deflection of main frame beams/girders shall be limited to Span/360. H/300 of main frame columns shall be limited to System Height/300, the lateral deflection in the column span between the end nodes shall be limited to System Height/300.
- The Contractor shall prepare the loading tree for the different structures considering all forces affecting the structures, including required safety factors.

- A safety factor of 2.0 shall apply.
- The data from the loading trees shall constitute the input data for the calculation of profiles, bolts etc. The results of the calculations shall be transposed into assembly and shop drawings.

Where not otherwise imposed by the applicable conditions on site, the steel structures shall be capable to withstand a wind pressure of 180kg/m^2, which corresponds to a wind speed of 150km/h, and with a coefficient of dynamic pressure of 1.5.

2.7.4 Manufacturing and Construction Requirements

The following requirements shall be met:

- All members of the steel structures shall be of structural steel of type S235JR and S355JR.
- Anchoring rods shall be manufactured of hot dip galvanized (at their entire length, including the threaded portion) structural steel of type S355JR. The minimum length of the thread shall be 130mm.
- All members of steel structures shall be hot dipped galvanized in accordance with ISO 1461.
- The boring, cutting and bending of all fabricated steelwork shall be carried out before galvanizing and shall be such as to prevent any irregularity which might cause difficulties in the erection of the steel structures supports on site. Site cutting or drilling of galvanized steel works shall not be done.
- All welding required for the fabrication of column beams and other steel work shall be carried out before the final galvanizing of these members.
- All members shall be marked to facilitate erection. The marking shall be made before galvanizing and shall correspond to the corresponding erection drawings.
- Holes shall be accurately located so that they will be truly opposite to each other when the members are in position and before being bolted up. Drifting of holes shall not be allowed.
- With the delivery of the steel structures, a minimum of 2% additional fastening material / assembling components (bolts, nuts, washers etc.) shall be provided, besides the material required for the erection of the steel structures. This additional material shall be delivered in separate packets.
- Metric thread bolts of class 6.6, in accordance with DIN 7990, shall be used. The minimum diameter shall be 12mm.
- All material shall be hot dip galvanized. Exceptionally, the threads of nuts shall be greased.
- When in position, all bolts or rods shall project through the corresponding nuts only as much as allowed by DIN 78 and, in any case, not more than 10mm.

2.7.5 Test Requirements

The following tests and checks shall be carried out:

- check of chemical composition certificates of the materials used
- galvanizing tests in accordance with ISO 1461, to verify the coating thickness, the mass per unit area, the adhesion strength and the homogeneity of the zinc coating (Table 2-1 below to be observed)
- dimensional checks (verification of main dimensions, cross sections and interchangeability between parts)
- bending tests in accordance with ISO 7438 on samples selected from members of structures of each steel type and of each cross section used
- impact tests in accordance with ISO 148 on samples selected from members of structures of each steel type and of each cross section used
- tensile tests in accordance with ISO 6892 on samples selected from members of structures of each steel type and of each cross section used (Table 2-2 below to be observed)
- for the purposes of verification of the correct construction and good workmanship, the Employer. In addition, the Employer reserves the right to request from the Contractor to assemble at their own (or their selected supplier's/manufacturer's plant, as the case may be) any of the structures that the Employer sees fit.

Table 2-1 Galvanizing tests - minimum requirements

Type of steel part	**Mean value Local coating thickness [µm]**	**Mean value Corresponding mass per unit area [g/m²]**	**Minimum local coating thickness [µm]**
thickness < 1mm	50	360	45
1mm ≤ thickness < 3mm	55	400	50
3mm ≤ thickness < 6mm	70	500	60
thickness ≥ 6mm	85	610	75

Table 2-2 Tensile tests - permitted limits

Tensile test	**S235JR**	**S355JR**
Ultimate breaking≥	340~470 N/mm²	490-630 N/mm²
Yield point≥	235 N/mm²	355 N/mm²
Breaking elongation≥	24%~26%	20%~22%

2.7.6 Packing Requirements

The following requirements shall be met:

- Loose steel structures or steel structure parts inside a container shall not be accepted.
- When container is used for shipping, this shall be of the open-top type.
- Parts packed together shall be bound by wrap wire of adequate strength to withstand lifting.
- All assembly components shall be delivered packed separately inside wooden boxes bearing appropriate marking.

2.8 Busbars Connections and Insulators

2.8.1 Busbar Conductors

2.8.1.1 Standards

Phase conductors, earth wires and materials shall comply as a minimum with the most up to date version of the following standards:

EN50341-1	Overhead electrical lines exceeding AC 1 kV - Part 1: General requirements - common specifications
BS EN 50182	Conductors for overhead lines - round wire concentric lay conductors
IEC 60889	Hard drawn Al wires for overhead line conductors
IEC 61089	Round wire concentric lay overhead electrical stranded conductor
ASTM B232	Concentric lay stranded Aluminum conductors, coated steel reinforced
IEC 61284	Overhead lines – Requirements and tests for fittings

2.8.1.2 Construction requirements

The phase conductor shall be of hard drawn Aluminum (A1), Zinc clad steel reinforced (S1 B) simplex bundle (one conductor bundle), as per the most up to date version of the IEC 61089 following the sizes as defined in ASTM B232.

The main characteristics of the phase conductor shall be as specified in the schedule of technical data.

The conductor surface shall be free from all imperfections visible by an unaided eye.

All wires of the conductor shall be concentrically stranded.

All wires shall lie naturally in their position in the stranded core, and where the core is cut, the wire ends shall remain in position. This requirement also applies to the outer layer of the Aluminum wires of the conductor.

Before stranding the Aluminum and the steel shall have uniform temperature.

There should be no joints in the zinc coated steel wire. No more than one jointed Aluminum wire is permitted in the conductor length.

The conductor materials and current carrying fittings shall be suitable for continuous operation at 80°C without deterioration.

The inner layers of the phase conductor shall be supplied greased. The grease shall protect the conductor from atmospheric corrosion during the conductor service lifetime specified without any specific maintenance required.

Grease shall be applied in accordance with IEC 61089, Annex C, case 2 and shall comply with all the requirements as per indications given in EN 50326 and as specified in the schedule of technical data. The performance of the grease shall be guaranteed by the manufacturer for the temperature range indicated in the schedules of technical data. Grease shall not drop out of conductor under normal operating conditions.

Grease shall be continuously applied to the conductor during manufacturing to all the wires in the inner layers up to the penultimate layer and shall be then wiped.

No grease shall be visible on the outer surface of the conductor.

2.8.1.3 Test requirements

The conductors offered shall be fully type tested as per the relevant standards. Type tests shall be performed according to IEC 61089 as follows:

- stress-strain curves of conductor and steel core according to IEC 61089 sub-clause 6.5.1 and 6.5.2
- tensile test of the conductor according to IEC 61089 sub-clause 6.5.3
- welding of Aluminum wires according to IEC 61089 sub-clause 6.5.4.

2.8.1.4 Sample tests

Samples shall be taken at random according to IEC 61089:

- cross sectional area according to IEC 61089 sub-clause 6.6.1
- conductor diameter according to IEC 61089 sub-clause 6.6.2
- linear density - mass per unit length according to IEC 61089 sub-clause 6.6.3
- breaking strength of wires according to IEC 61089 sub-clause 6.6.4

- surface condition according to IEC 61089 sub-clause 6.6.5
- lay ratio and direction of lay according to IEC 61089 sub-clause 6.6.6.

2.8.2 Tubular Busbars

2.8.2.1 Standards

The proposed busbars and connections shall comply with the General Technical Requirements and shall be in accordance with the following standards:

DIN 43670	Aluminum busbars - design for continuous current
DIN 46276-1	Expansion joints for busbars and flat terminals
EN 755-1	Aluminum and aluminum alloys - Extruded rod/bar tube and profiles - Part 1: Technical conditions for inspection and delivery
EN 755-2	Aluminum and aluminum alloys - Extruded rod/bar tube and profiles - Part 2: Mechanical properties
EN 755-7	Aluminum and aluminum alloys - Extruded rod/bar, tube and profiles - Part 7: Seamless tubes, tolerances on dimensions and form
IEC 60865-1	Short-circuit currents -Calculation of effects - Part 1: Definitions and calculation methods.
IEC 61089	Round wire concentric lay overhead electrical stranded conductors
IEC/TR 62271 301	High-voltage switchgear and controlgear - Part 301: Dimensional standardization of high-voltage terminals

2.8.2.2 Technical requirements

The Contractor shall calculate the required cross-sections of conductors to be used and submit the respective calculations for approval.

For tubular busbars Al or Al Mg Si 0.5 F22 conductors of annular cross-section shall be used. If the tubular busbar consists of several sections, the connections shall be made by clamps and flexible joints allowing the expansion of the busbar. Welding is not permitted.

For the connections, ACSR stranded conductors shall be used except for crossings of roads where Al or Al Mg Si 0.5 F22 conductors of annular cross-section shall be used.

All clamps connecting tubes, stranded conductors, aluminum equipment terminal pads etc. shall be free from copper.

An appropriate aluminum damp cable shall be laid inside the hollow tubes.

Moreover, drain holes of at least 10 mm diameter shall be present at bottom center points of the tubes to facilitate drainage of condensate moisture.

The Contractor shall supply HV-Terminals, joints, clamps and fittings completely prefabricated in any aspect; the terminal pattern shall follow IEC/TR 62271-301.

The Contractor shall keep in account the following safety factors for the bus bars design:

- mechanical stress based on elastic limit or 0.1% proof stress: 2.5
- mechanical stress on complete insulator units: 2.5
- insulator fittings based on elastic limit: 2.5

The diameter of the busbar and conductor tubes shall be such to reduce corona discharges.

The corona inception gradient shall be 18 kV/ cm (rms) or less if it is required by local particular conditions.

2.8.2.3 Factory test requirements

Factory tests, as foreseen in the respective standards, shall be carried out on the tubular and stranded conductors which shall be provided.

In any case, the following tests and checks shall be executed:

- jointing tests
- stress strain curves
- breaking strength
- cross section and overall diameter check
- resistance test
- appearance, finishing and surface condition check.

2.8.3 Post insulators

2.8.3.1 Technical requirements

Post insulators shall be of ceramic material solid core or of composite hollow material, as defined in the Technical Data Sheets and of the outdoor, cylindrical station post type.

The insulators shall conform as a minimum to the applicable requirements of the following standards (latest versions):

IEC 60071 1 Insulation coordination

IEC 60071 2 Insulation coordination

IEC 60273	Characteristics for indoor and outdoor post insulators with nominal voltage higher than 1000 V
IEC 60168	Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1000 V
IEC 60815	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions
IEC 61462	Composite hollow insulators – Pressurized and unpressurized insulators for use in electrical equipment with rated voltage greater than 1 000 V
IEC 62231-1	Composite station post insulators for substations with ac voltages greater than 1 000 V up to 245 kV
IEC 62217	Polymeric HV insulators for indoor and outdoor use
IEC 62772	Composite Hollow Core Station Post Insulators for substations with AC voltage greater than 1000 V and DC voltage greater than 1500 V.

Insulators shall be entirely suitable for operation under the system conditions specified, including system voltage rises.

The minimum cantilever strength of the insulator shall not be less than the maximum force encountered during a full short circuit plus its own weight of insulators and connected equipment.

Porcelain shall be manufactured by the wet process and shall be one piece, non-porous, homogenous and free from cavities or other flaws. The glazing shall be uniform in brown color and free from blisters, burns and other defects and shall meet all relevant requirements of the specified standard.

The equipment under the scope of this specification shall be provided with legible and indelible markings according to relevant IEC standard and shall include as a minimum the following information:

- name or trademark of the manufacturer
- year of manufacture
- reference mark.

As far as possible, post insulators shall be shipped fully pre- assembled. If required in order to facilitate handling and shipping, the post insulators shall be disassembled as far as necessary (e.g., fittings, etc.) and packed separately.

All parts which may be affected by moisture shall be properly, seaworthy and moisture-proof packed.

If not otherwise stated, packing material shall remain propriety of the Contractor.

If there are any special requirements concerning transport, this shall be indicated on the transport packing and in the drawing of the post insulators.

The Contractor shall be responsible for ascertaining the methods and limitations of transport to site.

2.8.3.2 Test requirements

Only type tested post insulators are accepted. Type test requirements shall be as per the relevant standard IEC 60168, respectively IEC 62231.

Special test requirements shall include:

- test for deflection under load according to IEC 60168 sub-clause 5.3
- radio interference test according to IEC 60437
- artificial pollution test according to IEC 60507.

Sample tests as stipulated in the IEC 60168, respectively IEC 62231 standard shall be carried out by the Contractor for several post insulators selected at random from the lot in accordance with IEC 60168, clause 3.4.1. respectively IEC 62231 Clause 10.1

In addition, routine tests, as foreseen in IEC 60168 respectively IEC 62231 shall be performed on all post insulators.

2.8.4 String insulators

2.8.4.1 Technical requirements

For connections of the incoming/outgoing overhead lines to the switchyards, string insulator assemblies on the dead-end gantries shall suspend the respective conductors.

The insulator strings shall be composed of insulator units. Insulator strings shall be of single suspension type and single tension type. The insulator units shall be of cap and pin type, and they shall be made of silicone or porcelain, as defined in the data sheets.

String insulators shall comply, as a minimum, with the following standards:

IEC 60071 1 Insulation coordination

IEC 60071 2 Insulation coordination

IEC 60383 1	Insulators for overhead lines with a nominal voltage above 1000 V - Part 1: Ceramic or glass insulator units for AC systems - Definitions, test methods and acceptance criteria
IEC 60383 2	Insulators for overhead lines with a nominal voltage above 1000 V - Part 2: Insulator strings and insulator sets for AC systems - Definitions, test methods and acceptance criteria
IEC 60305	Insulators for overhead lines with nominal voltage higher than 1000 V AC. for ceramic or glass insulators cap and pin type
IEC 61466-1	Composite string insulator units for overhead lines with a nominal voltage greater than 1 000 V - Part 1: Standard strength and end fittings
IEC 61466-2	Composite string insulator units for overhead lines with a nominal voltage greater than 1 000 V - Part 2: Dimensional and electrical characteristics
IEC 60372	Locking devices for cap and pin insulator units. Dimensions and tests
IEC 60120	Dimensions of ball and socket couplings for sting insulator units
IEC 60815	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions.

The equipment under the scope of this specification shall be provided with legible and indelible markings according to relevant IEC standard and shall include as a minimum the following information:

- name or trademark of the manufacturer
- year of manufacture
- reference mark.

Insulator units

The cap and pin shall be of such design, that it will not yield or distort under the specified mechanical load in such a manner as to change the relative spacing of the insulators or to add other stress to the shells. The insulator caps shall be of the socket type, provided with non-ferrous metal or stainless-steel cotter key. The cap shall be made of good commercial grade, malleable iron or open hearth or electric furnace steel, hot dip galvanized. The cap shall be truly circular, with the inner and outer surfaces concentric and shall be free from cracks, shrinks, air holes, burrs and rough edges, to minimize field concentrations and radio disturbances.

The insulator pins shall be made of malleable iron or drop-forged or machine steel, free from cracks and air holes. All bearing surfaces shall be smooth and uniform to distribute the loading stresses evenly.

The sockets shall be of galvanized, malleable, cast iron and the pin ball shall be made of galvanized steel. The zinc coating shall be smooth, clean, of uniform thickness and free from defects.

Insulators with bent or incorrectly set pins will not be accepted.

Ball and socket connections shall be provided with special designed cotter pins which effectively lock the connection against accidental uncoupling without detracting from its flexibility. The cotter pin shall be of stainless steel or phosphorous bronze.

Insulator strings

Insulator strings shall have ball and socket couplings in accordance with IEC 60120 complete with locking devices in accordance with IEC 60372.

The zinc coating on caps and pins shall comply with the requirements of Section VII-3, General Technical Requirements.

It is a primary requirement that insulators shall provide satisfactory, trouble free, long-term performance in service.

The insulator strings shall be free from visible and audible corona discharge and radio interference at the highest system voltage.

The Contractor shall ensure that the design of all insulators will provide the minimum electrical and mechanical characteristics and the minimum performance requirements as detailed in the Technical Data Sheets.

Fittings

The following fittings shall be considered for single suspension and single tension strings:

- bow shackle
- ball eye link for arching horns
- arcing horn's upper part and down part
- socket eye for arching horn.

Fittings shall be so designed that replacement of units and the arcing protection devices can easily be performed during maintenance.

The fittings shall be dimensioned and designed for the strength and a short-circuit current and duration as stated in the Technical Data Sheets.

The design of all fittings shall avoid sharp corners or projections, which produce high electrical stress in service.

The design of fittings shall be such as to minimize the risk of damage due to vibration.

Fittings shall be manufactured from materials that withstand all possible mechanical loads, vibration, electrical currents and environmental conditions at site. All materials of fittings shall be corrosion resistant and shall not cause corroding of any other parts of conductor and shall not deteriorate in service.

The design of adjacent metal parts and mating surfaces shall be such as to maintain good electrical contact under service conditions. Design of fittings shall avoid welds which are permanently stressed in service.

Insulator strings shall be equipped with arcing devices at both ends of the insulator set. Arcing devices shall protect the insulators from damage from the power arc. The function of the arc protection shall not be significantly affected by the power arc.

As far as possible, insulator strings shall be shipped fully pre- assembled. If required in order to facilitate handling and shipping, the insulator strings shall be disassembled as far as necessary (e.g., fittings, etc.) and packed separately. All parts which may be affected by moisture shall be properly, seaworthy and moisture-proof packed.

If there are any special requirements concerning transport, this shall be indicated on the transport packing and in the drawing of the insulator strings.

If not otherwise stated, packing material shall remain propriety of the Contractor.

The Contractor shall be responsible for ascertaining the methods and limitations of transport to site.

2.8.4.2 Test requirements (as per relevant IEC 60383 1)

Type test requirements shall be as per the relevant standard IEC 60383 1.

Sample tests as stipulated in the IEC 60383-1 standard shall be carried out by the Contractor for a number of insulators selected at random from the lot in accordance with IEC 60383 1 clause 8.

In addition, routine tests, as foreseen in IEC 60383 1 shall be performed on all string insulators.

3 High Voltage Gas Insulated Switchgear (GIS)

3.1 General

The below mentioned paragraphs deal with the high voltage gas insulated switchgear (GIS) for the voltage levels as defined in the Particular Technical Requirements, Technical Data Sheets and single line diagrams included in the Annex.

3.2 Standards

In addition to the international standards and codes defined in the VII-3 General Technical Requirements, in VII-4 Particular Technical Requirements and in the Sections below, high voltage switchgear shall comply with the latest editions of the following standards as a general requirement:

IEC 60071-1	Insulation coordination Part 1: Definitions, principles and rules
IEC 60071-2	Insulation coordination Part 2: Application guidelines
IEC 62271-1	High voltage switchgear and control gear - Common specifications
IEC 62271-100	High-voltage switchgear and control gear - Alternating current circuit breakers
IEC 62271-102	High-voltage switchgear and control gear - Alternating current disconnectors and earthing switches
IEC 62271-110	High-voltage switchgear and control gear - Part 110: Inductive load switching
IEC 62271-203	High-voltage switchgear and controlgear - Part 203: Gas-insulated metal-enclosed switchgear for rated voltages above 52 kV
IEC 62271-209	High-voltage switchgear and controlgear - Part 209: Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV - Fluid-filled and extruded insulation cables - Fluid-filled and dry-type cable-terminations

IEC 62271-211	High-voltage switchgear and controlgear - Part 211: Direct connection between power transformers and gas-insulated metal-enclosed switchgear for rated voltages above 52 kV
IEC TR 62271-300	Seismic qualification of alternating current circuit-breakers
IEC TR 62271-302	High-voltage switchgear and controlgear - Part 302: Alternating current circuit-breakers with intentionally non-simultaneous pole operation
IEC 62271-310	High-voltage switchgear and control gear - Part 310: Electrical endurance testing for circuit-breakers above a rated voltage of 52 kV
IEC 61869-1	Instrument transformers - General Requirements for Instrument Trans formers
IEC 61869 2	Instrument transformers - Additional requirements for current transformers
IEC 61869-3	Additional requirements for inductive voltage transformers
IEC 60270	High-voltage test techniques - Partial discharge measurements
IEC 60529	Classification of degree of protection provided by enclosures
IEC 60376	Specification of technical grade sulfur hexafluoride (SF6) for use in electrical equipment
IEC 60480	Guidelines for the checking and treatment of sulfur hexafluoride (SF6) taken from electrical equipment and specification for its re-use
IEC 60815	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions.

The following latest issues of the Regulations of the European Community (EC) concerning fluorinated greenhouse gases shall be followed regarding the insulation medium SF_6.

- EC 842/2006 Regulation (EC) No 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated greenhouse gases
- EC 1494/2007 Regulation (EC) No 1494/2007 dated 17 December 2007 establishing, pursuant to Regulation (EC) No 842/2006 of the European Parliament and of the Council, the form of labels and additional labelling requirements as regards products and equipment containing certain fluorinated greenhouse gases

- EC 305/2008 Regulation (EC) No 305/2008 of 2 April 2008 establishing, pursuant to Regulation (EC) No 842/2006 of the European Parliament and of the Council, minimum requirements and the conditions for mutual recognition for the certification of personnel recovering certain fluorinated greenhouse gases from high-voltage switchgear

3.3 Technical Requirements

The switchgear encapsulation shall be three- or single-phase design depending on the voltage levels defined in the Technical Data Sheets.

In three phase design the disconnector-earthing switch (three-positioned design) can be situated on the feeder side and in the bus bar compartment, having proved ability to withstand heating due to bus bar rated current flow.

Encapsulation shall be designed in such a manner so as to avoid any effects of VFTO (very fast transient overvoltages).

The switchgears shall be supplied complete with all auxiliary equipment necessary for safe operation, routine and periodic maintenance and repairs, as well as for the storage of used gas prepared for refurbishment.

The switchgears to be supplied shall have rated impulse and power frequency withstands voltages equal to or greater than the specified levels, at the minimum operating SF_6 gas density or pressure.

The actual guaranteed withstand voltages, applicable to the maximum filling pressure at 20°C minimum and nominal SF_6 gas pressures, is given in Technical Data Sheets.

The minimum clearances between phases and from phase to earth at the minimum working density shall be consistent with the specified impulse withstand level. In the event of leakage from any compartment, the equipment shall withstand rated voltage with SF_6 at atmospheric pressure.

For performance assessment, the continuous power frequency withstand voltage with the SF_6 gas at atmospheric pressure shall be stated in the schedules.

The insulation levels shall be able to withstand basic test voltages in accordance with the relevant standards for synchronizing operation for breakers.

Dielectric strength curves of GIS shall be submitted (insulation level in relation to gas pressure).

The switchgear shall operate satisfactorily and safely under all normal and fault conditions. Arc faults shall be positively confined to the originating compartment and shall not spread to other parts of the switchgear. Routine replenishment of insulating gas over the lifetime of the switchgear shall be reduced to a minimum.

The current carrying parts and earthing circuit of the switchgear shall have the ability to carry the specified rated peak withstand current and the rated short time withstand current.

Bus bar connections and enclosures shall be designed to absorb the effects of thermal expansion without application of stress to the supporting structure.

The layout and arrangement of the switchgears shall be made as shown on the drawings and shall fit in the available space. However, the layout may be adjusted as necessary to suit the manufacturer's standard design, subject to the provisions of this specification and the approval of the Employer.

Equipment foundation requirement details, complete with floor and structure fixings and consistent with the switchgear design shall be provided at an early stage in order to be incorporated into the civil works design.

The arrangement of the individual switchgear bays shall comply with the Single Line Diagrams and shall be such so as to achieve optimum space-serving, next and logical arrangement, and adequate accessibility to all external components. Optimized routing for feeder connections shall be taken into account. Space for the later extensions including all necessary equipment and connections shall be foreseen. The arrangement of the equipment offered must provide adequate access for operation, testing and maintenance.

For routine inspections and maintenance, all elements shall be accessible without removing support structures. The removal of individual enclosure parts, or entire breaker bays, shall be possible without affecting the adjacent compartments and bays, respectively, obtaining their continuous operation.

The design of the switchgear bays shall minimize assembly work during installation.

The manufacturer shall submit calculations showing all heat losses of conductors and enclosures to serve as basis for assessing and dimensioning of ventilation / air-conditioning system requirements.

The Contractor shall provide pressure rise calculations for the GIS room at maximum fault current in case of rupture disc opening, to serve as basis for assessing and defining the requirement for pressure relief measures for the GIS building.

Control facilities shall be simple and clearly designated with the respective function and instructions on operation and maintenance shall be unambiguous.

The following provisions shall be made for control and indications:

- Local Control cubicle placed next to equipment for control of circuit breakers, disconnectors and earthing switches complete with electromechanical indications, mimic diagram, and alarm annunciator, as well as the connections to gauges or density monitors.
- Remote control and protection panel in the substation control equipment room.
- Supervisory control from the system control center provision for control of circuit breakers, disconnector, maintenance earthing switches and high-speed earthing switches.
- PD sensors incorporated in the GIS enabling partial discharge monitoring during site testing, routine and maintenance testing
- All necessary local/remote and remote/supervisory control switches, relays, interposing relays and selector switches are to be provided as part of this Contract.
- All main and operating parts of the switchgear shall be suitably labeled; this shall include but not necessarily be limited to primary switches, auxiliary switches, gauges and valves.
- Circuit identifying labels shall be fitted at the front and rear of each individual circuit assembly and on the local control cubicle.

3.4 Safety requirements

The switchgears must offer a maximum degree of safety for the operators and bystanders under all normal operating and fault conditions.

It must be prevented to perform operations which may lead to arcing faults.

The primary design goal shall be to avoid any known reasons for internal arcing. Should it occur, nevertheless, the release of pressurized gas into the atmosphere must occur in such a controlled way that personnel standing at the operating position of the switchgear will not be hurt directly by the gas stream or any part of the release device.

Furthermore, no part of the enclosure, or any loose parts, may be blown away in such an event, and no holes may burn through the enclosure as per IEC 62271-203 paragraph 5.102.2, Table 104, which gives the performance criteria for the duration of the arc according to the performance of the protective system.

High speed earthing switches must be able to make full rated fault current minimum 2 times without exchange of contact system.

Maintenance earthing switches must be able to withstand the specified full rated short circuit current.

Storage springs of breakers and grounding switch actuators must be totally enclosed under normal operating conditions of the switchgear. No moving parts of the switchgear may pose any danger to the operator when standing at his normal operating position.

High-speed spring-operated earth switches shall be discharged in open/close position, they shall be charged when the command to open or close is given.

All interlocking devices that prevent potentially dangerous and – thus - not allowed operations must be constructed such that they cannot be defeated easily. The actual position of isolators and grounding switches must be positively displayed by mechanical indicators visible from the operating position.

3.5 Type of switchgear

The gas insulated switchgears shall be of the SF_6 gas insulated metal-enclosed type suitable for accommodation indoors and gas insulated bus ducts (GIB, if any) shall be suitable for outdoors capable of continuous operation under the climatic conditions existing at the site integrating all necessary components for switching, isolating and monitoring as a compact unit.

The arrangement of the switchgear shall be such that particular emphasis is put on the provision of adequate clearance between chambers in order to facilitate maintenance and later extensions.

The spacing of the feeders shall be provided to allow easy installation of the conductors and convenient access to the cable terminations. Intermediate bus sections shall be installed if the standard feeder spacing does not cope with this requirement.

The design shall include all facilities necessary to enable the performance of the specified site checks and tests. The Contractor shall state the test facilities provided and indicate any attachments or special equipment provided for this purpose.

Circuit breakers, disconnectors, earthing switches, VTs, CTs, cable termination chambers, all and any other chambers and components must be capable of withstanding possible gas overpressure of normal operating pressure continuously.

The pressurized casted or welded aluminum or steel housings shall be designed, and type and routine tested according to IEC 62271-203, EN 50052, EN 50064, EN 50068, EN 50069 and EN 50089.

The gas barriers have to withstand routine testing pressure of 2 x design pressure.

3.6 Temperature rise:

The temperature rise limits shall be in accordance with IEC 62271-203. The switchgear shall be capable of carrying the specified rated current at rated frequency continuously in accordance with normal service conditions as defined in IEC 62271-1.

Any derating to meet site ambient conditions shall be taken into account and declared in the schedules.

Every part of the switchgear shall also withstand, without mechanical or thermal damage the instantaneous peak currents and rated short-time currents pertaining to the rated breaking capacity of the circuit breaker. Rated duration of short circuit given in Technical Data Sheets apply.

The design of sliding type, current carrying connectors and joints shall be such that they meet the afore-mentioned conditions over the full permitted range of movement. Where such joints may be made or adjusted on site, full details of alignment procedure, together with any necessary alignment tools or gauges shall be described in the maintenance manual and included in the supply of special tools.

The maximum temperature of the external surface of enclosures accessible during normal operation shall not exceed 70°C.

3.7 Position indicators

Position indicators shall be provided for all circuit breakers, disconnectors and earthing switches to show whether the main contacts of these switches are in the fully open or closed positions.

Each pole of the breakers, disconnectors or earthing switches shall have a mechanical position indicator. The “ON" and "OFF " positions of the devices shall be labeled according to the regulations of the Country and shall be clearly visible.

If a disconnector or earthing switch is not in the fully open or closed position, an alarm shall be initiated, and electrical operation shall be blocked.

Indicators shall be of a reliable mechanical design and shall be positively driven in both directions by the final drive stage of the contact operating mechanism. Reference marks shall be punched or engraved on the main frame for this purpose. Each indicator shall be clearly visible to operating staff at operating control points and access routes provided under this Contract.

3.8 Enclosures

Manufacturer shall consider in surface treatment, material and protection class selection the influence of local climatic conditions for indoor and outdoor installations.

Equipment supplied shall be capable of continuous operation at the specified ratings without exceeding the maximum temperature rises stated in the appropriate IEC recommendations.

The main enclosures for the SF_6 gas insulated switchgear shall be of aluminum alloy and shall be designed to minimize losses and heating due to circulating currents.

Dimensioning of enclosure shall be such as to safely withstand overpressures caused by internal faults corresponding to maximum fault levels as per IEC 62271-203.

Pressure relief device shall be provided where necessary to prevent excessive pressure rise which could lead to bursting of enclosures and spacers. Circuit enclosures shall be of single phase or three phases depending on the voltage level.

All gas insulated outgoing single-phase connections to cables, SF_6/air or SF_6/oil bushings shall have a phase designation.

Evidence shall be provided to verify that enclosures have been designed and tested in accordance with established pressure vessel codes without encroaching on internationally agreed safety factors for this type of equipment. Each enclosure shall be tested and stamped by the inspecting authority issuing the test certificate that shall be independent from the manufacturer.

Ample provision shall be included for access to the circuit breaker, disconnector and earthing switch contacts for inspection and repair.

Voltages induced in the enclosures (touch voltage) shall not be allowed to exceed safe limits of 70 V. All enclosures containing discontinuity elements shall be earthed around the discontinuity via two (2) low inductive conductors from each side, having the capacity to withstand the same short circuit current as associated conductive parts inside the enclosures

Each enclosure shall be provided with lifting points to facilitate maintenance or repair works.

3.9 Busbars

Each bay shall have at both ends the barrier spacers for disabling the internal arc propagation over the bus bar. The facilities shall be obtained to enable the evacuation and filling or recovery of the maximal gas compartment in the frame of one day working hours.

The expansion joints will be positioned at every other bay to enable assembling and disassembling work, as well as to cover the thermal dilatation of the bus bars and prevent the stresses on the supporting structure.

End of bus bar will be equipped with barrier spacer, I element and end cover to enable the assembling of the future bay without SF_6 gas evacuation under the atmospheric pressure at the neighboring gas compartment.

In multiple bus bar design one bus bar and the last existing bay shall be possible to keep in service during the extension works.

3.10 Circuit breakers

3.10.1 Operating duty and performance

The requirements of IEC62271-100 in respect of type tests, service, operation and the making and breaking of fault currents shall be applied to the specified circuit breakers.

Circuit breakers shall be capable of making and breaking short circuit terminal faults in accordance with the requirements of IEC 62271-100 for the specified fault currents.

Like each bay and components, the circuit-breaker including its drive mechanism unit shall be assembled, adjusted and tested completely in the original factory.

The temperature rise of current carrying parts shall be limited to the values stipulated in IEC standards considering the specified rated current values and the environmental conditions on site.

All current carrying components shall be capable of withstanding these conditions for a time period required in Technical Data Sheets.

The current ratings for the circuit-breakers at ambient conditions shall be as outlined in the Technical Data Sheets.

Evidence shall be provided that enclosures subject to pressures in excess of normal atmospheric pressure during service operation have withstood approved pressure tests without leakage, permanent distortion or any temporary distortion such as might cause mal operation of the circuit breakers.

Each circuit breaker shall be equipped with an operation counter to record the number of operations. Single pole operated circuit-breaker shall have one conventional counter per phase without any electronic parts.

Facilities for measurement of circuit breaker contact resistance and timing tests without removal of covers or SF_6 gas filling shall be provided.

Circuit breakers shall use the SF_6 gas conforming to IEC as the insulating medium, as well as for arc quenching.

Circuit breakers shall operate on the principle of self-generating gas pressure within the interrupter for arc extinction, e.g. puffer type or auto puffer type. A lockout feature shall be incorporated to prevent operation of the circuit breaker whenever the gas pressure falls to a value below which it would be incapable of performing in accordance with its rated duty.

Gas density switches shall be provided for the CB, an alarm shall be incorporated to give indication of falling gas pressure prior to the lockout of the circuit breaker.

Suitable facilities shall be included for gas sampling and for draining and replenishing the gas volume for maintenance. Absorption of moisture and the decomposition products of arcing or discharge in the gas shall be achieved by proper equipment.

Circuit breakers shall be complete with spring or hydraulic-operated mechanisms. Where circuit breakers require other services, these shall be included in the supply and erection of the common services installation at the GIS switchgear and shall include alternative back-up facilities.

Emphasis is placed on reliability of design in order to give long continuous service with low maintenance costs.

3.10.2 Operating mechanism

The circuit breaker operating mechanism shall be power operated and of the type specified. Operation will normally be from a remote or supervisory position, but facilities shall be provided for operation locally by electrical release and by direct manual release from stored energy devices when the circuit breaker is isolated for maintenance. It shall be possible to padlock each local control function in the open position. Operation counters shall be fitted to all circuit breaker mechanisms.

Operating mechanisms to be provided shall be capable for single- or three-phase operations as specified in Technical Data Sheets.

The circuit breakers shall be provided with the facility for mechanical and electrical timing of the contacts. Pole discrepancies shall be less than 3 ms on closing.

The ability of circuit breakers to perform a rapid open-close-open cycle should be demonstrated in test records with oscillogram for opening (tripping) and closing characteristics.

Anti-pumping relays shall be provided to prevent reclosing if the closing coil remains energized and the circuit breaker fails to latch in the closed position or is tripped during closing.

CB fail protection (CB FP) shall be included in the CB control system with function of CB closing inhibit.

Power closing mechanisms shall be recharged automatically for further operations as soon as the circuit breaker has completed the closing operation and the design of the closing mechanisms shall be such that the circuit breaker cannot be operated inadvertently due to external shock forces resulting from short circuits, circuit breaker operation, or any other cause.

Operating mechanisms shall be capable of storing energy for at least one opening and one close-opening operation (O-CO), local to the equipment and without recharging.

Means shall be provided for the local manual "non-electrical" tripping of the circuit breaker, preferably by a shrouded push button and facilities shall be provided for locking off these means of tripping. It shall not be possible to lock mechanically the trip mechanism so as to render the electrical tripping inoperative.

Facilities shall be provided to permit manual slow closing and slow opening of the circuit breaker for maintenance purposes. It shall not be possible to "slow down" or "slow open" a circuit breaker when connected in the normal service condition.

Circuit breakers fitted with DC motor for charging spring-operated closing mechanism shall also meet the following requirements:

When fully charged, the spring mechanism shall have sufficient stored energy to permit the operating sequence O-C-O to be performed following the loss of supply to the charging motor.

The mechanism shall be charged automatically, for further operations, as soon as the circuit breaker has completed a closing operation. The time required to charge the spring shall not exceed 20 s.

The spring shall be fully charged before it can be released to close the circuit breaker. It shall not be possible for the breaker to close whilst the spring is being charged.

Spring closing mechanisms shall be designed in a way that it shall not be possible for a fully charged spring to be released inadvertently due to external shock or vibration caused by the breaker opening under short circuit conditions or any other cause.

The mechanisms shall be provided with means for manually charging the spring. This operation may be carried out with the doors of the cubicle opened. During this process no electrical or mechanical operation of the mechanism shall endanger the operator or damage the equipment.

A mechanical indicating device shall be provided to indicate the state of the spring. The indication shall be visible with the doors of the mechanism cabinet closed. An auxiliary switch shall give the remote indication of "spring discharged".

An indicating device shall be provided at the local control panel and the main control room and also over the supervisory system to indicate a spring failing to be charged by a preset time after circuit breaker closing.

Means shall be provided for discharging the spring when the circuit breaker is in the open position without the circuit breaker attempting to close.

3.10.3 Test certificates

Circuit breakers and all other metal-enclosed switchgear modules like bus ducts, disconnectors etc. shall be covered by type test certificates and complete test reports issued by an accredited internationally recognized independent short circuit testing laboratory, as defined in VII-3 General Technical Requirements, Clause 11.2.1 to certify the satisfactory operation of the circuit breakers at duties corresponding to the rated making and breaking capacities of the circuit breakers. The test duty shall not be less onerous than the requirements of IEC 62271-100 or equivalent.

Requirements of IEC 62271-100, IEC 62271-110, IEC TR 62271-310 and IEC TR 62271-302 (if applicable) in respect of rating, testing, performance and service operations - making and breaking capabilities - shall apply to the specified circuit-breakers.

Rate of rise of restriking voltage:

Attention is drawn to the transient recovery voltage (TRV) requirements of the BS and IEC Standards. Where not specifically stated in the test certificates submitted, the Bidder shall certify that the TRV to which the circuit breaker was subjected during the short circuit tests was the most severe condition that could be imposed by the available test plant for first pole-to-clear factor specified in Technical Data Sheets.

Drawings and data with respect to C.B. operation shall be submitted as per requirement of IEC standards.

Interrupting duties:

Apart from the requirements for interrupting terminal faults, all circuit breakers shall be capable of coping with the interrupting duties produced by the switching of low inductive currents associated with reactors and transformer magnetizing currents, and by the switching of capacitive currents associated with overhead line, cables and capacitor banks as may be applicable according to IEC 62271-100. Circuit breakers for these duties shall be of the restrike-free type only.

All circuit breakers shall also be capable of interrupting currents associated with short-line faults and the out-of-phase switching conditions that may occur in service.

Fault clearance time:

The overall fault clearance time including relay operating time shall be in accordance with the requirements specified.

3.11 Disconnectors and earthing switches

Disconnectors and Earthing Switches shall be of the metal enclosed design and shall generally comply with the requirements of IEC 62217-102 and 62271-203.

Isolating and earthing switches shall be arranged to permit safe maintenance of any section of the equipment when the remainder is alive. Disconnectors shall be arranged for operation while the equipment is live but will not be required to break current other than the charging currents of an open circuit breaker line.

Disconnectors shall be housed in compartments partitioned from the circuit breakers.

It shall be possible with such partitioning and with the disconnector compartments maintained at full gas pressure, to carry out high voltage insulation withstand tests on outgoing circuits, without taking adjacent equipment out of service.

Disconnector and earthing switch operating mechanisms shall comply with IEC 62217-102 and shall be of robust construction, carefully fitted to ensure free action and shall be unaffected by the climatic conditions at site. Mechanisms shall be as simple as possible and comprise a minimum of bearing and wearing parts.

They shall be so designed that the disconnector/ earthing switches cannot be opened by forces due to currents passing through them and shall be self-locking in both, the "open" and "closed" positions. The mechanism shall open and close all three phases simultaneously.

Power operated drives shall be provided suitable for local, remote and supervisory control and shall be fitted with a removable, manual emergency switch.

The mechanisms shall be capable of being locked and secured by padlock in the open or closed position with the motor automatically disengaged.

For supervision purposes the local control panel shall be equipped with position indicators. Nevertheless, local mechanical position indicators shall be provided for all disconnectors and earthing switches and shall be visible from ground level or from a suitable platform included in the scope of supply.

The mechanisms shall be electrically operated with provision for local manual operation. The contacts of these earthing switches shall have the same fault making capability as that of the circuit breaker. The operating mechanism of disconnector and the maintenance earthing switches shall be motor driven.

In the event of driving motor failure, means for hand operation shall be provided which are operable from ground level or walkways provided.

In case, power supply fails in the middle of operation, the driven motor shall not restart upon resumption of power and the disconnector/earthing switch shall be operated, manually only.

All earthing switches shall be assembled so that they may be used to facilitate such tests as CT primary injection, contact timing and voltage drop measurement without the necessity to open gas filled compartments and with a minimum use of tools and special fittings. Detailed means of performing these tests shall be provided.

The earthing cable of these earthing switches shall be fed through a bushing, insulated to at least 10 kV DC and connected to earth through a removable earth strap.

Each disconnector/earthing switch shall have its own separate power and control supply.

Each disconnector and earthing switch shall have viewing windows to inspect the main contacts.

3.11.1 Disconnectors

The nominal current ratings of disconnectors shall be correlated to the adjacent circuit breaker ratings (please refer to the Technical Data Sheets).

The disconnectors shall have a short time withstand current as specified in the Technical Data Sheets). Disconnectors shall be arranged to permit safe maintenance of any section of the equipment when the remainder is live.

Disconnectors shall be provided with motor driven mechanisms, operated from a low voltage DC supply and shall open and close all three phases simultaneously. It shall not be possible for the disconnectors to open or close inadvertently due to forces which may occur under operational or under short-circuit conditions.

All disconnectors shall be fully interlocked with associated circuit breakers, to ensure safe operation of the equipment under all service conditions. For maintenance purposes, the earthing switches shall be closed and remain locked in this position until the maintenance will be finished. Mechanical and electrical interlocking is required for maintenance and operation.

The insulation level for the isolating distance between disconnector contacts shall be higher than that for the remainder of the equipment as per IEC 62271-203. Disconnectors shall be capable of switching bus charging currents when shunted by a parallel path and capacitance charging currents associated with open bus bar, bushings and capacitor voltage transformers as per IEC 62271-102.

The Contractor shall submit the type test certificate and report to confirm that the disconnectors are able to carry out a load transfer at full load from one bus bar to the other without any reduction or interruption of load.

If the disconnectors are expected to generate fast rising transients during interruption of capacitive currents, adequate protection shall be provided for transient voltage control.

3.11.2 Maintenance earthing switches:

Earthing switches integrally mounted with disconnectors or separately mounted shall be provided for earthing in order to enable safe maintenance. Motor operated mechanisms shall be provided and operated by low voltage DC, but it shall be possible to operate the switch manually in emergency conditions.

The earthing switch shall have a short time withstand current, as specified in the Technical Data Sheets. No burning or welding of contacts shall occur.

Provisions for testing purposes shall be incorporated in the design of earthing switch to facilitate primary current injection tests and other low voltage checks. Fully insulated designs of earthing shall incorporate removable earth links, suitable for the short-time current rating specified. It shall be possible to apply maintenance earths on either side of the test zone for safety reasons.

All earthing switchgear shall be interlocked with associated circuit breakers and disconnectors so that it shall not be possible to close an earthing switch onto a live circuit or to make the circuit alive when the earthing switch is closed.

Facilities for padlocking earthing switches in the open and closed positions shall be provided together with means for isolating the motor drives.

3.11.3 High speed earthing switches:

High speed earthing switches shall comply with the requirements of IEC 62271-104 and IEC 62271-203.

These earthing switches shall be capable of making short circuit current and suitable for high-speed power operation. It shall be impossible to slow-close these earthing switches.

High speed earthing switches shall be fully type tested and shall be capable of withstanding the rated peak withstand current and sustaining the rated short-circuit current of the switchgear. They shall be located at all line feeder terminal points and bus bars or other location where there is no certainty that the point to be earthed is not energized. Power mechanisms operated by LV DC shall be self-locking in both open and closed positions.

Additionally, to switchgear internal interlocking, the feeder high speed earthing switches shall be interlocked against closing to voltage with the opposite switchgear disconnectors in the same substation or in overhead line bays using the feeder voltage transformers. In case these interlocking possibilities are not available for cable connection, tenderer shall provide capacitive voltage sensors in the cable end unit compartment to ensure interlocking and indication for all three phases in local control cubicles if available for the specified voltage level.

High speed earthing switches shall be capable of making and breaking small induced inductive and capacitive currents, as may be necessary to operate the earthing switches for earthing of one out of two or more long parallel lines.

Facilities integral with the earthing switch for primary current injection or low voltage checks shall be insulated from earth and incorporate a disconnectable earth strap.

These earthing switches shall otherwise be in accordance with the requirements for maintenance of earthing switches.

3.12 Current transformers

The current transformers to be supplied shall be suitable for the duty specified and comply with the requirements of IEC 61869 and IEC 61869-2 as appropriate.

Current transformers shall be of the toroidal core type, compatible with the switchgear.

Current transformers characteristics shall comply with the requirements of chapter Control and Protection. Where separate terminal boxes are used for current transformer's secondary wiring, the current transformer rating plate shall be fitted to the terminal boxes in a visible position but not on removable covers.

Current transformers including primary conductors shall have a short time current rating and duration not less than that of the associated switchgear. All current transformers shall have sufficient overload capacity to permit continuous operation with currents up to a value of the rated current of the associated equipment specified in the Technical Data Sheets.

Secondary windings of each current transformer shall be earthed through a disconnectable link at one point only, as defined in chapter Control and Protection.

Current transformers for tariff metering shall not be used for any other purpose. Current transformers for statistical metering may also be used for other instruments except for protection.

Where double ratio secondary windings are specified, a label shall be provided at the secondary terminals of the current transformer, indicating clearly the connection required for either ratio. These connections and the ratio in use shall be shown on the appropriate schematic and connection diagrams.

CT design calculations shall be submitted for approval.

For multi ratio current transformers, it shall be possible to select either ratio for each winding without alteration to the number of primary turns. All connections from secondary windings shall be led out and taken by means of separate insulated leads to a terminal board mounted in the local control cubicle.

Please refer to the Technical Data Sheets for the required technical characteristics of current transformers.

The characteristics of current transformers used for protection circuits shall be fully compatible with the protection relays and shall include the following requirements:

- For overcurrent protection, they shall not saturate, change ratio or produce harmonic voltages in the secondary winding, which will affect the accuracy of the relay with primary currents up to rated full load current as specified in the Technical Datasheets or maximum through fault current, whichever is higher.
- For earth fault protection and balanced forms of protection, when connected as in service, they shall not produce spill currents in excess of half the minimum operating current of the relay but provide stable equipment with primary currents up to rated full load specified in Technical Datasheets or maximum through fault current whichever is higher.
- Provision shall be made to carry primary injection test of bushing CTs for 100% rating.

The terminal board for CT connection shall have shorting, testing and disconnecting facilities which shall allow tests to be conducted with the circuit on load and which may be operated without disturbing the wiring.

It shall be possible to carry out primary injection testing of CTs with 100% rating when the switchgear is fully assembled or re-testing of the CTs during the service life of the switchgear without interruption of supply to adjacent circuits or any part of bus bar. The access for primary injection facilities for site testing shall be clearly identified.

Where it is required to accommodate free issue current transformers, the Contractor shall advise the limitations as to types and sizes of current transformers which can be accommodated and material limitations for the transformer to be compatible for use in SF_6 gas.

The secondary windings of each set of current transformers shall be capable of being open circuited as per IEC standards. The secondary wiring of all CTs shall be brought up to a common terminal block located within the local control cubicle.

The magnetization characteristic of all current transformers shall be checked up to 100% current rating to identify the current transformers with reference to the manufacturer's design curve. Special measures may have to be taken to ensure that the core is fully demagnetized before commencing the test.

CTs for protection shall not be used for metering. CTs for protection and metering shall be physically separate.

The rated short time thermal current on all taps shall not be less than the through fault capacity of the associated circuit breakers.

The characteristics of current transformers shall be submitted for approval, together with details of the protection, instrumentation or measuring equipment with which each current transformer is to be used. Each current transformer shall be capable of providing the necessary output to operate the related devices satisfactorily at the burdens involved.

All technical parameters are specified in the Technical Data Sheets.

Current transformers may be provided with extended current rating as defined in the Technical Data Sheet, in accordance with IEC 61869-2, up to an equivalent primary current rating not exceeding that of the associated switchgear circuit current rating.

The magnetic characteristics of the CTs of the circuit of each group shall be appropriate for the optimum operation of the protection system.

The polarity of the primary and secondary windings of each transformer shall be clearly indicated at the respective terminals and in addition, labels shall be fitted in a readily accessible position to indicate the ratio, class and duty of each transformer winding.

Current transformers shall be located as shown in the Single Line Diagrams.

3.13 Voltage transformers

Primary connections shall have the same short time current rating as the associated switchgear.

Voltage transformers shall be of dry type, compatible with the switchgear and shall not contain any hygroscopic insulating material which could affect the SF_6 gas in either the voltage transformer or in the associated switchgear chamber.

Voltage transformers shall comply with the common sections of this Specification, with the requirements of IEC 61869-1, IEC 61869-3 for inductive VTs and IEC 61869-5 for capacitive VTs and shall be provided with secondary windings, as specified in the Technical Data Sheets.

The rated star connected secondary voltages per phase and delta connected windings (if any) shall be as specified in the Technical Data Sheets including the rated voltage factor for continuous and short time overvoltage value.

The ratio and phase angle error of the voltage transformers shall not exceed the permissible values specified in IEC standard.

Voltage transformers (VT) shall be rated for the highest equipment voltage per Technical Data Sheets.

Voltage transformers shall be preferably integrated with the compact switchgear system and they shall be compatible with the switchgears. Facilities for isolating the primary connections without having to remove the VT from the switchgear are required.

It shall not be possible for voltage transformer's secondary windings to be connected directly in parallel, except through interposing voltage transformers associated with a synchronizing scheme. To prevent any possibility of back energizing a VT secondary winding via synchronizing circuits, circuit-breaker auxiliary contacts which are of the late make-early break type shall be employed.

Voltage transformers shall be capable of carrying continuously, without thermal damage, over-load specified in the Technical Data Sheets.

Voltage transformers shall be included in the protected zone provided by the feeder protection.

The secondary windings shall be protected by a miniature circuit breaker (MCB) with auxiliary contacts. Rating and tripping characteristic of the MCB shall be selected adequately to ensure protection of the VT.

The circuits for each main protection scheme shall be segregated in separate multi-core cables from the VT to the protection panels. An alarm (VT failure) shall be provided for each set of MCBs.

The neutral point of each voltage transformer's secondary circuit shall be earthed at one point only at the local control panel via a separate removable link of approved design. The earth link shall be situated in an accessible position and shall be suitably labeled.

The location of the voltage transformers to be installed on the primary switchgear shall be approved by the Employer/Employer's Representative.

The VT shall be completely gas insulated; the compartment shall be isolated from the adjacent gas compartments having separate gas supervision.

Mechanical shock recorders shall be fitted to VTs prior to dispatch from the factory, to indicate how the VT was handled during transit and to determine if detailed inspection is required at site.

Electromagnetic voltage transformers shall be capable of discharging the capacitance of line, cables and switchgears, which may remain connected to them during switching operations. The Bidder shall declare any limitations of the equipment for this duty.

The Contractor shall ensure that no disruptive overvoltage's will be generated due to ferro-resonance phenomena and if necessary, by suitably connecting resistors or damping units across the secondary's of VT after approval

3.14 Voltage Detectors (if any)

Voltage detecting and indicating system for gas-insulated switchgear cable feeders and related local control panels shall be provided according to IEC 62271-213.

The system shall be suitable for continuous operation and maintenance free.

All 3 phases in cable end unit compartment shall have capacitive couplers with voltage and current limiting elements and they shall be connected to the indication system in front of the local control panel.

The capacitive couplers and indication system shall be suitable for the climate/location existing for the cable end units and local control panels (indoor or outdoor).

Indication unit for all 3 phases independently shall consist of

- continuous monitoring of operating voltage present or not present
- phase failure indication
- voltage not operating voltage
- test function and earth sockets.

Additionally, potential free auxiliary contacts designed as closing contacts shall be provided for interlocking function of feeder high speed earthing switch and for remote indication.

3.15 SF_6 Surge arresters (if any)

Based on insulation coordination study which belongs to the scope of works, the lightning arresters if needed in the bus bars or in the outgoing feeders shall be indicated and they will be accordingly selected and designed so as to protect the associated equipment. For required Technical Data please refer to the Technical Data Sheets.

The design data shall be proven by calculations and shall be subject to approval.

Lightning arresters shall be of the metal-oxide type without gaps and shall be designed to fulfill requirements of IEC 60099.

A lightning arrester arrangement shall be proposed to suitably protect the switchgear.

The lightning arresters shall be designed as non-linear metal-oxide resistor type without spark gaps.

Each lightning arrester shall be equipped with a suitable lightning counter and an indicator for monitoring of the leakage current.

Lightning connectors shall be designed for continuous operation and shall be capable of passing repeatedly, without distress the maximum discharge current of the arrester. The lightning connector shall be connected to the main earth lead from the arresters. Bolted links shall be provided so that the lightning connector may be short circuited and removed without taking the arrester out of service.

Contractor shall give evidence about the suitability of the type and location of the employed arresters.

Beside the type tests documented by appropriate certificates routine tests shall be performed according to IEC 60099-4 and documented.

The following tests shall be performed as witness tests according to IEC 60099-4 under supervision of the Employer and / or his representative, in case agreed to be within the factory acceptance tests:

- Power Frequency Voltage Test on complete arrester
- Lightning Impulse Residual Voltage Test on complete arrester
- Internal Partial Discharge Test
- Thermal Stability Test.

3.16 SF_6 Terminations and Connections

Connections from the GIS to the power grid shall be provided in accordance with the Technical Data Sheets and as indicated in the Single Line Diagrams and Substation Layouts included in the Annex.

3.16.1 SF_6/Air Outdoor Bushings

Where specified SF_6/air outdoor bushings shall be provided corresponding to IEC 60137.

In the design the installation direction and necessary clearances on the over-headline gantry area with other possible high voltage equipments shall be considered.

SF_6/air outdoor bushings shall be in provided for the rated current at site ambient conditions, rated thermal short-time current and rated duration as defined in the Technical Data Sheets apply.

Very heavy severity class (“e”) design accordance with IEC/TS 60815 shall be selected, unless otherwise specified in Technical Data Sheets

The withstand voltage of the air bushings shall be suitable for the altitude of the substation site above sea level as defined in the Particular Technical Requirements.

SF_6 gas-insulated bushings shall be provided with a compound housing of silicone composite rubber with alternating long and short sheds.

Alternatively, if mentioned in the Technical Data Sheets the insulators may be of top-quality electrical grade porcelain, thoroughly vitrified, homogenous and non-porous, and shall be practically in one piece.

All bushing connecting nuts, bolts, washers, rings, caps on the top shall be of non- magnetic material and corrosion proof, suitable for the specified climate on site.

All bushings shall be designed for operation and storage in a horizontal position without any restriction.

For voltages of Ur = 245 kV and above bushings shall be equipped with corona rings designed for the specified voltage level.

SF_6/air outdoor bushings shall be provided with the necessary steel structure supports in accordance with section Steel Structures

3.16.2 Cable Terminations

The following requirements are applicable to switchgear equipment where the HV power cables are terminated directly in the SF_6 metal clad switchgear using cable sealing ends designed for use in SF_6 gas and shall comply with IEC 62271 – 203 and IEC 62271 - 209.

The contractor shall be responsible for the design, testing and supply of the insulating barrier, which provides sealing between SF_6 and air and also between SF_6 and the cable insulation.

The Contractor shall ensure that there will be no leakage of SF6 gas, oil or moisture across the sealing joint from one chamber to the other throughout the service life of the equipment. This barrier is to be designed to accept the cable sealing end provided by others.

The contractor will also be responsible for providing the electrical connection between the cable sealing end and his equipment.

Suitable cover plates and seals shall be provided as part of the switchgear contract for sealing each aperture where a cable sealing end is to be fitted, to enable the switchgear to be completely filled with SF_6 gas and tested when a cable sealing end is not available or fitted.

For the cable shielding connections suitable connection points shall be available in cable end unit flanges

3.16.3 SF_6/Oil Direct Transformer Connection (if any)

The direct transformer connection shall be provided according to IEC 62271-11and designed in coordination with transformer manufacturer.

In the design of transformer connections and its SF6 bus ducts and steel supports necessary clearances for transportation routes of transformer, place for transformer testing, service and maintenance shall be considered.

To avoid transformer vibrations to impair the GIS, compensators (bellows) shall be mounted in-between the transformer and GIS.

For proper completion of the works provisions shall be ensured, that necessary flanges, surge arresters, connection parts, bus ducts, isolating links, gaskets, adapter pieces and suitable location of the system considering possible dismantling, transportation, testing and maintenance of GIS components and transformer are available.

Supporting structure shall be designed so that transformer bushing, and adapter flanges are not overloaded.

3.16.4 Gas Insulated Bus-ducts (GIB)(if any)

Where specified SF_6 bus ducts shall be provided corresponding to IEC 62271-203 including type and routine testing.

GIB shall be provided for the rated current at site ambient conditions, rated thermal short-time current and rated duration as defined in the Technical Data Sheets apply.

Depending on the bus duct location surrounding specified climate conditions (indoor/outdoor) shall be considered. Necessary surface and flange treatment shall be implemented.

The bus duct supports, possible wall bushings and fixing structures shall ensure easy access, safe operation and maintenance as well necessary transportations.

Bus duct shall be sectionalized so that effects of possible fault are limited, and gas handling can be realized in reasonable time.

Extension and anti-vibration compensators (bellows) where necessary shall be provided to balance out the prevailing climatic and internal load stresses as well as to compensate for maximum different settlements of foundations, floor levels and supporting structures.

3.17 Partial Discharge Sensors

UHF partial discharge sensors for periodical measurements shall be installed in adequate locations in the gas insulated switchgear and indicated in the layout drawings. In the design later extensions shall be also considered.

The capacitive couplers shall serve for partial discharge measurement during site testing of GIS installation before energization. Necessary complete test equipment and connection items for site testing before installation shall be provided by the Contractor. After completion of site testing, the UHF partial discharge sensors shall be left in their position for later periodical measurements.

Complete PD measurement procedure including testing equipment's and documentation shall be subject to approval.

Approved records from the site testing shall be handed over to Employer for future measurement and comparison.

3.18 Local control cubicle for gas insulated switchgear

Each circuit breaker bay shall be equipped with local vermin - and weather-proof control cubicle in accordance with the requirements of section Electrical Cubicles / Cabinets.

The cubicle shall accommodate all necessary equipment for local control, interlocking, supervision, position and alarm indication of all in bay available switching equipment and functions.

The local control of the high voltage equipment shall be hard wired into the local control cubicle. Electronic bay control unit shall be located in the control equipment room.

All equipment for control (push buttons or control switches) and indication shall be on suitable position (height) for operation personnel. The mimic diagram in the front of the panel shall be identical to the single line.

Position indicators shall also indicate the discrepancy position of the high voltage equipment.

For plug-in cables for connection of HV equipment to local control cubicles the plugs shall have different coding for CB, DS, ES and HSES.

In case the local control cubicles attached to the GIS bays, it shall be possible to remove them in case of maintenance or for other reason without affecting the operation of other feeders.

All similar contacts of a three-pole circuit breaker shall close or open within a period of one third of a cycle or less with respect to each other. Failing of this requirement shall be detected.

Operation and fault operation counters shall be installed. All circuit breakers shall be designed for closing and tripping by remote, tele- and local electrical controls. Local electrical controls consisting of a "LOCAL" - "REMOTE" transfer switch and a "CLOSE" - "TRIP" control switch shall be mounted within the local control cubicle. When the switch is under local control, this shall be indicated in the control room.

All circuit breakers, disconnectors and earthing switches shall have the necessary number of auxiliary contacts, 15% of spare auxiliary contacts shall be provided as minimum.

Breaker tripping shall be indicated by a switch-discrepancy contact, made up of two signaling contacts. All contacts shall be wired to the terminal blocks for connection to external equipment.

The circuit breakers shall be provided with trip and close coils as specified in section C "Technical Data Sheet". The trip circuits shall be duplicated and automatically supervised through a trip coil supervision relay (TCS). The DC power supply to the circuit breaker trip coil and the control circuit wiring shall be provided with shielded cables (e.g. NYCY type) and other measures of protection in order to minimize the hazard of damage to these cables and the subsequent failing of control voltage. Auxiliary circuits, including switches, shall be capable of carrying at least 10 A continuously.

The pole discrepancy function shall be indicated in the circuit breaker.

3.19 SF_6-Gas, compartments and gas handling

3.19.1 Gas compartments:

The switchgear units and bus bar systems shall be divided into several gas-filled compartments, sealed from each other by gas-tight partitions so that any leakage may be quickly localized.

The various gas zones shall be further subdivided where necessary to restrict any internal arcing damage, particularly within sections of bus bars and to enable gas handling procedures to be completed with the minimum of delay. The partitions should confine any internal faults to a respective section of the switchgear. Enclosures shall be designed to minimize burn through in the event of internal arcing.

The number of gas compartments shall be such so as to limit the amount of switchgear which has to be isolated and taken out of service as a result of gas leakages, planned maintenance or internal faults.

Gas section volumes shall be as large as required to minimize the effects of any internal overpressure. They shall be consistent with the need to allow changes in the switching arrangements for maintenance, repair or extension whilst ensuring the remaining parts can remain energized.

The compact GIS bay shall at least consist of the following arc and gas-tight high-voltage compartments:

- busbar per each bay
- disconnector and earthing switch
- circuit breaker compartment
- feeder compartment
- potential transformer
- lightning arrester
- bus ducts (GIB) limited to maximum length considering reasonable evacuation, filling and recovery gas handling times.

Each gas compartment shall be provided with facilities for routine checking of moisture content and impurity level in the gas. Gas compartments shall be fitted with permanent connection points for filling, evacuating and gas treatment equipment without moving the switchgear.

Bus bar enclosures shall be segregated into gas-tight compartments of such volumes so as to ensure the minimum necessary time for the SF_6 gas evacuation and its subsequent vacuum treatment and refilling.

Total time for gas evacuation and filling of the largest chamber shall be possible in reasonable time. Please refer to Technical Data Sheets.

The equipment and connections within each compartment shall be so arranged as to allow easy removal and replacement of any section with minimum isolation and disturbance of adjacent pressurized sections.

This feature should also permit the erection and testing of extension units alongside equipment already in service with the minimum of outage time being required for final connections.

In case of double or more bus bar arrangements as well for ring-or 1 ½ breaker systems, it shall be possible to extend the switchgear with the existing feeders remining in service. Outage time requirements for single bus bar configuration shall be clearly indicated in the Technical Data Sheet.

Any external gas pipe work is not allowed.

Suitable arrangements shall be provided for the thermal expansion and contraction of the bus bars and bus bar chambers without detriment to the current carrying capacity or gas volume.

Where special tools are involved in the setting up of these arrangements on site, the special tools and full instructions shall be delivered to the Employer by the Contractor.

Special attention shall be paid to the sealing of housing joints so that leakage of SF_6 gas is kept less than specified in Technical Data Sheets for any single gas compartment.

All metal parts other than those forming part of any electrical circuit shall be connected to the earthing system to create one path for the short circuit current. Any necessary terminals on part of the equipment required for this purpose shall be provided by the Contractor.

The design of the GIS components shall be suitable to avoid the effect of trapped charges generated on the GIS equipment.

To prevent ingress of moisture or leakage of gas during the service life of the equipment, the sealing materials used at all joints and interfaces shall satisfy the following requirements:

- not affected by SF_6 gas
- non-hygroscopic, containing no silicon
- non-aging and non-shrinking
- retain resilience for long periods under stress
- stable under all temperature conditions.

Seals including those at compartment partitions shall continue to function correctly throughout the temperature and pressure ranges in service and the pressure differentials, including vacuum and test pressures, during erection, maintenance and subsequent extensions. All gas barrier spacers shall be clearly indicated by color banding at each seal.

Expansion bellows, diaphragms and pressure relief devices shall be designed to be free of leakage under the same conditions as stated for seals.

Where the use of cast aluminum is envisaged, the manufacturer shall submit to the Employer/Employer's Representative evidence of tests carried out for porosity and extended pressure testing to show the quality of the castings used.

Initial filling of the equipment must guarantee gas service periods of not less than specified in the Technical Data Sheets. Suitable sensitive leakage tests shall be performed on each shipping unit prior to dispatch from the factory and on all junction points of components assembled at site prior to commissioning.

Pressure relief devices shall be provided for each section of switchgear as appropriate to allow excessive pressure relief. All pressure relief devices shall be located in such a way operation of the devices shall not endanger personnel working on the equipment or in the vicinity of the equipment. Where necessary, the devices shall be fitted with cowls to deflect any gases or fragmented parts away from locations where personnel may be expected to be present. Internal relief devices into adjacent compartments are not acceptable.

Each separate compartment or gas zone must be provided with its own device for monitoring continuously the gas density. This means all phases in case of single-phase design shall have its own gas supervision (no gas piping between the phases). These devices shall be arranged to give individual compartment indication in the local control units and initiation of remote alarms. Means shall also be provided to facilitate the regular maintenance checking of moisture content. Each gas filled chamber where necessary shall be fitted with static filters to absorb any moisture which may be present. In addition, filters for removal of SF_6 decomposition products shall be provided in those compartments in which arcing, or corona discharge can take place.

The moisture content of the breaker compartment during service shall thereby be kept to a minimum so as to ensure satisfactory operation.

Each gas compartment must have its own independent gas supervision and alarm systems with contact density gauges for alarm and indication. Alarms shall be wired to and indicated in the local control cubicles.

Each compartment must provide the following functions by means of suitable fittings and valves:

- indication of the actual gas pressure by means of temperature-compensated indicators
- monitoring of pressure and alarming of pressure losses in two adjustable stages
- access for evacuating and filling via gas service cart.

Especially for the circuit-breaker compartments, the following shall be foreseen:

- Indication and monitoring of pressure and alarming of pressure losses in two adjustable stages and additionally two contacts for blocking of the circuit breaker.

3.19.2 Gas barrier and supporting insulators:

All internal support insulators and gas barriers shall be of a high-quality material design to minimize internal and surface electrical stresses. The materials shall be free of voids and partial discharges at the maximum working voltages.

The manufacturer shall submit the proof that all insulators have sufficient margin between Martens point of the insulating material and maximal operating temperature.

Gas barriers shall be gas-tight and of sufficient strength and factor of safety to withstand short circuit forces and the maximum pressure differential that can occur under internal fault conditions.

3.19.3 Gas Seals

All static and moving gas seals shall be designed to prevent gas leakages and moisture ingress under all normal conditions of service. The materials used for gas seals shall withstand exposure to SF_6 gas and its decomposition products without deterioration for the service life of the equipment.

Measures shall be incorporated to eliminate any deterioration of gas sealing surface, finishes and fixings due to the influence of climatic conditions. Seals between different insulating media, sliding or rotating surfaces and those exposed to the risk of deterioration due to their use outdoors shall preferably include multiple seals or other means should be obtained, what is subject to approval.

3.19.4 SF_6 Immersed Insulation:

Bus bars and items of switchgears shall be supported in the enclosures by insulators of materials compatible with SF_6 gas and the gas decomposition products.

Gas barrier insulators and bushings, including gasoil and gas-air bushings (if any) shall comply with the specified conditions for sealing of enclosures. The Employer/Employer's Representative shall be advised of design pressures used and may require test evidence to substantiate performance under extremes of differential pressure and temperature.

The surfaces of insulation in contact with SF_6 shall not be glazed or otherwise treated with silica compounds or other materials which may deteriorate in the presence of gas decomposition products due to arcing. Alternative glazing or surface treatment which is compatible with SF_6 and its by-products may be acceptable what will be the subject to prove the durability.

The insulation shall be tested for partial discharge free operation at the maximum service voltage according to IEC 62271-203 and other relevant Standards for the equipment.

SF_6 immersed insulation shall otherwise comply with the relevant clauses for insulators and bushings.

3.19.5 SF_6 gas requirements:

All SF_6 gas supplied for use in the switchgears shall comply with the detailed requirements of IEC 62271-303 which is the minimum standard acceptable.

The gas systems of the switchgears shall utilize low pressure to minimize leakages and eliminate any possibility of liquefaction at the lowest ambient temperatures.

The GIS equipment shall be designed in such a manner that no heating elements will be required for satisfactory operation within the range of ambient temperatures and pressure encountered under service conditions.

The maximum allowable dewpoint, relative to ambient temperature shall be given in Tender.

3.19.6 Gas monitors

Temperature compensated, digital type, gas density monitors shall be provided for each gas section and gas compartment. Facilities shall be provided to test these monitors without having to reduce the gas pressure.

The gas monitors shall be fitted with density monitors and / or manometers to indicate the gas density / pressure and electrical contacts which shall initiate an alarm to warn that the gas pressure/density is falling to a critical level. In the manometers necessary damping arrangement shall be provided. Manometer and contacts shall be in the same density monitor unit.

For circuit breaker compartments, a lockout feature shall be provided to prevent operation whenever SF_6 gas pressure is less than that permitted by the design for satisfactory operation. Contacts shall be included to initiate alarms to warn of this condition.

Two sets of voltage-free electrical changeover contacts shall be provided for every alarm for remote SCADA and repeat alarm facilities in addition to alarm facias, incorporated in the local control panel/marshalling kiosk associated with each primary circuit.

3.19.7 SF_6 gas handling

SF_6 is the gas with the highest molecular weight. It is an inert gas, colorless, tasteless and non-poisonous. It is heavier than normal air so it will gather at the lowest point, will displace air and oxygen and can cause death by asphyxia. Once inhaled, it can be exhaled only by making a headstand. Locations in which SF_6-handling takes place are strongly recommended to have facilities for efficient ventilation to prevent from accidents. In design, delivery and providing service and testing equipment, IEC 62271-4 and (EU) 517/2014 (Fluorinated greenhouse gases) requirements shall be fulfilled.

SF_6 can absorb a high amount of energy and thus is the ideal insulating and arc quenching gas available. However, SF_6 is not a natural gas but man-made. Once released to the atmosphere it takes 3,200 years for neutralization by means of high energy ultra-violet radiation. The impact to the atmosphere caused by 1 kg of SF_6 is as high as that of 22.8 tons of CO2 and thus it is a very efficacious greenhouse gas. Therefore, provisions have to be taken to minimize the release of SF_6 to the atmosphere.

3.19.8 SF_6 Pollution

During switching operations, SF_6 will be subject to decomposition due to the switching arc. It has to be assured by appropriate means that the gas will be held as pure as required for its employment as insulating/arc quenching medium. For this purpose, the content of decomposition products should be as low as possible during service life. Appropriate filters have to be employed where applicable or formation of these decomposition products should be reduced to a minimum. The Operation and Maintenance Manual shall describe measures considered and shall give evidence of their suitability to the Employer / Employer's Representative.

3.19.9 SF_6-Recycling

Measures shall be taken at the GIS to facilitate complete removal of the SF_6 for maintenance/repair/extension works. Respective tapping points for all gas compartments shall be easily accessible. The gas shall be stored in containers suitable to serve for the gas of the entire switchgear in its final extent plus 10% spare capacity, if other extent in Technical Date Sheets is not specified.

Suitable filtering and handling devices shall be supplied to purge the gas from moisture, decomposition products and other impurities so that the gas can be re-used after completion of the maintenance/repair/extension works. The said equipment shall be handed over to the Employer upon completion of installation and commissioning works.

3.19.10 Gas handling equipment

A gas handling plant shall be provided at each installation to permit emergency topping up of gas in the switchgears in the event of leakage.

In addition, mobile gas handling units, the size of which shall allow full mobility within the switchgear rooms, shall be included for the complete sampling, testing, filtering, drying, extraction and refilling of SF_6 gas.

These units shall be self-contained and comprise of a wheeled trolley housing all necessary compressors, gauges, piping and controls, etc., together with gas storage tanks with usable capacity compatible to the design of the switchgear. The capacity of the tank shall be such that at least the content of the biggest three phase gas compartment can be stored. The storage may be gaseous or liquid. Filters shall be provided in order to clean gas taken out of the switchgear or tanks to eliminate impurities such as decomposition products or moisture. The units shall be capable of evacuating air from the switchgear compartments and replenishing them with gas at the end of a maintenance period. They shall also be capable of being used for all gas (SF_6, nitrogen and air) operations necessary if replacement of a gas enclosure is undertaken. Facilities shall also allow for circulation of the gas from a compartment through filters in order to extract moisture present.

Additional mobile or static storage shall be provided for use in combination with the gas trolleys and to extend storage facilities.

All necessary pipe work, flexible hoses, couplings, valves, pressure and vacuum gauges shall be included to enable interconnection between the switchgear compartments, gas trolleys and storage tanks and the cylinders provided by major producers of SF_6 gas.

An approved SF_6 gas leakage detector, oxygen analyzer and moisture meter shall be provided.

To enable safe maintenance to be carried out on any portion of the switchgears when all electrical supplies to the local control units are switched off, a portable gas alarm unit shall be provided. The alarm unit shall be self-contained and capable of giving clear audible warning should the gas pressure in any adjoining gas-filled chamber become unsafe.

GIS manufacturer shall recommend adequate and user-friendly recycling equipment for SF_6 re-use, provide instruction and technical support.

SF_6 gas that cannot be reused on site shall be transported to a specialized Company in appropriate containers with a label according to the contamination level.

3.20 Arrangement/testing facilities

The switchgears shall be installed in buildings with cable channels or cable basements suitable for accommodation of all HV and LV cables, both rooms being maintained at a slight positive pressure of filtered air such that any SF_6 gas released in the building will be discharged externally via pipes from the lowest point.

The Contractor shall supply the necessary ladders and galleries for access to all levels of equipment during normal operation or maintenance.

The Contractor shall include in his supply power operated lifting appliances as appropriate to the size and weight of component parts of the switchgears which require to be lifted in the course of installation, maintenance or repair.

Testing flanges for connection of testing devices shall be provided where relevant on each circuit for HV withstand testing of switchgears. Each testing flange shall be positioned in a separate gas zone compartment which shall be independent of adjacent disconnector and earthing switch gas sections.

Suitable links shall be provided to allow disconnection of voltage transformers and cable heads without dismantling.

All test equipment and erection tools for the GIS included in the scope of supply shall be submitted before the end of the commissioning period.

3.21 Accessories

Accessories for proper operation of the switchgear shall be included in the base price.

Following accessories for maintenance and repairs shall be included in the scope of supply:

- complete gas service cart, including vacuum pump, compressor and gas pressure vessel for liquefying of SF_6-gas, all fittings, connections gauges and hoses. The gas handling units shall be suitably sized so as to enable gas evacuation and filling of the largest chamber to be carried out in normal working hours (see requirements in Technical Data Sheets).
- set of special tools
- breaker withdrawal and maintenance parts
- portable SF_6 gas detecting equipment for SF_6 purity (indication of O_2 content, dew point, moisture content)
- density guard tester with high accuracy pressure gauge

The Tenderer shall describe all accessories in detail to enable an evaluation of the proposal.

3.22 Marking, Labeling and Wall Charts for Gas Insulated Switchgear

For marking, labeling and packing the requirement in VII-2 Project Procedures and in VII-3 General Technical Requirements shall apply.

The Contractor shall provide for the GIS room the following wall charts (text in English language):

- related single line diagram, minimum size A2
- related gas compartment drawing, minimum size A2
- typical GIS bay section drawing (cutout) in color showing housings, gas, arcing chamber and switching elements, support and barrier insulators, primary parts, CT's and VT's as well the supports with part designation in a legend , minimum size A2
- gas filling values depending on temperature (filling curves), minimum size A3
- safety rules in gas handling, minimum size A3.

3.23 Steel Structures and Assembly Material for Gas Insulated Switchgear

The requirements under section Steel Structures shall apply. For the fixing of the GIS bays with base frame suitable embedded steel parts in the concrete shall be used. The design shall be based on the requirements from the GIS manufacturer. Static and dynamic loads shall be taken into consideration. This shall include all necessary steel works and supports required also for gas insulated bus ducts indoor and outdoor, cable supports and fixing in the GIS vicinity as well closing wall openings for the bus ducts.

Adequate information in the drawings as basis for the civil design shall be submitted. This shall clearly include also the relevant interface information between the gas insulated switchgear and the building.

All steel supports and structures for gas insulated switchgear and its components shall be earthed.

The earthing design shall also include the steel supports for the complete GIS scope of supply specified in VII-1 Project Description and Scope of Works.

3.24 Earthing and potential equalizing for gas insulated switchgear

For the earthing and potential equalizing system, the requirements under section Earthing and Lightning Protection shall apply.

The GIS manufacturer shall provide all necessary information of the earthing and potential equalizing design and the Contractor shall incorporate this into the overall earthing system design. The earthing connection plan for GIS shall include the main earthing connections based on the specified short circuit current and its duration for the GIS bays, steel base frame and floor irons, cable end units, bus ducts, all GIS network connections like cable end unit, SF_6/air bushings, transformer direct connections, and all steel supports and structures as well metal covers for wall and floor openings.

Adequate information in the drawings as basis for the civil design shall be submitted.

Earthing and potential equalizing shall include also the local control cubicles and the GIS related HV and LV cable routing.

3.25 Tests of gas insulated switchgear

3.25.1 Inspection and testing

In addition to General Technical Requirements VII-3, which shall be applied in relation to the general test requirements, the following requirements shall be applied:

3.25.2 Type tests and special tests

Type test certificates will be accepted for the equipment used in the similar applications if the proposed equipment does not deviate in the relevant technical characteristics and if the type tests are made in an internationally recognized test laboratory and if the reports are not older than 15 years.

3.25.3 Routine tests

At least the following measurements and tests shall be carried out on the equipment:

- Gas insulated switchgear 52 kV and above Test as per IEC 62271-203
- Circuit breakers Tests as per IEC62771-100.
- Disconnectors and earthing switches Tests as per IEC62771-102
- Current transformers Tests as per IEC 60186, IEC 60186-2
- Voltage transformers Tests as per IEC 60186, IEC 60186-3.
- Lightning arresters Tests as per IEC 60099-4.

Routine test shall be conducted in factory for completed transportation units. By 220 kV and above the switching equipment shall be tested in factory with their drive mechanism units (3-phase unit).

3.25.4 Site tests and other/special tests

Field acceptance tests after installation of the complete switchgears shall be made according to IEC 62271-203 and shall be subject to agreement between manufacturer and Employer/Employer's Representative before purchase order award. The Tenderers shall state in their offers the type of tests to be conducted on site. The dielectric tests shall comprise at least a power frequency voltage withstand test and partial discharge test according to IEC 62271-203 Procedure A for 170 kV and below and Procedure B for 220 kV and above, where partial discharge test shall include UHF - method. Voltage transformers shall also be tested, erected and assembled to GIS.

3.25.5 Other tests

The following checks and test measurements shall be made during erection and commissioning in accordance with agreed standards, but not limited to:

- measurement of insulation values
- verification of earthing grid neutralization conditions (e.g. step and touch voltage) in accordance with IEC 61936-1/IEEE80
- phase rotation
- polarity checks in the case of DC voltages
- protection circuit tests as detailed in chapter Control and Protection
- safety signs and warning signs
- setting indicators
- checks on wiring and cabling for conformity with the constructional circuit-drawings and plans
- high voltage test on cables and switchgear
- functional test on equipment.

All defects detected as a result of routine or on-site testing shall be repaired by the manufacturer and tests repeated at his own expense.

Acceptance of any equipment by Employer's representatives shall not relieve the manufacturer from any of his performance guarantees, or from any of his other obligations resulting from this Contract.

Where no tests are detailed for items of equipment, a full program of tests shall be agreed with the Employer/Employer’s Representative. The Employer/Employer’s Representative reserves the right to call for such extra tests as may be necessary to prove compliance with the specification.

3.26 Documentation for Gas Insulated Switchgear

The Contractor shall provide all necessary drawings, design specifications, design details, operation and maintenance manuals and other information in accordance with Part VII-2 Project Procedures for the complete delivery.

The documentation shall be prepared according to latest IEC and ISO standards, the language used in all drawings and documentation shall be as defined in the Contract.

The documents for the Gas Insulated Switchgear shall include the key documents below and shall be submitted as complete packages in the sequence and with content as detailed below:

1. Single Line Diagram, Gas compartment drawings, Layout& Sections:
   - single line diagram with key parameters and equipment designation
   - gas compartment drawing with gas compartments, density guard numbers and designation
   - arrangement and layout drawings with bay section drawings indicating all dimensions, rupture disc location and blowing direction as well location of all specified sensors or coupler (for example PD measurement)
2. Information for Civil Engineering and Earthing:
   - fixing method and embedded steel supports
   - required floor cutouts, cable channels, wall openings, etc.
   - static and dynamic loads
   - embedded earthing connections
3. Detailed Documentation
   - schematics for each individual bay consisting of
     - bay single line diagram with equipment designation and technical data
     - local control cubicle, front, side and inside view with dimension and location of secondary equipment, terminals, heating, lighting, panel socket, complete labeling etc.
     - terminal blocks, wiring and connection diagrams
     - part list with detail information for reordering

   - cable list with type, size and length information
- earthing plan for the complete gas insulated switchgear with the dimensions of the earthing connections and material
- Any special information like for transportation and hoistings shall be indicated in the drawings.

4. Operation and maintenance manuals
   - All necessary operation and maintenance manuals for the GIS and its accessories, service, testing and gas handling equipment.

3.27 Overhead Traveling Crane

3.27.1 General

This Specification provides for the design, manufacture, testing and delivery of the overhead travelling cranes for the gas insulated switchgear building. This Specification also includes spare parts, tools and all auxiliary equipment necessary for complete installation.

All materials, equipment and services shall be provided as required to make a complete, properly functioning installation and shall conform to the highest standards of engineering design and workmanship.

The crane shall be used for the erection and maintenance of equipment installed in the GIS building. For technical data please refer to the Technical Data Sheets.

3.27.2 Scope of works

The supply and services to be performed by the Contractor shall comprise the design, manufacture, shop testing, packing, transport, insurance, unloading, storage at Site, construction works, erection, corrosion protection, site testing, submission of documentation, commissioning, training of user personnel and warranty of the Works. The Contractor is bound to provide complete works, even if the equipment or services to be provided are not mentioned specifically in the following Scope of Works.

3.27.3 Equipment requirements

The crane shall be designed as a single girder crane with two lifting gears in accordance with the principles of DIN 120, 4100, 4132, 9837, 15018, and 18800. The nominal carrying capacity of the crane shall be designed by the Contractor according to the requirements of the equipment to be supplied by him. The main lifting gear of the crane shall be capable to lift and transport the heaviest and / or bulkiest transportation unit of the GIS or the heaviest and / or bulkiest transportation unit of the control and protection system.

The minimum lifting force shall be confirmed in the technical data schedules. The second lifting gear shall be suitable for GIS equipment installation. The end carriages of the crane shall be of welded box girder construction. Buffers shall be provided at the faces on the end carriages.

The end carriages shall also be fitted with wheel-breakage supports designed to prevent derailment as well. The crab assemblies shall be of rigid construction.

Buffers shall be provided at the faces of the crab. Particular attention should be paid to ensuring that the smallest possible clearances are achieved for crane and crab. The load hooks shall be equipped with ball-thrust bearings so that they can rotate. Crane control shall be by a suspended control. The suspended control shall be fitted with rocker type MS push button switches for the crane functions. A key switch shall be provided in the suspended control. The emergency stop switches are to be designed in the form of mushroom-shaped switches which, when struck by hand, disconnect the entire supply to the crane. The main power supplies to the cranes shall be in the form of sheet-steel enclosed 4-pole safety power tracks with protection against accidental contact. The crab power supplies and the power supply to the suspended control panel shall be in the form of travelling cables (festoon type) with cable carriers running in tubular tracks.

All motors, switching installations, control equipment and switchgear shall be designed for a local existing maximum ambient temperature and must be fully operational at this temperature. The control voltage to be used for the crane shall be as given in the Technical Data Sheets.

All travelling and traversing drives are to incorporate pole reversible squirrel-cage gear motors with sliding armature and brake. The lifting gears may consist of standard electric hoists with sliding armature motor and cone brake or disc brake.

The precision speed control of the lifting gears shall be provided by an additional squirrel-cage inching gear motor, with sliding armature and brake, fitted to the electric hoist. The precision speed control of the lifting gears shall have a suitable ratio for GIS installations.

The crane shall be complete with - but not limited to- the following accessories:

- the crane runway girders (I-beams) complete with rails and end stops
- the crane bridge with crane drive gear
- the crab with crab drive gear
- the lifting gears complete with ropes and hook fittings
- slings and shackles
- the complete electrical equipment, basically including
- the lockable multi-pole mains disconnector switch (main crane switch)
- the rising cable from the multi-pole mains disconnector switch up to the feed point of the main power supply
- the main power supply including current collector

- the main contactor (crane switch) with short circuit protection
- the crab power supply
- all electric motors
- the necessary equipment to provide precision speeds
- the motor protection by PTC sensor, and all the equipment necessary for this
- the limit switches for the lifting gears
- the limit switches for the travel gears including all the necessary strikers
- all the necessary contactors and relays as well as the necessary contactor cabinets for these
- all cable and miscellaneous material for the complete installation of the crane
- the complete wiring of the crane
- the control transformer
- the control panel with all requested accessories.

3.27.4 Inspection and tests

General

Tests shall be carried out in order to determine whether the material and equipment comply with the required properties. Testing shall comply with the EN 13135 and applicable national standards of the country of the Employer. All tests on material and equipment shall be made in accordance with IEC/EN Standards. If some tests are not covered by or if a method of testing is not specified in EN/IEC Standards or if there are options in relevant EN/IEC Standards, the Contractor shall submit the method by which he proposes to conduct the tests for approval.

Workshop tests

The cranes shall be subjected to the following tests after complete assembly at the shop:

- inspection of structure and dimensions
- operational tests of all drives, including measuring of the operating speeds and of the load switches
- function tests of the complete control system
- insulation test on the entire electrical crane installation
- dynamic and static load test.

Site tests

On arrival to the site, during and after completion of erection all items of equipment shall be inspected and tested in order to check quality, correct operation and correct installation of the equipment. The following tests shall be performed:

- electrical testing of correct wiring and cabling of all control, monitoring and power circuits
- testing and setting of all relays, limit switches, etc.

- testing of correct functioning of the crane including travelling and hoisting ranges
- dynamic load test and measuring of maximum deflection of the crane bridge at rated load.

All measuring equipment, including test loads, test loads carrying structures, ropes, etc. shall be provided by the Contractor.

Commissioning tests shall be done according to a program agreed with the Employer. The crane shall be site tested as per the applicable safety regulations of the country of the Employer with approved test procedure and witnessed by the Employer.

3.27.5 Installation / dismantling

In accordance with the General Technical Requirements VII-3, the Contractor shall furnish and install all specified equipment and accessories.

3.27.6 Packaging, Shipping and Transport

Packing, shipping and transport shall be arranged according to the requirements in the General Technical Requirements VII-3.

3.27.7 Training

Works to be done under this section include training of Employer's personnel to operate and maintain equipment efficiently and safely. The main requirements for training are described in the General Technical Requirements. There shall be no constraints on the number and category of Employer's personnel to be trained.

4 Medium Voltage Metal Clad Switchgear

This section specifies the requirements for Medium Voltage Air-Insulated Switchgear and Gas-Insulated Ring Main Unit Switchgear

4.1 Standards

The switchgears shall be constructed and tested in accordance with the latest versions of the following standards:

IEC 62271-1	High voltage switchgear and control gear - Common specifications
IEC 62271-1	High-voltage switchgear and control gear - Part 1: Common specifications
IEC 62271-100	High-voltage switchgear and control gear - Part 100: Alternating current circuit-breakers
IEC 62271-102	High-voltage switchgear and control gear - Part 102: Alternating current disconnectors and earthing switches
IEC 62271-103	High-voltage switchgear and control gear - Part 103: Switches for rated voltages above 1 kV up to and including 52 kV
IEC 62271-105	High-voltage switchgear and control gear - Part 105: Alternating current switch-fuse combinations for rated volt ages above 1 kV up to and including 52 kV
IEC 62271-200	AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV
IEC TR 62271-300	Seismic qualification of alternating current circuit-breakers
IEC 61243 5	Voltage detecting systems
IEC 61869-1	Instrument transformers - General Requirements for Instrument Trans formers
IEC 61869 2	Instrument transformers - Additional requirements for current transformers
IEC 61869-3	Additional requirements for inductive voltage transformers

IEC 61243	Live working - Voltage detectors - All relevant parts
IEC 60071-2	Insulation coordination Part 2: Application guidelines
IEC 60529	Classification of degree of protection provided by enclosures
IEC 60376	Specification of technical grade sulfur hexafluoride (SF6) for use in electrical equipment
IEC 60480	Guidelines for the checking and treatment of sulfur hexafluoride (SF6) taken from electrical equipment and specification for its re-use
IEC 60296	Fluids for electrotechnical applications – Unused mineral insulating oils for transformers and switchgear.

4.2 Air Insulated Metal Enclosed Switchgear

4.2.1 Technical requirements

4.2.1.1 General

The switchgear shall be designed so that normal service, inspection and maintenance operations, determination of the de-energized state of the main circuit, checking of phase sequence, earthing of connected cables, locating of cable faults, performance of voltage tests on connected cables and apparatus and the elimination of dangerous electrostatic charges, can be carried out safely. Internal failure shall not have any consequences for the operator standing in front of the switchgear.

The steel encapsulation shall protect all live parts from soiling, humidity, foreign bodies, etc. as well as against access to hazardous part. It will additionally have the mechanical and thermal properties which are deemed to be suitable for the project.

The metal-clad panels shall have separate compartments for cable connection, circuit breaker, air-insulated busbar and low voltage. Thus, the possibility of transmitting of arc and failure from one compartment to another will be eliminated.

The switchgear shall be of the LSC (loss of service continuity) category LSC2 B, the partition class shall be PM and the switchgear shall be Internal Arc Classified IAC A FLR.

Each panel shall be a self-contained unit whose busbars shall be connected to the busbars of the adjacent panels.

LV section will be in the front upper part of each panel, for the accommodation of the protective and monitoring devices.

The cable connection compartment will be in the lower part of each panel; access to cables must be provided after removing the lid of the respective section from the front/back side of the panel.

Current transformers will be placed in the CB panels and the disconnecting panels. Unipolarly isolated voltage measuring transformers will be located either in a part of cable connection section or over the buses, depending on the application.

All operating elements and indicators of the switchgear must be located on, or be visible from, the front side of the equipment.

All necessary fixing and earthing material and works are included in the scope of supply and services.

The switchgear shall comply, as a minimum, with the technical data specified in the Technical Data Sheets.

4.2.1.2 Enclosure

The switchgear and busbar shall all be contained in a sheet-steel enclosure.

Each panel will be shielded by metal and will be arc-proof. The panel units will be mechanically assembled to each other by means of screws.

The finish of interior surfaces of the metal-clad enclosures shall facilitate cleaning and inspection.

Each compartment must have, as a minimum, IP51 as degree of protection.

On the front side of each panel, appropriate engraved plates shall denote its name and function.

The panels will be able to be installed on foundation frame or on raised false floor.

A grounding bus rated to carry the rated fault current shall be provided along with the full length of each unit. All units shall be provided with external studs for earthing connections.

4.2.1.3 Bus section

The bus section shall consist of the main copper buses, which shall be rated for the normal and short time current presented in the Technical Data Sheets.

Busbars will be supported by appropriate insulators and connectors.

4.2.1.4 Function requirements - modules

The following basic functions shall be available for the MV AIS switchgear, each of them being accomplished by a basic functional module.

These modules shall be constructed in such a way that unauthorized operations shall be prevented by means of interlocking.

- direct incoming unit or riser unit with measurement and busbar earthing
- circuit breaker unit (with a withdrawable vacuum type circuit breaker measurement and earthing switch)
- metering unit with voltage transformer and fuse.

4.2.1.5 Direct incoming unit

The direct incoming unit shall firmly connect the incoming cables to the busbar section and shall be equipped with measurement and earthing switch.

The earthing switch will be manually operated, and its live components will be located in the busbar compartment.

4.2.1.6 Circuit breaker unit

The withdrawable circuit breaker unit shall be used for the control, protection, and connection/disconnection of the incoming and outgoing feeders. Therefore, it must be equipped with measurement (current transformer, voltage detection). A manually operated earthing switch is necessary for maintenance and repair.

The circuit breaker shall be of withdrawable three-pole vacuum, motor operated spring type. In case, that control voltage is not available, it shall be possible to charge the spring manually.

Mechanical opening/closing of the circuit breaker shall be enabled through ON/OFF push buttons on the front side of the switch drive. The ON/OFF push buttons shall be operable also when the circuit breaker is in the racked in position however, it shall be possible to block the mechanical "ON" activation when the breaker is racked in.

Electric activation of the circuit breaker shall be possible locally from the LV compartment and from remote via the bay control unit.

The fixed mounted contacts of the circuit breaker unit shall be provided with shutters which shall open mechanically when the circuit breaker is being racked in and close when the circuit breaker is being racked out. In the racked-out position it shall be possible to open the shutter for the busbar contacts and for the feeder contacts manually, independently from each other. Both shutters shall be provided with facilities to lock them with padlock, independently from each other.

The circuit breaker and its rack in mechanism, the earthing switch, and the access doors to circuit breaker and cable compartment shall be interlocked in accordance with IEC 62271-200.

Design data of the circuit breaker unit shall be in accordance with the technical data sheets.

4.2.1.7 Instrument transformers

All instrument transformers must be suitable for continuous operation for 20% overload when installed in the switchgear under the ambient site conditions and for service under all rated and fault conditions.

Accuracy classes and burdens shall be in accordance with IEC standards for current and voltage transformers, as defined in the Technical Data Sheets.

Current and voltage transformers terminals for metering purpose shall be sealable for prevention of any accidental or voluntary influence on the metering equipment.

Current transformers must have shorting type secondary terminals. The CT rating plates, and the terminals must be accessible after power cables have been installed.

Voltage transformers for busbar metering shall be of the inductive type, mounted directly on the busbar enclosure or at a separate compartment of the bus section.

4.2.1.8 Voltage Detector System

All incoming and outgoing feeders shall be provided with a voltage detector system.

The voltage detector system shall be tested and manufactured according to the requirements of IEC 61243-5. These devices shall be auto powered by small leakage current coming from medium voltage insulators hence they are independent from aux power of switchgear.

4.2.1.9 LV section

The LV section of the panels shall be completely enclosed by steel sheets and shall be separated from the other sections. It shall accommodate all protection relays and auxiliary devices and shall be in accordance with the requirements for electrical cubicles.

In each LV compartment, a main terminal board shall be provided, to which all incoming auxiliary cables can be connected. At least 25% of additional spare terminals shall be provided.

Mimic diagram, all instruments, operating elements and indicators of the switchgear, DC trip circuit test facilities, push buttons and lamps shall be mounted on the front of this compartment.

All necessary auxiliary contacts shall be provided to enable remote control, remote alarm, and indication of the position/state of any circuit breaker and disconnector/earthing switch.

Completely separated and isolated circuits shall be used for switchgear control, tripping, alarms, and auxiliary devices.

These circuits shall have separate control power buses and feeders, suitably protected, for each power bus section with outgoing feeders, and for each pair of incoming power feeders and the associated bus tie breaker in secondary selective systems.

Each control circuit shall be protected by a two-pole miniature circuit breaker with auxiliary N/C contact. The auxiliary contacts of all MCBs of the same circuit type, e.g. breaker motor control, alarm, space heater, trip, etc. shall be wired in series to suitable group alarm terminals.

Voltages for control, trip and alarm shall be monitored by built-in normally energized auxiliary relays, separate for each bus or feeder section. These relays shall be time delayed on drop-off and their contacts shall be wired to group alarm terminals.

Remotely controlled circuit breakers shall have key-operated selector switches installed in their low voltage compartment with the following functions. The key shall be removable in a "remote" position only.

The switch shall have these positions/functions:

- LOCAL: The breaker can only be operated locally by its pushbuttons or mechanically.
- OFF: The breaker cannot be operated electrically.
- REMOTE: The breaker can only be operated from the remote-control room location.

Space heaters shall be installed in each low voltage cabinet to prevent condensation. Each heater element shall have an integral thermostat for control. Each switchgear section shall have a common space heater feeder, fed from a separate power source, and protected by a two-pole MCB with auxiliary N/C contact wired to a group alarm terminal.

4.2.1.10 Expansion joints and flexible connections

If necessary, the number and position of expansion joints or flexible connections are to be determined by the manufacturer to ensure that the complete installation will not be subject to any expansion stresses which could lead to distortion or premature failure of any piece of the equipment, support structures of foundations.

Expansion joints, flexible connections and adjustable mountings shall be provided to compensate for reasonable tolerances in the manufacture of associated equipment to which the switchgear may be connected and to ensure that unreasonably excessive accuracy is not required when installing such equipment and construction the associated foundations or support structures, e.g. transformers or the interconnection of isolated sections of switchgear by means of long busbar or duct installations.

4.2.2 Test Requirements

4.2.2.1 Type test

Only type tested MV panels are accepted.

Type tests shall be in accordance with IEC 62271-200, including tests to assess the effects of arcing due to an internal arc fault.

4.2.2.2 Factory Acceptance Test

All routine tests, as per IEC 62271-200, shall be performed on all items of equipment.

4.2.2.3 Site Acceptance Test

All tests after erection on site, as per IEC 62271-200, shall be performed, including the following:

- visual inspection
- functional tests.

5 Transformers

5.1 Performance, Standards and Codes

The transformers shall conform to this specification and comply with the latest editions of the following listed IEC standards:

IEC 60071-1	Insulation coordination
IEC 60071-2	Insulation coordination
IEC 60076-1	Power transformers - Part 1: General
IEC 60076-2	Power transformers - Part 2: Temperature rise for liquid-immersed trans formers
IEC 60076-3	Power transformers - Part 3: Insulation levels, dielectric tests and external clearances in air
IEC 60076-4	Power transformers - Part 4: Guide to the lightning impulse and switching impulse testing - Power transformers and reactors
IEC 60076-5	Power transformers - Part 5: Ability to withstand short circuit
IEC 60076-7	Power transformers - Part 7: Loading guide for oil-immersed power trans formers
IEC 60076-8	Power transformers - Part 8: Application Guide
IEC 60076-10	Power transformers - Part 10: Determination of sound levels
IEC 60076-18	Power transformers - Part 18: Measurement of Frequency Response
IEC TS 60076-19	Power transformers - Part 19: Rules for the determination of uncertainties in the measurement of the losses on power transformers and reactors.
IEC TS 60076-20	Power transformers - Part 20: Energy efficiency.
IEC 60076-22-1	Power transformers - Part 22-1: Power transformer and reactor fittings - Protective devices.
IEC 60076-22-2	Power transformers - Part 22-2: Power transformer and reactor fittings - Removable radiators.
IEC 60076-22-3	Power transformers - Part 22-3: Power transformer and reactor fittings - Insulating liquid to air heat exchangers.

IEC 60137	Insulated bushings for alternating voltages above 1000 V
IEC 60214-1	Tap-changers - Part 1: Performance requirements and test methods
IEC 60214-2	Tap-changers - Part 2: Application guide
IEC 60247	Insulating liquids - Measurement of relative permittivity, dielectric dissipation factor (tan d) and d. c. resistivity
IEC 60270	High-voltage test techniques - Partial discharge measurements
IEC 60296	Fluids for electro-technical applications - Unused mineral insulating oils for transformers and switchgear
IEC 60529	Degrees of protection provided by enclosures (IP Code)
IEC 60567	Oil-filled electrical equipment - Sampling of gases and analysis of free and dissolved gases - Guidance
IEC 60599	Mineral oil-impregnated electrical equipment in service - Guide to the interpretation of dissolved and free gases analysis
IEC 60616	Terminal and tapping markings for power transformers
IEC 60947	Low voltage switchgear and control gear (all relevant parts).
IEEE 32	Requirement, Terminology and Test procedure for Neutral Grounding Devices

In case of any conflict between this specification and the standards, this specification shall prevail.

The transformers shall operate satisfactorily within the rated values and within the environmental conditions, as specified such that Routine maintenance to any of its components shall not be required in intervals less than 5 years. Internal components shall be maintenance-free for at least 20 years.

5.2 Power Transformers and Autotransformers

5.2.1 Introduction

This part of the Technical Specifications covers the design, manufacture, factory testing, supply, delivery to site, off-loading, installation and oil filling, site testing, placing in successful operation etc. of the power transformers and autotransformers to be installed in the substations.

In the following paragraphs the term "*transformers*" is used collectively for both power transformers and autotransformers.

5.2.2 General requirements

This section describes the common characteristics of the transformer categories mentioned above.

The required -minimum guaranteed- technical characteristics of the transformers are presented in the Technical Data Sheets.

Design shall take into consideration the specified ambient conditions.

The transformers shall be capable of operating continuously within the specified temperature rise limits at the rated power (full name plate rating) at 10% over- or under-excited operation. The latter is applicable for tap changer settings and under all specified site and installation conditions.

The transformers and all associated facilities (e.g. tap changer) shall have the ability to withstand the effects of short-circuit currents, defined as symmetrical short circuit current in the Technical Data Sheets, when operating on any tapping position, according to requirements of IEC 60076-5.

All metal parts of the transformers, except for the individual core laminations, core bolts and associated individual side plates, shall be maintained at the same fixed potential.

The earthing structure shall be designed to carry, without damage, the maximum possible earth fault current for a duration at least equal to the short circuit period of the main windings.

The design and manufacture of the transformers and auxiliary plants shall be such that the level of vibration does not adversely affect any clamping or produce excessive stress in any material.

The design shall be such so as to ensure that leakage flux does not cause overheating in any part of the transformer, and it 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.

Built-in short circuit limiting reactors, if any, shall not be installed in a separate tank appended to the main tank.

5.2.2.1 Magnetic cores

The transformers shall be of core type. The magnetic circuit shall be insulated from all structural parts and shall be capable of withstanding a test voltage to core bolts and to the frame of 3 kV r.m.s. for one minute.

The magnetic cores shall be constructed from high-grade, non-aging, low loss, high permeability, cold rolled, grain oriented, silicon transformer sheet steel. The sheets shall be clamped strongly enough to prevent displacement by short-circuit or other stresses. The clamping frames must be insulated against the sheets.

Should the Contractor be able to provide adequate evidence that there will be no adverse effects due to core or stray flux heating with the quality of steel employed, designs may be offered such that when operating under the most onerous conditions, the flux density in any part of the magnetic circuit does not exceed 1.8 T and the magnetizing current must not exceed 5% of the rated load current at normal rated voltage. In any case, the flux density at rated voltage and frequency, on main tapping shall not exceed the value indicated in Technical Data Sheet.

The cores shall be clamped and braced to withstand, without damage or deformation, the forces caused by short-circuit stresses, transportation, or handling, and to prevent the shifting of the core laminations.

The bolts, nuts, and end plates of the assembly and clamp structure shall be of a nonmagnetic type and shall be effectively insulated and locked so that they ensure an even pressure on the whole core assembly and are not loosened by vibrations caused by transport and operation. The supporting framework of the cores shall be designed to avoid the presence of pockets which shall prevent complete draining of the tank or cause the trapping of air when filling during service.

Adequate metallic bridges shall be provided between the core lamination packets in order to keep all portions of the core assembly at the same potential. Lifting eyes or lugs shall be provided at suitable points of the core assembly.

The cores shall be earthed to the clamping structure at one point only through a removable link with a captive bolt and nut, accessibly placed beneath inspection housing on the tank cover or tank wall.

All earthing connections except for those from individual core clamping rings, shall have a cross sectional area of not less than 80 mm^2. Connections inserted between laminations shall have a cross sectional area of not less than 20 mm^2.

The cores shall be free from over fluxing which can cause damage or dysfunction of the protection equipment when the transformers are operating under the continuous overvoltage condition specified in the Technical Data Sheets.

Use of timber for insulation parts subject to test voltage stresses equal to or higher than LI: 550 kV and/or AC: 230 kV shall not be accepted. The Contractor shall be responsible for the selection of insulation material.

5.2.2.2 Windings

The transformer windings shall be made of high conductivity electrolytic copper.

The windings shall be thoroughly seasoned during manufacture by the application of axial pressure at a high temperature for such a time so that further shrinkage -while in service- shall be unlikely to occur.

The windings and their leads shall be designed and arranged to withstand the shocks, which may occur through rough handling and vibration during transport and all kinds of over-voltages (switching and other transient service conditions). Coil clamping rings shall be of steel or of a suitable insulating material, built up from flat laminations. Protective capacitors and ZnO protective elements shall not be accepted.

Conductors shall have a constant cross-section and the current density shall not exceed 2.7 A/mm^2 in any part of the windings, under rated conditions.

The insulation material of the windings and connections shall be free from insulation compounds subject to softening, shrinking, collapsing, disintegrating or any other poor performance, during service.

Impedance voltages on extreme tappings shall not deviate from those for principal tappings by a percentage value of more than two third (2/3) of the difference in percentage tapping factor between the concerned tappings and the principal tappings. The power transformer shall have the highest losses at the highest current taps (lowest voltage taps).

5.2.2.3 Vector group and neutral earthing

The vector group the transformers shall be as per the respective Technical Data Sheets.

The neutrals of the autotransformers shall be brought out to bushings and shall be directly or indirectly earthed, as indicated in the single line diagram and defined in the Technical Data Sheets.

The connections to earth shall be properly designed and earthed with separate earthing rods, connected to common earthing system, as described in section Earthing and Lightning Protection. The copper earthing conductors shall be properly clamped to a supporting steel structure.

5.2.2.4 Tank and conservator tank

Each transformer tank shall be of a welded construction with bolted cover, fabricated from steel plates of adequate strength so that, when containing the core with coil assembly and being fully oil filled, lifting or any other handling shall not cause overstressing of any part of the tank or leakage. The tank shall also withstand the forces sustained during testing, transport, installation and service. The tank body, tap changer compartment, radiators and associated piping shall be capable of withstanding full vacuum (less than 133 Pa) when containing no oil.

The tank cover must not get distorted when lifted and shall be provided with suitable flanges having sufficient and properly spaced bolts.

Inspection openings shall be provided to give access to the internal connections of bushings, windings and earthing links.

The tank and cover shall be designed in such a manner so as not to leave any external pockets in which water can lodge nor internal pockets in which air can be trapped when filling the tank.

Additionally, easy access to all external surfaces for painting shall be provided. The interior surface of the tanks shall be painted with an oil resistant coat, the exterior surface with a primer and two finish coats.

Wherever possible, the transformer tank and its accessories shall be designed without internal pockets wherein gas may collect. Where pockets cannot be avoided, pipes shall be provided to vent the gas into the main expansion pipe. The vent pipes shall have a minimum inside diameter of 25 mm and, if necessary, shall be protected against mechanical damage.

All gaskets shall be gas and oil resistant, made of such a material (heat and oil resistant nitrile rubber) that no serious deterioration occurs under service conditions. 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. Over-tightening shall be prevented by a suitable measure.

Pockets (minimum five (5)) shall be provided for a dial type thermometer. These pockets shall be located in the position of maximum oil and winding temperature. Caps shall be provided to prevent the ingress of water to the thermometer pockets when they are not in use.

Two (2) earthing terminals of adequate size shall be placed diagonally at the lower tank frame, on either side of each transformer tank, in such a way that a low-resistance connection to the local earthing system, is guaranteed.

Each transformer unit shall be equipped with a conservator tank to accommodate the changes in oil volume caused by changes of the ambient temperature or of the transformer load.

The conservator tanks shall be arranged above the highest point of the circulating system. Connections to the main tank shall be at the highest point to prevent the trapping of air or gas under the main tank cover. The capacity of the conservator tank shall be adequate for the expansion and contraction of oil in the transformer under the specified operation conditions. Conservator tanks shall also be provided with a filling cap, drain valve with captive cap and oil level gauge.

A silica-gel air dehydrator shall be fitted to the conservator with a size commensurate with the climatic conditions at the site. Breathers shall be fitted at a convenient height of approximately 1.5 m above the ground.

The necessary filter and drain valves for filling and drainage of oil as well as air vents shall be provided for the tanks (main, conservator, radiators) and they shall have provisions for locking in the closed and open positions.

All devices fitted to the transformers shall be designated visibly with suitable alphanumerical designations.

The following moving and handling facilities shall be provided for each transformer unit tank:

- The tanks shall have four (4) jacking points for the use of hydraulic jacks. They must be rated for the most unfavorable load distribution on two diagonals.
- Underneath the upper tank edge, four (4) lifting hooks shall be arranged to enable the entire transformer to be lifted by a crane. The load carrying capacity of each lifting hook shall not be less than 50% of the total weight of the transformer.
- lifting eyes or lugs for lifting the core, coils, tank, tank cover and the complete transformer. The minimum length of the base of the lugs shall be 300 mm for transformers of a weight up to and including 10 t, and 500 mm for transformers of a weight above 10 t.
- pushing and pulling eyes for moving the transformers in any direction
- Tank stiffeners and mounting brackets shall be continuously welded to the tank.
- four (4) transportation rollers (flanged wheels). Each of the rollers shall rotate 90° to enable longitudinal and transversal movement of the transformer without dismantling and shall have a roller bearing with lubricator. The device for fastening the rollers on the rails is part of the delivery and shall be designed to withstand seismic forces acting upon the transformers. The transformers, when erected, will be left standing on their wheels.
- one (1) oil conservator tank access ladder of zinc-powder coated mild steel with platform(s) and handrails at the upper end fixed above the tank cover
- filter valves of the slide valve type for oil inlet and outlet arranged diagonally on lower part of tank. A suitable valve for vacuum application shall also be provided in a convenient floor height.

- Oil sampling valves (top and bottom) with suitable adapters of R ¾" 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 floor height.
- padlocking facilities for all valves including radiator butterfly valves
- Two (2) adequate earthing terminals completely made of stainless steel capable of carrying for 5 s the full lower voltage short circuit current of the transformer shall be provided and installed diagonally at the bottom of the transformer unit tank.

5.2.2.5 Cooling system

General

The cooling system of the transformers shall meet the requirements of the Technical Data Sheets.

The cooling plant shall comprise detachable flanged radiators, designed in such a manner that all painted surfaces can be cleaned and painted easily. The design shall also avoid pockets in which water can be collected and shall be capable of withstanding the pressure test.

Each radiator group shall be fitted with drain valve and air release plug and sufficient number of cooling fans. 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 while the latter is in service. Dismantling of one of the radiators shall be possible without causing the temperature to rise above the permissible values.

The cooling system shall be designed in way so as to ensure that failure of one part of it will not result in the loss of more than 50% of the total forced cooling capacity.

Radiators

The radiators shall be suitable for and installed at the transformer unit tanks. The conservator vessels shall be mounted thereon. Radiators of multiple type and similar arrangements shall not be accepted.

Valve mountings shall be provided on the tanks of the transformer units so as to enable the cooling equipment to be mounted at either end of the tanks. The mountings not in use shall be blanked off without valves.

The radiator fins shall be welded with at least 8 mm round stiffening rods horizontally and diagonally, to prevent vibration during operation. The distance between horizontally arranged bracing straps shall not exceed 100 cm.

Radiators shall be fully vacuum-proof, pressure-tested (minimum 2 kg/cm^2 for at least 5 mins) and liquid-tight (leak-proof against transformer oil, 125°C, 1 kg/ cm^2).

The radiators shall be fitted with suitable drain and vent plugs, ensuring them being completely drained and vented. No radiators shall be fitted underneath of air-filled cable boxes.

The radiators shall be connected to the tank or external headers by butterfly valves in such a manner that each radiator can be removed without taking the transformer out of service and without draining any oil from the tank and/or common heads, as applicable. The lower radiator headers shall be connected in a height of not less than 80 cm above floor level. The mechanical tolerance of the arrangement shall allow the exchange of all radiators of the same type without additional fitting.

The assembly of the radiators and their fitting shall be such so as to provide mechanical protection and prevent vibrations. Suitable stiffening bars of stainless steel shall be fitted along the radiators on top and bottom side. The bars shall not be arranged crosswise on top and bottom side of radiator groups.

The oil circuit of all radiators shall be provided with the following:

- a valve at each point of connection to the tank
- a valve in the main oil connection at the bottom of each radiator removable blanking plates to permit the blanking off of the main oil connection to the top of each radiator. The blanking plates, when not in use, shall be bolted to some suitable structure on the equipment.
- a drain valve at the lowest point of each radiator
- a thermometer, pocket fitted with a captive screwed cap on the inlet and outlet oil branches of each radiator
- machined flanges on all items
- a 50-mm filter valve at the top and bottom of each radiator
- On all air-cooled radiators, which have no natural oil circulation rating, a differential pressure gauge across the oil inlet and outlet of the cooler, marked to indicate correct oil circulation shall be provided. Where forced oil circulation radiators are provided in addition to such radiators, an oil flow indicator with electrical contacts is to be fitted. These contacts shall comprise one pair normally open.
- flanged air release plugs
- isolating valves on either side of individual radiators.

Oil piping and flanges

The necessary oil piping shall be provided for connecting each transformer unit to the radiators and oil pumps and for any equalizing connection when more than one unit is connected to any oil cooling equipment. The oil piping shall be with machined flanged joints. Cast iron shall not be used.

An approved expansion piece shall be provided in each oil pipe connection between the equipment and the oil radiators.

Drain valves shall be provided in order that each section of pipe work can be drained independently.

Blowers and ducts

The blowers for use with the radiators shall be motor driven and shall be suitable for continuous outdoor operation and capable of dealing with the maximum output and head required in service.

The blowers shall be capable of withstanding the stresses imposed when brought up to speed by the direct application of full line voltage to the motor.

The blowers shall be complete in all respects.

The blowers and radiators shall be designed so that they operate with a minimum of noise or drumming. In order to reduce the transmission of noise and vibration, an approved form of anti-vibration mounting shall be adopted for the blowers.

It shall be possible to isolate and remove individual blowers, complete with motors to enable maintenance without disturbing the operation of the others or dismantling the cooler structure framework.

Blades or runners fabricated to form hollow sections shall not be used. Unless otherwise approved, blades shall be of galvanized steel.

The ducts and casings shall be made of galvanized steel not less than 2 mm thickness, suitably stiffened by angles or tees.

Galvanized wire mesh guards with a mesh not greater than 25 mm shall be provided to prevent accidental contact with the blades. Guards shall be provided over all moving shafts and couplings.

Radiator control

Each motor or group of motors shall be provided with a three-pole electrically operated contactor, fitted with auxiliary alarm contacts, and with control gear of approved design both for starting and stopping the motors by hand and automatically from the contacts on the winding temperature indicating device.

Individual, overload and single phasing protection with alarm contacts shall be provided. This equipment shall be accommodated in the marshalling kiosk.

The control arrangements shall be such that motors totaling more than 15 kW shall not be started simultaneously when the cooling plant motors are started automatically, or by hand by means of a single switch operation.

Where blowers and oil pumps are provided, the connections shall be so arranged as to allow the motors or groups of motors to be started up and shut down either collectively or individually.

Where transformers are cell mounted, auxiliary contacts are to be provided to control the transformer bay ventilation fans. These will start/stop the fans in the event of the transformer cooling fans operating.

At least the following alarm/ signal initiating devices having N.O. contacts shall be provided:

- main power supply failure for each main power source
- power supply-auto change-over
- auxiliary supply failure
- cooling fans failure for each fan group
- cooling fans running for each fan group
- cooling fans stopped for each fan group
- cooling system on automatic control
- cooling system on manual control.

ONAN/ONAF Cooling

The motor of the fans shall be connected to the starting contactors by two groups. Approximately 50% of all cooling fans including specified extra fans shall be related to each fan group. The specified additional fan shall not be connected separately in any way, and they shall run together with the other fans during normal operation at site.

For example, the first group (fan 1, 3, 5, etc.) shall come into operation at lower temperature (i.e. at 75°C hot spot temperature) and the second group (fan 2, 4, 6, etc.) at higher temperature (i.e. at 85°C hot spot temperature).

The control shall be such that, if the first group fails to come into operation on winding temperature reaching the set value on the contacts of winding temperature indicator, the second group when it comes into operation, consequently, to winding temperature reaching higher set value, shall bring the first group of fans also into operation.

ONAN/ONAF/ODAF Cooling (if any)

The fans shall come into operation at lower temperature (i.e. at 75°C hot spot winding temperature, and the pumps at higher temperature (i.e. at 85°C hot spot temperature).

The control shall be such that, should the fan group fail to come into operation on winding temperature reaching the set value on the contacts of winding temperature indicator, the oil pumps when they come into operation, consequently, to winding temperature reaching higher set value, shall bring the fan groups also into operation. Starting of cooling pumps must not initiate a Buchholz alarm and/ or trip. Use of time delayed relays for Buchholz alarm and/ or trip is not acceptable.

The fan motors and oil pumps shall be connected to the starting contactors by three individual groups each. Time delay relays shall be provided for sequential starting of the fan groups and oil pumps to prevent mal operation of the Buchholz relays.

In addition to the above requirements, the following alarm/ signal initiating devices having N.O. contacts shall be provided:

- cooling pumps failure for each cooler group
- cooling pumps running for each cooler group
- cooling pumps stopped for each cooler group.

5.2.2.6 Corrosion protection and painting

Particular attention shall be given to the corrosion protection of all metal parts of equipment to be delivered.

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 following treatments shall be applied.

External surfaces

All steel surfaces shall be sand blasted in accordance with ISO 12944-5 (corrosivity category C5-M) and shall then be painted in the following sequence:

1. One (1) primer coat 60 µm

Binder: epoxy polyamide resin, ethyl silicate or polyurethane

Pigment: zinc oxide, zinc phosphate, (zinc-rich primer)

2. Two (2) intermediate coats 100 µm

Binder: epoxy polyamide resin

Pigment: anti-corrosive phosphate

4. One (1) topcoat 60 µm

Binder: acrylic, epoxy polyamide or polyurethane resin

Pigment: titanium dioxide, micaceous iron oxide, tinting additives.

Total coating thickness (dry-film incl. tolerances) shall be as a minimum 320 µm.

The final coat of painting shall be of pore-free and homogeneous quality and shall be of a uniform non-glossy shade of color code RAL 7032 (silica-grey). For extensions the color code of the existing units shall be applied.

If any hot dip galvanized steel parts will be provided the same painting method shall be applied. However, instead of the primer coats or zinc powder coat one adhesive coat and one base coat shall be applied. In this case, the minimum thickness of galvanizing shall be 100 µm.

In case of ordinary stainless steel, the primer coats may be replaced by a suitable undercoat.

Mechanical damage of painting shall be repaired at site with the same type of painting as above.

Internal surfaces

Inside the transformers sand blasting shall be performed in accordance with ISO 12944. After that, an oil resistant insulating coating shall be applied to all steel surfaces in contact with the oil (e.g. tank, cover, core steel plates etc.).

The minimum dry film thickness shall be 35 µm (Color code RAL 9010 (white) or equivalent).

The equipment must be so designed that any features which may encourage the formation of rust, are avoided.

5.2.2.7 Transformer oil

The insulation oil shall be either inhibited naphthenic based mineral oil with antioxidant (phenol) additives or Bio-based oil (in accordance with IEC 61099), as defined in the technical data sheet and shall have properties such as to avoid formation of copper Sulphide under continuous heavy loading conditions even without passivator additives.

The oil is a subject to Employer approval.

It shall be severely hydro-treated, and shall have properties complying with latest IEC 60296, and shall have aging properties meeting special applications as specified in this standard. However, the typical dielectric dissipation factor at 90°C shall not exceed 0,01 after laboratory treatment and, the typical flash point shall not be less than 140°C.

Gas absorbing oil (e.g. oil with negative gassing tendency) shall not be provided.

With regard to more efficient detection of corrosive Sulphur the oil shall have also passed tests in accordance with IEC 62535, and ASTM D 1275 method B. Both tests must be fulfilled.

The Bidder/Contractor is held responsible to prove the dryness (water content less than 5 ppm) and all other properties of the oil before utilization.

The water content in ppm and the dielectric strength of the insulation oil shall be also proved at site during commissioning.

Samples of used paper shall be tested during factory acceptance tests to prove the specified properties:

- degree of polymerization
- min. 1000 (sample of paper insulation after drying transformer)
- min. 1200 (sample of paper insulation before drying transformer)
- moisture content after drying: less than 0.3%.

The change of gas concentration during the heat run test shall not exceed the following values:

- H_2 <9 ppm
- CH_4 <9 ppm
- C_2H_6 <9 ppm
- C_2H_4 <9 ppm
- C_2H_2 <0.1 ppm
- CO unspecified
- CO_2 unspecified.

5.2.2.8 Topping up with oil and drying out on site

If oil is to be added to a transformer at site prior to commissioning, the oil in the transformer shall first be tested for dielectric strength and water content and each container of additional oil shall be similarly tested.

Should it be found necessary to resort to oil treatment before a transformer is commissioned, the Contractor shall submit, in writing, a full description of the process to be adopted, the equipment to be used and a statement of the precautions being taken to prevent fire or explosion.

Should a transformer arrive at site without positive pressure of gas in the tank, it shall be dried out at site at the Contractor's expense using hot dry air and vacuum filling. Adequately rated hot air dryer, suitable for use on the largest shall form a part of supply of special equipment and tools.

Clear instructions shall be included in the maintenance instructions regarding any special precautionary measures, which must be taken before vacuum treatment can be carried out. Any special equipment necessary to enable the transformer to withstand vacuum treatment shall be provided. The maximum vacuum, which the complete transformer, filled with oil, can safely withstand without taking any special precautionary measures, shall be stated in the maintenance instructions.

5.2.2.9 Audible noise limits

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. The measured values shall not exceed the values as defined in the respective Technical Data Sheets.

5.2.2.10 Bushings

The transformers shall be equipped with bushings of outdoor type, as defined in the Technical Data Sheet. The bushings shall be arranged on the tank cover in an upright position and must be easily exchangeable without lifting of the cover plate.

The bushing castings shall be free from blow holes, surface blisters, cracks and cavities and all sharp edges and corners shall be blurred and rounded off. All ferrous parts shall be hot dip galvanized.

The terminals and all other current carrying parts shall be designed and manufactured to have minimum contact resistance. The bushing connections shall be designed to reduce the effect of corona and radio interference to the minimum.

All bushings shall at least be of the same insulation level as the related windings and/or neutral.

All bushings shall be capable of withstanding the seismic stresses foreseen in these Tender Documents.

The bushings shall be equipped with following:

- oil level indicator
- test tap suitable for measurement of the dielectric dissipation factor, capacitance and partial discharge value of the bushing. The test tap will be always earthed when not in use.
- air release plug
- oil expansion compensator
- oil sampling and oil filling plugs
- possibility of oil sampling for DGA purpose
- rating plate indicating the Manufacturer's name, year of manufacture and serial number, maximum operating phase-to-phase voltage or rated operated phase-to-earth voltage, rated frequency, rated current, insulation levels, bushings capacitance, dielectric dissipation factor, dimensions, mass and angle of mounting.

5.2.2.11 Bushing current transformers

Current transformers (CTs) for temperature monitoring and transformer protections shall be foreseen. They shall be installed in suitable bushing turrets and shall be arranged and connected in such a manner that easy removal of the same is possible without cutting or removal of any insulation material of the leads to the bushings required and without lowering of the oil to such a level where the windings are exposed to the atmosphere.

All of the concerned bushing turrets shall be equipped with appropriate current transformer termination boxes for direct connection of the related CTs. Separate termination boxes shall be provided for current transformers for protection and those used for the thermal replica.

The technical data shall also be coordinated with the protection requirements and the related switchgear CTs. If a higher rated output and/or ratio than the specified one turn out to be necessary, the Contractors shall provide the current transformers for the required ratings without claiming additional costs.

5.2.2.12 On-load tap changer

Each transformer shall be provided with tap changing for varying its effective transformation ratio whilst the transformers are 'on-load' and without producing phase displacement. Tap changers shall be of the diverter switch type and shall be suitable, without alteration, for forward or reverse power flow. The tap changer shall be of the vacuum type.

The operation of the on-load tap-changer shall be safeguarded even at low temperatures by a thermostat-controlled electric heating and thermal insulation for the motor-drive mechanism.

On load tap changers shall be provided on taps of the high voltage winding. The tap changers shall comply with the relevant IEC standard and shall be suitable for power flow in both directions. Only designs which have been type tested in accordance with the standard in mention will be accepted. The OLTC shall be suitable for oil change without dismantling the diverter unit.

Tap selectors with "make before break" switches shall be housed in a separate compartment which shall be integrated in the transformer tank. The design shall ensure that any gas formation or air will pass the pressure relay. The OLTC compartment must have its own pressure relay.

The tap-changer must include a separate oil system, such as oil drain valves, separate section in the oil conservator, oil level indicator with oil level contacts, air-dehydrator etc. The compartment shall be easily accessible for inspections of contacts. It must be possible to carry out inspection of tap changer without draining the oil of the transformer. The on-load tap changer shall be designed to withstand maximum short-circuit current as specified for the transformer.

First maintenance shall be necessary the earliest after 300,000 switching operations. Second maintenance and replacement of the vacuum interrupters shall be due the earliest after 600,000 operations. Third maintenance the earliest after 900,000 operations. The exchange of the diverter switch shall be necessary the earliest after 1,200,000 operations.

The tap-changer must be designed for supervisory as well as for normal remote control and in emergency cases for local control. 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. However single signals shall be provided in the local control cubicle and the control room.

The tap changer assembly must be equipped with a pressure relief device in the tap changer head flange assembly, of the spring-operated resettable type.

The following operation conditions shall apply to the on-load tap selector controls:

- It must not be possible to operate the electric drive when the manual operating gear is in use.
- It shall not be possible for any two electric control points to be in operation at the same time.
- Operation from the control switch shall cause one tap movement only unless the control switch is returned to the off position between successive operations.
- All electrical control switches and local manual operating gear shall be clearly labeled in an approved manner to indicate the direction of tap changing.
- It shall be possible to operate the transformer manually, with individual AVR (automatic voltage regulator) and by parallel operation.
- The local control switches shall be mounted in the Tap Changer Motor Drive Unit.

In the above context "local" means at the transformer, "remote" means at the remote-control panel and "supervisory" means over the SCADA System from the System Control Center.

Special measures shall be provided together with the operation of the AVR (automatic voltage regulator) for parallel operation of transformers:

- In case that each individual transformer will feed to the individual busbar system, each transformer can operate either on "manual" or "automatic".
- In case that two or three transformers are feeding to the same busbar system (i.e. coupling closed), then an "out of step" protection has to ensure that all transformers are operating on the same tap, given the transformers have similar characteristics.

Deviation in the position of tap changers has to stop further function of AVR.

The equipment shall be so arranged as to ensure that when a tap change has commenced it shall be completed independently of the operation of the control relays or switches. If a failure of the auxiliary supply during a tap change or any other contingency would result in that movement not being completed, approved means shall be provided to safeguard the transformer and its auxiliary equipment. Electrical and mechanical means shall also be provided to prevent damage to the tap changing mechanism when end of travel has been reached.

Apparatus of approved type shall be provided for each transformer:

- to indicate the number of tapping in use on the transformer, mechanically at the transformer location and separately dedicated devices shall be used to electrically transmit the tap position to the remote and supervisory control points. The numbers shall range from 1 upwards, the lowest number representing the tapping position corresponding to the maximum number of winding turns, i.e. the plus per cent position, and the highest number representing the tapping position corresponding to the minimum number of winding turns, i.e. the minus per cent position.
- to give an indication at the remote and supervisory control point that a "tap change is incomplete", "tap changer out of step" and any other indication specified.
- Full supervisory control facilities shall be provided. A selector switch located at the local point is to be provided to transfer control to the remote point and at the remote point a further selector switch will transfer control to the supervisory point. The remote/supervisory switch will be common for both tap change and circuit controls.

All indicating devices shall operate correctly at any voltage between the limits of 85% and 115% of nominal value.

Arc extinguishing shall be under vacuum.

The tap changing switches and mechanism shall be mounted in oil tanks or compartments mounted in an accessible position on the transformer tank and shall be supported from the main tank or its base. "Drop down" tanks which necessitate the provision of pits in the foundations shall not be used.

Any enclosed compartment which is not oil-filled shall be adequately ventilated. A metal-clad heater shall be provided in the driving mechanism chamber and connected in parallel with the heater in the marshalling kiosk.

The oil in those compartments of the main tap changing apparatus which do not contain contacts used for making or breaking current shall be maintained under conservator head by means of a 50 mm inside diameter pipe connection from the highest point of the chamber to the conservator.

This connection shall be controlled by a suitable valve and shall be arranged so that any gas leaving the chamber will pass into the gas and oil actuated relay. There shall be no restrictions on the interconnecting pipework.

It shall not be possible for the oil in those compartments of the tap change equipment which contain contacts used for making or breaking current to mix with the oil in the main transformer or to mix with the oil in the compartments containing contacts not used for making or breaking current.

When a conservator is provided and used to maintain oil level in compartments which contain contacts used for making and breaking current, it shall be clearly separate from the main transformer conservator.

Two (2) oil gauges shall be provided. One shall be of the prismatic type and the second one of the magnetic types shall be fitted with contacts for initiation of a low oil level alarm to each alarm station. A breather shall be fitted to each such conservator.

Each compartment in which the oil is not maintained under conservator head shall be provided with an oil gauge of approved design.

Limit switches shall be provided to prevent over-running of the mechanism and shall be directly connected in the circuit of the operating motor. In addition, a mechanical stop or other approved device shall be provided to prevent over running of the mechanism under any condition. Limit switches may be connected in the control circuit of the operating motor provided that a mechanical declutching mechanism is incorporated.

Thermal devices fitted with alarm contacts or other approved means shall be provided to protect the motor and control circuits. All relays, switches, fuses, etc., shall be clearly marked to indicate their purpose. Switches for the initiation of a tap change shall bear the inscription "Raise Tap Number" or "Lower Tap Number".

The driving motor shall be rated for 400/230 V AC and shall be equipped with thermal and overload protection to be installed in the motor drive cubicle. Proper working of the driver motor shall be ensured even at voltages up to 25% below the rated voltage. Limit switches shall be provided to prevent over-running of the tap changing mechanism. These shall be directly connected to the operating motor circuit. In addition, mechanical stops shall be fitted to prevent over-running of the mechanism under any conditions.

For on-load tap change equipment, these stops shall withstand the full torque of the driving mechanism without damage to the tap change equipment.

The apparatus shall be of robust design and capable of giving satisfactory service without undue maintenance under the conditions to be met in service, including frequent operation. In addition, a lifting device shall be provided to allow easy removal of the tap changer for maintenance.

A device shall be fitted to the tap changing mechanism to indicate the number of operations completed by the equipment.

A permanent legible lubrication chart shall be fitted within the driving mechanism chamber.

After installation and commissioning tests, the terminals of the operating motor shall be clearly and permanently marked with numbers corresponding to those on the leads attached thereto.

Means shall be provided for ensuring that the tapping or other switches are making full contact. When such contact is made it shall be possible to lock the apparatus at any setting.

5.2.2.13 Parallel operation and voltage regulation

Transformers shall be able to be operated in parallel other transformers of the same characteristic.

All equipment necessary for this purpose shall be included in the Scope of Supply and Services.

For automatic voltage regulation, an electronic voltage regulator (AVR) shall be supplied for each transformer suitable for voltage regulation without hunting.

The regulators shall be installed in a dedicated AVR cabinets installed inside the control equipment room and shall meet the minimum requirements set in the Technical Data Sheets.

The voltage regulator shall contain, at least, the following main items:

- matching transformer, r.m.s.
- converter with integrator
- limiter stages for higher and lower
- set point adjuster
- timing stages for command duration
- amplifier
- current compensation
- compensation limiting, max. and min. limiter states
- selectable parallel operation modes:
  - power factor
  - minimum circulating current
  - master-follower.

Voltage drop compensation for the active and reactive voltage component shall be provided. In addition, the voltage regulators shall be provided with a manual/auto selector.

It must also be possible to operate the voltage control equipment for each transformer independently, whether on load or for test purposes, and to obtain independent indications.

In general, the voltage regulators shall realize the following functions:

- automatic regulation of voltage on one side of power transformer; measuring of voltage by direct connection to secondary side of voltage transformer
- commands to OLTC in automatic mode and manually by local command or command from the SCMS or through the gateway from the load dispatch center
- Local-Remote-Switch
- manual and automatic operation, switch-over locally at the regulator and by command from the SCMS or through the gateway from the load dispatch center
- indication of the regulated voltage
- minimum two adjustable set points, that can be switched over locally or by command from the SCMS or through the gateway from the load dispatch center
- acquisition and indication of TAP position (e.g. as BCD code – to be coordinated with supplier of power transformer)
- indication of set point deviation
- supervision of voltage and current on high and low limits; possibility of blocking of the regulator, when limits are reached
- adjustable time delays for TAP commands, supervisions etc.
- supervision of the running time of the TAP changer motor
- blocking of the regulator by external signals
- parallel operation with second power transformer.

The regulators shall be equipped with a display and buttons for control, input and navigation. The display shall indicate amongst others the TAP position, the regulated voltage, the active set point and the actual set point deviation. Buttons shall be available for direct control of the OLTC and switchover between Manual and Automatic operation.

LEDs with editable labels shall indicate important alarms. The assignation of alarm to LED shall be done in the parameterization.

The parameterization shall be done locally at the regulator through display and buttons and via a PC interface at the front of the device. The regulators will be connected to the substation level by protocol according to IEC 61850 and fiber optic connection. The regulators shall be supplied from the DC system.

5.2.2.14 Marshalling kiosks

For each transformer, a separate marshalling kiosk shall be provided so as to accommodate the transformer ancillary apparatus. The marshalling kiosk shall be located in an easily accessible position.

Marshalling kiosks shall comply with the requirements for Electrical Cubicles and Cabinets and shall include the following:

- temperature indicators, cooler control "auto-hand" changeover switch and test links and winding temperature indicators
- control and protection equipment for the cooling plant, including an isolating switch in the incoming circuit, capable of carrying and breaking the full load current of all cooling plant motors and of being locked in the open position, together with means for isolating each motor circuit or group of motor circuits when a multi-fan arrangement is adopted

The temperature indicators shall be mounted in a way ensuring that the dials are not more than 1.6 meters from ground level.

Facilities shall be provided to permit the temperature indicators to be removed from the kiosk without the necessity of passing the capillary tubing and bulbs through the various compartments.

Sharp bends shall be avoided where the capillary tubes enter the kiosk.

5.2.2.15 Cabling and wiring

5.2.2.16 Protection and condition monitoring

Beside the protection relays installed in the control room, each transformer shall be protected by the following devices mounted on the transformer:

- one (1) Buchholz relay for the transformer. The pipes connecting the Buchholz relay with the tank shall have slide valves to enable dismantling of the relay without oil leakage.
- one (1) Buchholz relay for the OLTC.
- one (1) dial type thermometer for oil temperature measurement, equipped with two (2) adjustable contacts for alarm and trip functions (range of maximum adjustment to be from 60°C to 120°C). The oil temperature thermometer shall be so placed that accurate reading is possible from ground level.
- one (1) oil level indicator each for main tank and OLTC, each one equipped with low oil-level alarm and trip contacts. The indicator shall be so placed that accurate reading is possible from ground level.

- one (1) resistance type thermometer, winding temperature measurement with heater coil. The winding temperature thermometer shall be a 2stage device having alarm and trip contacts and shall be so placed that accurate reading is possible from ground level.
- transformer condition monitoring, as described in more detail below and defined in the Technical Data Sheets, including:
  - Top Oil and winding temperatures (FO)
  - DGA (>3 gases) and moisture in oil
  - ambient temperature
  - Calculations: Winding hot spot, bubbling temperature, ageing rate, water content in winding paper insulation, cooling system efficiency.

5.2.2.17 Buchholz relays

Buchholz relays shall be twin float relays, designed for a pipe diameter 80 having DN80 flanges with four bore holes. They shall be free from operation caused by pump surges.

Moreover, covered sight glasses shall be provided, arranged in opposite position to each other to increase their visibility.

The Buchholz relay shall be equipped with a gas sampling and testing device.

The Buchholz relay shall have a test valve and a test key.

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.

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.

5.2.2.18 Oil flow operated protective relays

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.

5.2.2.19 Pressure relief devices

Pressure relief devices shall be of spring-loaded type. The operation indicator shall be metal pin-type and shall actuate directly the dual trip contact. It shall be installed in metal housing of protection degree IP 65.

5.2.2.20 Thermometers

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.

5.2.2.21 Oil level indicators

Oil level indicators shall be installed inclined downwards, the angle shall be about 30°. The scale shall indicate 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.

Oil level indicators shall be of magnetic type.

5.2.2.22 Transformer condition monitoring system

Where defined in the technical data sheet, transformers shall be monitored by a Transformer Condition Monitoring System.

The system in mention shall collect data from all the transformer devices and all other necessary sensors -which might not be explicitly mentioned above- so as to offer online condition monitoring.

The objective of such a system is this of optimizing the load capacity, lowering maintenance costs and thus extending the transformer's life expectancy.

This system shall provide monitoring information on -at least- the following aspects:

- capacitance and dissipation/power factor of HV bushing
- top and temperature
- ambient temperature
- temperatures of incoming and outgoing radiator pipelines
- operating current taken from the internal instrument transformers
- dissolved gas analysis (detecting as a minimum 6 gases)
- moisture in oil
- operating voltage measurements
- power factor measurements
- on load tap changers:
- switching position
- motor condition
- diagnostic information
- partial discharges.

The system shall control and monitor the transformer providing a report about the condition of the equipment to load dispatch center. The software shall be able to extrapolate the expected remaining transformer life and maintenance program from the comparison between transformer design data and transformer heat-run test data from one side and the operational temperatures from other side.

The measured and calculated parameters shall be used in the model for calculating, recording and making available to load dispatch center or other remote substations the following:

- cooling/overload forecast
- real time status/availability
- lifetime, aging rate, loss of life according to IEC 60076-7
- event recording
- condition based maintenance, including cumulative ageing rate and OLTC contacts usage (together with actual current and OLTC steps)
- winding hot spot temperature according to IEC 60076-7
- actual losses
- temperatures
- autotransformer bushing – change of capacitance, tan delta.

The system shall be provided with the relevant software, which will -preferably - be integrated in the overall SCMS. The software shall also be able to provide the following information:

- archived data and report examination, main parameters for review
- statistic data analysis
- data and analysis results archiving
- sensors – server connections monitoring, sensors operation supervision
- connected equipment status examination
- data archiving in standardized data base (MS SQL, ...)
- automatic stored data duplication for security reasons (backup)
- display and print of any selected data combination on the monitoring system
- On the display, operation data and alarm states of the autotransformer shall be simultaneously visible from NCC or other remote substations.
- Display of transformer shall include also a picture of the corresponding device.
- possibility to retrieve limit values for measured process values (low active, low inactive, etc.) by load dispatch center or other remote substations.

5.2.2.23 Special equipment and tools

All special equipment and tools necessary for erection, installation, maintenance, test and operation purposes are deemed to be included in the present Scope of Supply and Services.

Special equipment and tools shall include, but shall not be limited to, the following:

- lifting ropes necessary to handle the transformer by crane
- spreaders necessary to avoid damage of the bushings when lifting the transformer
- hydraulic jacks
- one (1) mobile lockable tool chest comprising worktable, drawers and compartment to accommodate an assortment of hand tools required for prevention maintenance
- one (1) set of hemp rope for bushing handling
- one (1) set of testing bushings.

5.2.2.24 Rails

For supporting the transformers rails are required. The rail system shall be completed, and the steel quality shall be at least EN 10025 S235JR or equivalent. The device for fastening the rollers on the rails is part of the delivery and shall be designed to withstand seismic forces acting upon the transformers.

5.2.2.25 Rating plates

The equipment under the scope of this specification shall be equipped with rating plates and connection diagrams according to relevant IEC 60076-1.

Further labels shall be provided, as considered necessary, providing easily understandable and unmistakable information regarding the maintenance and/or the operation of the equipment.

All plates and labels, including their fixing material, shall be corrosion resistant and shall always be clearly legible (antiglare).

5.2.2.26 Inspection and tests

General

Each transformer shall be subject to inspections and tests to be performed at the manufacturer's premises/test institutes and at site, as specified, to verify their conformity with the guaranteed and other design data.

The transformers shall be completely assembled in every respect prior to testing.

Prior to shipment, copies of all routine test certificates shall be made available. If, during testing, changes are made to the equipment, these deviations must be corrected in the drawings and documents submitted to reflect the accurate "as built" condition of the transformers and on delivery.

Tests on transformer tank and accessories

Prior to all testing, as addressed in the following paragraphs, the Contractor shall submit for approval test certificates for the following tests:

- vacuum test on tank and all oil-filled compartments (150 Pa for at least 5 hours)
- pressure test on tank and all oil-filled compartments (100 Pa measured on tank bottom for at least 24 hours)
- insulating oil tests
- bushing tests as per IEC 60137 (all routine tests have to be performed - type and special tests may not be performed if the respective test reports for identical bushings are submitted)
- current transformers tests as per IEC 61869
- tap changer (as per IEC 602141) and related equipment tests.

Factory Acceptance Tests (Type and special tests)

The following type and special tests as stipulated in the relevant IEC standards shall be carried out by the Contractor on one transformer for each type/rating:

- temperature-rise test (IEC 60076-2). 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.

- dielectric type test (IEC 60076-3)
- short duration AC voltage test (IEC 600763)
- measurement of zero-sequence impedance (IEC 600761)
- determination of sound levels (IEC 6007610)
- measurement of the harmonics of the no-load current (IEC 600761)
- measurement of the power taken by the fan and oil pump motors (IEC 600761)
- 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)
- 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).
- Frequency response analysis (SFRA-test in accordance with IEC 60076-18) with a -SFRA device using swept frequency 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
- Ability to withstand the dynamic effects of short circuit (IEC 60076-5, subclause 4.2).
  In case the Bidder/Contractor decides to demonstrate the ability to withstand the dynamic effects of short circuit by calculation, the Bidder/Contractor shall submit a proof that the sourcing transformer factory has already successfully demonstrated the same by test for at least one similar transformer

The maximum permissible deviation between twin and sister transformers shall be for each of the measurements in the ranges A to D according to IEC 60076-18, B2 "*Frequency Response Comparison*".

Factory Acceptance Tests (Routine Tests)

All routine tests as stipulated in the relevant IEC standards -IEC 60076-1, IEC 60076-2 and IEC 60076-3- shall be carried out by the Contractor on all transformers. In specific, the following tests shall be carried out:

- measurement of winding resistance (IEC 600761)
- measurement of voltage ratio and phase displacement (IEC 600761)
- Measurement of short-circuit impedance and load loss (IEC 600761), the measurement shall be performed with all tapping positions.
- Measurement of no-load loss and current (IEC 600761), 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.

- dielectric routine tests (IEC 600763), as follows:
  - separate source AC withstand voltage test
  - lightning impulse withstand test
  - switching impulse withstand test
  - long duration induced AC voltage test
- tests on on-load tap changer (IEC 600761), as follows:
  - operation test
  - auxiliary circuits insulation test
- leak testing with pressure for liquid immersed transformers (tightness test, IEC 60076-1, s-c 11.8)
- check of the ratio and polarity of built-in current transformers (IEC 60076-1)
- check of core and frame insulation for liquid immersed transformers with core or frame insulation (IEC 60076-1, s-c 11.12).

Site tests (minimum requirements)
Principles

All items of equipment shall be inspected and tested in order to check the quality, correct installation and operation so to ensure that there shall be no delay in commissioning due to supply of incorrect or damaged equipment. The Contractor shall thoroughly dry all equipment that may absorb humidity during installation before all following site tests.

Test during and after completion of erection - pre-commissioning of transformers

In order to ensure correct installation of the equipment, as well as to prove that the equipment has been correctly installed, these tests shall be performed during and after completion of erection on all equipment, as a means of pre-commissioning tests. All tests shall be performed in accordance with a detailed test program and test procedures prepared by the Contractor and approved by the Employer/ Engineer.

Among others, the SFRA test described shall be repeated for each transformer after completion of erection. It shall thus be verified that the transport and erection has been performed without jeopardizing the condition of the transformer windings. To this purpose, the tested transformers shall be in the same conditions as when the base line readings were derived.

For the maximum permissible deviation on any particular transformer, ranges A to D, according to IEC 60076-18, figure B.6, shall be observed. In case of exceedance of the permissible deviations, the transformers shall be repaired and fully retested by the Contractor.

After successful completion of the tests the Contractor can proceed with commissioning tests, as elaborated in the following paragraphs.

Commissioning tests of transformers

Commissioning shall be performed in accordance with a detailed commissioning test program and test procedures prepared by the Contractor and approved by the Employer / Engineer.

During the site test period, the Employer's staff shall be made fully acquainted with the operation and the routine maintenance of the plant.

The following tests shall be performed at site as a minimum requirement:
- visual checks
- measurement of the excitation current with low voltage (AC, 3phase) when the transformer is completely de-magnetized
- oil tightness check on tank assembled with radiators
- measurement of voltage ratio at all tap positions
- check of vector group by voltmeter method
- measurement of winding resistances at all tap positions
- measurement of d.c. insulation resistance, each winding to earth and between windings
- functional tests on cooling plant (including check of rotation direction of motors, control), supervisory and OLTC equipment
- measurement of tan δ value and dielectric strength of the insulation oil
- dissolved gas-in-oil analysis
- check of water content in ppm. for oil
- re-calibration and current injection test on winding temperature indicators (45 min).

The Contractor shall at his own cost and expense execute shop and field tests of all materials and equipment supplied by him or his Subcontractor required in accordance with the applicable IEC standards. This shall not preclude the Employer's/Engineer's right to call for further tests, if he considers them necessary.

All equipment and materials necessary for execution of the tests shall be furnished by the Contractor. Measuring apparatus and their calibration certificates shall be approved by the Employer/Engineer.

The Contractor shall submit to the Employer/Engineer for approval the test results showing conditions of tests performed, the test circuits and oscillograms, etc.

5.3 Substation Auxiliary and Earthing Transformers

5.3.1 Introduction

This section covers the technical requirements of the substation auxiliary transformers and earthing transformers. The auxiliary and earthing transformers shall be three-phase, oil-immersed, hermetically sealed type, suitable for outdoor installation, with data as defined in the Technical data Sheets.

5.3.2 Magnetic cores

The magnetic cores of the auxiliary and earthing transformers shall be constructed from non-aging, cold-rolled, grain-oriented silicon steel sheets. Each lamination shall be insulated with high quality insulation coating. The sheets shall be clamped strongly enough to prevent displacement by short-circuit or other stresses during shipment or installation.

The magnetic circuit shall be insulated from all structural parts and shall be capable of withstanding a test voltage to core bolts and to the frame of 2.5 kV r.m.s. for one minute.

5.3.3 Windings

Windings shall have uniform insulation. The neutral(s) shall be brought out and shall be insulated to withstand applied voltage tests as specified.

Electrolytic copper of a high conductivity (class A, in accordance. with IEC) shall be used.

The winding shall be thoroughly seasoned during manufacture by the application of axial pressure at a high temperature for such a time as will ensure that further shrinkage is unlikely to occur in service.

The windings and their connection leads shall be braced to withstand the shocks which may occur through rough handling and vibration during transport, switching and other adverse service conditions.

5.3.4 Tank

The transformer tank shall be of the upper flange type with bolted cover and shall be equipped with corrugated sheet steel type radiators incorporated with the tank or welded-on radiators.

Lifting lugs shall be provided on the cover.

Two earthing terminals of adequate size shall be provided, installed diagonally at the bottom of the transformer tank.

5.3.5 Bushings

The transformers shall be equipped with top quality, electrical grade silicone or porcelain bushings, as defined in the data sheets, on both the primary and secondary side, in compliance with the standards listed in this specification. The bushings shall be arranged on the tank cover in an upright position and must be easily exchangeable without lifting of the cover plate.

5.3.6 Cooling

The auxiliary and earthing transformers transformer cooling shall be ONAN.

5.3.7 Off load tap changer

The station auxiliary transformers shall be equipped with manually operated off-load tap-changers in accordance with the Technical Data Sheets. A dial-type indicator, with numbers of the selected tap position, shall be so fitted and arranged as to be easily visible from the side of the transformer.

5.3.8 Measuring, protection and monitoring equipment

Hermetically sealed type auxiliary transformers shall be provided with a dedicated protection device for hermetically sealed type transformers, which shall include the following functions

- temperature monitoring with visual indication of thermometer and maximum temperature and adjustable thermostat switches for alarm and trip
- overpressure sensor with trip contact
- oil level / gassing indicator and sensor with trip contact

All protection devices shall trip the primary and secondary circuit breakers.

5.3.9 Ancillary devices

Auxiliary and earthing transformers shall be provided with the following ancillary devices:

- earthing terminals of adequate size capable of carrying the maximum possible earth fault current. The terminals shall be positioned diagonally at a convenient location near the base of the frame.
- wheels or skids
- drain plug
- protection device for hermetically sealed type transformers

- lifting lugs
- off load tap changer
- filler cap
- rating plate.

5.3.10 Test and inspections

For all substation auxiliary and earthing transformers, type test certificates including detailed type test report shall be submitted and all routine tests stipulated in the relevant IEC standards IEC 60076-1, IEC 60076-2 and IEC 60076-3 shall be performed.

5.4 Performance Guarantees, Capitalization of Losses, Penalties, Tolerances and Rejection

Performance Guarantees, Capitalization of Losses, Penalties, Tolerances and Rejection will be applied at the following equipment: power transformers, autotransformers, auxiliary transformers and reactors.

5.4.1 Introduction

The following paragraphs refer to the performance guarantees, capitalization of losses, penalties, tolerances and rejection for all types of transformers and reactors to be provided for Project.

The term "*transformer*" refers to power transformers, autotransformers, and auxiliary transformers, accordingly.

The guaranteed values stated by the Contractor in "*Technical Data Sheets*" will be strictly observed.

5.4.2 Evaluation

When evaluating the individual bids received from the various Bidders the transformer and reactor losses will be capitalized using the guaranteed value indicated in "Technical Data Sheets".

The transformer losses shall be capitalized as follows:

- Load losses USD 2,500.00 per kW
- No-load losses USD 5,500.00 per kW
- Auxiliary losses USD 500.00 per kW

5.4.3 Penalties

During the execution of the project, penalties shall be applied as follows:

5.4.3.1 Losses

Loss determination shall be performed in accordance with IEC 60076.

For three-winding transformers and autotransformers with tertiary winding, the determination of the load losses shall be performed in accordance with IEC60076.8 subclause 7.7.

If no-load losses, load losses and auxiliary losses measured during routine tests are higher than the corresponding value indicated in "*Technical Data Sheets*" by the Contractor, the Contractor shall pay the penalties resulting from application of the following formulas.

Load losses[1]

- Sll = (Pllm – Pll) x 2.5 USD/W

  Where:

  Sll = penalty for load losses

  Pllm = load losses (W) measured during routine tests[2]

  Pll = load losses indicated in the "*Section C Technical Data Sheet*"[3]

No load losses

- Snll = (Pnllm – Pnll) x 5.5 USD/W

  Where:

  Snll = penalty for no-load losses

  Pnllm = no-load losses (W) measured during routine tests

  Pnll = no-load losses indicated in the "*Section C Technical Data Sheet*"

Auxiliary losses

- Al = (Anlm – Anl) x 0.5 USD/W

  Where:

  Al = penalty for auxiliary losses

  Anlm = auxiliary losses (W) measured during routine tests

  Anl = auxiliary indicated in the "*Technical Data Sheet*", i.e. the guaranteed values

5.4.3.2 Temperature rise

If the test of temperature rise carried out on any transformer should reveal that the temperature rise of the transformer exceeds the values guaranteed in the "Technical Data Sheet", the rated power and output of the transformer at operation conditions as specified above will have to be down rated to such a degree as to obtain the temperature rise guaranteed.

[1] .

[2] The auxiliary power losses for cooling fans (if any) of transformers as measured during the factory tests will be included in Pllm,

[3] Pll will include the corresponding value as per "*Technical Data Sheets*".

If, according to the results of the tests, the measured temperature rise exceeds the guaranteed value, the price for all transformers shall be reduced as a compensation for decreased life expectancy as follows:

Temperature rise over the admissible limit °K	Compensation in percent (%) of the total CIP price of the transformer
0 - 1.99	4.5

5.4.3.3 Noise Level

Should sound power level (LPA) determined in accordance with IEC 60076-10 via the sound pressure method exceed the required values for transformers in the "*Section C Technical Data Sheet*", the Contractor shall pay the penalties of USD 8,000.00 per dB(A).

It is hereby understood that values of 0.5 dB(A) and above will be rounded up to the next full dB(A).

The transformers or the reactors shall be tested at rated voltage and no-load current (*vide* 6.1 and 6.2 of IEC 60076-10) with the tap-changer on the principal tapping.

5.4.4 Tolerances and rejection

The total losses, no load losses, load losses, rated voltage ratio, short circuit impedance, no load current, temperature rise and audible noise shall not exceed the guaranteed values filled in the "Technical Data Sheets" by the Contractor plus the tolerances indicated here below.

In case one of the parameters mentioned above exceeds the tolerances specified below, the Employer shall have the right to reject the transformer.

5.4.4.1 Transformer total losses

The difference between the total losses considered for rated voltage and frequency, with tap changer at rated tap and the corresponding value indicated in the "*Technical Data Sheet*" by the Contractor shall not be higher than 10%.

5.4.4.2 Transformer no-load losses

The difference between the no load losses considered for rated voltage and frequency, with tap changer at rated tap and the corresponding value indicated in the "*Technical Data Sheet*" by the Contractor shall not be higher than 15%, provided that the tolerance for total losses is not exceeded.

5.4.4.3 Transformer load losses

The difference between the load losses considered for rated voltage and frequency, with tap changer at rated tap and the corresponding value indicated in the "*Technical Data Sheet*" by the Contractor shall not be higher than 15%, provided that the tolerance for total losses is not exceeded.

5.4.4.4 Rated voltage ratio

The no-load voltage ratio with the OLTC on the rated tap shall not differ from the rated voltage ratio stated in the Technical Data Sheets by more than the minimum of the following values:

a) ± 0.5% of the required rated voltage ratio
b) ± 1/10 of the actual short circuit voltage with OLTC on the rated tap.

The voltage ratio on other tappings (same pair) shall not differ from the rated voltage ratio stated in the Technical Data Sheets by more than ± 0.5% of the design value of turns ratio

The voltage ratio for further pairs shall not differ from the rated voltage ratio stated in the Technical Data Sheets by more than ± 0.5% of the design value of turns ratio

5.4.4.5 Short circuit impedance

- Short-circuit impedance for a separate-winding transformer with two windings, or a specified first pair of separate windings in a multi-winding transformer.
  a) principal tapping
     When the impedance value is ≥10 %: ±7,5 % of the declared value
     When the impedance value is <10 %: ±10 % of the declared value
  b) any other tapping of the pair
     When the impedance value is ≥10 %: ±10 % of the declared value
     When the impedance value is <10 %: ±15 % of the declared value
- Short-circuit impedance for an auto-connected pair of winding, or a specified second pair of separate windings in a multi-winding transformer:
  a) principal tapping: ±10 % of the declared value
  b) any other tapping of the pair: ±15 % of the declared value for that tapping

  Further pairs of windings shall be ≥15 %.

5.4.4.6 No-load current

At rated voltage and frequency, with the tap changer at rated tap, the no-load current shall not differ more than + 30% from the guaranteed value indicated in the "*Technical Data Sheets*".

5.4.4.7 Temperature rise

The temperature rises of the windings measured by means of tests shall not exceed the value indicated in the "*Technical Data Sheets*" by more than 2°K.

5.4.4.8 Audible noise level

The transformers or the reactors shall not exceed by more than 3 dB (A) a sound power level (LPA) determined in accordance with IEC 60076-10 via the sound pressure method of the values stated in the "*Technical Data Sheet*".

The transformers or the reactors shall be tested at rated voltage and no-load current (*vide* 6.1 and 6.2 of IEC 60076-10) with the tap-changer on the principal tapping.

It is hereby understood that values of 0.5 dB(A) and above will be rounded up to the next full dB(A).

For all the other values, the margins stated in IEC standards are applicable.

5.5 Packing, Shipping and Transport

The present paragraph addresses the packing, shipping and transport considerations for all power transformers, auxiliary transformers and reactors etc., included in section "Transformers". Here below, the term "transformer" is used to collectively refer to all the aforementioned equipment.

Transformers of up to 40 MVA, and depending on the manufacturer's guidelines and practices, can be filled with oil during the transportation. Power transformers of more than 40 MVA shall be in any case shipped without initial oil, filled with nitrogen kept under positive pressure.

If the transformer is to be transported with oil, it shall be filled to such a level as to cover the windings completely.

If the transformers are to be shipped without oil, the tank shall be filled with either dry air or nitrogen gas. Automatic pressure regulating equipment shall be provided to maintain a slightly positive pressure above the outside atmosphere to ensure that the windings remain as dry as possible while the oil is absent.

The amount of oil, which will be separately shipped, shall be adequate to fill the transformers, together with tap changer compartment, plus a volume of ten percent (10%) of the total quantity required for the transformer. The oil shall be shipped in tank pressurized by dry nitrogen.

At site, the transformers will be filled with hot (50-70C^0) and degassed oil via the high vacuum filtration unit (mobile oil purifying plant). They shall be evacuated before the filling starts and the filling shall be made from the bottom.

Where gas charged from bottles fixed at the equipment's tank will be used, the bottles, reduction valves, pressure gauges and humidity control equipment shall maintain a constantly monitored gas pressure inside the tank, throughout the transport. Care shall be taken so as during the transport and storage at site, a sufficient and monitored overpressure shall occur inside the tank (in order to avoid access of moisture). At each intermediate step of the transport (i.e. in factory, port of departure, port of arrival -if applicable- and site), the pressure shall be recorded.

In all cases, to facilitate handling and shipping and avoid damages of the equipment, external accessories (bushings, insulators, conservator vessels and breathers, radiators, wheels etc.) shall be protected properly and removed if deemed to be necessary. Bushings, radiators and all accessories which may be affected by moisture shall be properly, seaworthy and moisture-proof packed.

Oil for the first filling shall be provided and to be supplied by the manufacturer in non-returnable drums.

All parts shall be carefully packed for transport in such a manner that they are protected against mechanical injury and the injurious effects of water and climatic conditions encountered during transit to their destination, as well as during long storage before erection.

For the transport, two (2) independent impact recorders shall be provided. Before the transport, the manufacturer shall declare the maximum admitted accelerations in XYZ-directions. The setting of the detection limits shall be agreed upon between the Contractor and the Employer. The operation of the impact recorders shall be regularly checked during the transport.

After the transport, the Contractor shall supply the impact recorder registration along with a report indicating main events during transport and whether the transformer is ready to be installed.

The Contractor shall be responsible for ascertaining the methods and limitations of transport to site. Designs affected by these factors shall be subject to agreement.

Each consignment shall be accompanied by a detailed packing list containing, at least, the following information:

- name of the consignee
- details of consignment
- destination
- total weight of consignment
- handling and unpacking instructions
- bill of material indicating contents of package.

The Contractor shall prepare and submit for approval drawings and complete instructions about the means and methods to be used for the installing and removing of heavy equipment, such as transformers.

6 Electrical Cubicles/Panels

6.1 General

The below mentioned paragraphs deal with electrical cubicles for control, protection, metering and distribution of auxiliary supplies to be provided within the scope of the Contract. The paragraphs below define the minimum requirements applicable to electrical cubicles / panels in general, further detailed particular requirements are defined along with the equipment specifications and in the Technical Data Sheets.

6.2 Standards

Electrical cubicles shall be constructed and tested according to the latest editions of all applicable standards, especially those specified in the respective equipment specifications and in the Technical Data Sheets.

6.3 Technical Requirements

6.3.1 General

Electrical cubicles shall be industrially produced, made by reputable manufacturer.

Electrical cubicles located within the same room shall be harmonized as far as possible with regards to size, color and physical appearance in order to achieve a uniform impression.

Cubicles shall be designed for continuous operation at the ambient temperatures of the substation(s) and with solar gain if installed externally.

6.3.2 Mechanical

Electrical cubicles shall generally be free standing or wall mounted type and shall be constructed of folded sheet steel of adequate thickness to provide rigid support for the control and monitoring equipment which shall be mounted thereon. Floor mounted cubicles shall be mounted on base frames. and shall be extendable at both sides.

Electrical cubicles shall be sized adequately to accommodate the electrical components and terminal blocks. plus, a minimum of 15% spare space. Due consideration must be given to required separation of equipment with regards to heat dissipation, electrical separation, accessibility for cable connection, operation and maintenance and to the total heat loss of the components installed inside the cubicle.

Cubicle doors and compartments shall be provided with locks and keys.

Front mounted elements for operation and indication shall be mounted in a height so that they can be read and operated without the use of steps (not higher than 1.6 m).

For seismic withstand capability the complete cubicle shall be qualified according to the requirements of IEEE 693 and shall meet the requirements of the high qualification level. The test report shall be submitted together with the bidding documents.

6.3.3 Corrosion Protection and Coating

The cubicles shall be completely corrosion protected in accordance with Section VII- 3 General Technical Requirement. Cold galvanization is restricted to treating of edges and refinish treatment.

Panel enclosures shall be provided with a coating in accordance with a proven industrial coating system, compliant with Section VII- 3 General Technical Requirement. The thickness of the dry film shall be at least 80 µm; the adhesive strength shall be GT1 or better according to the standard ISO 2409.

The Employer/ Engineer reserves the right to review and approve the proposed coating system and to determine the thickness of coating in accordance with Section VII- 3 General Technical Requirement.

The coating under visual examination, must in any case present the appearance of an accurate application and be free of lesions, porosity, cracks or bubbles.

Where sharp edges cannot be avoided by constructional means edge protections shall be applied.

6.3.4 Enclosure and Ventilation

Electrical cubicles shall be vermin proof and shall be protected against dust and water by protection class IP55, and against external mechanical impacts according to protection code IK06.

All electrical devices and material installed inside the cubicle shall be as a minimum IP2 (finger safe) in accordance with IEC 60529 or shall be provided with covers.

Electrical cubicles shall preferably be self-cooling, without ventilation louvres, i.e., the heat loss generated by components installed shall be dissipated via the surface of the cubicle, without additional measures.

If additional louvres are required for natural ventilation, these shall be provided with filters to ensure the required degree of protection and to avoid ingress of dust. The louvres shall be preferably arranged at bottom and top of the front door of the cubicle. Louvres at the cubicle side and/or rear shall be avoided

Cubicle for external installation shall be fitted with rain and insect protected ventilation holes and draining eyelets.

6.3.5 Labelling and Identification

Each cubicle shall be provided with a designation label on the top of the cubicle, with cubicle identification number and designation in accordance the requirements for Plant and Equipment Identification of the General Technical Requirements.

Front mounted control, indicating, measuring elements, protection relays, etc. shall be provided with engraved labels with clear circuit reference and function (e.g., "Busbar Voltage. "Automatic Transfer Manual/Auto", "Busbar Protection Main"). Identification labels without clear circuit reference and function (e.g., "Voltmeter", "Selector Switch", "Protection Relay") are not acceptable.

Elements inside the cubicle shall be provided with durable labels with circuit identification.

6.3.6 Cable entry

Unless specified or agreed differently, Electrical Cubicles shall be designed for bottom entry. Cable entries shall be provided with gland plates and / or with suitable seals to prevent the ingress of dust or vermin and the propagation of possible fires. During transport and installation, a provisional sealing of cable entries is required.

Inside the cubicles a cable fixing rail shall be provided at suitable distance from the cable entry to allow for proper entry and fixing of the incoming cables.

Close to the cable fixing rail, a screening rail shall be provided. Cable screens shall be grounded via EMC compatible cable glands or by EMC compatible cable screen clamps which shall provide a circumferential large surface connection to the screening rail.

6.3.7 Terminal blocks

Terminal blocks shall be provided for all incoming and outgoing cables, connection of cables directly to components is not acceptable. Separate terminals must be provided for each cable core to be connected (including spare cores). PE terminals are to be provided for connection of earth continuity conductors of incoming and outgoing cables.

Terminals for incoming and outgoing circuits shall be sized to suit the cables connected (derating, voltage drop, requirements for safe tripping, etc. may require larger cross sections).

- Terminals for alarm signals shall be provided with isolation and test facilities
- CT terminal blocks shall have shorting links and injection test facilities
- VT terminals shall have isolation and injection test facilities
- Terminals for measuring/metering purpose shall be provided with facility for sealing.

Terminal blocks shall be arranged with sufficient space for easy connection of incoming cables. Parallel rows of terminal blocks shall be spaced at least 150 mm apart. At least 20% spare terminals shall be provided in each block.

6.3.8 Internal Wiring

Internal wiring within shall be provided with minimum cross section as follows:

- for control and annunciation circuits: 1.5 mm²
- for voltage transformer circuits: 2.5 mm²
- for current transformer circuits 4 mm².

Power-frequency withstand voltage of internal wiring shall be as follows:

- current transformer (CT) and voltage transformer (VT) secondary circuits:
  3 kV in accordance with IEC 61869
- power, auxiliary and control circuits > 60 V:
  2 kV in accordance with IEC 61439
- power, auxiliary and control circuits > 60 V:
  500 V in accordance with IEC 61439

Internal wiring shall be halogen free and flame retardant.

All internal wiring shall be neatly trunked in halogen free wiring troughs. The wiring troughs shall be filled as a maximum up to 75%. Cable fixation by cable-tie, by adhesive fixation and flying wires are not permitted.

Wiring of conductors to hinged doors, wing frames, etc. shall use extra flexible wires arranged in a flexible hose suitable for the purpose. Bended cable harness is not permitted.

Wires shall be numbered or otherwise marked at both ends in accordance with the applicable schematic and wiring diagrams.

Wiring between terminals of various devices shall be point-to-point, no splicing or "T" connection shall be allowed. Only one wire is allowed to be connected to one terminal.

6.3.9 Earthing

PE terminals of incoming and outgoing cables the screen rail and all metal parts of the cubicle must be electrical bonded. Flexible earth connectors must be provided for movable parts, such as panel doors, swing frames, etc.

A minimum of two earth terminals must be provided for connection to the earthing system.

6.3.10 Power Supply and Switching Devices

As a general rule, control, alarm and trip circuits, shall be supplied by DC, power circuits and circuits for motor drives, heaters, lighting and other auxiliaries shall be LV AC. Separate circuits shall be provided, as a minimum, for control, alarm, trip circuits and auxiliary

Power circuits depending on their rating, shall be protected by air circuit breakers (ACB), molded case circuit breakers (MCCB) or miniature circuit breakers (MCB). Control, alarm, trip and VT circuits shall be protected by miniature circuit breakers (MCB). All switching devices shall be selected in accordance with the requirements of IEC 60364 with due regard to the following criteria:

- the short circuit rating of switching devices must be selected to withstand and interrupt the maximum fault current
- current rating and tripping curve, respectively the tripping characteristic must be selected to adequately protect the circuit and the load connected against overload and short circuit
- current rating and tripping curve, respectively the tripping characteristic must be selected to ensure safe tripping for minimum fault current of the circuit connected
- particular attention shall be given to the selectivity of all MCBs.

The Contractor shall provide design evidence that the criteria as detailed above have been considered on request.

Where a voltage source is used for various purposes (e.g., measurement, metering), separate MCBs shall be provided for each sub-circuit.

All switching devices shall be provided with auxiliary contacts which shall be integrated in the substation control and monitoring system.

6.3.11 Lighting, Power Outlets and Heating

Each cubicle shall be provided with the following:

- cubicle illumination operated by door switch
- low voltage power outlet for maintenance
- temperature and humidity-controlled space heater with on-off switch to prevent condensation within the cubicle.

Anti-condensation heaters must be easily replaceable and electrically and thermally safe to touch or prevented from touching.

The circuits for the above-mentioned devices shall be protected by miniature circuit breaker (MCB), for the low voltage power outlet additional earth fault protection by residual current device (RCD) is required.

6.3.12 Control and Indication

All indications on electrical cubicles shall comply with IEC 60073.

For all LV AC and DC power distribution cubicles, the front panel of each compartment shall be provided with the following indicator lamps and controls:

- red indicator circuit energized
- green indicator circuit de-energized
- yellow indicator circuit tripped

In addition, they shall be equipped with an externally linked operating handle for circuit energization/isolation.

The in-feed compartments shall also be provided with:

- selector switch manual/automatic
- red pushbutton close circuit breaker
- green pushbutton open circuit breaker

Pushbutton controls shall be installed beneath protective covers to prevent inadvertent operation. The “Close circuit breaker” pushbutton shall only be operable when “Manual” operation is selected.

6.3.13 Mimic diagram and signage

A mimic diagram and circuit list shall be provided for each main switchboard. A circuit diagram and circuit list shall be provided for each main switchboard and each distribution panel which must contain at least the following:

- the source(s) from which the switchboard or distribution panel is supplied
- the rating of the equipment and circuit breakers contained within the switchboard/distribution panel
- the connected load identified by plant identification number name
- operating instructions where more than simple distribution with incoming and outgoing MCBs /MCCBs exist.

7 Auxiliary Supply

7.1 Introduction

The paragraphs below define the minimum requirements applicable to:

- Low Voltage (LV) AC distribution switchgear and panels.
- DC rectifier / battery charger systems
- Batteries
- DC distribution switchgear and panels.

All switchgear and distribution panels shall be designed and manufactured in accordance with the requirements for Electrical Cubicles and shall comply with IEC 61439.

Switching devices, shall be provided as air circuit breakers (ACB), molded case circuit breakers (MCCB), miniature circuit breakers (MCB) or contactors and shall be selected in accordance with the criteria described in requirements for Electrical Cubicles und clause Power Supply.

All switching devices in the equipment provided under this chapter are to be provided with auxiliary contacts for signaling purposes.

Regarding the AC and DC installations, the following paragraphs shall be read in conjunction with the requirements set out under Electrical Cubicles and in the Technical Data Sheets.

7.2 AC Distribution Main Switchgear and Panels

7.2.1 Standards

AC Distribution Main Switchgear and Panels shall be constructed and tested according to the latest editions of the following standards:

IEC 61439-1	Low-voltage switchgear and controlgear assemblies - Part 1: General rules
IEC 61439-2	Low-voltage switchgear and controlgear assemblies - Part 2: Power switchgear and controlgear assemblies
IEC 61439-3	Low-voltage switchgear and controlgear assemblies - Part 3: Distribution boards intended to be operated by ordinary persons (DBO)
IEC 60947	Low-voltage switchgear and controlgear - All Parts
IEC 60364	Low-voltage electrical installations - All relevant parts

7.2.2 General

The LV AC distribution system for the substations' AC services shall be supplied as a general rule from two auxiliary transformers and one emergency generator, unless defined differently in the Scope of Supply.

The LV AC distribution system shall be a three phase TN-C-S multiple source system with separate protective conductor and neutral conductor to current using equipment in accordance with IEC 60364-1. No direct connection from either of the sources (i.e., the transformer neutral point or the generator star point) to earth is permitted. The interconnection conductor between either the neutral points of the transformers or the generator star points shall be insulated. The function of this conductor is like a PEN; however, it shall not be connected to current-using equipment. Only one connection between the interconnected neutral points of the sources and the PE shall be provided inside the main switchgear assembly, as detailed in IEC 60364-1, Figure 31D.

7.2.3 Main LV AC switchgear

The main LV AC switchgear shall be a metal-clad power switchgear assembly, designed and manufactured in accordance with IEC 61439 with internal separation and enclosure as defined in the technical data sheet.

The main switchboard shall be a single busbar, AC board with bus tie breaker and three in-feeds, from two auxiliary transformers and a diesel generator set, unless defined differently in the Scope of Supply.

The infeeds and bus tie shall be provided as withdrawable circuit breaker panels with air circuit breakers (ACB) according to IEC 61439. Outgoing feeders shall be provided as molded case circuit breakers (MCCB) or miniature circuit breaker (MCB) and may be fixed mounted according to IEC 61439.

Withdrawable circuit breakers and plug in type outgoing feeders of same rating shall be interchangeable.

The in feeds from the auxiliary transformers shall each supply a section of the busbar and shall be provided with under voltage protection and an automatic changeover such that loss of either in feed will automatically open the circuit breaker for the affected in feed, close the bus section circuit breaker, and transfer the load to the other in-feed. Loss of both auxiliary transformer in-feeds shall open both in-feeds from the auxiliary transformers, send a start signal to the diesel generator and open the bus-tie between the non-essential and essential load sections.

Starting of the diesel generator shall cause automatic closure of the in-feed from the generator once rated voltage and frequency has been achieved by the generator. The bus-tie between non-essential and essential busbar sections shall remain open during generator operation.

Restoration of voltage and frequency on either of the auxiliary transformer in-feeds, within limits pre-set on the under-voltage relays, shall initiate a re-transfer back to normal supply after a pre-set time delay and shall open the incomer from the diesel generator. Restoration of normal supply shall initiate a signal to stop the generator, open the generator in-feed to the essential busbar, and close the bus-tie between the non-essential and essential sections of busbar.

Restoration of voltage and frequency on both auxiliary transformer in-feeds, within limits pre-set on the undervoltage relays, shall initiate a re-transfer back to normal supply after a pre-set time delay and shall open the incomer from the diesel generator. Restoration of normal supply shall initiate a signal to stop the generator, open the generator in-feed to the essential busbar, and maintain the bus-tie between the non-essential and essential sections of busbar in an open status.

Each infeed shall be capable of carrying the full rated secondary current of the auxiliary transformer, respectively emergency generator.

All units, when built up into a complete switchboard, shall be such that the completed switchboard is of free-standing flush fronted design having a neat and clean appearance and is readily extensible.

The incomer control cubicles of the switchboards are to house all protection equipment, including lighting, heating and socket outlets as required.

Incoming circuit breakers shall be provided with integrated multi-function protection relay. Trip of any outgoing unit shall alert the substation operator and provide an output to the SCMS by a group alarm specific to the main LV switchgear.

The Contractor shall size the main LV AC switchgear to meet the requirements of the equipment to be provided under this project, including spare capacity as specified.

7.2.4 Air circuit breakers (ACB)

Air circuit breakers (ACB) shall be of withdrawable three-pole air break type and shall comply with IEC 60947. The operating mechanism shall be of the stored energy type using pre-charged springs, with spring charging motor and facility for manual charge.

Mechanical opening/closing of the circuit breaker shall be enabled through ON/OFF push buttons on the front side of the circuit breaker. The ON/OFF push buttons shall be operable also when the circuit breaker is in the racked in position however, it shall be possible to block the mechanical “ON” activation when the breaker is racked in.

The operating mechanism shall be provided with shunt close and trip coils to enable electrical operation of the circuit breaker locally from the control compartment and from remote via a common bay control unit of the SCMS.

Air circuit breakers shall be provided with integrated electronic trip units with the following protection functions:

- overload protection
- short-circuit inverse or definite short time-delay protection
- instantaneous short-circuit protection adjustable trip current threshold
- earth fault protection.

The electronic trip unit shall allow setting of the protection functions, provide indication of trip cause and trip data and shall work without external power supply.

All necessary auxiliary contacts shall be provided to enable remote control, remote alarm, and indication of the position/state of the ACB.

7.2.5 Distribution panels

LV distribution panels shall be three-phase TN-S with separate neutral and PE in accordance with IEC 61439 with internal separation and enclosure as defined in the technical data sheets. LV distribution panels shall be fitted with manually operated incoming breaker and outgoing feeder breakers (MCB or MCCB). Additional residual current devices (RCD) shall be provided for socket outlet circuits and other circuits requiring earth leakage protection.

Each building shall have its own distribution panel(s) for building services requirements. In outdoor areas distribution panel(s) shall be provided at strategic locations.

7.2.6 Meters and Current transformers

Each infeed of the main switchboard shall be provided with a multifunction meter for indication of current, voltage, active, reactive, and apparent power and energy.

Three single-phase current transformers shall be provided for each in feed.

Current transformers with cast-resin insulation shall be used. The current transformers must be capable of withstanding the dynamic and thermal short-circuit stresses available.

The current transformer accuracy classes shall be in accordance with the requirements of the Technical Data Sheets.

7.2.7 Terminals and cabling

All connection terminals for main switchgear and distribution panels shall be housed in a separate compartment.

Tripping of an MCB within a distribution panel shall be indicated in the control room and alert the substation operator by a group alarm signal from the distribution panel.

Tripping of a circuit breaker within the main AC or DC switchgear shall alert the substation operator and provide an output to the SCMS by an individual alarm.

7.2.8 Signaling

All signaling, monitoring and other contacts must be wired to the associated terminal strip of the relevant switch unit and are to be processed by the substation control and monitoring system.

For MCBs a summary alarm shall be shown on the cubicle and in the control room.

7.2.9 Test requirements

All Routine Verification tests shall be carried out as per IEC 61439 and IEC 60947 and corresponding test reports shall be provided.

Site acceptance tests shall include functional tests and dielectric tests of the main circuits.

7.3 DC Installations

7.3.1 General

The DC installations are required for protection and control and for telecommunication, as defined in the scope of supply, with data as defined in the technical data sheets and shall include the following components:

- industrial rectifiers/battery chargers for DC systems
- main DC switchgears
- DC distribution systems
- batteries for DC systems.

7.3.2 Industrial rectifiers and battery chargers for DC systems

7.3.2.1 Standards

The rectifiers/chargers shall be in full accordance with the latest versions of the following standards:

IEC 601461-1-1	Semiconductor converters - General requirements and line commutated converters - Part 1 1: Specification of basic requirements
IEC 60146-2	Semiconductor converters - Part 2: Self-commutated semiconductor converters including direct DC converters

7.3.2.2 Technical requirements

The rectifiers shall comply with IEC 60146 and shall be adequately sized by the Contractor. Each rectifier /battery charger shall be sized for the anticipated full Substation load plus the battery charging current, as calculated by the Contractor during the design process for the equipment to be provided under this Project.

The rectifiers shall be 12 pulse thyristor-controlled devices with isolating transformer, naturally ventilated, with constant voltage/current characteristics for Ni Cd cells and shall be suitable for parallel redundant operation with load sharing whilst simultaneously charging the battery and supplying the DC loads. The charging voltage shall be automatically varied such that the cells are not overcharged.

- Automatic and manual boost/float charging facilities shall be provided
- Readily replaceable inlet air filters shall be provided
- The radio interference suppression of the rectifiers shall comply with the appropriate IEC regulations
- The static voltage regulation, DC output ripple and voltage stability shall be as per the requirements of the Technical Data Sheets
- Blocking diodes shall be included in the output circuit of each rectifier
- Rectifiers shall be provided with earth fault monitoring systems
- Internal lighting and a thermostatically controlled anti-condensation heater shall be provided
- Rectifiers shall be provided with analogue meters for input voltage, input current, output voltage, battery current and load current

Rectifiers shall as a minimum be monitored for the following fault conditions:

- input voltage failure
- rectifier fault
- rectifier high temperature
- output voltage high
- output voltage low
- high DC ripple
- battery circuit failure/battery voltage low; and
- ground fault alarm (only for systems operates isolated).

All alarm conditions shall be indicated on the front panel of the rectifier by LEDs and shall be repeated as a group alarm per rectifier at the Substation control room.

The DC outputs shall supply two separate DC busbars which are equipped with bus coupler.

7.3.3 Main DC switchgear

A DC positive and negative 2 wire system shall be provided for the DC station services. The supplies will be taken from the station rectifiers and batteries. Each rectifier/battery supply shall be capable of carrying the full load.

DC switchgear shall comply with IEC 61439.

The switchgear shall be designed and manufactured as a type-test verified assembly.

The main DC switchgear assembly is to be metal-clad with internal separation end enclosure as define in the data sheets.

The main DC switchboard shall be a single busbar, 220 V DC board with two in-feeds.

The in-feeds from both rectifiers shall operate normally closed and shall automatically share the load. Loss of either in-feed due to a rectifier and battery failure will automatically open the circuit breaker for the affected in feed, and the load shall be fully supported by the other infeed.

Restoration of voltage on the in-feed, within pre-set limits, shall initiate an automatic closing of the circuit breaker and rectifier load sharing when automatic mode of operation is selected.

The Contractor shall size the main DC switchgear to meet the requirements of the equipment to be provided under this Project, including spare capacity as specified.

Fault detection on any outgoing unit shall alert the Substation operator by a group alarm specific to the main DC switchgear.

7.3.4 DC distribution

DC distribution panels shall be 2 wire-fitted with double pole miniature circuit breakers.

Each switchyard shall have its own distribution panel(s) for DC supplies to switchyard equipment. Each item of switchyard equipment shall be supplied on its own circuit or circuits, as necessary.

The Contractor shall note the requirements of the protection and control system in these specifications regarding separate supply requirements for circuit breaker tripping coils, main and back up protection systems, etc.

Contractor is to size the panels and the number required to meet the requirements as detailed in the specifications.

7.3.5 Test requirements

- For rectifiers/chargers, the type and routine tests shall be as per IEC 60146 1 1.
- For DC switchgear, the verifying and routine tests shall be as per IEC 61439 and IEC 60947.

7.4 DC Batteries

7.4.1 Standards

The batteries shall be valve-regulated Nickel Cadmium (Ni-Cd) type, rechargeable, suitable for indoor installation. The overall battery installations shall comply with the latest versions of the following standards:

IEC 60623	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Vented nickel-cadmium prismatic rechargeable single cells
IEC 62259	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Nickel-cadmium prismatic secondary single cells with partial gas recombination
IEC 62485-1	Safety requirements for secondary batteries and battery installations - Part 1: General safety information
IEC 62485-2	Safety requirements for secondary batteries and battery installations - Part 2: Stationary batteries
IEEE 1115	IEEE Recommended Practice for Sizing Nickel-Cadmium Batteries for Stationary Applications

7.4.2 Technical requirements

The batteries shall be of robust design i.e., resilient in harsh conditions.

Their discharge rate shall be low, and they shall be able to a dual rate charging method, i.e., float and boost charging.

Each cell shall be contained in a separate case of polymer material, thus enabling replacement of single cells.

Each cell shall bear durable marking providing at least the following information:

- type designation of cell
- manufacturer
- positive terminal indication
- nominal voltage.

The scope of supply is deemed to be complete including, without being limited to, the following items:

- batteries
- mounting insulators
- connectors, lugs, connecting cables between cells etc.
- battery racks.

The battery cells shall be delivered in entirely closed wooden boxes of adequate thickness. The rack for each battery shall be delivered in a separate box.

The Contractor shall pay attention to the ventilation requirements for the room where the batteries shall be installed. The respective calculations and the relevant ventilation system proposed by the Contractor shall be subject to approval.

7.4.3 Battery racks

The batteries shall be mounted on suitable battery steel racks. The racks in mention shall have coating ensuring electrical insulation and ability to withstand electrolyte corrosion.

The cells will be placed on rubber insulators, thus avoiding direct contact with the racks.

7.4.4 Battery rating and sizing

Battery rated voltage and discharge time shall be as defined in the Technical Data Sheet. The capacity shall be selected adequately to supply all consumers connected during the discharge time defined in the Technical Data Sheet and shall be based on a sizing calculation in accordance with IEEE 1115.

7.4.5 Test requirements

The type approval tests for the battery cells shall be in all regards in compliance with IEC 60623 / IEC 62259.

Routine tests for batch approval shall be performed as per IEC 60623 / IEC 62259.

7.5 AC Uninterruptible Power Supply (UPS)

7.5.1 General Design Requirements

The uninterruptible power supply (UPS) system shall provide continuous uninterrupted AC power to consumers requiring safe AC supply, such as SCMS, etc. The UPS system shall comprise all necessary control, static switches, manual bypass switch, etc. necessary for the reliable operation of UPS system under all operating conditions of the substation.

The UPS system shall comprise but not be limited to the following major items:

- rectifiers
- inverter
- static transfer switch
- manual by-pass switch with bypass transformer
- UPS distribution with MCBs / MCCBs
- UPS battery.

The output power shall be designed to meet the requirements of the consumers requiring uninterrupted supply.

The UPS shall be suitable for continuous operation, and function satisfactorily with a combination of variations of the incoming supply voltage and frequency as defined in data sheets.

The UPS system shall be fed from LV AC essential switchboard via suitably rated MCCBs.

The enclosure of the UPS shall be in accordance with the chapter "Electrical Cubicles".

Manual by-pass switch with bypass transformer and outgoing feeders shall not be installed separately from the rectifier / inverter to allow maintenance of these, while the consumers are on bypass operation.

As a minimum, the following status and alarm indications shall be provided locally and for remote indication:

- AC Supply Fail
- Battery - High Voltage
- Battery - Low Voltage
- Charger Fail Indication
- Battery Earth Fault
- DC Supply Fail
- Float Charger On
- Boost Charger On
- Inverter Fail Indication
- UPS on bypass
- Output MCB Trip (Common for all MCBs).

7.5.2 UPS Batterie

The batteries shall be valve-regulated Nickel Cadmium (Ni-Cd) type, rechargeable, sealed type, suitable for indoor installation in cubicles in electrical operating rooms. The overall battery installations shall comply with the latest versions of the following standards:

IEC 60623	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Vented nickel-cadmium prismatic rechargeable single cells
IEC 62259	Secondary cells and batteries containing alkaline or other non-acid electrolytes - Nickel-cadmium prismatic secondary single cells with partial gas recombination
IEC 62485-1	Safety requirements for secondary batteries and battery installations - Part 1: General safety information
IEC 62485-2	Safety requirements for secondary batteries and battery installations - Part 2: Stationary batteries

The battery shall be mounted inside a battery cubicle. The battery cubicle shall be sufficiently ventilated by natural ventilation and shall be suitably protected against corrosion by the battery electrolyte. The battery shall be spaced to permit sufficient access to all individual cells to allow replacement of cells and/or checking cell voltages and connections.

The discharge capacity of the battery shall be sufficient to supply the loads during a discharge time given in data sheets of this specification.

The battery sizing shall consider that the service voltage required shall not drop below recommended figures (permitted voltage tolerances of the individual loads) and the voltage fluctuations caused by power consumption of various loads shall be kept within permitted limits.

Minimum 25% spare capacity in each battery shall be considered while sizing the batteries and ageing factor as per standards / as recommended by the manufacturer for a life period (see also data sheets) shall be considered.

7.5.3 Inverters

The inverters with static transfer switches shall be supplied and installed to provide power supply, voltage and frequency as detailed in the data sheets. The output of the invertors shall be continuously synchronized to the input of the static transfer switches.

The inverters shall have load switches for the input circuits, as well as the contactors locally/manually and automatically operated for the output circuits, located upstream the static switches.

The inverters shall have overload and short circuit protection.

7.5.4 Static Transfer Switches

A static transfer switch shall be provided to transfer the critical load from the inverter directly to the main power source (via bypass transformer), and vice versa, without interrupting or degrading computer operations. This operation shall occur if the inverter system fails or an over-load beyond the capabilities of the inverters develops either by load faults or inrush currents. The static transfer switch shall consist of static interrupters located on the output of each inverter and a static switch on the bypass transformer.

The static switch shall be capable to feed the output loads and shall be rated 30 % above the nominal inverter rating.

Internal failures in an inverter unit shall cause the static interrupter to trip with minimum damage to the inverter and isolate only the inverter which failed. Failure of two inverters or overload conditions discussed above shall remove the inverters and bypass to the main supply. Necessary voltage, frequency and automatic synchronizing devices for synchronization of the inverter outputs with the main supply shall be provided.

7.5.5 Manual By-pass Switches

This switch shall allow the load to be supplied from the AC distribution board, during periods when the UPS is being repaired. The switch transfer shall be "make-before-break" to assure loads power continuity.

Isolating Bypass Transformer

Bypass transformers shall be single phase two winding isolating transformers with electrostatic screen to provide galvanic isolation between LVAC incoming supply and UPS output. Tappings shall be provided to permit matching of the output voltage to the requirements of the load. The trans-formers shall be of the air-cooled type, rated to accommodate overloading and to meet the performance required in the transient and short-circuit states and shall comply with IEC 60076 as appropriate.

7.5.6 UPS Output Protection (Including Outgoing Lines)

UPS outgoing feeders shall be protected by MCBs/MCCBs. The rating and tripping characteristic of the MCBs/MCCBs shall be selected carefully to ensure protection of the connected load and its supply cable. Due care must be taken to ensure the following:

- MCBs/MCCBs of outgoing feeders shall not trip due to possible inrush currents of the protected system
- MCBs/MCCBs must trip within the times required by IEC 60364 in case of fault at the remote end of the feeder

7.5.7 Test requirements

- For UPS systems, the type and routine tests shall be as per IEC 60146-1-1.
- For DC switchgear, the verifying and routine tests shall be as per IEC 61439 and IEC 60947.
- For batteries, the type- and batch acceptance tests shall be as per IEC 60623 / IEC 62259.

8 Diesel Generator Units (DGU)

8.1 General

A diesel generator unit shall be provided in order to ensure that essential auxiliary supplies are maintained in the event of outage of the HV or LV systems.

The diesel generator shall comprise but not be limited to the following items:

- Diesel engine with governor and accessories; synchronous generator, 400-volt, 50 Hz, 3-phase 4-wire, exciter and voltage regulator
- fuel tank and stand
- mounting hardware
- control panel
- battery supply for control and starting complete with automatic battery charger
- generator circuit breaker
- tools, sufficient for routine maintenance
- two sets of "Start-up" spares
- interconnecting wiring of engine controls
- exhaust system, complete with silencer.

The generator rating indicated in the Technical Data is a provisional assessment of the requirement, the Contractor shall size the generator for the substation to suit the sum (plus 25%) of the maximum individual demand kVA of each of the following loads:

- battery chargers
- control room lighting & air-conditioning
- protection & control lighting & air-conditioning
- communications room air conditioning
- switchyard distribution panel
- external guardhouse(s)
- security lighting
- CCTV system (if any).

The fuel tank shall be installed at a safe and convenient adjacent location. The tank shall contain sufficient fuel for three days continuous operation. The ambient air temperature is as specified in Specification VII-4

The engine may be required to run for extended periods of time during maintenance, without benefit of its assigned generator loads.

Equipment may be exposed to wind-borne sand and dust, and therefore shall be equipped with appropriate fuel, oil and air filters.

Although the diesel generator set is intended for stand-by / emergency duty, all ratings must be based on full load 72-hour continuous service, without benefit of interruption or load cycling, to allow for power outage of indefinite duration.

The net volume of the tank shall be sufficient for operating the DGU during 48 hours at 100% load without refilling.

The engine shall be started automatically on failure of normal power supply.

The generator will be connected automatically to the load.

8.2 Technical Requirements

8.2.1 Diesel engine

The engine shall be water- cooled, with a closed-circuit radiator and fan. The radiator and fan assembly, which shall be installed inside the diesel generator room, shall have the necessary anti-corrosive treatment/material. Suitable electrical heating of the cooling water during standstill of the diesel generator set shall be provided, if required, to allow for the specified starting time.

The diesel engine shall be directly coupled to the generator, and both installed together on a common base frame. Vibration absorbers shall be used to prevent transmission of vibrations to the surrounding area.

8.2.1.1.1 Lubrication system

The engine shall be fully force lubricated. The main oil pump shall be gear-driven by the main shaft. Where necessary, a suitable interval lubricating equipment shall be provided to allow for the specified starting time.

8.2.1.2 Fuel supply and injection system

The fuel oil tank shall be located at an adequate distance from the diesel engine room and shall be sufficiently sized for 24 hours of continuous full-load operation of the diesel generator. The tank shall be topped- up manually.

An integrating fuel meter shall be installed, suitably connected to the engine's fuel admission and return system, to measure the actual consumption of the engine.

The outlet connection of the fuel extraction line on the diesel storage tank shall be at least 10 cm above the fuel tank bottom, or otherwise suitably positioned to prevent the intake of any sludge or water which may have accumulated in the bottom of the storage tank.

A drain valve shall be fitted to the tank to permit the drain off of any such accumulation of sludge or water.

The ventilation openings of the tanks shall be protected by a flame trap.

8.2.1.3 Air intake and exhaust system

The engine shall be fitted with an air-intake filter.

Flexible connections to the air intake duct, exhaust line and all other external pipework shall be provided.

Temperature-resistant materials shall be used for the exhaust piping and the required expansion bellows. Expansion joints in the exhaust pipe shall be made of metal and exhaust silencers shall be galvanized.

The engine exhaust gas outlets and ventilation inlet ducts shall be arranged to ensure that the exhaust gas is not channeled back into the ventilation air inlet system.

8.2.2 Generator

8.2.2.1 General

The relevant IEC regulations shall apply, except where more stringent rules are stated below.

The generators shall be air cooled with forced ventilation. A heater shall be provided to protect the generator against humidity during stand-still.

Six double element Pt 100 temperature sensors shall be provided, embedded in the stator windings and wired to terminal boxes.

Temperature detectors shall also be provided for stator end plates and other positions if mentioned elsewhere in the Specification.

Overvoltage and overspeed protection shall be provided.

8.2.2.2 Bearings

Bearings and, if necessary, also couplings and auxiliary lines shall be insulated so as to ensure that no damage or injury of any kind would result through currents caused by shaft voltages.

8.2.2.3 Excitation

A brushless rotating diode rectifier excitation system shall be provided. The rotating diodes shall be easily accessible for maintenance.

The excitation equipment shall be so designed that the highest voltage is reached at 5/4 load and a power factor of 0.7. The excitation response ratio shall be greater than 1.0/second (IEC 60034-3).

During short circuits, the time taken to de-excite from rated voltage to 10% of rated voltage shall not exceed 8 seconds. The de-excitation time for open circuit de- excitation from rated voltage to 10% of rated voltage shall not exceed 30 seconds.

The excitation and de- excitation control equipment shall be combined with the voltage regulation equipment in cubicles and shall be located in the diesel generator room or attached to the diesel generator.

8.2.2.4 Generator main connection

The generator main connection shall be provided with LV power cables.

All necessary current and voltage transformers for protection, excitation, measuring, etc. shall be provided in the generator line connection cubicle which feeds power to the 400V distribution board. The generator circuit breaker shall be in the generator line connection board.

8.2.2.5 Voltage regulator

A solid-state type voltage regulator, with automatic and manual control within ±5% an accuracy of ±0.5% of the rated voltage, ranging from no-load to full-load conditions at rated frequency, shall be provided. A suitable transfer control system with transfer switch and necessary meters and controls shall be provided for a smooth bumpless transfer from automatic to manual and from manual to automatic voltage control. Bumpless and smooth transfer shall be automatically initiated in the case of a sudden failure of the voltage regulator.

The Contractor shall supply all required auxiliaries such as generator field breaker, discharge/suppression resistor, motor-operated voltage adjusting rheostat and other accessories, which are required for safe and continuous operation.

8.2.2.6 Generator protection

The protective relays used for generator protection shall be of the digital/numerical type. The relays shall be of a well proved design with 5 – 10 years operational experience.

The protective relays shall be installed in a steel-sheet cubicle, this cubicle shall be mounted in the diesel generator room along with the other cubicle for control, monitoring, regulating, signaling excitation and voltage regulation. The scope of protection relays shall be proposed by the Bidder.

8.2.2.7 Control and monitoring

The following control and monitoring equipment shall be provided as a minimum at the load control panel:

- remote/local selector switch
- automatic/manual selector switch
- engine ON/OFF
- voltage regulator higher/lower switch
- voltage set point adjustment switch
- speed regulation higher/lower switch
- circuit breaker control switches implemented in a mimic diagram
- indication instruments at least for:
- cooling water inlet and outlet temperature
- fuel oil tank level
- lube oil pressure
- lube oil temperature(s)
- generator active power
- generator reactive power
- generator current (all three phases)
- generator voltage with selector switch
- generator frequency/engine speed
- generator stator winding temperature (six)
- exciting current
- all required positions and alarm indication
- hours run metering.

A relay assembly shall be mounted in the control panel to provide dry alarm contacts for remote indication of engine safety device operation.

Additional features shall be provided if required for safe and satisfactory operation.

All control and monitoring cubicles shall be installed locally in the diesel generator rooms.

All necessary interlocking and alarm circuits shall be provided to eliminate any possible damage to the equipment due to malfunctioning of instruments or operational errors.

8.2.2.8 Required technical data

The required technical data for the diesel generator is specified in the data sheet.

8.2.3 Test requirements

Functional tests shall be provided at the manufacturer's workshop, including load test.

9 Control & Protection System

9.1 Instrument Transformer Requirements

The rated burden of the protection cores indicated in the data sheets are to be considered as minimum requirements for all possible ratios.

The Contractor is responsible for defining the final characteristics of the CT, VT and CVT cores for protective relaying, to comply with the performance and functional requirements of the offered protection terminals under the actual short circuit condition. Corresponding calculation shall be prepared and presented for approval to Employer in a form of design calculation in which all the inputs and calculation formulas or other methods used shall be clearly indicated. The calculations shall be submitted for approval before start of production.

Current transformers shall be of the low reactance type and with secondary taps in case of multiple ratios. The performances shall not be inferior to that defined in the IEC Publications.

For class “PX” type, the knee-point voltage (defined as the point on the excitation curve at which a 10% increase in the RMS value of the applied voltage results in 50% increase in the RMS value of the secondary exciting current) shall be for each of the possible ratios above the secondary voltage for maximum short-circuit conditions, actual secondary winding resistance at 75°C and 150% of the anticipated external burden.

The magnetizing current at knee-point voltage shall not be higher than 5% of the nominal secondary rated current. For high impedance protection, scheme specific requirements shall be taken into consideration for selecting knee-point voltage and magnetizing current.

For the electricity metering, based on the actual consumption of electricity meters proposed, the contractor shall prepare and provide the following for approval:

- calculation of CTs secondary burden
- calculation of cross-section of secondary current circuits
- calculation of VTs secondary burden
- calculation of Voltage drops from VT’s secondary outlets to meter
- calculation of cross-section of secondary voltage circuits.

The limits of voltage error and phase displacement error for high precision metering cores shall be in accordance with the above-mentioned standards.

Means for checking the integrity of CT, VT and CVT circuits either automatically or manually shall be provided. The integrity check shall be possible in service without inhibiting or jeopardizing the protection function.

CT, VT and CVT terminals of the relay panels shall be equipped with links for forming of star points and for isolating or shorting the respective circuit as well as providing measuring points.

Each CT circuit shall be earthed only at one point. For protection circuits, the earthing shall be made at relay side. The metering cores shall be earthed only at CT/marshaling kiosk sides. The CT circuits shall be provided with earthing facilities at the CT boxes.

9.2 References

The protection equipment supplied under this Contract and the associated software shall have at least three years of operational experience in HV/EHV substations. The Contractor shall quantify the number of installations for the protection equipment and associated software version which have been installed at similar voltage levels and environmental conditions over the last three years.

9.3 Housing, Wiring, Identification

Protection equipment shall be grouped in the necessary number of fully wired, floor mounted, sheet steel cubicle type panels. Where cubicles are installed internal to buildings in an air-conditioned environment, the cubicles shall meet the requirements of the IEC Publication 60529, IP 52 class. All cubicles installed external to buildings shall be IP65.

The Contractor shall ensure that adequate cooling of external cubicles is provided to compensate for the high summer temperatures. Temperature within the cubicles shall stay ≤ 40°C where electronic modules are installed, unless the equipment specification is such that the device proposed can cope with high temperatures anticipated.

Each protection cubicle -except for cubicles for bus bar differential protection- shall be dedicated to one single protected element.

The sequence of the cubicles shall be defined in detailed design. Cubicles shall be fitted with window type, flame-retarding, protective full doors. Each cubicle shall be provided with an anti-condensation heater with an internal thermostat/humidity sensor to prevent the formation of condensation within the cubicle.

Where protection cubicles are installed in air-conditioned relay rooms of control buildings, the protection cubicles shall be of the self-ventilated type and shall comply with all construction requirements of the above-mentioned sub-section of this Specification.

The final paint finish shall comply with the requirements of the General Technical Requirements and the color shall be subject to Employer's /Employer’s Representative’s approval.

The Contractor shall ensure that in the event of any failure of the air-conditioning system, the protective relaying systems and their associated signaling, monitoring, control, and alarm equipment, remain in full operating condition for a minimum of 24 hours without any detrimental effect to equipment performance, taking cognizance of the outside ambient temperature and the maximum humidity possible for the Project location.

Equipment identification shall include:

- feeder (bay) labels
- individual relay identification (device, ANSI designation numbers and functions)
- terminal identification of external relay connections to CTs, VTs, CVTs, DC and AC alarms, trips and communication equipment
- control cable labels.

All internal and external wiring shall be identified using ferrules at each point of connection.

9.4 Testing Facilities, Indications

Except as stated otherwise, no provision for automatic test facilities is required. Each protection functional assembly shall be provided with easily accessible field-testing terminal blocks/sockets for CTs and VT circuits. Where duplicated protection systems are provided, testing of one protection system shall be possible without degrading the function of the other.

The protection schemes shall be provided with local and remote DC supply supervision and with following minimum local indications, manually or electrically resettable, allowing for a reliable and precise post-fault/test response analysis:

- faulty phase (where applicable) or general starting
- operating time or time zone
- tripping (phase selective where applicable)
- receiving and sending of all associated HF signals (blocking/ permissive/ direct trip)
- associated fiber optic or PLC channel(s) failure
- test /in /off status, in conjunction with a lockable switch with remote position indication.

The operating indications shall not be lost in case of auxiliary supply interruption. Means for testing of the indicators shall be provided at relay case or panel level. The indications shall be clearly visible without opening of relay cases or relay cubicle doors. Resetting shall be possible without opening relay cases.

9.5 Auxiliary Supply

The supply of all multifunction protection terminals shall be by DC/DC converters. Duplicated or Main/Back-up protection systems of the same feeder shall be supplied by two independent DC sources (battery/charger). A cold stand-by charger shall be provided for back-up circuits. Relay cubicle DC supplies shall be monitored, and a central alarm shall be issued whenever the voltage exceeds the limits for reliable operation. Supply schemes shall be based on the fail-safe principle, e.g., loss or open circuit shall not cause incorrect opening or closing of protection contacts.

If not stated otherwise, the following basic design data apply:

- DC trip/control voltage 220 V DC (+10 % ... -20 %)
- VT phase secondary voltage 110/√3 V
- CT phase secondary current 1 A
- Frequency 50 Hz (-6 % ... +2 %)

Within the specified DC voltage and frequency variations the offered relays shall retain their rated characteristic accuracy and full operation capability.

9.6 Tripping Circuit Supervision and Pole Discordance Protection

The trip contacts shall be hardwired and act via tripping relays on the trip coils of the relevant circuit breaker. Two tripping relays with remote reset via the station controller shall be implemented for all HV circuit breakers, with one trip relay combining the Main protection relays and the second combining the Backup protection relays. Each trip relay shall act on a separate trip coil of the circuit breaker. The trip output individual protection functional assemblies shall be of relay type.

Trip circuits shall be continuously supervised in the closed and open position of the circuit breakers. The trip circuit supervision shall include to the extent feasible, all loops between trip contacts.

Circuit breaker pole discordance protection shall be provided as integral part of the CB control.

9.7 Electromagnetic Interference and Insulation

All the necessary measures at substation/control building/cubicle level for ensuring proper function and component safety of the offered relay types with respect to over-voltages induced in the secondary wiring (from primary and secondary equipment switching) as shielding and grounding of control cables, are part of the scope.

The relay equipment shall meet following specifications as a minimum:

- HV test: 2 kV 50Hz, 1 min or 2.8 kV DC 1 min
- HV impulse: IEC 60255-4/5, Class III, 5 kV
- HF test: IEC 60255-22-1, Class III
- electrostatic discharge: IEC 60255-22-2, Class III
- radiated electromagnetic field: IEC 60255-22-3, Class III
- fast transient tests: IEC 60255-22-4, class IV
- temperature: IEC 60068-2-1/2, –5+55 °C 96h
- relative humidity: IEC 60068-2-3 severity 56d
- enclosure: IEC 60529, IP 50
- vibration: IEC 60255-21-1, Class 1
- shock & bump: IEC 60255-21-2, Class 1
- seismic IEC 60255-21-3, Class 3.

Signal interfaces between protection and control equipment and switchgear or communication equipment shall be of opto-coupler type.

9.8 Quality Assurance

Type tests

Approved type tests, certificates and documentation shall be available for each functional assembly of the proposed protection systems similar in all essential respects to the equipment included in the Contract. The contractor shall submit all required test records. If not relevant for the actual service conditions, the Employer reserves the right to require re-testing or additional tests to be included in the routine test program.

Factory acceptance tests

Equipment for modular static protection systems (e.g., bus bar protection) pre-assembled in the relevant boards/cubicles etc. shall be tested in the Contractor's workshops as far as wiring and proper function is concerned. Simulated inputs (binary signals, current and voltage inputs from test power supplies) shall be used for the tests.

The Employer/Employer's Representative reserves the right to attend the factory tests for the main protection equipment.

Software updating

The Employer/Employer's Representative reserves the right to attend the factory tests for software testing/updating of the main protection equipment.

Commissioning tests

The commissioning test program shall be submitted to the Employer and the Employer's Representative for approval. Minimum test requirements are as follows:

- insulation resistance of all secondary circuits (current and voltage transformers, control, indication and alarm circuits, etc.), continuity tests of all secondary circuits (current and voltage transformers, control, indication and alarm circuits, etc.)
- primary injection of current transformer circuits, including differential protection circuits, to prove all connections and to check ratios, fault threshold, stability, and correct phase detection
- stability tests and in-zone fault test for differential protection schemes
- secondary injection of AC and DC relays to check their operating characteristics, alarm, and indication circuits
- operation of relays and tripping elements at reduced DC supply voltage
- measurement of the end-to-end signaling channels latency
- simulation by secondary injection of the various protection transferred trips, and auto-reclosing programs with associated circuit breakers
- measurement of the end-to-end HF teleprotection channels transmission times
- combined logic tests of HF signaling /protection /autoreclosing /schemes under various simulated fault and operating conditions
- fuses, overcurrent trips, short-circuit trips, time settings, relay settings.

9.9 Functional Requirements

9.9.1 General

The required functionality and the grouping in protection terminals (Intelligent Protection Relay IPR) for each individual feeder were described in the Scope of Supply and Services VII-1. This section gives details on the requirements for the major protection functions, irrespective of the specific assignment to a particular terminal. The Contractor can propose alternative arrangements suitable to the offered IPR types, subject to approval of the Employer.

All IPR shall be provided with an optical interface for connecting to the station bus according to IEC 61850. Monitoring and basic configuration of all input and output logical signals shall be possible locally and from SCMS. Disturbance and Sequence of Event records shall be retrievable from substation SCMS and from the Control Center. Evaluation software with mathematical operations and reporting format templates shall be provided at both locations.

All multifunctional protection terminals shall have at least 4 remotely selectable setting groups.

9.9.2 Line differential protection (87L)

The current differential-based protection shall be suitable for EHV/HV transmission system applications, featuring as a minimum:

- phase selective measuring units and trip outputs
- separately adjustable sensitivity for phase and earth-faults
- typical operating time max. 30 ms
- direct transfer trip for one-side fault infeed
- direct transfer trip by external input, max. 20 ms transmission time, opto-coupler input
- charging current compensation
- saturation detector
- compensation of skewed end-to-end transmission time delays
- master-slave CPUs synchronization
- five zones quadrilateral shaped distance function backup for phase and earth faults, including mutual zero sequence compensation
- IN/OUT switches for function and transfer trip enabling
- 4 setting groups
- comprehensive hardware and software self-supervision, including communication links
- disturbance and event recorder using substation - synchronized time tagging (1ms resolution).

At 220kV level dedicated OPGW pair is provided under this Contract for the functional link to the remote end. All necessary additional devices, plug connectors, hardwired or fiber optic short connections to the patch panel are part of the supply.

9.9.3 Distance protection (21)

The phase and earth fault full scheme distance protection shall be suitable for EHV/HV transmission system applications, featuring:

- typical operation time less than 30 ms
- simultaneous measurement of all fault loops
- quadrilateral characteristic for phase and earth faults
- unlimited directional discrimination by cross-polarization and voltage memory
- correct performance in the presence of CT saturation and CVT transients
- accurate impedance measurement down to 10% of the rated current
- separate measuring units for accelerated Zone 1
- 4 impedance back-up zones (forward / backward selection, timer-controlled)
- permissive or blocking signaling assignable to any of the impedance zones
- phase segregated trip
- power swing blocking selectable for all zones
- out of step tripping (pole slip protection)

- weak infeed and current reversal logic
- switch-on-to-fault feature
- parallel line zero sequence compensation
- distance- to- fault locator with compensation of the remote fault infeed, arc resistance, load current, and mutual coupling of parallel lines
- VT supervision
- Loss of VT zone blocking
- DC supply supervision (local and remote alarms)
- hardware and software self-supervision, including blocking in case of communication link failure
- disturbance and event recorder with substation- synchronized time tagging (1ms resolution).

One dedicated permissive or blocking end-to-end signal is provided for the distance function signaling. All necessary additional devices, plug connectors, hardwired or fiber optic short connections to the patch panel are part of the supply.

9.9.4 Auto-reclosing (79)

The function shall initiate a single-shot auto-reclosing cycle. Following programs shall be selectable:

- 1-phase AR for 1-phase fault
- 3-phase AR for 1-phase faults and lock-out trip for multiple faults
- 3-phase trip for all kind of faults
- out of service
- Closing pulse length and maximum wait time shall be settable. Dead times for 1-phase and 3-phase AR cycles shall be independently and continuously adjustable. Following checking options shall be provided:
- deadline/live bus
- dead bus/live line
- synchronism check

The scope of supply includes all necessary time/auxiliary relays, etc. external to the protection terminal. The AR function shall be externally blocked-in case of:

- manual closing of the line
- delayed trips (back-up zones)
- trip by busbar and breaker-failure protection
- circuit breaker interlockings.

Following local indications shall be provided:

- AR blocked
- AR initiated
- AR out of service
- 1-phase AR in progress
- 3-phase AR in progress.

All inputs from external equipment shall be provided with opto-couplers.

9.9.5 Non-directional overcurrent backup (50/51, 50N/51N)

Two phase and earth overcurrent stages shall be included in each multifunction protection terminal. It shall be possible to select a wide variety of time-dependent trip characteristics according to IEC and IEEE standards.

It shall be possible to select for each stage if the pick-up threshold measurement is based on peak or on RMS current values.

The overcurrent back-up functions shall be automatically enabled in case of loss of voltage measurement.

9.9.6 Directional overcurrent backup (67/67N)

Two directional phase overcurrent stages (67) shall be provided, allowing for selection of any IEC and IEEE current trip characteristics. Although not required by the present protection philosophy, provision shall be included for a future signaling-aided directional comparison scheme.

Two time/ trip threshold stages shall be provided for the earth fault directional protection (67N), featuring:

- One signaling-aided stage (permissive or blocking)
- IEC and IEEE overcurrent trip characteristics.

All necessary additional devices, plug connectors, hardwired or fiber optic short connections to the communication equipment interface are part of the supply.

9.9.7 Unbalance protection (46)

This protection shall detect asymmetrical loading or broken conductors, featuring:

- negative sequence current calculation
- insensitivity to frequency fluctuations
- alarm and trip stages.

9.9.8 Overload protection (49)

The overload protection shall be based on a thermal replica model, featuring:

- alarm and trip stages
- connection to external temperature detector.

9.9.9 Busbar and circuit breaker failure protection (87BB, 50BF)

The busbar protection for the 220kV and 132 kV switchgears shall be of low impedance decentralized type. It shall provide fully discriminative fault clearance in all operational configurations, without introducing sequential tripping. For the existing 132kV switchgears and MV switchgear shall be of centralized type.

Releasing of a trip command shall be based on at least two different criteria. Tripping shall be initiated to all connected circuits to the faulty busbar, contributing or not to the fault infeed.

Stability for external faults shall be ensured:

- up to the short-circuit ratings of the switchgear, irrespective of the distribution of current between individual circuits
- under full CT saturation of any of the outgoing circuits.

Sensitivity setting shall ensure dependable operation for phase-to-phase and phase-to-earth faults under minimum system conditions. The operating time shall not exceed 30ms including scheme's own tripping relays. Separate measuring elements are required for each phase.

The protection shall not operate for faults in the secondary wiring when any primary circuit is carrying full load current. In case of open CT condition under rated primary load, the equipment shall not suffer any damage.

The protection scheme and associated cubicle shall be capable of being extended in a later stage with a least 50% of the specified number of bays.

The breaker-failure scheme shall be started by the trip command of any protective relay and shall initiate, via a settable breaker-dedicated time relay:

- selective tripping of all adjacent breakers (busbar protection trip logic)
- transformer inter-trip at all voltage levels
- remote-end circuit breaker trip by direct signaling channel

The scheme shall be supervised by fast reset overcurrent relays, operating on all fault types and under saturated CT conditions. It shall operate correctly in case of evolving faults (single-phase to multiple phase).

9.9.10 Overvoltage protection relay (59)

The overvoltage protection shall include two stages and trip the local and the remote circuit breaker.

9.9.11 Undervoltage protection relay (27)

The protection shall include single phase undervoltage detection with minimum 2 stages. It shall trip the local and /or the remote end circuit breaker.

9.9.12 Synchro check relay (25)

The synchronism and voltage check function shall be provided in the BCU and protection terminals for the control of the auto-reclosing function initiated by the distance and line differential function. Enabling criteria shall include deadline and dead bus.

Adjustable values shall be the operating mode, voltage difference, frequency difference, angle difference, and supervision time.

9.9.13 300 MVA auto-transformer 220 kV side protections

The overall layout shall be based on duplication of IPRs specialized in the protection of large EHV/HV transformers. Full segregation of wiring, trip circuits, auxiliary supplies and housing cubicles shall be achieved to provide a highly redundant and secure protection scheme. Generally, the transformer overreaching stages of the non-unit protections (distance and directional overcurrent) shall have 3-time stages. The trip philosophy is subject to Employer’s approval.

The transformer biased differential protection (87T) shall feature:

- phase selective measuring units
- dual slope trip characteristic
- high stability during through faults with deep CT saturation
- inrush restraint (2nd and 5th harmonic).

Other required functions are:

- 87N- low impedance restricted earth fault protection
- 21- three steps back-up distance protection with quadrilateral characteristic for phase and earth faults, power swing blocking, VT-MCB blocking
- 50/50N/51/51N– overcurrent phase and earth fault back-up protection (enabled only in case of voltage loss)
- SOTF switch on to fault
- 67- two steps directional phase fault overcurrent protection
- 67N -two steps directional earth fault overcurrent protection.
- 46 -two steps negative phase sequence overcurrent protection

- 24 - over-excitation protection (V/Hz)
- 4 setting groups.

The overall scheme shall integrate specific protections (transformer guards) supplied by the transformer manufacturer, for which the following minimum requirements apply:

- Buchholz main tank protection trip/alarm (63 TANK)
- winding temperature trip/alarm (26 WIND)
- oil temperature trip/alarm (26 OIL)
- overcurrent tap change blocking
- tap changer gas surge trip/alarm (63 OLTC)
- main and tap changer oil level alarms (P- OLTC)
- pressure relief device trip/alarm (63 PRD).

9.9.14 300 MVA Autotransformer 132 kV side protections

Generally, the overreaching back-up protections shall trip in the first stage the local circuit breaker and all other sides or bus -couplers in time-staggered stages. The trip philosophy is subject to Employer's approval.

Required functions are:

- 21- three step distance protection with quadrilateral characteristic for phase and earth faults, power swing blocking, VT-MCB blocking
- 50/50N/51/51N– overcurrent back-up protection phase and earth fault protection (enabled only in case of VT loss)
- SOTF- switch on to fault
- 67 - two step directional overcurrent protection
- 67N - four step directional earth fault overcurrent protection.
- 46 - two step negative phase sequence overcurrent protection
- 24- over-excitation protection (V/Hz)
- 49- thermal overload protection
- 4 setting groups.

9.9.15 IPR-integrated disturbance and event recorder

Each multifunctional protection terminals shall include a disturbance and sequence of event recorder function, having the minimum following capacity:

- analogue inputs (7 currents and 4 voltages)
- digital inputs (all internal signals and 8 external).

The record shall be triggered by under /over-function of any analogue or digital input and manually. The required minimum performances are:

- minimum pre-fault buffer 10s
- record length up to 30s.

9.9.16 Protection coordination study by Contractor

The minimum content shall be:

- CT/VT instrument transformer sizing
- fault current calculations
- protection setting principles and coordination with existing remote-end and adjacent equipment protections
- protection terminal configuration, communication interface and protection function settings
- Selectivity diagrams for overcurrent earth and phase fault and distance protections, preferably using Power Factory DigSilent or Siemens CAPE software.

The reports shall be subject to review and approval by the Employer / Engineer.

9.9.17 Synchrophasor Measurement Unit

For each EHV AC busbar at the Lekhnath and New Damauli 220kV S/S high accuracy Synchrophasor Measurement Unit (PMU) according to IEEE C37.118 shall be provided. Integration of the PMU in the Bay Control Unit or the Digital Fault Recorder shall be offered, subject to Employer´s approval.

PMU measurement shall be integrated in a Wide Area Monitoring system to be gradually deployed over the entire NEA transmission system; therefore, it shall comply with the P- class specification acc. to IEEE C37.118 and be synchronized to GPS or other low jitter time tagging system with accuracy of not less than 1 micro-second. For the present time, the proposed architecture shall be a stand-alone system for monitoring voltage and relevant currents monitoring of feeders evolving from the 220kV and 132 kV buses installed within the Project.

The PMU shall have a measurement capability of min 6 currents and 6 voltages on a constant time basis. The required total vector error shall be less than 1%; other performance requirements are:

- measurement magnitude ranges 0.1-2 In for current and 20- 140V for voltages
- off-frequency accuracy +/- 5 Hz
- harmonic distortion 10% (on individual harmonic)
- automatic change-over in case of bus VT unavailability.

The system shall have a proven interoperability and be prepared for future streaming to a central Synchrophasor Central Processor located at the NEA Dispatch Center.

9.10 Point-on-Wave (PoW) Controller

9.10.1 General Requirements

Point On Wave (POW) controllers shall serve to open and close the contacts of independent pole operation (IPO) circuit breakers (CB) at a pre-determined point on wave to minimize switching transients and thereby reduce the disturbance to the network, as well as the stresses to the associated equipment.

The PoW controllers shall be part of the control and protection system and shall be integrated into digital substation concept. The PoW controllers shall be in compliance with IEC 60255-1 and all requirements mentioned in chapter "Control and Protection System" above. In addition, the following general requirements are applicable for the PoW controllers:

- The PoW controllers shall have local HMI (LCD, LED, push buttons) for parameterizing and indication purposes.
- The controller shall have a built-in self-supervision system continuously monitoring the hardware and software. Upon unreliable performance of the controller, this shall be communicated to the alarm annunciator as well as SCMS.
- The controller shall provide a role-based authentication system with administrator programmable individual passwords for the viewer, operator, engineer, and administrator.
- The controller shall fulfil the requirements for cyber-security according to IEC 62443 and IEC 62351.

9.10.2 Inputs and Outputs

All inputs of the PoW controllers shall meet the requirements of IEC 60255-1. The following inputs and outputs shall be provided as a minimum:

- analogue inputs for measuring of the following quantities directly from CTs and VTs:
  - 3-phase busbar voltages
  - 3-phase bay voltages
  - 3-phase bay currents
- freely configurable binary inputs with settable threshold in a wide range for the following applications
  - close/open operation
  - phase-segregated spring charge level for blocking of the operation and for accuracy optimization
  - phase-segregated NO and NC auxiliary contacts as well as primary contacts.

  - for remote resetting of the latched LED status
  - for manual triggering of the waveform recorder.
- phase-segregated high-speed binary outputs for close/open commands
- binary outputs for signaling of alarms and warning to SCMS.
- auxiliary supply voltage meeting the requirements of chapter “Auxiliary Supply” above.

9.10.3 Communication interfaces

The controller shall be equipped with the following communication interfaces on the front and rear:

- On the front, USB (or other equivalent serial interfaces) or Ethernet interface for parametrization and reading events.
- On the rear, the following interfaces shall be provided as minimum:
  - The controller shall provide at least two redundant ethernet interfaces for communication with the station bus over IEC 61850-8 Protocol including GOOSE messaging and Parallel Redundant Protocol.
  - The controller shall be able to receive the digital sampled value (voltage and current) over IEC 61850-9-2(LE) over redundant optic fibre interfaces. At least, data exchange with 3 merging units (1 for busbar voltages, 1 for bay voltages, 1 for bay currents) shall be supported.
  - IRIG-B or NFTP for time synchronization.
  - RS485 serial interface.

9.10.4 Functional Requirements

The controller shall cover a wide range of load applications namely for capacitor banks, shunt reactors, power transformers, and transmission lines and power cables.

9.10.4.1 Configuration and parametrization

The device shall be configurable using local HMI, PC-based with user-friendly graphical user interfaced as well as a web-based software to ensure configuration through SCMS. In order to cover different load applications, at least the following parameters shall be user-configurable:

- The design-related parameters of the circuit breaker shall be freely configurable.
- Phase rotation of the system shall be user selectable between L1-L2-L3 and L1-L3-L2
- single-pole, two-pole and three-pole operations shall be configurable.
- The reference signals shall be user configurable. The following shall be at least selectable:
  - busbar voltage (selectable between single-phase or 3-phase; and phase voltage or line voltage)
  - bay voltage (selectable between single-phase or 3-phase; and phase voltage or line voltage)

  - bay current
  - status indication of the auxiliary contacts
- The switching phase angle for making and interrupting events shall be separately user-configurable for each phase with a resolution of 1°.
- To each electrical and mechanical parameters (e.g. contacts changeover, current making, and etc.) a threshold shall be assigned and continuously monitored. In case the performance is near threshold value, a warning signal shall be issued and in case of exceeding threshold, an alarm signal shall be released. Both alarm and warning signals shall be logged in the event logger (SER).

9.10.4.2 Accuracy optimization

PoW controllers shall control both interrupting and making switching events. Upon arrival of switching commands, the controller shall calculate the optimal switching target phase angle considering the reference voltage or reference current signals.

PoW controllers shall continuously supervise events and signals and switching accuracy and shall provide adoptive correction to optimize the estimated operating times of the circuit breakers in the next operation.

PoW controllers shall compensate the influence of internal and external parameters. For this purpose, additional measured values shall be necessary. The Controller shall either measure the additional values or they shall be sent to the controller using analog GOOSE message. For each influencing parameter, a user-defined compensation curve shall be configured.

9.10.4.3 Disturbance recorder or waveform recorder

Each received switching command shall trigger the disturbance recorder or waveform recorder and all analogue and digital channels shall be recorded. However, the recorded channels shall be configurable. Manual triggering using local HMI and digital inputs shall also be possible.

The pre-trigger and post-trigger as well as the sampling rate shall be configurable. The data shall be readable either from the front side of the device or remotely in COMTRADE format according to IEC 60255-24. A software shall be provided along with the unit for visualising the recorded switching events.

10 Substation Control and Monitoring System (SCMS)

10.1 General Requirements

10.1.1 General System Requirements

The Substation Control and Monitoring System, further on along this document named as SCMS, shall comprise full station and bay protection as well as control, monitoring and communication functions and provide all functions required for the safe and reliable operation of the substations.

It shall enable local station control and monitoring via operator workstations by means of a human machine interface (HMI) and control & monitoring software package, which shall include a comprehensive range of system control and data acquisition (SCADA) functions.

Additionally, it shall include communication switches and gateways, station-bus, intelligent electronic devices (IED) for bay control and protection as shown in the general system architecture.

Furthermore, the SCMS shall also include an engineering workstation for configuration as well as parameterization tasks.

All materials and parts which are not specifically mentioned hereinafter but are necessary for erection, assembly and operation of the equipment shall be furnished and are deemed to be included in the scope for this subsection.

The minimum requirements for the SCMS are as follows:

- proper and trouble-free operation and support maintenance of each Substation through the corresponding operator control station
- proper and trouble-free operation from the bay control and/or protection units (IEDs) with position indicators for all circuit breakers, disconnectors and earth switches
- all alarms and indicators associated with protection and remote-control activation and tripping
- all items for control, monitoring, remote control, protection and interlocking circuits
- communication links to remote control centers via international standard protocols
- protection and control management from local and remote
- event recording including sequence of events with real time information
- disturbance analysis
- archiving of commands, events and alarms on non-volatile storage media for medium and long-time range.

In order to meet the requirements of this specification the detailed design of the SCMS is within the Contractor’s responsibility, but subject to approval by the Employer.

Only experienced and technically capable manufacturers of digital control and protection systems for electricity generation and transmission and distribution applications will be accepted.

In order to establish their technical capabilities, the Contractor is required to present the following documents with his bid:

- block and functional diagram showing the proposed control, protection and monitoring schemes
- technical data and description of system
- digital control and monitoring system layout
- catalogues of equipment and devices to be used
- material list of equipment contained in the cubicles
- certificate of conformity with the communication protocol IEC 61850 for each type of the components
- brochures and references of manufacturer supplying the control, protection and monitoring system.

Preferred manufactures will be those who have experience in deliveries of the full scope of station automation systems and services. This experience has to be substantiated by means of reference installations having been in service under similar functional requirements and environmental conditions for at least 2 years.

10.1.2 System Design

10.1.2.1 Design Principles

The SCMS to be established shall be a microcomputer based digital control and monitoring system suitable to supervise and operate the switchgears in each Substation complete in every respect for monitoring and control inclusive all facilities, e.g. of the power transformers which will be equipped with OLTC (on-load tap changer) and AVR (Automatic Voltage Regulator).

SCMS shall be suitable for supervision, operation and maintenance of the complete Substations including future extensions.

Design and arrangement of the system offered shall be state-of-the-art compliant with international standard IEC 61850 for operation under electrical conditions (including electrical discharge and disturbance level) prevailing in high voltage substations, follow the latest modern engineering practice, ensure optimum continuity and reliability of supply and ensure the safety of equipment and the operating staff. The highest degree of uniformity and interchangeability shall be provided.

Design of the hardware and software shall be suitable for all voltage levels used by the Employer to enable a standardized technical concept.

SCMS shall be designed in such a way that personnel without any computer background will be able to operate the system with ease and shall incorporate user-friendly features without causing undue operational delay.

The whole equipment shall be pre-assembled and pre-programmed at the supplier's workshop. It is understood that all auxiliary facilities/devices and services necessary are to be provided, i.e. for generation of data base, of displays, programming and for testing, adjustments, parameter settings etc., even if not specified in detail.

The whole equipment shall be designed for indoor installation, installed in steel sheet cubicles with hinged frames and glass door having a protection degree as stated in the technical data sheets.

All components shall be suitable for the local climate and environmental conditions prevailing on site.

SCMS shall be designed for easy modification of hardware and software and for easy extension of the Substations. Maintenance, modification or extension of components may not force a shut-down of the whole SCMS. Self-monitoring of single components, modules and communication links shall be incorporated to increase availability and reliability of the equipment and minimize maintenance.

Failure of any component of the system shall not force a total system failure.

10.1.2.2 Hot stand-by redundancy

As the SCMS to be established serves for monitoring & control of high voltage Substations with major operational importance for the countrywide power system, the design of the system must be in a fully redundant hot stand-by configuration, as described below.

As a minimum requirement the station computers as well as the operator stations must operate in a redundant hot-stand-by configuration. The same requirement applies for the gateways to the higher level National/Regional Network Control Centers.

The Contractor shall clearly state, to the Employer's satisfaction, how the required hot-stand-by redundancy is being achieved with the offered SCMS System.

In addition to the above, Contractor shall explain in the bid, how continuous operation without any down time will be ensured in the event of loss of one of the redundant equipment such as server, operator station or database.

The Contractor shall ensure that after handing over, a minimum of 50% spare function capacity (hardware and software, number of I/O to be handled by the SCMS) and 20% spare parts for future extensions are available (for each type of component at-least one).

10.1.2.3 Availability and Reliability

The SCMS shall be designed to satisfy the very high requirements concerning reliability and availability as set out with international standard IEC60870-4, as follows:

- reliability Class R3 (MTBF > 8760 hours
- availability Class R3 (>99.95%).

In order to meet specified requirements, the SCMS shall comprise:

- solid mechanical and electrical design
- security against electromagnetic 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, 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 incl. indication of intermediate state
- distributed solution
- independent units connected to the station bus
- back-up functions
- cubicle design appropriate to any harsh electrical environment and ambient conditions
- cubicle grounding immune to transient ground potential rise.

The SCMS shall provide an MTBF (mean time between failure) and a MTTR (mean time to repair) rate as defined in the technical data sheets. The offered values are to be indicated by the Contractor.

The availability shall reach at least the value stated in the technical data sheets. In order to provide this availability, some main (or weak) components shall be of redundant design e.g. the power supply of the fiber-optic coupler.

The outage of one communication link from an individual device to the central components shall not affect any other communication link between the central components and all other devices.

The Contractor shall clearly define how the offered architecture meets the availability requirements. A system block diagram shall therefore be submitted with the offer.

10.1.2.4 System Capabilities

SCMS shall provide full operation of each station corresponding to Project's requirements.

Security of control selections is of paramount importance and every precaution must be taken in the software and hardware design to ensure that false selection or execution of a control is rejected. Failure of a communication, either partial or total, intermittent or permanent, shall not lead to a false control action. Noise, either spuriously occurring or injected manually into the communication link shall not lead to a false control action.

The system software shall be a standard software as per actual mainline product. The software structure shall be specifically designed for the important requirements of switchgear and Substation operation in high voltage applications.

The system hard- and software shall consist of basic modules and standardized supplementary function modules, which are subject to parameterization/customization depending on the layout and operation concept of the Substations.

The system shall restart automatically after halt or loss of supply voltage, all necessary information shall be kept in memory in case of supply voltage outage.

After automatic restart the displays shall present the same displays like before system hold, operator workstations (HMI) shall be in "display only" level.

It shall be possible to test the system without any hazard of unwanted influence to the Substation. Test facilities shall include both function and data.

10.1.2.5 System performance

Time for updating and refreshing information on the screens of the operator station in the Substation shall be as follows:

Table 10-1 Required System Performance

Function	**Required response time**
Exchange of display after manual request (first reaction)	< 1 s
Presentation of a binary change in the process display	< 0.5 s
Presentation of an analogue change in the process display	< 1 s
Time from manual command to process output	< 0.5 s
Time from manual command to updating the display	< 1.5 s

10.1.2.6 System behavior

When auxiliary voltage is restored after an auxiliary voltage failure, the entire system shall perform automatically a start up on its own (automatic restart time < 5 min).

After each restart, an automatic general interrogation with old/new comparison shall be carried out and changes shall be communicated to all functional modules that require the new information.

In addition to securing the parameter values in each functional module, the process data base including manual entries shall also be secured against failures in order to avoid new inputs during restarts.

Each action by the operator shall be logged as an event and result in a reaction from the system. System reaction shall be parameterizable whether visible/audible and to be acknowledged. Operator actions rejected by the system must contain an explanation with easily understandable error messages. The starting and ending of an operator input shall be user friendly at all control levels. System reaction shall be parameterizable whether visible/audible and or to be acknowledged.

If a local/remote transfer switch is operated, an acknowledgment and cancellation procedure shall automatically be initiated.

10.1.2.7 Compliance with standards

Technical data, dimensions, quantities etc. shall be given in the SI-System of units (International System of Units). Protection designation shall be carried out in ANSI.

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

General

IEC 60038: IEC Standard voltages

IEC 60068: Environmental testing

IEC 60255: Electrical relays

IEC 60664: Insulation coordination for equipment within low-voltage systems

IEC 61000: Electromagnetic compatibility (EMC)

IEC 60073: Basic and safety principles for man-machine interface, making and identification-coding principles for indication devices and actuators.

CE-marking

EN 61000-6-4 Emissive (Industry)

EN 61000-6-2 Immunity (Industry)

General for Substation Automation

IEC 61850: Communication Networks and Systems in Substations

IEC 60870-5-101: Communication with remote control centers

IEC 60870-5-103: Communication with third party devices having no IEC 61850-Interface

IEC 60870-5-104: Communication with remote control centers

IT Cyber Security

ISO/IEC 27k group of standards (generic standard defining an information security management system) and

IEC 62443 (generic standard defining among others a cyber security management system taking into account best practices from industrial automation)

IEC 62351 "Power Systems Management and associated information exchange" (technical standard designed to secure the control communication within energy automation systems) series.

Data Integrity

The data integrity classes apply to the information transfer from the source to its destination and refer to:

- the probability of undetected falsification of information and
- the probability of undetected information loss.

The SCADA/EMS system and SCADA/SCMS systems shall comply with data integrity class and residual information error probability as stated in the technical data sheets.

10.1.3 Principle System Architecture

For safety and availability reasons the SCMS shall be based on a decentralized architecture and on a concept of bay-oriented, distributed intelligence.

Functions shall be decentralized, object-oriented and located as close as possible to the process. The main process information shall be stored in distributed databases.

In the sketch below the basic principal system architecture is depicted, adaptations for satisfaction of specific requirements such as hot stand-by redundancy, number of required operator workstations, engineering workstations etc. might be necessary and must be explicitly highlighted.

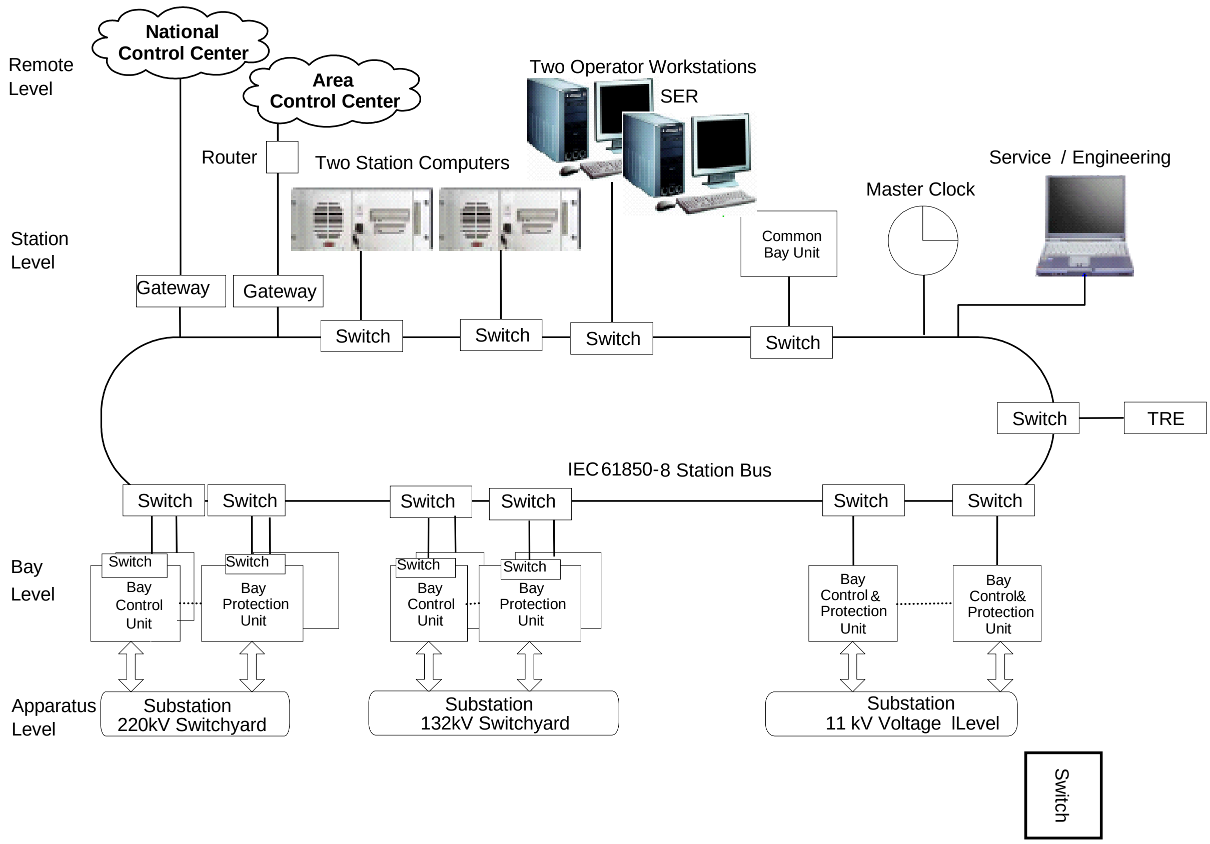

Figure 10-1 Principle architecture of a substation control and monitoring system (SCMS)

Principally the architecture of the SCMS is structured in the following levels:

- Remote level:
  System control operations shall be possible from the remote-control centers.
- Station level:
  System control operations shall be possible from the operator workstations.
- Bay level:
  System control operations shall be possible from the bay control and/or protection units (IEDs).
- Apparatus level:
  System control operations shall be possible by local control from the individual equipment.

The substation shall be controlled and supervised from up to two remote control centers or from the operator workstations while individual bays are supervised and controlled from the bay level devices in the control cubicles.

Interlocking between the levels shall be possible by customization. SCMS shall prohibit carrying out the control at the same time from different control levels.

It shall be possible to control and monitor the individual bays from bay level in case the communication link fails. The station wide interlocking shall also be available when the station computer fails.

At station level, the entire substation shall be controlled and supervised from the operator workstations (HMI).

The station level contains the station-oriented functions, which cannot be realized at bay levels, e.g. alarm list or event list related to the entire substation. Communication with remote control centers via a gateway shall also be a part of the station level.

To provide highest reliability, the station computer, the operator workstations (HMI) and the gateway shall work completely independent, meaning retrieving the process data directly from the bay level devices.

A dedicated master clock for the synchronization of the entire system shall be provided for the complete substation. The master clock shall be independent of the station computer and of the gateway and shall synchronize all devices via the station bus. The deviation of the different internal clocks shall not be more than 1 ms.

The master clock shall be synchronized by a satellite receiver (GPS). While running without GPS signal maximum time deviation shall be less than 50 ms per day. The master clock in the substation shall be battery buffered.

Data transmission between the devices on station and bay level shall take place via the station bus, realized by using fiber-optic cables in a ring configuration, thereby guaranteeing disturbance free communication.

To increase system performance and availability, the system shall support several physically separated networks for the station bus e.g. separate networks for different voltage levels.

At bay level, the bay and/or protection units (IEDs) shall provide all bay level functions regarding control, monitoring and protection, inputs for status indications and outputs for commands. IEDs shall be directly connected to the switchgear without any need for additional interposition or transducers.

IEDs shall be installed in the local control cubicles independent of each other and the operation shall not be affected by any fault occurring at the station level or in other IEDs of the substation.

The SCMS shall contain the following main functional parts:

- Station Computer System
- Human Machine Interface (HMI) with process data base
- gateway for remote supervisory by control centers
- gateway for interfacing the existing Substation RTU/SCMS
- master clock (e.g. GPS receiver)
- protection fault processing
- service, analysis and engineering system
- data exchange between the different system components via serial bus utilizing fiber-optical links
- collection of the relevant data concerning the substation and distribution of the data where needed
- bay and station level devices for control, monitoring and protection
- process interface parallel wired or connected by a process bus
- weather station for monitoring the main weather parameters such as: temperature, Humidity, Lightness (Luminosity), Wind speed, Wind direction, Rainfall.

10.1.3.1 IEC 61850 Communication Profile

Application of IEC 61850 communication profile shall assure compliance of the offered solution with the minimum requirements requested in the international standard of the IEC 61850 and also shall ensure that the offered architecture can be realized with the offered products and their implemented services.

For interoperability, not only data shall be standardized but also access to these data called services. Relevant areas to be covered by the profile are:

- communication services
  abstract communication services (ACSI) (7-2)
- data modeling
  common data classes (7-3), Nodes (7-4).

The data modeling is not specifically listed but the supplier shall fully comply with the logical nodes described in the standard. As a minimum requirement all mandatory data of the used logical nodes shall be supported.

As a guideline the following picture shall give a better understanding of what communication services shall be supported by which devices.

The system architecture of SCMS shall be based on a completely distributed approach. To support the distributed approach as a minimum the below shown communication services between the particular system devices shall be supported as a minimum:

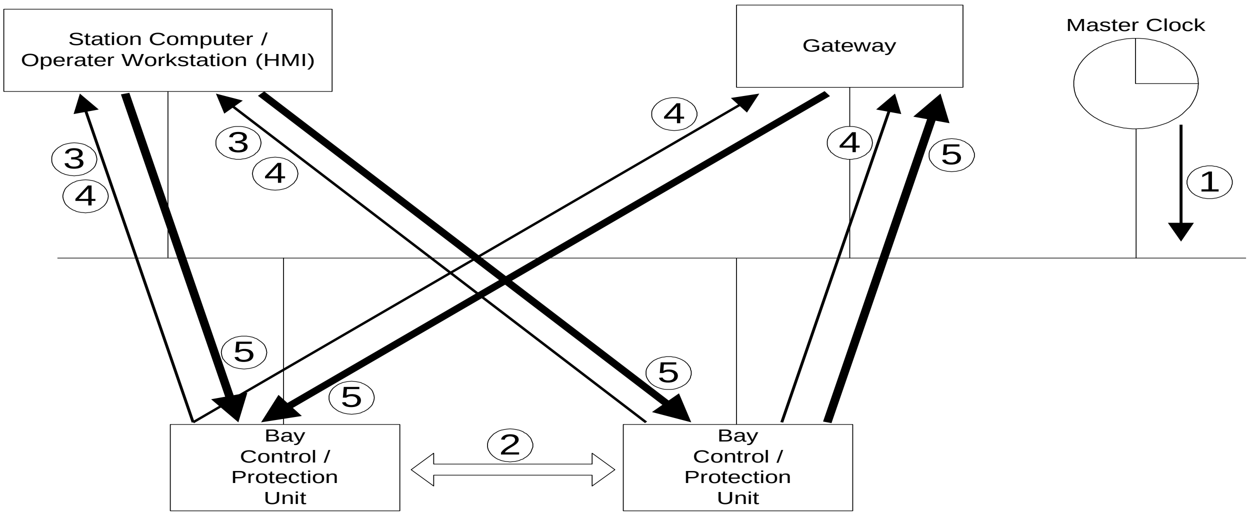

Figure 10-2 IEC 61850 Communication Profile

1) Time synchronization
2) GOOSE-Communication between bay level devices (Interlockings)
3) File transfer
4) Reporting
5) Commands Execution.

10.1.3.2 Ethernet Topology

The station bus according IEC61850-8-1 is mapped to MSS/Ethernet (with priority tagging and with 100 MBit/s). The standard is not making any provision on the Ethernet communication infrastructure.

Suitable state-of-the art and managed routers or switches based on Ethernet data transfer technology that fulfill the hardened requirements concerning temperature, EMC and power supply in accordance with data sheets suitable to be installed in substations shall be provided, i.e. the same data as common for numerical protection.

To ensure a certain level of quality, performance and availability at least the following described criteria shall be fulfilled concerning the Ethernet switches and the topology:

- The switches shall be equipped with a double supply input. If there is an existing redundant DC system in the station (2 different batteries with 2 supply systems), the switches shall also be redundant, for example. each switch's supply input has to be connected to a different supply system.

- compliance with the IEC 61850-3 standard for high level of immunity to electromagnetic interference
- compliance with IEEE 1613 (power substations) standards for error free communications performance under EMI stress
- a rapid network fault recovery (less than 20 milliseconds) and redundant power supplies for higher network availability (ideally isolated redundant power inputs with universal 24/48 VDC or 110/220 VDC/VAC power supply range)
- fanless design in order to enhance the overall reliability of devices
- extended temperature tolerance to withstand climate extremes (within -40 to +85°C)
- RSTP/STP for network redundancy
- compliance with IEEE1588 for a precision Clock synchronization protocol for networked measurement and control Systems to synchronize real-time clock
- configuration recovery adapter
- sufficient number of optical ports as specified in the datasheets
- Port Monitoring RMON (Remote Monitoring).

The proposed design will be subject to Employer/Employer's Representative approval during further implementation design phase.

Additionally, the compliance of the Ethernet switches with IEEE802.1x is preferred. In this case, if some of the network components are not able to authenticate on the network using IEE802.1x, the MAC-Bypass functionality shall be provided as a minimum solution.

The use of Ethernet hubs is not permitted as they do not provide collision free transmission. The switches shall support priority tagging and open standards for ring management like fast spanning tree to ensure that e.g. for later system extension utility has not to rely on one switch supplier only. External switches are preferred as they have the advantage that there is no interruption or reconfiguration of the Ethernet network if one or several bay devices are taken out of service.

The system architecture shall be based on completely distributed approach also concerning the connection of any device to the system. Meaning any device, control as well as protection and station level devices shall be connected to the Ethernet network via a corresponding switch (two switches for one bay).

The distribution of the IEDs on the switches shall be designed by the Contractor so that the IEC61850 properties of the station bus are not compromised.

To ensure maximum performance also for large systems it shall be possible to have more than one physical separated network. The network shall be designed that the number of switches used keeps the latency for time critical applications to a minimum.

Protection and control devices shall be connected in double optic ring connections.

The proposed design will be subject to Employer/Employer's Representative approval during further implementation design phase.

10.1.4 IT Security Requirements

The SCMS systems to be supplied under the Project shall comply with security standards as per

- ISO/IEC 27k group of standards (generic standard defining an information security management system) and
- IEC 62443 (generic standard defining among others a cyber security management system taking into account best practices from industrial automation).

In addition to the above, the new SCMS systems shall comply with the IEC Security Standards for "Power Systems Management and associated information exchange" as laid down in the IEC 62351 (technical standard designed to secure the control communication within energy automation systems) series, in particular with:

- IEC 62351-3: Data and Communication Security – Profiles Including TCP/IP
- IEC 62351-4: Data and Communication Security – Profiles Including MMS
- IEC 62351-5: Data and Communication Security – Security for IEC 60870-5 and Derivates
- IEC 62351-6: Data and Communication Security – Security for IEC 61850 Profiles
- IEC 62351-7: Data and Communication Security – Security Through Network and System Management (NSM) data object models.
- IEC 62351-8: Data and communications security - Role-based access control for power system management **(**RBAC).

In addition to the above, the following requirements shall be fulfilled:

For IT-security reasons all servers with access from external networks shall be located in a separated part of the network, called the "De-Militarized Zone" (DMZ). The DMZ shall be redundantly connected to the process LAN via firewalls/routers.

Any communication between SCMS system and users/applications located externally shall be decoupled via the DMZ and the related firewalls.

All settings of the firewalls have to be closely coordinated with the Employer's IT department.

The firewall cascades for decoupling the different zones shall be of different type and make to enhance security against intrusion and hacks.

Any communication to the external networks (Corporate IT, Office LAN if any) shall be secured and encrypted wherever possible. All kind of services provided shall be highly secured, for example using secure ftp instead of simple ftp, https instead of http etc. All servers and workstations shall be hardened by removing or disabling any unnecessary services.

The software shall provide security mechanisms meeting at least the following requirements:

- protection against unauthorized access and intrusion
- Creation of new users shall be done according to the four-eye-principle; the user account shall be created by the administrator and shall be activated only after confirmation by top management.
- check of utilization rights
- check of access rights
- check of registration
- check on user- and group- passwords
- attack detection and prevention
- security settings of applications.

The results of the security checks shall be alarmed and documented in a detailed security protocol.

The system shall have the capabilities to disable any process/service at any time.

In order to protect the SCMS system from malwares such as viruses, Trojans, spy ware etc. all incoming traffic shall be scanned by suitable antivirus software of a reputed vendor. The definition files of this software shall be updated automatically on a daily basis. The Contractor shall provide necessary licenses for the lifetime of the system.

10.2 Functional Requirements

All control and monitoring functions necessary for a secure and reliable operation of the Substation shall be provided.

The following are the minimum functions required:

- acquisition of binary signals (single and double indication)
- acquisition of analogue signals
- initiation and monitoring of execution of commands and set points to the process
- automatic chronological control of standard switching routines
- station and bay interlocking
- tap changer control of power transformers inclusive automatic voltage regulator AVR
- supervision of the entire Substation
- station control via operator workstations
- alarm handling
- sequence of event recording

- tagging
- analogue value processing
- display of trend values
- archiving, display and evaluation of historical data
- fault indication
- disturbance analysis
- all hardware, software and telecommunication facilities for remote control
- emergency control of each bay from the related bay units and local control cubicles
- ALC (Automatic Line Coloring)
- during command execution in the event list should clearly show from which system the command was executed (from National LDC/ECC, from SCMS or from Switchgear (not SCMS)).

The different voltage apparatus within the station shall be operated from different places:

- from the remote-control centers (up to two control centers simultaneously)
- from the operator workstations
- from the bay control and/or protection units (IEDs)
- from the individual equipment.

It has to be ensured, that operation is only possible by one operator at a time. Clear control priorities shall prevent that operation of a single switch can be initiated at the same time from more than one various control levels, i.e. remote level, station level, bay level or apparatus level.

Priority shall always be on the lowest enabled control level but shall be possible to adopt other philosophies by parameterization.

10.2.1 Station level functions

For supervision of the entire substation on station level as a minimum a redundant server station computer and two operator workstations (HMI) shall be installed. The number of operator workstations shall be possible to be extended to up to four in future.

The position of switching devices (e.g. circuit breakers, disconnectors, earthing switches, transformer tap changers etc.) shall be supervised permanently. Apparatus positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO).

An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.

Every detected change of position shall be immediately visible in the single-line diagram on the screen of the operator workstations (HMI), recorded in the event list and a hard copy printout shall be produced as required by the operator. Alarms shall be initiated in the case of spontaneous position changes.

The Bid shall include complete operation workplaces (including desk, chair, etc.) for each operator workstations and engineering workstation. Also interface connection for engineering note book and protection relay interrogation shall be envisaged.

The operation workplaces desk shall be 75 cm high, double pedestal type of reinforced and stiffened steel construction with flush paneling. The desk shall be ergonomically designed and shall contain the following:

- concealed power outlets in adequate number for supply of workstations, monitors, printers, etc.
- concealed communication ports in adequate number for connection of workstations, monitors, printers, etc.
- conveniently arranged power outlets and communication ports in adequate number for connection of mobile equipment such as notebook, mobile phones, etc.
- concealed wiring ducts to accommodate all wiring of workstations, monitors, printers, etc.
- adequate number of drawers for writing utensils, paper and documents.

10.2.1.1 Chairs for operator desk shall be ergonomically designed and robust type for industrial environment. Station Computer

The station level of SCMS shall include a redundant station computer in a hot stand-by configuration, equipped with high performance microprocessor and real time operating system.

The station computer shall have access to all subsystems at the bay level, collect signals and information, issue commands and perform the signal processing required for the connected substation.

LEDs shall indicate the status of the respective circuits on the front of the station computer.

The station computer shall be accommodated together with all necessary input/output equipment in cubicles in the control room. The station computer shall be supplied from the station battery power supply.

10.2.1.2 Workstations (HMI)

Operator and Engineering workstations (OWS and EWS)

The engineering workstation shall be able to act also as an operator workstation. In normal cases it shall be used for system configuration and software implementation. The specifications of the engineering and operator workstation are given below.

The operator workstation (OWS) is emblematic for Human Machine Interface (HMI) and shall provide supervision of the substation on station level:

- presentation of user defined displays (switching status and analogue values), standard displays, trend curve displays and reports
- effective and safe dialogues for manual control of the substation and for release of control sequences including select-before-execute
- tagging
- presentation of alarms and events on the operator's video display units and printouts on the printer
- archiving, retrieval, display and evaluation of historical data
- hardcopy facility for printouts of any screenshots.

The OWS and EWS shall be high performance operator workstations, based on high performance and maintenance-free computer systems equipped with two LED monitors each. The LED monitors shall have a size of at least 32" diagonal, with a resolution of 3840 × 2160 pixels (UHD 4K)

Two high speed color printers (one A4 and one A3) shall be supplied for graphic hardcopies of the displays and for reports. Page-sensitive printing shall be provided.

One high speed color printer shall be supplied for graphic hardcopies of the displays and for reports and the other printer shall be supplied for printing logs of all the events and alarms reported from the bay control units.

The AC power for the EWS and OWS, the monitors and printers shall be supplied by the station UPS power supply.

The operator shall have access via the operator workstation to the distributed intelligence. For control of the substation the operator will use a functional keyboard and a graphical locator (trackball, mouse, etc.). The keyboard shall be designed to meet Employer's specific requirements.

The operation procedure needs to be easily used and understood and must be designed in a user-friendly way. Switching status of the substation in terms of actual measured values (currents, voltages, active and reactive power) as well as positions of transformer tap changers shall be displayed. The OWS and EWS shall give the operator and/or engineer access to the equipment of the high and medium voltage levels.

Display selection, parameter setting, alarm acknowledgment, selected printouts of reports and command outputs shall be performed from the operator/Employer's Representative's keyboard.

The system has to distinguish between alarm lists and event lists selectable on the monitor by the operator. Beside of these lists on the screen, there shall be a chronological print out of any alarm or event in an event log.

In addition, a historical archive-file including the events of at least the past 30 days shall be generated and stored on the hard disc.

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

As a minimum, the following items shall be presented on the operator & Engineering workstations (HMI):

- status diagrams showing switching status and measured values of:
  - the entire Substation
  - each voltage level of the Substation
  - each busbar section of the Substation
  - each bay of the Substation
- user authority levels
- command procedures
- control dialogues
- tagging
  - control inhibits
  - permit to work
  - grounded
- event list:
- station – oriented
- bay – oriented
- SCMS-internal
- alarm list:
  - station – oriented
  - bay – oriented
- SCMS-internal
- event and alarm log
- system status diagram
- reports
- curves from actual measured values
- curves from archived and historical values
- trend values.

Status diagrams

The station diagrams displayed on the operator workstations (HMI) shall include as a minimum a diagram of the entire Substation, an individual diagram for each voltage level of the Substation and individual diagrams for each busbar sections and bays of the Substation.

A diagram shall be able to show a single line with all relevant data (at least 50 switching devices like circuit breakers/disconnectors/earthing devices, 20 measuring values, 40 additional indications).

New displays shall be designed in an interactive dialog without taking the total Substation control system off-line.

Layouts of the displays are subject to the approval by the Employer.

User authority levels

It shall be possible to restrict activation of the station diagrams within a certain user authorization group. Each user shall then be given access rights to each group of objects. At least the following authority levels shall be provided:

- display only
- normal operation (e.g. open/close apparatus)
- restricted operation (e.g. by-passed interlocking)
- system administrator.

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

- no engineering allowed
- engineering/configuration allowed
- overall entire system management allowed.

The access rights shall be defined by passwords or, alternatively, by key card readers etc. assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.

Command procedures

To ensure a high degree of security against unintended operation, a special operation procedure select-before-execute shall be provided.

After selection the operator shall be able to recognize the selected device at the screen and all other switching devices shall be blocked.

The operator shall only be in a position to execute a command if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay level.

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

Control dialogues

The operator shall give commands to the equipment of the high voltage and medium voltage via mouse clicks on soft keys located on the diagram. Data entry shall be performed with the keyboard. Dedicated control dialogues for controlling at least the following devices shall be available:

- circuit breakers, disconnectors and earthing switches
- transformer tap-changers
- output of set points
- device of control sequences
- device of load shedding.
- devices for single command outputs such as reset of protection devices etc.

Event list

The Substation event list shall include events that are important for the control and monitoring of the Substation, sample for event: “Circuit Breaker closed”. The time shall be displayed corresponding to the event in real time with a resolution of at least 10ms.

The operator shall be able to call up the chronologically sorted event list on the monitor at any time for the entire Substation or sections thereof.

A printout of each displayed event list shall be possible on the printer. Features for page-sensitive printing shall be provided.

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 operator workstations (HMI). The information shall be obtainable also from a printed event log.

The chronological event list shall contain:

- position changes of circuit breakers, disconnectors, earthing devices and tap changer operations
- indication of protective relay operations
- fault signals from the switchgear
- indication when analogue measured values outside upper and lower limits
- loss of communication
- operator’s commands and tagging.

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.

Alarm list

Faults and errors which may occur in the Substation shall be tabulated in the Substation alarm list and shall be available to be simultaneously transmitted to the remote-control centers. The alarm list shall replace a conventional alarm tableau and shall constitute an actual evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults.

Date and time of the occurrence of alarms shall be indicated. The time shall be displayed corresponding to the alarm in real time with a resolution of at least 10ms. The sequence of alarm indication in the alarm list shall coincide with the occurrence of the alarms.

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

- date and time of the alarm
- name of the alarming object
- a descriptive text
- acknowledgement state.

The operator shall be able to select displays which contain only a section or subsection of the substation overall alarm list.

The operator shall be able to acknowledge alarms at the keyboard, acknowledged alarms shall be marked in the list.

Faults which appear and disappear without being acknowledged shall be specially marked in the alarm list.

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

The alarm list shall be presented on the display screen. It shall be possible to obtain hardcopies of the alarms on the printer. Features for page-sensitive printing shall be provided.

SCMS internal alarm list

The SCMS shall constitute an actual evaluation of internal SCMS alarms, e.g. of defect SCMS input/output boards or defect SCMS communication nodes. It shall contain unacknowledged alarms and persisting faults as mentioned before.

Event and alarm log

The event and alarm log shall be the spontaneous listing of events and alarms displayed on the monitor.

This log shall contain the same alarms and events as mentioned above, but chronologically listed as soon as they occur.

Each alarm shall be configurable in this way that a second message can be listed if the alarm disappears.

System status diagram

The SCMS shall be comprehensively self-monitored such that faults are immediately indicated to the operator, possibly before they develop into serious situations.

The system status diagram shall cover the entire SCMS configuration and the status of all devices of the SCMS including bay level devices, substation level devices and communication links.

Reports

The reports shall provide time-related follow-ups of measured and calculated values. The data displayed shall comprise:

Trend reports

- day (mean, peak)
- month (mean, peak)
- semi-annual (mean, peak)
- year (mean, peak)
- selectable periods.

Historical reports

- day
- week
- month
- year
- selectable periods.

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

It shall be possible to print out the report on request and automatically at pre-selected times.

Trend display (historical data)

A trend is a time-related follow-up of process data. It shall be possible to illustrate all types of process data as trends (binary and analogue data). The trends shall be displayed in graphical form as column or curve diagrams with a maximum of 10 trends per screen.

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.

Common bay unit

The station level shall include a common bay unit for acquisition of inputs/outputs not assigned to dedicated bays.

The common bay unit shall be placed together with all necessary input/output equipment in cubicles in the control room. The common bay unit shall be supplied from the station battery power supply.

System service and analysis

For fault evaluation and monitoring as well as integrated disturbance monitoring and analysis a service and analysis system shall be implemented with each SCMS.

Automatic disturbance file transfer

For the bay level devices with integrated disturbance recorder as well as for dedicated disturbance recording systems, all recorded data shall be automatically uploaded (event triggered or once per day) to the station computer or a dedicated computer and be stored on the hard disk.

Disturbance analysis

The SCMS shall provide all relevant information for fault-finding, analysis, and troubleshooting on a dedicated disturbance analysis system. Suitable and user-friendly fault evaluation software shall be included in the scope of supply, providing short fault summaries and automatic printouts of the fault history and fault location.

For the IEDs with integrated disturbance recorder, all recorded data shall be automatically uploaded (event triggered or once per day) to the disturbance analysis station and be stored on the hard disk.

The protection engineer may have his own PC-based system to evaluate all the required information for proper fault analysis, independent of the network control centers.

The disturbance analysis system shall be a workstation, based on a high performance and maintenance-free computer system equipped with one LED flat screen monitor. The LED flat screen monitor shall have a minimum size of 32” with a resolution of 3840 × 2160 pixels (UHD 4K).

The scope of supply includes all required equipment, communication lines and installations to enable the disturbance analysis workstation for the proper connection and communication with the protection units.

Parameter setting

Under this function it is understood the capability of reading out and writing information from/to the IEDs, in particular parameterization, setting, visualizing and analyzing disturbance and event records through the service and analysis system:

- from the operator workstations (HMI), by use of standardized IEC 61850 protocols
- from the remote-control centers
- from a modem-connected evaluation station situated at a remote location.

Setting of parameters or activation of parameter sets shall only be allowed after entering a password.

It is proposed to include under the scope of this Project all required modems and software licenses for the remote evaluation station.

Load shedding

The choice of feeders to be shed shall be shown at station level and shall be modified remotely.

The load shedding functionality shall be realized by combining frequency functions at bay level and priority settings downloaded from the station level to the bay.

10.2.1.3 Service, Analysis and Engineering Unit

For each SCMS a portable service, analysis and engineering unit based upon a standard personal computer shall be foreseen for on-site modifications of the control and protection devices. This service unit shall be used for documentation, testing and commissioning.

The service unit shall permit the user to study changes in the substation. The service unit shall be able to monitor data in the running SCMS and to present changing variables on the display screen, selectable in tabular form or in graphic representation.

The service unit shall be used for the following purposes:

- system configuration
- system testing
- help functions
- program documentation
- down and uploading of programs
- system commissioning
- data base management
- changing peripheral parameters program entry
- on-line parameter setting features
- other subjects depending on the requirements during engineering stage.

The service unit shall be integrated into the IT security regime to be established.

The service unit shall be used for detail engineering of the SCMS.

As the result of the design process for IEC 61850 based systems shall formally be described in an SCD (System Configuration Description)-file, which contains the logical communication connections between IEDs within sub-networks and routers between sub-networks. The detail engineering on system level has to determine the communication addresses and the detailed data flow between the IEDs in terms of data sets and signal inputs to clients. This signal-level data flow engineering replaces to a big extent the engineering of the conventional wiring.

Due to the inherent semantics of the IEC 61850 data model, this step can also be supported with object based or even automated signal engineering. The resulting SCD file contains individualized IED descriptions for the system under design.

These descriptions shall be downloaded via the service unit to the IEDs to make them aware of their place in the system and their connections to other IEDs.

The service unit has to be supplied at the beginning of the commissioning period and shall be available for training of the Employer’s personnel.

Software development tools and maintenance

Program development editing, compilations and linking shall be available on the workstation and laptop.

This implies that all source files containing source programs shall be supplied to enable future software development and modification.

All program development and support functions to be supplied shall be described in detail to enable the trained personnel to use the system.

The programming languages supported by the system shall be stated.

Any apparatus that enables testing, configuration and diagnosis of bay control units, gateway and substation LAN e.g. laptops, communication devices is to be included in the offer.

10.2.1.4 Interface to Remote Control Centers

Communication to the remote-control centers shall be provided by data communication, utilizing international standard protocol IEC 60870-5-104.

It is the obligation of the Contractor to coordinate and parameterize settings with the existing SCADA interfaces of the relevant Control Centers in order to ensure interoperability.

It must be possible to interface with two remote Control Centers simultaneously by using dual port capability, while protocols must be possible to be different on both ports (e.g. IEC 60870-5-101 on port 1 and IEC 60870-5-104 on port 2). However, IEC 60870-5-104 is envisaged to be used for the current Project. The redundant gateways protocol shall be according to IEC 60870-5-104 (main and backup gateway channels).

Change of the protocol on both ports shall not require any change of software or firmware but need to be selectable via parameterization.

Minimum transmission speed shall be

- 9600 bit/s for IEC 60870-5-101 ports
- 64k bit/s for IEC 60870-5-104 ports.

From control centers all related voltage apparatus of the substations shall be possible to be remotely controlled and monitored.

All signals of each substation required for the control and monitoring from the remote-control centers shall be made available for data transmission via redundant gateways.

The scope of supply includes all required equipment and installations to enable each of the substations for the proper connection of the required control and monitoring signals towards and from up to two higher level remote-control centers Main/ Emergency National Load Dispatch Center of NEA NEPAL NLDC / ECC (as applicable in the related NEA National TSO network).

Substation Gateway

The communication gateway to be provided by the Contractor shall be a network node capable to interconnect both the substation and the remote-control center(s) NLDC/ECC networks together by performing a protocol translation/mapping necessary to ensure system interoperability. The gateway shall be based on high performance and maintenance-free computer equipped with a real-time operating system. The access to all subsystems at the station level shall be guaranteed.

The Bidder shall state in his offer all the protocols that are supported by the gateway.

The gateway to be provided shall include at least the following features:

- Process communication
  - IEC61850-8-1
  - Modbus serial
  - Modbus TCP
  - IEC 60870-5-103

- Remote communication
  - IEC 60870-5-101
  - IEC 60870-5-104.

Furthermore, the communication gateway shall also have:

- an efficient and intuitive configuration tool (Gateway management tool)
- a drag-and-drop protocol mapping to map complete structures from the source data
- an efficient handling of large amounts of data in list views
- tooltips
- remote configuration and administration.

Additionally, at least the following security features shall be included:

- user authentication
- individual user accounts
- password authentication.

All licenses shall be provided by the Contractor and specifically the license for a gateway management tool to be installed at the engineering workstation. The gateway management tool shall enable the engineer to transfer the configurations of the objects to the gateway computer.

The gateway management tool shall display at least the following license information for the device in a window:

- owner of the license
- product revision
- protocols supported by the license
- number of servers supported by the license
- number of clients supported by the license.

The updating of the license as well as the downloading of the configurations shall be easily executable.

10.2.1.5 Interface to Interconnected local Station RTU/SCMS

Communication to the interconnected Substation RTU/SCMS shall be provided by data communication, utilizing international standard protocol IEC 60870-5-104. Contractor shall apply Master/Slave configuration as per the Scope of works requirements at the related Project Substation.

It is the obligation of the Contractor to coordinate and parameterize settings with the existing SCADA/SCMS/RTU interfaces of the relevant interconnected Substation RTU/SCMS in order to ensure interoperability.

It must be possible to interface with one interconnected Substations simultaneously by using dual port capability, while protocols must be possible to be different on both ports (e.g. IEC 60870-5-101 on port 1 and IEC 60870-5-104 on port 2). However, IEC 60870-5-104 is envisaged to be used for the current Project. The redundant gateways protocol shall be according to IEC 60870-5-104 (main and backup gateway channels).

Change of the protocol on both ports shall not require any change of software or firmware but need to be selectable via parameterization.

Minimum transmission speed shall be

- 9600 bit/s for IEC 60870-5-101 ports
- 64k bit/s for IEC 60870-5-104 ports.

From the interconnected Substations SCADA/RTU/SCMS all related voltage apparatus of the substations shall be possible to be remotely controlled and monitored. Software inhibit shall be provided as applicable on commands/control by the Contractor on the Project related scope Substation side.

All signals of each substation required for the control and monitoring shall be made available for data transmission via single gateway.

The scope of supply includes all required equipment and installations to enable each of the substations for the proper connection of the required control and monitoring signals towards and from up to one interconnected Substation SCADA/SCMS/RTU at the existing LEKHNATH 132 kV Substation and future New DAMAULI 400 kV Substation (as applicable in the related NEA National TSO network).

Substation Gateway

The communication gateway to be provided by the Contractor shall be a network node capable to interconnect both the interconnected substation networks together by performing a protocol translation/mapping necessary to ensure system interoperability. The gateway shall be based on high performance and maintenance-free computer equipped with a real-time operating system. The access to all subsystems at the station level shall be guaranteed.

The Bidder shall state in his offer all the protocols that are supported by the gateway.

The gateway to be provided shall include at least the following features:

- Process communication
  - IEC61850-8-1
  - Modbus serial
  - Modbus TCP
  - IEC 60870-5-103
- Remote communication:
  - IEC 60870-5-101
  - IEC 60870-5-104.

Furthermore, the communication gateway shall also have:

- an efficient and intuitive configuration tool (Gateway management tool)
- a drag-and-drop protocol mapping to map complete structures from the source data
- an efficient handling of large amounts of data in list views
- tooltips
- remote configuration and administration.

Additionally, at least the following security features shall be included:

- user authentication
- individual user accounts
- password authentication.

All licenses shall be provided by the Contractor and specifically the license for a gateway management tool to be installed at the engineering workstation. The gateway management tool shall enable the engineer to transfer the configurations of the objects to the gateway computer.

The gateway management tool shall display at least the following license information for the device in a window:

- owner of the license
- product revision
- protocols supported by the license
- number of servers supported by the license
- number of clients supported by the license.

The updating of the license as well as the downloading of the configurations shall be easily executable.

10.2.1.6 Station Protection Functions

The protection system is described in a separate subsection. However, the following items are also important for SCMS as the protection functions are an integral part of the SCMS.

Station protection functions are protection functions which are normally not allocated to the particular bay. This concerns essentially busbar and breaker failure protection schemes (by busbar protection the part of equipment can be allocated in the particular bays, which are connected with central part via a proprietary bus).

All protection functions realized in the station level shall be based on numerical technology. Remote access to the protection devices shall be made available from SCMS.

The station protection units shall be serial integrated for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various station protection units shall be compatible with the overall system communication and data exchange requirements.

The operation shall depend on the conditions of other functions, such as interfaces, local HMI, event and disturbance recording, data-storage, self-supervision, etc. (see description in chapter "Bay control functions").

10.2.2 Bay Level Functions

In a decentralized architecture the functionality shall be as close as possible to the process.

In this respect, the following functions shall be allocated at bay level:

- bay control functions
- bay protection functions
- data collection functionality.

In application for:

- high voltage levels:
  bay control functions and bay protection functions shall be carried out in separate units
- medium voltage levels:
  bay control functions and bay protection functions may be carried out in a combined unit.

All bay internal programs, command sequences, collection of signals and information, outputs of commands and signal processing required for the different switchgear units of the corresponding bays shall be performed by the IEDs.

The protection and controls IEDs shall be linked in double ring FO connections.

Power supply to the IEDs shall come from the station battery and shall be redundant.

The IEDs are placed together with all necessary input/output equipment in the local control cubicles in the control room of the control building. The bay level devices shall be supplied from the station battery power supply.

10.2.2.1 Bay Control Functions

Control mode selection

The different high voltage and medium voltage apparatus within the station shall be operated from different places:

- from the remote-control centers
- from the operator workstations
- from the bay control and/or protection units (IEDs)
- from the individual equipment.

It has to be ensured, that operation is only possible by one operator at a time. Clear control priorities shall prevent that operation of a single device can be initiated at the same time from more than one various control levels, i.e. remote level, station level, bay level or apparatus level. The priority shall always be on the lowest enabled control level.

OFF mode

It is not possible to operate any object, neither locally nor remotely.

EMERGENCY mode

The position indication shall be directly from the primary equipment circuit breaker.

On the mimic board, the selection push button and either the ON or OFF push button has to be pushed simultaneously in order to close or open the circuit breaker.

To control in the emergency mode requires a special key. Control operation from other places (e.g. from REMOTE) shall not be possible if the emergency select key is in the emergency operation position.

LOCAL mode

On the local HMI on a display at the IEDs (and local mimic on the control panels, if any) it the object has first to be selected. In case of blocking or interlocking conditions, the selection will not be possible, and an appropriate alarm annunciation shall occur. If a selection is valid, the position indication will show the possible direction, and the appropriate ON or OFF button shall be pressed in order to close or open the switching device.

Control operation from other places (e.g. REMOTE) shall not be possible in this operating mode.

REMOTE mode

Control authority in this mode is given to a higher level (station or remote level) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

It shall be possible to adopt other philosophies by parameterization.

10.2.2.2 Interfaces

All IEDs shall be provided with an optical interface for connecting the station bus and communication to station level devices and remote level devices according to IEC 61850.

Additionally, the IEDs shall be provided with an optical front interface for connecting a personal computer or a laptop.

The monitoring, controlling and configuration of all input and output logical signals, all binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely.

10.2.2.3 Local HMI

A local HMI at the IEDs shall permit controlling and monitoring the individual bays from bay level.

The local HMI shall be front-mounted and based on a user-friendly, menu-structured program and performed with the use of a permanently installed HMI-unit, type tested together with the IED.

The diagram of the individual bay shall be showing the switching status and measured values.

Service values of current and voltages as well as active and reactive power shall be available. Also, characteristic analogue values related to the activated functions (e.g. impedance in case of distance protection) shall be available.

Additionally, an alarm annunciation for bay alarms shall be included in the local HMI.

Command supervision

Perfect collection and processing of all switchgear positions of the entire substation must be ensured at all times. Unclear information, such as intermediate switchgear positions, switchgear fault, faulty data transfer etc. must never allow switching operations.

Control, regulation and synchronizing functions shall require perfect collection and processing of all information of the substation. The information has to be up to date and valid.

Maloperation of control and regulation facilities such as on-load switching of a disconnector, switching on in asynchronous state etc. shall be avoided.

If remote and/or station level control and regulation facilities are failing, back-up control shall be possible.

Interruption of drive latching in case runtime is exceeded.

When the runtime is exceeded, the command has to be cancelled.

Pole discrepancy monitoring

A pole discrepancy function, based on the measurement phase over currents and current differences between phases shall be provided.

Select-before-execute-procedure

Select-before-execute-procedure shall be applied for the operation of circuit breakers. For safety reasons the command is always given in two stages: selection of the object and command for operation. These two stages are realized with one contact each and only when both contacts are closed will the final command (open or closed) executed.

10.2.2.4 Station Interlocking

Interlocking facilities shall be installed in the switchgear to prevent damages and accidents in case of false operation.

Within the bay itself, software interlocking controlled via bay control units shall be used. The station interlocking systems shall be provided via station bus, double FO ring configuration, followed with redundant number of Ethernet switches. The arrangement of FO links and Ethernet switches is subject to the Employer’s/Employer’s Representative’s approval. The provided number of Ethernet switches shall allow the separate connection of 220 kV controls, 220 kV protections, 132 kV controls, 132 kV protections, 11 kV controls, 11 kV protections etc.

The separate Ethernet is needed for station common signals. The bid shall describe the scenario while an IED of any bay is switched off or fails.

The primary interlocking of the substation feeders shall be provided via hardwired parallel cabling as specified.

The station interlocking system shall make it easy to add new feeder (lines, transformers etc.) and future modification and extension of the station control shall be possible without interference to the operation of other parts of the installation (e.g. moving of existing feeders including all parameters and settings to enable installation of new feeders).

It shall be a simple layout, easy to test and simple to handle when upgrading the station with future bays. Modifications shall be possible to be carried out by the Employer’s staff without the presence of the Contractor.

The function and design of the switchgear interlocking systems shall be a hardware interlocking with parallel copper cabling as specified and shall be extremely reliable and safe.

For the switching and operation of the substations, the following interlocking concept shall be applied:

- The disconnector shall be operable only when the relevant circuit breaker is in the off-position and all the relevant earthing switch have been removed.
- The earthing switch is operable only when the disconnectors have been opened and the relevant location is free of voltage.
- Closing of circuit breaker shall only be possible when the relevant earthing switches have been removed and the protective relays and corresponding lock-out relays are not actuated or if they are actuated, the faults have been cleared and the respective lock-out relays have been reseated.
- Busbar change-over shall be possible with the busbar disconnectors and bus coupler in closed position without power supply interruption.

- When a pressure drop signal is received from gas monitoring device for a SF_6 circuit breaker, the tripping and the closing signal shall be locked out.
- other interlocks as found necessary during engineering stage.

An override function shall be provided which can be enabled to bypass the interlocking function.

Service interlocks shall be provided for future remote operations and maintenance interlocks shall be provided for local operations.

The interlocking system is to be designed in such a way that testing is possible during normal operation.

10.2.2.5 Synchrocheck

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

- adjustable voltage, phase angle, and frequency difference
- energizing for deadline-live bus, live line-dead bus or deadline–dead bus
- Settings for manual close command and autoreclose command shall be adaptable to the operating times of the specific switchgear.

Synchrocheck function shall be applicable for all breakers.

Voltage selection

The voltages relevant for the synchrocheck functions are dependent on the station topology, i.e. on the positions of the circuit breakers and/or the disconnectors. The correct voltage for synchronizing is derived from the corresponding voltage transformers or from bus voltage image with special relay control and shall be selected automatically by the control and/or protection IEDs.

10.2.2.6 Autoreclosing

The autorecloser should be settable for the modes of operation detailed in section 9.9.4 .

10.2.2.7 Transformer Tap Changer Control

Voltage regulation for transformers with on-load tap changer shall be either included in the numerical control unit for the power transformer bay or located in a separate on-load tap changer control device which is associated with the power transformer. In case of utilizing a separate tap changer device, this shall be an integral part of the SCMS like any bay-oriented device.

10.2.2.8 Event and Disturbance Recording

Each IED shall contain an event recorder capable of storing at least 256 time-tagged events.

Having bay protection functions, the IEDs shall provide the user, either locally or remotely, with complete information on the last ten disturbances.

A disturbance recorder with a minimum of 5 s recording time for at least 10 disturbances shall provide the user with time-tagged disturbance records. At least the analogue inputs as well as 16 binary signals must be recorded with a sampling rate that guarantees the presentation of a fifth harmonic component of any recorded analogue signal. The pre-fault and fault currents and voltages shall be recorded for each disturbance and be made available for further evaluation purposes.

Data-storage

Data storage of at least 500 events (cyclical buffer).

Self-supervision

The electronic system shall be provided with functions for continuous self-supervision and test. Each circuit board shall contain circuits for automatic testing of its own function. These circuits shall interact with a test and diagnostic program controlled by the central unit.

Faults in a unit shall be indicated by the illumination of a red LED on the front edge of the unit and reported to the higher operation levels. The error indications/messages to be generated shall allow fault localization down to the card level.

Time for fault tracing and replacement of a faulty unit shall be reduced to a minimum.

Self-supervision shall also comprise the power supply system, the internal system bus and the ability of the central unit to communicate with different circuit boards.

10.2.2.9 Bay Protection Functions

The protection system is described in a separate subsection. However, the following items are also important for SCMS as the protection functions are an integral part of the SCMS.

All protection functions realized in the bay protection units shall be based on numerical technology. Remote access to the protection devices shall be made available.

The bay protection units shall be serial integrated for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various bay protection units shall be compatible with the overall system communication and data exchange requirements.

The operation shall depend on the conditions of other functions, such as interfaces, local HMI, event and disturbance recording, data-storage, self-supervision, etc. (see description in chapter "Bay control functions").

10.2.2.10 Data Collection Functionality

Generally, the following basic data collection functions shall be performed by the IEDs:

- signal acquisition
- acquisition of measured and counted values
- monitoring of execution of commands
- calculation of derived operational measured values
- generation of group signals.

The position of each switching device (e.g. circuit breaker, disconnector, earthing switch, transformer tap changer etc.) shall be supervised permanently.

Every detected change of position shall be immediately visible in the single-line diagram on the local HMI and reported to the station and remote level.

Alarms shall be initiated in the case of spontaneous position changes.

The positions of each switching device shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which shall give antivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.

Analogue inputs for voltage and current measurements with high accuracy of 0.5% shall be provided. The values of active power (W), reactive power (VAr), frequency (Hz) and the rms values for voltage (U) and current (I) shall be calculated.

The measured values shall be displayed locally on the station HMI and reported to the higher levels. Threshold limit values shall be selectable for alarm indications.

Additionally, digital inputs for acquisition of active and reactive power in line and transformer bays shall be ensured.

IEDs shall be provided within a process interface for acquisition data directly from the high voltage and medium voltage apparatus:

- binary inputs and outputs
- analogue input and outputs:
  - 0 – 100 (110) V

- 0 – 1/5 A
- 0/4 – 20 mA.

The provided quantity of inputs and outputs in the bid shall be based on the single line diagrams of each substation to consider the quantity of binary and analogue inputs/outputs as indicated in the IEDs.

The quantities of binary and analogue inputs/outputs as indicated are minimum requirements. Any further requirements as per the Substation manufacturer and identified during engineering stage, site testing/commissioning stage shall be included.

10.3 Design Requirements

In order to meet the requirements of this specification, the detailed design of the SCMS is within the Contractor's responsibility, but subject to approval by the Employer. The following important requirements should be guaranteed in any case:

- Distributed architecture that allows the placement of bay level devices in a cubicle and the station equipment in a central building.
- Bay level devices like IEDs are directly connected to the station bus also the protection equipment of other manufacturers.
- In the case of Main 1/main 2 protection schemes, the two protection terminals shall be of different hardware and software.
- Back-up protection functions can be allocated in the bay control unit.
- Station-oriented protection functions (busbar and breaker failure protections) may be integrated into one system.
- Reclosing and associated synchro check or voltage check functions can be considered as control functions.
- A separate control unit has to be associated to each circuit breaker.

The Contractor shall present the layout of the different cubicles used in the Project, following a bay-oriented arrangement.

10.3.1 Station Level Design

Station level devices like switches, gateways, station computer, operator workstations, etc. are directly connected to the station bus also the protection equipment of other manufacturers.

The Contractor shall present a detailed schematic and the drawings of the station level and the bus connections.

10.3.2 Bay Level Design

For each type of bay (line, transformer and coupler bay) the Contractor shall present the principal arrangement of the cubicles within type of hardware units and associated functions.

The protection scheme is an integral part of the SCMS system, and the protection relays shall therefore be directly connected to the station bus, in order to provide unrestricted access to all data and information stored in the relays and for changing protection parameters remotely. Back-up protection schemes can be allocated in one or the other units already mentioned.

In some applications or voltage levels a higher degree of integration is acceptable, e.g. integration of control and main protection functions or integration of busbar and bay protection functions.

A high integration of functions and a low number of units is permitted under consideration of the method of fulfillment of the reliability requirements.

Line bay

Cubicle with:

- the already mentioned control unit (control, recloser, synchro check) per breaker with the associated bay mimic (position indication) and depending on voltage level also with protection schemes
- the already mentioned main and back-up protection schemes for the line
- the protection unit for the busbar and breaker failure protection functions per set of current transformers (in the case of a double-busbar scheme, the breaker failure protection may be associated with the line protection)
- the dedicated disturbance recorder unit (depending on the required sampling rate).

Transformer bay

Cubicle with:

- the already mentioned control unit per voltage level (control, recloser, synchro check) with the associated bay mimic (position indication)
- the already mentioned main protection for the power transformer
- the protection unit for the busbar and breaker failure protection functions (in the case of a double-busbar scheme, the breaker failure protection may be associated with the line protection)
- the back-up protection in one separate unit or in the control unit
- the units for dedicated disturbance recorder (depending on the required sampling rate).

Coupler bay

Cubicle with:

- the already mentioned control unit (control, recloser, synchrocheck) per breaker with the associated bay mimic (position indication) and depending on voltage level also with protection schemes
- the protection unit for the busbar and breaker failure protection functions. Normally one set of current transformers is sufficient, because the busbar protection is designed to work correctly even if only one set of current transformer is available
- the protection functions (normally overcurrent functions) can be mounted in one of the units already mentioned or in a separate unit.

10.3.3 Quantity of Inputs and Outputs

The Bid shall be based on the number of necessary BCUs and digital protection relay devices as indicated in the single line diagrams and the tables given in the protection section of each of the relevant substations.

The Contractor shall consider the quantity of binary and analogue inputs/outputs as indicated below for the bay control units. The quantities of binary and analogue inputs/outputs, as indicated, are minimum requirements.

In addition to the quantities as indicated, the Contractor shall include a reserve in the amount of 20% in their offered scope.

Any further requirements as per the Substation manufacturer and identified during engineering stage, site testing/commissioning stage shall be included.

Minimum binary inputs (counted as single indications):

- 8 per circuit breaker
- 5 per disconnector
- 4 per earthing switch
- 16 per line feeder from protection
- 6 from busbar protection
- 50 general/auxiliaries for the whole Substation
- 8 for status of transformer operation.

Minimum binary outputs (single commands):

- 2 per circuit breaker
- 2 per disconnector
- 2 per earthing switch

- 2 per tap changer lower/raise
- 2 per tap changer automatic/manual
- 2 as a reserve per AVR.

Minimum analogue inputs (11 bits + sign bit measuring):

- 3 voltages per busbar section
- 3 voltages per transformer bay
- 3 currents per coupler bay
- 3 currents per transformer winding
- 1 active power per transformer
- 1 reactive power per transformer
- tap changer position per transformer
- winding temperature per transformer
- oil temperature per transformer
- hot spot temperature per 400/220 kV cable system
- 4 analogue inputs per Substation as a reserve.

The SCMS shall have at least one serial interface for meter data. Protocols shall be selectable as per the relevant protocols mentioned in the relevant section of the present document.

10.4 Other Requirements

10.4.1 General

During the project implementation phase the following activities shall be considered:

- engineering
- FAT
- site installation
- commissioning
- SAT
- training
- operation
- service, after sales and maintenance.

10.4.2 Engineering

The specific functionality and boundary conditions of the SCMS shall be adapted to the requirements which are related to the particular voltage level and specific substation layout.

During the engineering phase, at least the following items are very important and shall be supplied for approval by the Employer:

- overall single-line diagram, including position of the different objects (CTs, VTs, isolators, etc.), which is the basis for the engineering work
- general system architecture of the entire SCMS for each substation
- functional design specification of SCMS, which describes in detail the equipment and the functionalities
- layouts of the displays at station level and bay level as single-line diagram, event list, alarm list, etc.
- lists of events and alarms (including their names) with the indication of the particular signal to be sent (station event list, remote, etc.)
- data transmission towards and from the remote-control centers
- station interlocking
- cubicle layout
- IT security risk assessment according to IEC 62351 and the IEC 27k group of standards including appropriate recommendations for mitigation measures. The IT security measures applied shall be fully compliant with any requirement generated from outside systems, like the SCADA system in the connected NLDC/ECC.

10.4.3 FAT and SAT

10.4.3.1 General

The Contractor shall submit a test specification for the factory acceptance test (FAT) and the site acceptance tests (SAT) of the SCMS for approval. For the individual devices applicable type test certificates shall be submitted.

The manufacturing phase of the SCMS shall be concluded by the FAT. The purpose is to ensure that the Contractor has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the Employer.

All (100% of the subject units, but not only sampling) shall be subject to factory routine test. The relevant routine test for each specific unit shall be submitted before any delivery. The general philosophy shall be to deliver a SCMS to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab.

FAT shall be done for 100% of the subject panels/equipment. If the FAT comprises 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 some parts of SCMS are already installed on site, the FAT shall be limited to subsystem tests. In such a case, the complete system test shall be performed on site together with the site acceptance test (SAT).

10.4.3.2 FAT and SAT Requirements

All materials and equipment used in the Contract Works are subject to inspection by the Employer/Employer's Representative in order to determine whether the material and equipment comply with the required properties.

The Contractor shall at his own cost and expense execute shop and field tests of all materials and equipment supplied by him or his Subcontractor required in accordance with the applicable IEC standards. This shall not preclude the Employer's/Employer's Representative's right to call for further tests, if he considers them necessary.

All equipment and materials necessary for execution of the tests shall be furnished by the Contractor. Measuring apparatus and their calibration certificates shall be approved by the Employer/Employer's Representative.

The Contractor shall submit to the Employer/Employer's Representative for approval the test results showing conditions of tests performed, the test circuits and oscillograms, etc.

High temperature operation tests shall be performed at the maximum ambient temperature.

The Contractor shall submit a test specification for the factory acceptance test (FAT) and the site acceptance tests (SAT) of the SCMS for approval. For the individual devices applicable type test certificates shall be submitted.

The manufacturing phase of the SCMS shall be concluded by the FAT. The purpose is to ensure that the supplier has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the Employer.

All (100% of the subject units, but not only sampling) shall be subject to factory routine test. The relevant routine test for each specific unit shall be submitted before any delivery. The general philosophy shall be to deliver a SCMS to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab.

Workshop test, the shop assembled units shall be completely assembled, adjusted and tested at the shop. After assembly the complete units shall, as far as possible, be tested for operation under design conditions to assure the proper functioning of the equipment.

Type tests shall be performed on each type and rating of the specified equipment with the purpose of proving its properties. If evidence is available of successfully carried out type test on identical apparatus or apparatus which is for practical test purposes similar, in a recognized independent testing laboratory or independently witnessed, this may be accepted in lieu of these tests.

FAT, the complete substation control system (e.g. substation level equipment while communicating with all bay level equipment) shall be tested. FAT shall be performed to verify the performance of the system. The test shall apply to all aspects of the system, including communication to other systems, all Inputs/Outputs and the complete processing of all events, alarms, measuring and other information's.

Factory acceptance tests (FAT) shall be performed in presence of Employer/Employer's Representative in manufacturer laboratories before shipment.

The Factory Acceptance Tests shall commence by switching on power to all equipment bootstrapping and loading the software system for each computer terminal, verifying that each step is properly described in the operating instruction manual the substation control system shall be tested with all software loading and running.

The test shall include:

- checks of proper functioning of all hardware, software and firmware by a thorough exercise of all system functions
- verification of compliance with operating speed requirements
- verification that orderly computer system shutdown procedures are initiated following an interruption of the DC supply
- verification that system performance is not affected by DC power source abnormalities involving voltage variations (+10%; -20%)
- demonstration of all required performances. This demonstration shall include verification of functional requirements and verify that programs are (not unduly) interdependent, and furthermore that incorrect manipulation via HMI is properly identified and causes no system lock-ups.
- test of all discrete input points
- test of all control outputs
- test on bay interlock units
- test on assembled interlocking system
- check of analogue measurements accuracy
- test of SOE buffering, retrieval, and local logging
- demonstration of techniques and methods for modifying the database, including point additions and deletions
- demonstration of techniques for changing a communications port to use another protocol
- test of communication within protection monitoring system, and dialogue with distributed protection demonstration
- test of communication towards and from the higher-level Control Centers (NLDC/ECC) based on verification of correctness of the exchanged data traffic between SCMS and the Control Centers (NLDC/ECC) SCADA/EMS System under application of suitable test equipment (e.g.

test program for monitoring and exchange of IEC101 and/or IEC104 telegrams and frames, SCADA/EMS Substation SLD Displays).

SAT, on arrival at Site and during and after completion of erection, all items of control, SCMS, SCADA equipment shall be inspected and tested so to ensure that there shall be no delay in commissioning due to supply of incorrect or damaged equipment.

The commissioning of the primary equipment and the wiring between the primary equipment and cubicle terminals of the SCMS system is not part of the commissioning of the SCMS and has to be finished before commissioning of the secondary equipment.

The site tests are subdivided into:

- test during and after erection
- commissioning tests, site acceptance test – SAT
- hot test, test after energizing of the facilities
- guarantee tests.

The Contractor shall be responsibly to carry out the site acceptance tests including secondary tests of the protection equipment, the station control unit, local SCADA operation and remote control.

The site acceptance test will exercise all functions of the system and duplicate selected factory acceptance tests to the extent possible. The Contractor shall issue the site acceptance test certif-icates.

The following requirements related to the SAT are to be checked by Contractor:

- The control system is properly integrated into the entire system of substation and SCADA/EMS System at NLDC/ECC.
- The control system is suitable and functions correctly in its environment.
- The protective and control devices operate properly, as required.
- The interfaces with other systems (if applicable) are compatible and function correctly.

This testing will include, but not be limited to, the following conditions:

- each subsystem initialization
- diagnostics of primary equipment and self-diagnostic
- checks of proper functioning of hardware, software, and firmware by exercising of selected subsystems functions

- system communication interfaces including failure modes
- database modification and expanding
- inspection and approval of the VDU presentations
- test dialogues
- operation of HV/MV/LV apparatus
- test of interlocking system
- test of event list
- test of measuring functions (including trends)
- test of operation of tap changer
- test of alarms
- test of substation monitoring system (SCMS)
- Test of proper communication between SCMS and higher-level Control Centers via IEC101 and/or IEC104 standard protocol
- Test of proper integration between SCMS and higher-level Control Centers SCADA/EMS System.

Also, during this test the reliability of hardware and software shall be checked. Tests may include checks of drawings and lists, as well.

Procedures and methods for each commissioning/acceptance site tests, including those to be performed on-load, as well as formats of site test reports for each test, are subject of the Employer/Employer's Representative approval.

The commissioning is concerned as complete when the relevant equipment is energized and loaded and the necessary tests, measurements and checking done.

10.4.4 Commissioning

The commissioning of the primary equipment and the wiring between the primary equipment and cubicle terminals of the SCMS system is not part of the commissioning of the SCMS and has to be finished before commissioning of the secondary equipment.

After SAT , the Point-to-point test to prove the adequate integration of the Project related Substations SCMS into the SCADA/EMS System at NLDC/ECC shall be performed by the Contractor for each individual Substation.

10.4.5 Service, after-sales and maintenance

In order to reduce maintenance, training and commissioning costs, it is required to use the lowest number of different hardware platforms as possible.

A guarantee period including replacement of defective material for a period of 60 months, starting from the date at which the system has been taken over or for a period of 66 months after the last delivery by the factory supported by performance guarantee, shall be agreed upon.

The Contractor shall assure long-term maintenance and availability of spares. Moreover, a guarantee shall be submitted for the availability of spares during the lifetime of the SCMS (not less than 10 years).

Spare parts shall be foreseen for all the main equipment. A complete list of spare parts recommended by the Contractor shall be submitted.

The Contractor shall provide spares considered necessary for the bay control units, gateway and other equipment that the Employer may require to replace damaged components in order to bring the system to full operation. All special tools and test equipment required for maintenance of the system shall be included in the offer. The complete spare parts list recommended and submitted by the Contractor shall be subdivided into:

- Short-term spare parts that are necessary for two (2) years of operation as mentioned above. These spare parts shall be included in the contract and shall comprise at least one spare module for supplied equipment and basic tools for system maintenance.
- Long-term spare parts necessary during the lifetime of the SCMS (not less than ten (10) years of operation).

10.4.6 Training

Before and during erection, commissioning and trial operation, the employer's selected operating & maintenance staff is to be familiarized with the functions of the SCMS, including also the integration into the existing SCADA/EMS System at NLDC/ECC. The contractor shall arrange appropriate training in the operation and maintenance of the SCMS equipment for the Employer's personnel at site as well as at the Manufacturer premises.

A tentative training program shall be submitted by the contractor. The training program shall consider the availability of the "shift personnel" and shall be structured accordingly. The training shall be performed before installation, during installation as well as during commissioning.

The training sessions shall be conducted by for this purpose specially trained personnel of the Contractor, which are employees of the related systems Manufacturers.

The training sessions shall be performed in English language.

The focus of the training shall be on the general and basic structure of the SCMS and its components as well as configuration and setting of parameters respectively the maintenance and error correction. It shall also include the Project related SCMS integration into the existing SCADA/EMS System SINAUT SPECTRUM manufactured by Siemens at the NLDC/ECC.

The training shall include as a minimum Training at the Manufacturer premises and field training of the Employer's Operation &maintenance staff so that the following tasks can be executed:

- knowledge of the structure of the SCMS and its components
- design, configuration, parametrization and operation of the SCMS
- maintenance& operation of the facility including troubleshooting and error correction
- testing& commissioning of the SCMS
- knowledge of the structure of the SCADA/EMS system and its hardware& software components
- design, configuration, parametrization and operation of the SCADA/EMS System
- maintenance& operation of the SCADA/EMS System facility including troubleshooting and error correction
- testing& commissioning of the SCADA/EMS System for the Substation SCMS Integration into SCADA/EMS System at NLDC/ECC.

On-job training shall be regularly performed during the erection and commissioning of the equipment in the substation.

In order to safeguard that the selected staff of NEA will be sufficiently skilled and trained for such data engineering works, a series of on-job-training to be performed by the Contractor System Vendors at the NEA premises on-site. A series of 3 consecutive training sessions with duration of 3 weeks each is considered adequate to cater for such data engineering capabilities.

Before energizing, a series of three (3) consecutive training sessions with duration of three (3) weeks each, one(1) series for Operation staff and the other two(2) series for the Maintenance staff (configuration, parametrization, troubleshooting, error correction, testing etc.), separated into different sessions shall be performed. The Contractor shall provide comprehensive training documents. Furthermore, particular attention shall be paid to maintenance and repairs.

Kindly refer to the Table in chapter Training of VII-1 Scope for details for the required Training man weeks, segregated among Training abroad and Training in Employer's country:

10.4.7 Documentation

The hardware and software documentation shall comprise but is not limited to the following:

- list of drawings
- control room layout
- assembly drawing
- single line diagram
- block diagram
- circuit diagram

- list of apparatus
- list of labels
- Functional Design Specification (FDS)
- test plan and specification of Factory Acceptance Test (FAT) and of Site Acceptance Test (SAT)
- standardized IED capability description (ICD) files written in SCL according to IEC 61850-6
- standardized substation configuration description (SCD) file written in SCL according to IEC 61850-6
- front view and side view of all different cubicles
- circuit diagrams for cubicles
- connection tables for cubicles
- logic diagram
- list of signals
- product manuals
- operator's manuals
- IT risk assessment
- description of IT security measures applied.

The size of all documents and drawings shall conform to ISO standard, and be of size of A1, A2, A3 or A4.

Larger sizes than A1 shall be avoided. All documents in size A3 and A4 shall bound in hard covers. The schematic diagrams, apparatus and cable lists shall be size of A3 or A4.

All drawings shall be carried out in the latest version of AutoCAD, or a similar computer aided drafting software package. Scales to be used shall be 1:10, 1:20, 1:40, 1:50 and multiples of this series.

All system hard- and software documentation, the application hard- and software documentation and the operating instructions shall be provided in English language.

During the project, the contractor shall maintain a list of documentation to be updated whenever needed. This list of documentation shall include the date of the original issue of each document submitted as well as the date of each revision. A time schedule for the submittal of the documentation shall also be included in this list.

10.5 SCADA Requirements

10.5.1 General

As described under VII-1 Scope, the new Project related Substations SCMS shall be integrated into the existing SCADA/EMS System at NEA NLDC/ECC consisting in all respects (hardware wise/software wise/management wise) to be an integral part of overall network and any hardware/software required at intermediate / end stations shall be provided & implemented by the contractor.

During the project implementation phase the following activities shall be considered:

- engineering
- FAT
- site installation
- commissioning
- SAT
- training
- operation
- service, after sales and maintenance.

10.5.2 Engineering

The specific functionality and boundary conditions of the SCADA/EMS shall be adapted to the requirements which are related to the particular voltage level and specific scope substations layout.

During the engineering phase, at least the following items are very important and shall be supplied for approval by the Employer:

- overall single-line diagram, which is the basis for the engineering work
- individual Substation SLD
- general system architecture of the entire SCADA/EMS for each substation
- functional design specification of SCADA/EMS, which describes in detail the equipment and the functionalities
- SCADA/EMS System Extension Block Diagram
- layouts of the displays at station level and bay level as single-line diagram, event list, alarm list, etc.
- lists of events and alarms (including their names) with the indication of the particular signal to be sent (station event list, remote, etc.)
- data transmission towards and from the remote-control centers
- station interlocking
- cubicle layout

- Substation SCADA Signal List
- IT security risk assessment according to IEC 62351 and the IEC 27k group of standards including appropriate recommendations for mitigation measures. The IT security measures applied shall be fully compliant with any requirement generated from outside systems, like the SCADA system in the connected NLDC/ECC.

10.5.3 FAT and SAT

Included under SCMS.

10.5.4 Training

Included under SCMS.

10.5.5 Documentation

Included under SCMS.

10.6 Weather Station

This section gives details on the requirements for weather stations. The Weather station shall serve for continuous acquisition and transmission of all important meteorological data and shall include the following key components:

- weather sensors
- weatherproof interface module enclosure
- SCADA integration

The weather sensors shall measure and transmit the following parameters as a minimum requirement:

- wind direction
- wind speed
- temperature
- relative humidity
- barometric pressure
- solar radiation
- precipitation

All sensors shall meet the requirements of IEC 61724-1 for Class A systems.

The interface modules for the weather sensors shall be accommodated in a weatherproof interface module enclosure for outdoor installation close to the weather sensors. This enclosure shall also accommodate a communication interface for integration to the SCADA system and for remote transmission to the LDC. All electrical components within the weather station shall be protected reliably against surge voltages.

All required software for configuration and operation of the weather station shall be provided.

11 Telecommunication Systems

11.1 General

This section deals with the telecommunication system and equipment concerned of new 220 kV GIS substation Lekhnath and new 220 kV GIS substation Damauli under the Contract.

The latest editions of international standards mentioned in relation to telecommunication equipment: SDH and MPLS – TP equipment for Transport and Access, IP-PBX, OPGW, underground optic cables and accessories are the minimum requirements.

This specification describes the functional and performance requirements of the system and covers only those general aspects that are meant to ensure a minimum standard of quality and performance. Other details and specific data will be contained in the Technical Data Sheets and in the Employer's Specification **"Fiber Optic Based Communication Equipment"** attached as Annex D5-21.

The new communication equipment shall be integrated into the existing fiber optic communication network consisting in all respects (hardware wise/software wise/management wise) to be an integral part of overall network and any hardware/software required at intermediate / end stations shall be provided & implemented by the Contractor.

The Hybrid technology equipment shall be capable of interfacing to the existing Telecommunication Network Management System (TNMS) to facilitate the operation and maintenance of the overall fiber optic communication network.

For all services, applications and all types of communications required, or to be provided, the Contractor shall provide a suitable state-of-the-art turnkey solution, to be integrated entirely and properly into the existing overall telecommunication systems including their Telecommunication Network Management System, ready for use. Major characteristics of the solution to be provided shall comprise but not be limited to:

- low latency
- highest availability and reliability
- 1 + 1 hardware redundancy
- traffic protection concepts
- data security, IT-security and safety according to current standards
- sustainability
- convertibility and technical flexibility
- expandability, upgradeability
- interoperability and compatibility with existing systems, incl. TNMS
- state-of-the-art transmission technology and features.

11.2 Optical Line Terminal Equipment for SDH and MPLS – TP Hybrid technology

The Fiber Optic Transmission System is specified in Employer's Specification **"Fiber Optic Based Communication Equipment"** attached as Annex D5-21 and is integral part of this specification.

11.3 IP-Privat Branch Exchange (IP-PBX)

State-of-the-art IP-Privat Branch Exchanges shall be provided and installed in the communication network.

The IP-PBX shall be preferably a self-hosted on-premises solution using dedicated HW and SW or alternatively a Software-based PBX running on a computer.

System requirements

The IP-PBX shall support:

- CTI-Applications (Computer Telephony Integration) and provide
- Telephony Application Programming Interface TAPI and drivers for Email and CMR system integration.

The IP-PBX shall be compliant to the Session Initiation Protocol (SIP) according to RFC 3261 and shall provide VoIP channels for intern and extern telephone communications.

Voice over IP (VoIP) security by Session Initiation Protocol Security (SIPS) shall be supported with encrypted signaling with TLS/SSL and Secure Realtime Transport Protocol (SRTP).

SIP-Trunking and SIP-DDI (Direct Dial In) shall be supported by the IP-PBX.

The IP-PBX shall support the integration/migration to Unified Messaging and Unified Communications. The IP-PBX shall support multiple site operation via Virtual Private Network (VPN).

A soft migration from analogue to IP-Telephony shall be supported by the IP-PBX.

VoIP terminal equipment

The IP-PBX shall support the use of:

- IP phones
- DECT phones
- Conference phones
- Softphones
- Smartphones via SIP-Client
- analogue devices via Gateway.

11.4 Power Line Carrier Equipment

The present project does not include any PLC equipment, as the lines involved in the project are equipped with OPGW.

11.5 Fiber Optical Cables

The fibers of optical ground wires (OPGW) and underground fiber optic (UGFO) cables need to have the same physical and optical transmission properties. Hence, they need to be of the same fiber type.

In order to limit necessary spare parts, all connections preferably shall be realized by the same OPGW and UGFO cable types. Two types of UGFOs incorporating either 24 single-mode fibers or 48 single-mode fibers (matching the respective number of single-mode fibers from OPGWs), which shall comply with IEC 60793 and IEC 60794 standards and with ITU-T G.652D shall be provided.

In general, the OPGW, the UGFO cables, the splice boxes and the complete optical distribution frame (ODF) with all components like pigtails, connectors etc. need to be compatible to each other.

Characteristics and Performance

Optical fibers to be provided and installed in the Project shall at least comply with following fiber characteristics:

Table 11-1 Characteristics of optical fibers

Characteristics	**Values/limits**
Complying standard	ITU-T G.652D
Transmission wavelength	1310 nm and 1550 nm
Cut-off wavelength	≤ 1260 nm
Mode field diameter	9.9 – 10.9 µm at 1550 nm, 8.8 – 9.6 µm at 1310 nm
Optical cladding diameter	125 µm ± 1.0 µm
Concentricity error	≤ 0.5µm
Cladding non-circularity	≤ 1.0 %
Optical attenuation for any fiber in every drum, to be measured from both ends for wavelengths	≤ 0.21 dB/km @ 1550 nm, ≤ 0.34 dB/km @ 1310 nm
Optical attenuation @ mechanical splice	≤ 0.15 dB per fiber @ 1550 nm, to be measured from both ends
Optical attenuation @ fusion splice	≤ 0.04 dB per fiber @ 1550 nm, to be measured from both ends

Characteristics	Values/limits
Optical attenuation per connector pair	≤ 0.5 dB @ 1550 nm
Insertion loss @ connector	≤ 0.1 dB per fiber @ 1550 nm
Optical attenuation @ joint	≤ 0.15 dB per fiber @ 1550 nm, measured and calculated on the fully installed joint from both ends
Chromatic dispersion (CD)	At 1310 nm: ≤ 3.5 ps/(km x nm)
Chromatic dispersion (CD)	At 1550 nm: ≤ 18 ps/(km x nm)
Polarization Mode Dispersion (PMD)	≤ 0.1 ps/√km
Operational temperature range	-60 °C to +85 °C
Life span	≥ 30 years

No joints shall be allowed in any fiber in any drum length.

The Contractor shall supply a graph of attenuation versus wavelength over the range of 1310-1625 nm

Discontinuities will only be acceptable if:

Optical time domain reflectometry (OTDR) traces from both ends of the cable at 1550 nm wavelength shows a difference of less than 0.04 dB/km for every fiber in every drum.

The Contractor shall state the refractive index of the optical fibers @ λ = 1460 nm, @ λ = 1625 nm and @ λ = 1550 nm.

The Contractor shall present details about dispersion measurements at the installed fibers, at least about chromatic dispersion (CD).

CD measurement method shall be according to ITU-T G.650.1 (3.1), (4.5), the calibration of the test instrument shall be according to IEC 61744.

Details about polarization mode dispersion (PMD) for each deployed fiber are desired but at least for each deployed fiber PMD shall be as good as 0.1 ps/√km (respectively ≤ 40 ps @ STM-16, respectively ≤ 80 ps @ STM-4) or better.

Underground Fiber Optic Cables

To mitigate the risk of high induced voltages or earth potential rise, the fiber optic cables (FOC) shall be free of any metallic components.

The fiber optic cable shall be circular in cross section and free from pinholes, joints, and other defects.

The FOC shall be adequately designed and manufactured not to affect the physical or optical properties of the optical fibers.

The optical fibers shall be contained within color coded loose tubes, arranged in a circular configuration and filled with a water-blocking compound to prevent water penetration. The underground fiber optic cables (UGFO) shall have Rodent Protection.

The individual optical fibers shall be uniquely identifiable through a color-coding scheme in accordance with ITA/EIA-598-C.

In case duplicate colors are to be used, the fibers shall be uniquely identifiable through black tracers.

The fiber optic cables with fiber count up to 48 fibers shall include sufficient peripheral strength members to withstand a tensile load of 2100 N during pulling and 1200 N in operation (permanent), in accordance with IEC 60794-1 E1 without deteriorating the performance of the optical fibers.

Similarly, for cables with more than 48 fibers the peripheral strength members shall withstand a tensile load of 3000 N during pulling and 1700 N in operation (permanent).

The glass yarn layer will be designed, manufactured and tested to cope with the required strength efforts and simultaneously to efficiently protect the cables against rodents.

The fiber optic cables shall be designed, manufactured and installed to operate with temperatures with the range: -20°C to +70°C.

Figure 11-1 shows an example for the required fiber optic cable cross-section for fiber counts up to 72 fibers (6 active tubes each with 12 fibers):

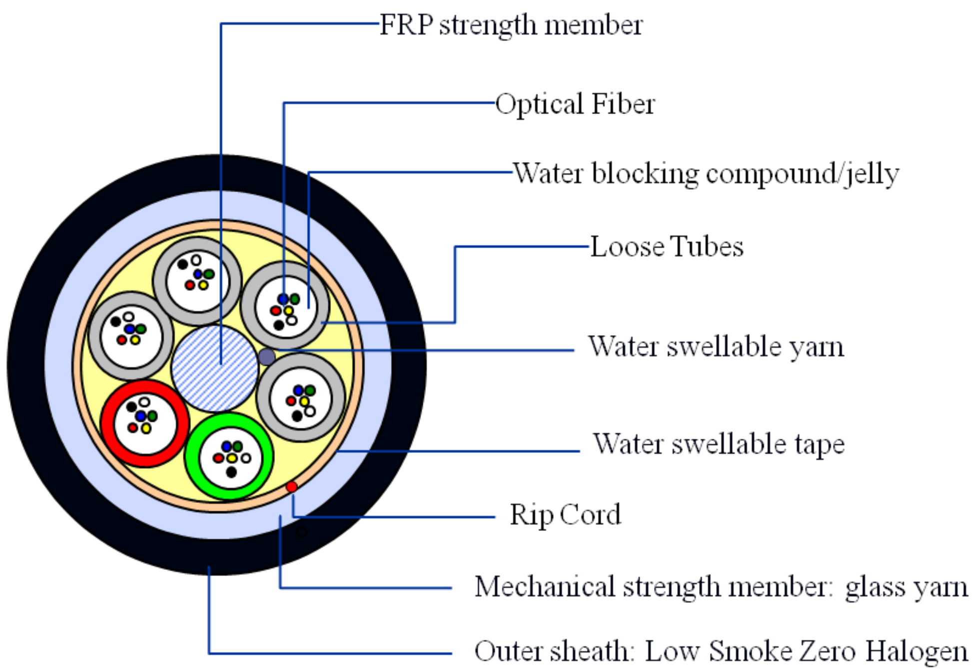

Figure 11-1: Fiber optic cable cross-section

For higher fiber count additional loose tubes will be required.

The outer sheath of the fiber optic cables shall be marked, including:

- Employer name
- cable type/manufacturer
- metric marking.

Fiber optic cable test

The Contractor shall provide evidence - through suitable type tests -that the proposed cable complies with the cable test requirements depicted in below.

Table 11-2 Fiber Optic Test

Test	Test Method	Required values
Tensile strength	IEC 60794-1-2 E1. For cables up to 72 fibers: 2100 N. For cables from 72 to 144 fibers: 3000 N.; Length > 50 m	Maximum fiber strain < 0.33 %. No attenuation change @ 1550 nm (< 0.05 dB)
Temperature cycling	IEC-60794-1-2-F1 Sample length≥ 500 m - Temperature step: TA=-20°C, TB=+70 °C - 6 cycles, min 8 hours/step	Attenuation change, @1550 nm ≤0.05 dB/km
Crush	IEC-60794-1-2-E3 -Load: 1200 N -Length of plate: 100 mm -Time: 15 minutes - Test point: 3 points	- No damage in cable element - No attenuation change @ 1550 nm (< 0.05 dB)
Impact	IEC-60794-1-2-E4 - Impact energy: 5J with R = 10mm - Impact point: 3 points - Impact distance: 500 mm - Impact times: 1 time for each point	- No attenuation change @ 1550 nm (< 0.05 dB) - No damage in cable element
Propagation of flame for a cable isolated vertically	IEC 60332-1 A parameter control: - Ignition temp and time - Burning time after stopping the ignition - Begin of the propagation of the flame	
Emission of corrosive and toxic gases	IEC 60754-1 IEC 60754-2	- The quantity of gas ≤0.5% - Smoke acid pH > 4.2
Smoke density	IEC 61034-1 IEC 61034-2	Min. 50% No of samples: 4

Underground optical fiber characteristics

The optical fibers shall comply with the minimum requirements set out in Table 11-3.

Table 11-3 Underground Fiber Optic Cables

Fiber Characteristics	**Required values**
Fiber Type	ITU-T G.652D
Max. Attenuation at:	
1550 nm	0.21 dB/km
1310 nm	0.35 dB/km
Chromatic dispersion	
Max. Chromatic dispersion at 1550 nm	≤ 18 ps/(nm x km)
Max. Chromatic dispersion at 1310 nm	≤ 3.5 ps/(nm x km)
Polarization Mode Dispersion (PMD):	
Max. individual fiber	0.1 ps/√km
Cable Cut-off wavelength (λcc)	≤ 1260 nm
Mode field diameter, IEC 60793-1-C9A	9.9 – 10.9 µm @1550 nm
Mode field diameter, IEC 60793-1-C9A	8.8 – 9.6 µm @ 1310 nm
Optical cladding diameter, IEC 60793-1-A2	125 ± 1.0 µm
Cladding non-circularity, IEC 69793-1-A2	≤ 1.0%
Bending test, additional loss, 100 turns on 60mm mandrel	0.03 dB at 1550 nm
Bending test, additional loss, 1 turn on 32mm man-drel	0.03 dB at 1550 nm
Proof test	≥100 kpsi

Fiber Patch Cords

Fiber equipment cables and fiber cross connecting cables shall be single fiber installation cables consisting of one tightly secondary coated fiber (tight buffer), strength element and flame retardant LSZH-sheath in accordance with 60332-1.

The maximum outer diameter of the cable shall be 3.0 mm and the nominal thickness of the sheath shall be not less than 1.4 mm.

The mean value of the thickness shall be not less than 1.4 mm and any individual value shall be not less than 1.0 mm.

The cables shall withstand following installation properties:

- tensile strength 200 N
- minimum allowed bending radius = 40 mm.

The fibers shall meet the geometrical, optical and transmission requirements of the ITU-T Recommendation G.652D.

The fibers shall have tight secondary coating (tight buffer).

Fiber optical cables accessories

Optical distribution frame

The optical distribution frames (ODF) with FC/PC connectors for Fiber Patch Cords shall have the following characteristics:

- The fiber optic cable gland shall accept metal free optical cable with min 24 and max 96 single mode fibers and loose buffered construction.
- Two types of optical distribution frames (patch-panels) shall be provided:
  - to accept 48 single mode fibers to be spliced with pigtails with FC/PC connectors
  - to accept 96 single mode fibers to be spliced with pigtails with FC/PC connectors.
- Maximum optical attenuation shall be 0.10 dB per splice.
- The housing of the box shall be standing type, tamper-proof sealed and of rugged construction.
- the appropriate optical connectors and plugs.

Connectors and plugs

The appropriate state-of-art optical plug/connector type shall be provided for new installations in the Project.

The Contractor shall also respect and consider appropriate connectors& plugs for the concerned new components and installations (e. g. ODF, ports etc.), as feasible. Compatibility with the existing connectors and plugs shall be ensured.

11.6 Employer's Telecommunication Systems

General

The Employer operates a fiber optic based SDH communication network in Nepal. The operational SDH communication network is used to for data (SCADA, metering, protection etc.) and voice communication

The basis of this telecommunication system is an SDH network based on ABB FOX 615 and Siemens hiT 7025 SDH multiplexers. The existing SDH network mainly operates on Synchronous Transfer Modules STM-4 (1+1 MSP).

The Employer will upgrade the existing fiber optic based SDH communication network by deploying latest technology communication equipment and planned to change its communication equipment to Hybrid technology which can support MPLS - TP facilities as well as SDH STM - 4 level.

The new fiber optic network shall be based on Hybrid technology which has the functionality of both Synchronous Digital Hierarchy (SDH) as well as Multiprotocol Label Switching – Transport Profile (MPLS – TP) technology. The network shall consist of overhead fiber optic links with a minimum bit rate for SDH shall be STM-4 (622 Mbps) and 10G for MPLS – TP.

The Contractor can propose a system based on higher bit rate systems and SFPs, if required, so as to meet the link budget requirements or any other specification requirement.

The Contractor can propose as mentioned above Hybrid technology which can be accommodated in a single sub – rack or a multiple sub – racks but the total nos. of MSP protected direction (1+1) for SDH and MPLS – TP must be fulfilled. The fiber optic-based communication equipment shall have 4 MSP protected direction for SDH at STM – 4 level as well as the same 4 MSP (1 +1) protected direction for MPLS –TP at 10G level.

If the contractor proposes multiple sub – rack, then the interconnection between such sub – racks in any bit rate (not less than above mentioned level) will not be considered as separate MSP protected directions.

The two new 220 kV GIS Substations Lekhnath and Damauli shall be equipped with Hybrid technology system equipment providing the functionality of both Synchronous Digital Hierarchy (SDH) as well as Multiprotocol Label Switching – Transport Profile (MPLS – TP) technology. The extended fiber optic network shall provide the connections between the SCMS in the two new

220 kV GIS Substations and the Load Dispatch Center (LDC) located in Syuchatar, in the west side of Kathmandu.

Furthermore, the fiber optic-based communication network is used for protection communication, synchro phasor streaming and voice and video communication.

Hybrid technology network

The existing SDH network shall be extended with Hybrid technology system equipment to insert the new 220kV GIS Lekhnath Substation and the new 220/132/11kV GIS Damauli Substation.

Figure 11-2 below provides an overview over the new SDH network configuration.

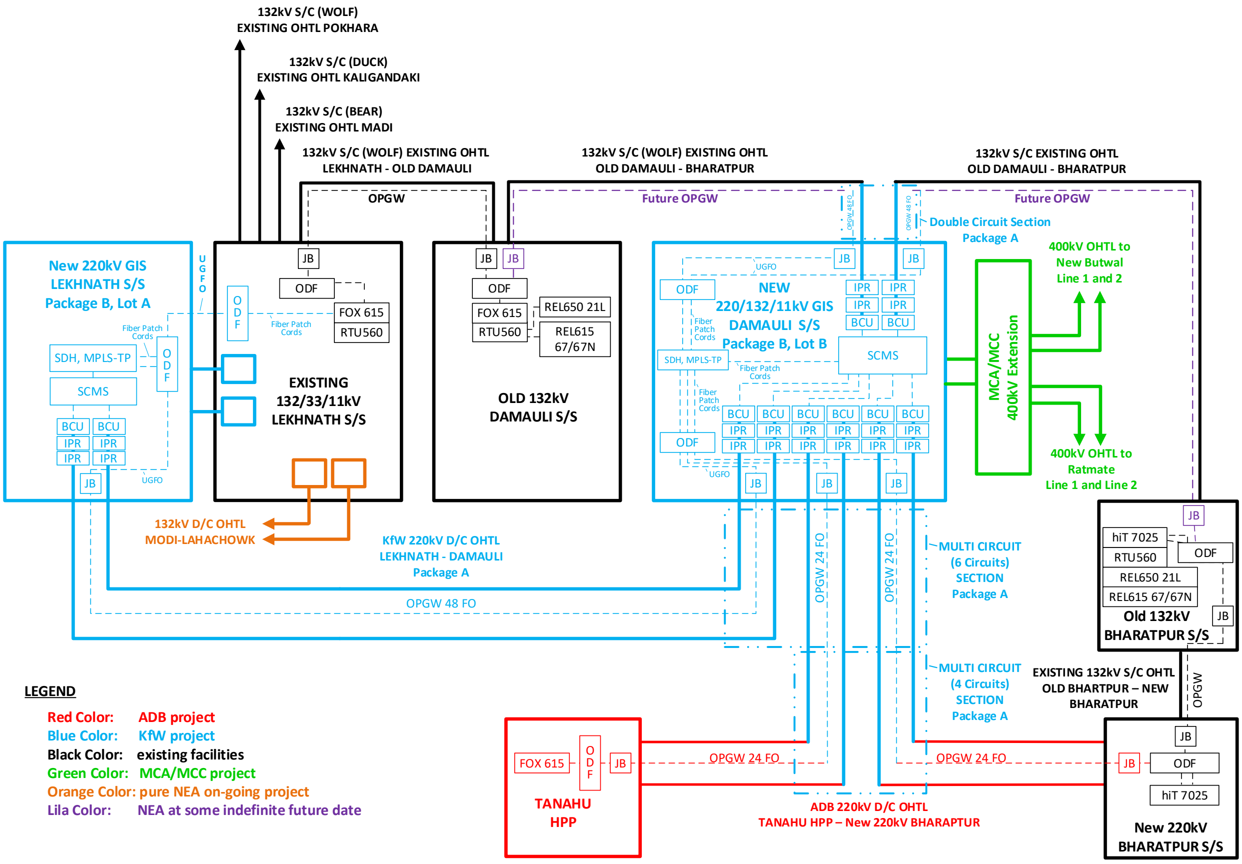

Figure 11-2 General Scheme

The fiber optic network shall be extended to interconnect the following concerned Substations:

Old 132 kV Damauli S/S – existing 132/33/11 kV Lekhnath S/S – new 220 kV GIS Lekhnath S/S – new 220/132/3311 kV GIS Damauli S/S – Tanahu HPP – new 220 kV Bharatpur S/S – old 132 kV Bharatpur S/S.

The Tanahu HPP shall be connected by an OPGW, running on the ADB 220KV D/C OHTL between Tanahu HPP and new 220 kV Bharatpur S/S, to the new 220/132/33/11 kV GIS Damauli S/S (with a new tie-in / tie-out from ADB 220 kV D/C OHTL to new 220/132/33/11 kV GIS Damauli S/S).

The existing Substations: 132/33/11 kV Lekhnath S/S and old 132 kV Damauli S/S are equipped with operative SDH multiplexers of type ABB FOX 615. The existing old 132 kV Bharatpur S/S and new 220 kV Bharatpur S/S are equipped with operative SDH multiplexers of type Siemens hiT 7025.

In order to facilitate easy and effective operation and maintenance of the SDH equipment in one TNMS at the LDC the new substations 220 kV GIS Lekhnath and new 220/132/33/11 kV GIS Damauli shall be equipped with the same type or compatible type Hybrid technology multiplexer to the existing type of ABB FOX 615 multiplexer.

Compatible Hybrid technology equipment needs to be provided also for Tanahu HPP in the project.

The optical fibers are provided by OPGWs running between the Substations:

- existing 132/33/11 kV Lekhnath S/S – old 132 kV Damauli
- old 132 kV Bharatpur S/S – new 220 kV Bharatpur S/S
- new 220 kV Bharatpur S/S – new 220/132/33/11kV GIS Damauli S/S
- new 220/132/33/11 kV GIS Damauli S/S – Tanahu HPP.

A new UGFO cable containing 48 optical fibers shall be provided between the new 220 kV GIS Lekhnath Substation and existing 132/33/11 kV Lekhnath Substation. The UGFO cable shall be terminated in new ODFs installed in the telecommunication rooms in both substations, the new and old Lekhnath Substation.

New UGFO cables containing 48 optical fibers shall be provided for the following Substations:

- new 220 kV GIS Lekhnath Substation: running from the Junction Box (JB) at the gantry of the 220 kV D/C OHTL LEKHNATH – DAMAULI to the ODF in the telecommunication room.
- new 220/132/11 kV GIS Damauli Substation: running from the Junction Box at the gantry of the 220 kV D/C OHTL LEKHNATH – DAMAULI to the ODF in the telecommunication room
- new 220/132/11 kV GIS Damauli Substation: running from the Junction Box at the gantry of the **tie-in** of the 132 kV S/C OHTL Old Damauli – Bharatpur to the ODF in the telecommunication room
- new 220/132/11 kV GIS Damauli Substation: running from the Junction Box at the gantry of the **tie-out** of the 132 kV S/C OHTL Old Damauli – Bharatpur to the ODF in the telecommunication room.

The 48 optical fibers of the UGFO cables shall be spliced with the optical fibers of the OPGW cables in the corresponding Junction Boxes at the Gantries and shall be terminated (spliced with the pigtails) in new ODFs installed in the telecommunication rooms.

New UGFO cables containing 24 optical fibers shall be provided for the new 220/132/11 kV GIS Damauli Substation:

- running from the Junction Box at the gantry of the **tie-in** of the 220 kV D/C OHTL TANAHU HPP- NEW 220 kV BHARATPUR Substation
- running from the Junction Box at the gantry of the **tie-out** of the 220 kV D/C OHTL TANAHU HPP- NEW 220 kV BHARATPUR Substation

The 24 optical fibers of the UGFO cables shall be spliced with the optical fibers of the OPGW cables in the corresponding Junction Boxes at the Gantries and shall be terminated (spliced with the pigtails) in new ODFs installed in the telecommunication rooms.

The Substations with access to optical fibers and provided with SDH equipment as described above shall be connected at the old Damauli S/S via SDH links to lower Mirsingandi Power House and from here to the LDC, see LDC_System_Layout_nea_dated 28.09.2020 attached.

Timing, Synchronizing and clock system

Timing and synchronization shall conform with ITU-T G.783, G.811, G.812, and G.813. Timing references, number of timing references available, switching time to a different timing reference, type and level of clocks shall be stated. Formation of timing loops shall be avoided.

The equipment shall automatically switch over to another clock source if the reference timing is lost and shall automatically revert upon restoration.

Accuracy of the internal clock as well of the details of the clock distribution shall be stated.

IT security requirements

The new telecommunication equipment and its installation shall be protected by currently relevant IT security standards like IEC 27011, IEC 27019, IEC 62351, and NERC CIP in their latest release.

The Contractor shall perform a Project related IT Risk assessment workshop together with the Client in order to identify all risks and to define the required mitigation measures for state-of-the-art protection.

Electromagnetic compatibility and safety regulations

All Telecommunication equipment will be situated in high voltage electricity substations which are subject to rises in earth potential at times of system faults. Precautions shall be taken to prevent damage occurring to the equipment.

The system shall incorporate all reasonable precautions and provision for the safety shut-off of the optical source to prevent exposure to laser light during installation, maintenance and repair work.

The Telecommunication equipment shall be suitable for operation in substations with harsh environment with high electromagnetic interference, be highly reliable and provide secure communications for real time signals.

It shall comply with the latest ITU-T recommendations as well as with the following standards:

- Electromagnetic compatibility and insulation shall comply with requirements for emission and immunity EN 50081-2, EN 50082-2, EN50022 class A and IEC 61000.
- Electrical safety shall comply with the safety requirements according to IEC 60950.

Requirements for software licenses for the telecommunication systems

All required software licenses for operation, configuration and management of all devices and systems of the telecommunication systems (operational telecommunication and protection communication including synchro phasor communication) shall be supplied.

Software licenses shall be provided:

- for new Hybrid technology equipment and for extension of existing SDH multiplexer in the operational telecommunication system, if required for additional cards
- software for operation, configuration, management etc. of switches of the operational telecommunication systems for data communication (SCADA, SCMS, metering, etc.) and voice communication
- software extension for the central PABX systems, if required
- software extension for the Telecommunication Network Management Systems, if required
- and other required operation, configuration, management and supporting software for systems required.

The following shall be fulfilled:

- the licenses shall be timely unlimited throughout the lifetime of the device or system
- failure rectifications and upgrades shall be implemented by the Contractor until the end of the warranty period within the contracted version
- safety relevant failures rectification patches shall be provided until the end of the lifetime of the device or system.

11.7 Telecommunication Network Management System

The new Hybrid technology communication equipment shall be capable to be monitored and managed by the existing Telecommunication Network Management System (TNMS) of type ABB FOXMAN-UN Network Management System to facilitate the operation and maintenance of the overall fiber optic transmission system.

As already mentioned, the scope shall include the implementation and integration of the new telecommunication equipment to the existing TNMS as well as its adaption, if required (including all required services, integration, adaptations, configurations, upgrades (if required), hardware equipment, software, customer service).

After the integration one TNMS shall be capable to manage the entire telecommunication network and shall support all features provided by the new telecommunication equipment.

11.8 Telephony

In the new Substations new state-of-the-art and appropriate telephone sets shall be installed, ready for use. The new telephone sets shall be fully compatible and interoperable with the existing IP PABX in the LDC.

System languages of telephone sets shall be English.

Documentations of telephone sets shall be provided in English.

11.9 Revision Levels and Modifications

All equipment, firmware and software delivered as part of the communications network shall be at the most current revision level. All modifications and changes necessary to meet this requirement shall be completed prior to the start of the factory tests.

All field modifications required to update the hardware, firmware and software to a later revision level occurring after the above specified testing, shall be disclosed, fully documented and presented to the Employer for his consideration. The intent is to provide the Employer with documentation and opportunity to consider negotiating their implementation.

All field modifications of the hardware, firmware and software that are required to meet installation and/or performance specifications, shall be fully documented as part of the deliverables, both as separate field modifications records and as corrected equipment/configuration documentation.

11.10 Expandability

The equipment shall include provision for expansion such that the expansion is accomplished by the addition of plug-in modules, and cables.

Equipment supplied shall be sized (though not necessarily equipped) to support expansion to full capacity according to the specified aggregate transmission rates. The equipment units provisioned for unequipped sub-unit expansions shall be terminated at appropriate patching facilities or termination blocks.

Power supplies and remote monitoring shall be sized for maximum equipment capacity.

11.11 Telecommunication Power Supply Equipment

The power supply system shall consist of a storage battery and a charging rectifier system. The system shall serve the power supply requirements of the Substation’s telecommunication equipment and shall have a control & monitoring unit, main switchgear and a DC distribution panel.

The equipment shall have protection against transient voltages and operate without degradation in performance for a supply voltage variation stipulated in the Technical Data Sheets. The power supply input to individual items of equipment shall be individually fused.

The 48 V DC system shall meet the power requirements of the connected telecommunication equipment at each site with 50% spare capacity.

The positive pole of the 48 V DC power supply system shall be earthed. All terminal strips shall be easily accessible for maintenance or rewiring.

The terminals for high voltage wiring shall be protected by a non-metallic cover and carry a conspicuously marked warning. Screw-type terminals of an approved type shall be permitted.

Fire resistant insulation for all wiring shall be utilized.

Overvoltage protection must be very strong.

The batteries, battery charging rectifier, main and distribution boards shall meet the requirements as required in the Technical Data Sheets and other parts of this document.

Performance requirements

The equipment shall also comply with the following requirements:

- availability
  >99.9999% for 48 V DC supply
  >99.999 for UPS
- Electromagnetic compatibility and insulation shall comply with requirements for emission and immunity (EN 50081-2, EN 50082-2).
- Electrical safety shall comply with the safety requirements according to IEC 60950.
- Seismic conditions- All telecommunication power supply equipment shall be designed to resist earthquake loadings resulting from accelerations specified in Part I -General Technical Requirements.
- ambient conditions for normal operation:
- temperature range – 0°C to 50°C
- relative humidity – 5% to 95%.

11.12 Equipment Life Span

All equipment supplied shall have a minimum expected life of 15 years from the date of final acceptance, if not specified otherwise. Extended liability period should be for a period of 60 months, starting from the date at which the system has been taken over or for a period of 66 months after the last delivery by the factory supported by performance guarantee.

The Contractor shall certify that spare parts will be made available for 10 years and shall notify the Employer, in writing, whenever equipment supplied under this Contract, including equipment purchased from subcontractors, will no longer be supported with either spare parts or repair services.

Notice shall be given half a year in advance of the end of production of any subassemblies (such as printed-circuit boards, modular power supplies, custom integrated circuits, etc.) as to permit the Employer to purchase additional spares.

Additionally, the Contractor shall agree to make available at no extra cost to the Employer the pictorial diagrams, manufacturing drawings and rights to manufacture those subassemblies declared by the Contractor as no longer supported.

For each subassembly, the specific parts supplied shall be identified and referenced in supplied documentation.

11.13 Cubicles/Cabinets

The general design of telecommunication cubicles shall be subject to approval, but they shall in general be of fabricated steel construction provided with shelves on which mounting plates can be accommodated. Cubicles shall be free standing and shall permit anchoring to the floor.

The following dimensions shall not be exceeded:

- width: 800 mm
- height: 2200 mm
- depth: 800 mm.

Hinged doors shall be provided and arranged to open 180°so as not restrict access to the apparatus contained within the cubicle. Hinged doors shall be of the lift-off type unless there is wiring on the door. They shall be secured with integral handles and shall be flush fitting and sealed with a gasket of rubber or other approved material to prevent the ingress of dust.

Provision shall be made for locking, with two keys provided for each lock. Cubicles and doors shall be structurally sound and not liable to distortion. The door of the cabinet shall have a see-through window as an option finally defined during design phase.

Each item of equipment in a group (i.e., a cubicle in a suite of cubicles) shall be individually fused and shall provide an alarm indication on loss of supply. Power supply bus bars in cubicles shall be carefully routed and each bus bar shall be shrouded. It shall not be possible to inadvertently short bus bars either between themselves or to earth.

It shall be possible to remove/replace cards without damage and without interfering with the operation of the rest of the equipment or system.

If necessary, consideration shall be given to switching off the supplies locally to a card to prevent inadvertent interference to the equipment or system when removing/replacing a card.

The environmental requirements of the specification shall be taken into account when considering ventilation arrangements. Heat dissipation of cubicle mounted equipment shall be kept as low as possible. For equipment, which will be supplied to this specification, the average dissipation per cubicle shall be stated. Natural cooling is preferred.

The approval of the Employer must be obtained in all cases where it is intended to incorporate forced cooling. Where the use of forced cooling has been approved, means shall be provided for indicating and alarming any significant reduction in air flow, and the equipment shall be so protected that no damage occurs due to failure of the forced cooling. Air blown through equipment for cooling purposes shall first be passed through an efficient dust filter. Multi-stage filters, arranged to permit individual filters to be removed for cleaning, are preferred.

The cubicles and all alarm lamps shall be clearly labelled. All modules shall be identified as to their shelf location, and it shall be preferable to use coded key slots in the edge connectors in order that modules cannot be plugged into the wrong position.

At least 1 earthling strap shall be available in each rack, bond all the different parts of cabinet together.

12 Metering Equipment

12.1 Energy Meters

12.1.1 General

This part of the Particular Technical Requirements regards current transformers-operated and voltage transformers-operated, electronic, three-phase energy meters.

These meters shall be in conformity with the standards mentioned in the following, relevant paragraph, as well as with the quality and performance requirements of the Country regulations.

Further detailed and specific data are contained in the Technical Data Sheets and other documents that form part of these Particular Technical Requirements.

The meters shall be complete in all respects, as necessary for their effective and trouble-free operation when connected to the system.

The meters shall be totally microprocessor-based polyphase electrical energy meters with a large LCD display image area and an integral register that collects, processes, and memorizes energy use and demand data on multiple rates, time of use, and demand basis.

The meters shall have the facility to be reprogrammed by any other transformation ratio by the Employer, using security passwords provided by the manufacturer. This transformation ratio shall be displayed on the scrolling meter screen.

The meters shall be factory calibrated and no calibration adjustments shall be possible outside the factory facilities.

12.1.2 Applicable standards

The three-phase electronic meters shall comply with the latest versions of the following directive and standards:

Directive 2014/32/EU of the European Parliament and of the Council of 26 February 2014 measuring Instruments Directive (MID)

IEC 62052-11	General requirements – Part 11: Metering equipment
IEC 62052-21	General requirements, tests, and test conditions – Part 21: tariff and load control equipment

IEC 62053 -22	Electricity Metering Equipment (AC) Particular Requirements – Part 22: Static meters for active energy (classes 0.2 S and 0.5 S)
IEC 62053-23	Particular requirements – Part 23: static meters for reactive energy (classes 2 and 3)
IEC 62053-61	Particular requirements – Part 61: power consumption and voltage requirements
IEC 62054-21	Electricity metering (a.c.) - Tariff and load control - Part 21: Particular requirements for time switches
IEC 62056	Electricity metering – Data exchange for meter reading, tariff and load control (Parts 21, 31,41,42, 46, 47, 51, 52, 53, and 61, depending on the communication method)
IEC 62058-11	Acceptance inspection – Part 11: general acceptance inspection methods
IEC 62058-31	Acceptance inspection – Part 31: particular requirements for static meters for active energy (classes 0.2s, 0.5s, 1, and 2)
IEC 61000-3-2	Electromagnetic compatibility (EMC) - Part 3: Limits - Section 2: Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)
IEC 61000-4-3	Electromagnetic Compatibility (EMC) - Part 4: Testing and Measurement Techniques - Section 3: Radiated, Radio-Frequency, Electro-magnetic Field Immunity Test
IEC 61000-4-4	Electromagnetic Compatibility (EMC) - Part 4: Testing and Measurement Techniques - Section 4: Electrical Fast Transient/Burst Immunity Test
IEC 61000-4-5	Testing and Measurement techniques - Surge Immunity Test
IEC 60529	Degrees of protection provided by enclosures (IP Codes)

12.1.3 Basic requirements

The meters shall be designed and assembled with state-of-the-art microprocessor components to perform -without any metrological degradation- over a wide dynamic current range, under harsh operating conditions. The meters shall maintain accuracy throughout their useful life. These energy meters shall be microprocessor-based, high-precision meters with accuracy class 0.2 S for active and 1 for reactive power conforming to IEC 62053.

The meters shall be capable of displaying the energy readings. These readings shall be stored for a minimum period of 60 days before being overwritten.

The load profile for at least 8 channels shall be configurable. Load profile data shall be captured at programmable intervals ranging from 15 minutes to once a day. Load profile storage capacity is a function of the number of channels and the log interval.

The storage capacity shall be designed to retain half-hourly data on each single channel for a period of not less than 365 days.

The meters shall have a built-in clock and calendar having an accuracy of at least 0.5 s per day in accordance with IEC 62052-21/62054-21, without the assistance of an external time-synchronizing pulse. The date and time shall be displayed on demand. The clock shall be synchronized by time signals received through the local or remote communication interface.

Each meter shall have a unique identification code proposed by Contractor and agreed by Employer and shall be marked permanently on the front and also on the non-volatile memory.

The meter shall have a separate built-in impulse device, that is, a galvanically isolated communication port as specified in the technical data sheets, for remote reading and for local communication with handheld device or laptop through an optical port.

The microprocessor-based meter shall have a direct data transfer capability through this port to a PC in numeric form. The meter supplier shall provide the necessary software.

The meters shall have built-in, self-diagnostic features as well as tamper-evident features.

The meters shall be, as a minimum, 16-bit microprocessor-based energy-measuring devices employing the latest microprocessor-controlled instrumentation and measurement technology.

The meters shall have state-of-the-art surface mount technology (SMT) components. The cover shall be made of plastic and fitted in such a way that the internal parts of the meter are accessible only after breaking the meter cover seals. The plastic for the terminal block, meter cover, and base shall be flame-retardant and UV-stabilized. The terminal block may be integral with the meter base.

Components with critical content materials (mercury, cadmium, cobalt etc.) shall be avoided. A simple separation into different fractions for disposal (no metal parts molded in plastics) in a recycling process at the end of the meter lifetime shall be possible.

The meters shall have tin-plated brass terminals suitable for termination of CT secondary leads and potential leads. The manner of fixing conductors to the terminals shall ensure adequate and durable contact such that there is no risk of them coming loose or heating up unduly. Two nickel-plated brass screws shall be provided in each current terminal for effectively clamping the external leads with thimbles. Each clamping screw shall engage at least 3 threads in the terminals.

The screws shall not come in direct contact with the conductors. Instead, the conductors shall be clamped by a frame in order to optimize the contact and so to minimize the resistance.

Pressure strips of copper that is nickel or tin-plated shall be fitted in the terminal holes to reduce the chances of the leads coming loose or heating up in the terminal block. The clearance and creepage distances shall conform to the relevant clauses of the applicable standard.

The terminal cover shall be sealable independently of the meter cover. The terminal cover shall enclose the actual terminals, the conductor fixing screws, the external conductors and their insulation, whereby no part of the meter and cables shall be accessible from the front of the meter.

The fixing screws used on the terminal cover for fixing and sealing shall be retained in the terminal cover. The terminal block, terminal cover, and meter case shall ensure safety against the propagation of fire or thermal overload of live parts coming into contact with them.

The meters shall be capable of being sealed in accordance with regulations applicable in the Country.

12.1.4 Design features

12.1.4.1 Demand period

The meters shall be provided with the facility to select a relevant demand period from one of the values of 60, 30, 20 and 15 min.

12.1.4.2 Measurement system

The meters shall be equipped with three measuring elements so as to allow measuring of energy with 4-wire connection diagram and 3 measuring elements (3 CT and 3 VT) and respectively 3-wire connection diagram programmable by Employer.

12.1.4.3 Display

LCD programmable display with - as a minimum - 8 digits is required. Place of decimal point shall be programmable by Employer’s employees with the provided service software. The default factory programming shall be proposed from the Contractor and approved by Employer/Engineer before the delivery of the meters. The height of the digits shall be minimum 8.0 mm. The active tariff shall be designated on the display. The identification of the energy registers on the display shall be with OBIS-codes, in accordance with the relevant IEC standard. Indication for presence or absence of the three-phase voltages shall be available. The display shall have special symbols for designation of the operating quadrant.

It also shall have explanatory symbols for designation of the type and dimension of the measured value/for example kWh, kVArh, kW, kVAr, A, V, PF, Phase Angle, Hz, Total, Max, etc.

12.1.4.4 Scrolling display

Necessary pushbuttons shall be provided so as to allow the display of the contents of measured and stored values. The sequence of the display shall be clearly indicated on the nameplate of the meter.

The meters shall display the following parameters, and these shall also be displayed through a local port on the computer screen on demand:

- display test
- real time
- date
- cumulative active energy in kWh
- cumulative reactive energy in kVArh
- cumulative apparent energy in kVAh
- instantaneous kW
- instantaneous kVAr
- instantaneous kVA
- instantaneous power factor
- internal diagnostics
- tamper occurrence.
- Hz

The process of the above-LCD scrolling data display shall either be automatic in a cyclic manner, or by pushbutton, configurable by Employer's engineers with the provided software. The above, and any other essential parameter, shall be mutually agreed upon between the Employer/Engineer and the Contractor before factory configuration. The shown parameters on the display shall be programmable by Employer's employees with the provided software.

The meters shall have an ON time of at least 10 s for each measured value for auto display cycling. In the case of a manual reset button, the same shall be sealable.

The energy displayed on the meter shall be total energy. It shall be a summation of fundamental energy and harmonic energy.

12.1.4.5 Internal diagnostics

Indications to show the satisfactory performance of the meters shall be provided in the meter themselves. The meters shall have the capability to regularly perform a complete automatic self-check of its circuits, initial memory locations, integrity of data and parity etc., against any mal-functioning.

Any abnormal results shall be immediately indicated on the display and communicated to the Remote Meter Reading System (if available).

It shall be preferred that whenever the meter is optically interrogated by local or remote interrogation commands, this self-test is carried out. Any parity error shall set an error flag on the display, providing an indication of the nature of the error.

An indication of unsatisfactory function or non-function of the following shall be provided:

- time and calendar
- real-time clock
- all display segments
- non-volatile memory.

12.1.4.6 Test output device

The meters shall be equipped with a test output device that is accessible from the front in the form of a flashing LED in proportion to the meter constant to test accuracy of the meters on site.

12.1.4.7 Design life

The meters shall be designed for not less than 15 years of operation. The accuracy of at least 98% from the delivered meters shall be guaranteed for the lifecycle.

12.1.4.8 Non-volatile memory and battery backup

The meters shall have non-volatile memory for a data storage life of 15 years without battery support.

The meters shall also be provided with lithium battery and a super-capacitor as backup.

Spare supply of the meter shall assure the clock operation and RAM for a minimum of 2 years if the meter is stored without voltage supply at storage conditions and after that period another period of minimum 15 years operation life working under operating conditions.

The meters shall be equipped with super-capacitor which will allow the meter to support the calendar-clock in the minimum 10 days without voltage supply.

In the power-down case, all parameters, configuration data and metered data, as well as calculation data, shall be recorded in the EEPROM.

The meters shall have warning signal when battery is in a near-disabled condition.

12.1.4.9 Communication interfacing facility

The meters shall have a Data Optical Interface, as per IEC 62056-21. Serial interfaces RS 485 for connection of two external remote reading devices shall be available. Simultaneous communication between meter and both external communication devices shall be possible. The communication protocol DLMS in accordance with IEC 62056-21 is required.

A communication session shall also be available via local optical port with laptop (this laptop and optical prove to be provided by the contractor without additional cost to the employer) with the respective software provided by the Contractor. All the access levels shall be password protected as described in the Security Features section.

12.1.4.10 Data collecting from electronic energy meters

As a minimum, the following data shall be collectable from the meter with laptop or handheld terminal or via remote metering system (if available):

- active energy of each phase
- reactive energy of each phase
- load profile data (15, 30, 60 min power)
- current for each phase
- voltage for each phase
- voltage quality (minimum/maximum voltage)
- statuses and alarm signals:
- customer switch on/off status
- unauthorized opening of the meter or terminal block cover
- any other attempt at meter tampering
- voltage failure
- power supply failure
- any other available status.
- Power factor
- Phase angle
- Frequency

In addition, a permanent serial communication and data transfer of the meter to the IED of the SCMS system shall be established.

The meters shall store the monthly active energy (kWh) in registers for a minimum period of one year.

12.1.4.11 Security features

Meter access shall be password protected. The authorization shall require multi-level password protected access for:

- reading of read out file
- set up the clock and reading of read out file
- programming and parameterization of meter (display, read-out file content, connection diagram, measurement coefficient, etc.)
- change of passwords
- access level with the other passwords.

The authorization is required for both local and remote access. The passwords shall be changeable from the Employer's staff with the provided service software.

12.1.4.12 Minimum testing facility

The manufacturer shall possess a fully computerized meter test bench system for carrying out routine and acceptance tests as per IEC 62053-22 and IEC 62052-11, and an error test report with error curve for each and every meter that shall be produced.

Testing facilities shall be available at the manufacturer's works for carrying out tests such as:

- insulation resistance measurement
- no-load conditions
- starting current test
- accuracy requirement
- power consumption
- tamper conditions test.

12.1.4.13 Meters' maintenance software and manuals

The meters shall be delivered with the respective software for programming, testing, reading, etc. The software shall be compatible with Windows 10 or more recent versions. It shall allow reading, setting up and programming of the meter with the respective password level of authorization.

The software with the required open licenses shall be provided with all related Users' manuals, descriptions, etc. at no additional costs for the Employer.

The Contractor shall deliver all necessary data (protocols, drivers, passwords, etc.) for connection of meters to the remote meter reading software to his supplier/developer.

12.1.4.14 Connection diagram and terminal markings

Each meter shall be clearly marked with the connection diagram. The diagram shall also show the phase sequence.

12.1.5 Testing and inspection

Testing of the meters shall be performed in line with this specification and in accordance with the relevant IEC standards.

Acceptance of any unit by the Employer/Engineer shall not relieve the manufacturer of any of his performance guarantees or any other obligations.

Test certificates for each unit shall be submitted prior to delivery of the unit.

12.2 Communication Equipment

12.2.1 General

This Specification covers the design, manufacturing, testing, marking, sealing, installation, site testing, and commissioning of communication equipment which shall ensure communication between meters and remote metering system of Employer via Cellular Network.

The devices shall be built-in GSM/ UMTS communication devices and will be used for remote metering and reprogramming of the meters through Remote Meter Reading software.

12.2.2 Applicable standards

The relevant communication equipment shall comply, in all respects, with the latest versions of the following standards:

IEC 60950	Information technology equipment - Safety
IEC 61000-4-2	Electromagnetic compatibility (EMC) - Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test
IEC 61000-4-3	Electromagnetic Compatibility (EMC) - Part 4: Testing and Measurement Techniques - Section 3: Radiated, Ra dio-Frequency, Electro-magnetic Field Immunity Test
IEC 61000-4-4	Electromagnetic Compatibility (EMC) - Part 4: Testing and Measurement Techniques - Section 4: Electrical Fast Transient/Burst Immunity Test

IEC 61000-4-5	Electromagnetic Compatibility (EMC) - Part 4: Testing and Measurement Techniques - Section 5: Testing and Measurement techniques - Surge Immunity Test
IEC 61000-4-6	Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques - Section 6: Immunity to conducted disturbances, induced by radio-frequency fields
IEC 61000-6-2	Electromagnetic compatibility (EMC) - Part 6: Generic standards - Section 2: Immunity for industrial environments
IEC 61000-6-3	Electromagnetic compatibility (EMC) - Part 6: Generic standards - Section 3: Emission standard for residential, commercial and light-industrial environments
IEC 62056-21	Electricity metering – Data exchange for meter reading, tariff and load control – Part 21: Direct local data exchange.

12.2.3 Basic requirements

The communication device shall be meter built-in and shall ensure connection between meter and remote meter reading system via GSM / UMTS.

12.2.4 Design details

Communication between meter and communication device

The communication between meters and the communication device shall be via RS485. The communication protocol shall comply with the communication protocols of the meters (DLMS/ COSEM), shall allow transparent communication.

Communication between communication device and Remote Meter Reading System (RMR)

The communication device shall be able to open the communication session between RMR and meter for reading and writing of data. It shall ensure connection between energy meters in the substations and RMR system via GPRS communication.

Configuration/Service software

The device shall be configurable via software with GUI or web-based interface. It shall be compatible with Windows 10 or respectively web browsers Internet Explorer 7 and/or Google Chrome 25 or newer versions.

The device shall be accessible for programming remotely via respective connection or locally via cable provided by the Contractor.

Voltage supply

The supply of the communication equipment shall be ensured from meter. The communication device shall be in operation also in case that the meter is supplied by external supply.

Sealing

The device shall be sealed under the meter cover which shall protect the SIM card, the programming buttons (if available) any connections against influence.

12.2.5 Testing

The communication equipment shall be type tested in an independent testing laboratory for all applicable tests as per afore mentioned standards.

Copy of certified type test reports for metering boxes and terminals shall be submitted along with the tender documents.

12.3 Metering Panel

12.3.1 General

The electricity meters devices shall be installed in a separate metering panel located in the control room of the Substation Control Building. The panel's capacity shall be such so as to accommodate the number of necessary electricity meters, along with all related equipment and communication devices.

12.3.2 Applicable standards

The metering panel and the relevant equipment shall comply -in all respects- with the latest versions of the following standards:

IEC 60529	Degrees of protection provided by enclosures (IP Codes)
IEC 60999-1	Connecting devices - electrical copper conductors - safety requirements for screw-type and screwless-type clamping units - Part 1: General requirements and particular requirements for clamping units for conductors from 0,2 mm[2] up to 35 mm[2] (included)
IEC 60947-7-1	Low voltage switchgear and controlgear - Part 7: Ancillary equipment - Section 1: Terminal blocks for copper conductors

IEC 60947-7-2	Low voltage switchgear and controlgear - Part 7: Ancillary equipment - Section 2: Protective conductor terminal blocks for copper conductors
IEC 61439-1	Low voltage switchgear and controlgear assemblies - Part 1: General rules
IEC 61439-2	Low voltage switchgear and controlgear assemblies - Part 2: Power switchgear and controlgear assemblies

12.3.3 Basic requirements

The metering panel shall be installed in the control room of the Substation Control Building. The panel shall be made of galvanized steel. The construction shall ensure sealing of the door(s) of the panel. Window(s) shall allow reading of the meters without opening of the door. The protection class shall be IP42 or higher in air-conditioned rooms. The metering panel shall be resistant against external mechanical impact.

In the metering panel, meters, connection terminals and LV protection equipment will be installed. The connection terminals shall allow easy and safe testing and replacement of meters.

12.3.4 Design features

12.3.4.1 Enclosure

The body of the metering panel shall be made of galvanized steel with minimum thickness 2 mm. The door(s) shall be made from the same material with minimum thickness 1.5 mm. The panel shall be covered with coating to prevent corrosion.

The following requirements shall be met:

- The metering panel shall include door(s), hinges and locking devices.
- Protection degree according to IEC 60529 shall be IP42 as minimum after complete installation according to the prescription of the producer.
- The metering panel shall be dust- and vermin-proof.
- Window(s) for reading of the meters shall be foreseen.
- The design and construction of the metering panel shall guarantee the safety of personnel against electrical shocks. It shall allow unrestricted performance at the rated currents without exceeding permissible temperature within the enclosure.
- It shall be corrosion-protected by appropriate coating (durable, powder coating without metal compounds is recommended).
- The finishing color of the metering panel shall be light grey (RAL-7035).
- The metering panel shall be lockable and sealable. Access to the internally installed equipment shall not be possible without unlocking and damaging of the seal of the metering panel.

- A sign, warning of high voltage shall be applied on the cover. The sign shall be in English and local language and showing the appropriate symbol for high voltage.
- The body as well as the door(s) of the metering panel shall be fitted with earth straps.
- All metal elements used inside and outside the metering panel (like bolts, nuts, and other creepage elements) shall be corrosion resistant.
- The construction of the panel shall allow normal maintenance process of the equipment from the front side of the metering panel.
- Cable bushings from insulation material for the incoming and outgoing cables shall be foreseen.
- The unused bushings shall be with closed outlets.

12.3.4.2 Earthing inside metering panel

The body of the panel shall be firmly connected to the Substation earthing system. The door(s) shall be connected to the body with suitable earth straps. Grounding conductors shall be fixed to the grounding busbar of the panel through bolt connection. Connection of more than one conductor to one bolt connection and usage of screws for fixation of the conductor shall not be allowed.

12.3.4.3 Windows

In the front door(s) of the metering panel a window for visual inspection of the meters shall be foreseen. The window(s) shall allow visual inspection of the meters' registers as well as LV protection equipment and terminals shall be visible. One window per door shall be foreseen.

The meters windows shall be UV-resistant, unbreakable, transparent, minimum 2 mm thick, heat resistant, non-hygroscopic, insulating polycarbonate. As alternative, glass with minimum thickness of 3 mm is accepted. It shall be fixed to the front door(s) of the metering panel.

On each of the meters measured line shall be indicated. The indication facilities shall not damage the covers of the meter.

12.3.4.4 Connection terminal block and MCBs

In the metering panel, cable connection terminal blocks for each meter shall be installed. The terminal block shall allow connection of copper cables with cross section of 4 mm². Each single terminal shall be marked. The terminal block shall contain three sets of current terminals, three voltage terminals for the three phases and two grounding terminals installed between groups of current and voltage terminals.

Each set of current terminals shall have a factory produced bridge for shunting of the meter's respective current circuit.

Each first terminal of the current terminal sets shall have two points for connection of standard metering equipment - one at the input and one at the output.

Each voltage terminal shall have one point for connection of standard measurement equipment.

Grounding terminals shall be connected to each other and shall allow connection to the main grounding of the box through insulated wire.

A rail for connection between current terminals and grounding terminal shall be foreseen. The external part of the rail shall be insulated. It shall be installed in a manner not disturbing operation with the cables and prevailing accidental contact with the phase conductors.

The MCBs and the terminals shall be installed on a DIN rail. In the beginning and at the end of the terminals fixing plates shall be installed. The connection terminal block shall have transparent cover which shall be sealable. The cover shall prevent any unauthorized access to the bolts of the terminals and connections between cables and terminals.

On the voltage circuits of the metering group, before the connection terminal, three single-phase MCBs with a nominal current of 6 A shall be installed. The MCBs shall allow sealing.

12.3.4.5 Internal wiring

Internal wiring shall be according to the relevant codes and standards.

Internal wiring shall be performed with wires following the IEC color code. For each phase a different color shall be used.

The internal wiring for the measurement circuits shall be performed with multi-stranded copper wires with cross section 4 mm^2. The cables shall be with the respective cable end crimps.

Each single wire shall be marked with the respective label on both sides.

12.3.4.6 Doors and locking

There could be one or two doors. If two doors construction is proposed each of the doors shall cover half of the metering panel. The hinges shall be minimum 2 per door. The hinges shall be covered by the door i.e. when the door is closed they shall be invisible from outside. When opened, the door(s) shall be fixable on 120 degrees from the surface of the panel.

The locking mechanism shall ensure reliable locking of the door (both doors) in three (3) locking points (top, down and middle). The lock cylinder shall be protected against dust and water. Alternative could be usage of two lockers respectively with two lock cylinders installed on the top and bottom area of the metering board’s cover.

The Contractor shall be able to ensure keys compatibility. The lock cylinders' keys compatibility shall be agreed with Employer.

12.3.4.7 Installation construction

The metering panel shall be installed on a metal foundation. The foundation shall be constructed with the same material as the main part of the metering panel with minimum thickness of 2 mm. It shall be corrosion-protected like the other parts of the panel.

The minimum height of the foundation is 200 mm. The metering panel shall be connected to the foundation through bolt ties. The connection of the foundation to a concrete base or a metal frame shall be also ensured through bolts. The construction shall guarantee excellent mechanical stability of the metering panel.

12.3.4.8 Testing

The offered metering panels and terminal blocks shall be type tested in an independent testing laboratory, for all applicable tests, as per afore-mentioned IEC standards.

Routine tests for all relevant equipment shall be performed in accordance with the respective IEC standards.

13 Cable Systems

13.1 Cable Systems General

13.1.1 General

This section provides the minimum functional technical requirements for cable systems.

The Contractor shall carry out a Detailed Engineering to demonstrate and document full compliance with the concept and minimum performance requirements prescribed by this functional specification.

The Detailed Engineering to be undertaken by the Contractor after the Contract award, shall include all the studies and surveys deemed necessary for the design, permitting, manufacture, installation, testing, commissioning and safe operation of the cable system described in this functional specification.

The Contractor shall carry out all studies deemed necessary to prove that the cable systems will be able to deliver the minimum performance levels prescribed in this Functional Specification and operate safely and efficiently along the envisaged service lifetime.

All the required data to perform the studies and substantiate the performance, protection, operation and maintenance of the cable systems, shall be duly validated by the Contractor. The Contractor shall be solely responsible for the reliability of the data used in the studies.

The studies shall be performed using proven models duly validated against all relevant tests. The Contractor shall demonstrate via parameterization of standard models any results obtained via proprietary models.

All the associated costs for any studies and surveys deemed necessary shall be included in the Contract price.

13.1.2 Definitions

Cable Accessories - sectionalized joints, non-sectionalized joints, cable terminations, link boxes, earthing system, clamps and all other components/devices required for operation of a fully functional 132 kV Cable System.

Cable System - set of cables, accessories and other components required for a robust and fully functional transmission line. The Cable System shall be designed, manufactured, installed and tested to permit energization and operation under the most onerous conditions expected during the respective lifetime service period.

Detailed Engineering - Contractor shall be responsible for the design of the Cable Works and for the accuracy and adequacy of the data presented in the Technical Specifications and Technical Data Sheets.

Drum Length - single length of 132 kV cable supplied in a metallic or wooden drum with suitable size and robustness for transport to site and subsequent cable pulling.

Factory Acceptance Test (FAT) - tests undertaken by the manufacturer of the Cable System on the completed cable to verify that each length meets the specified requirements. These tests should be carried out in the presence of the Employer.

Failure - Incapacity of the 132 kV Cable System to perform the required function. A Failure will lead to a fault in the 132 kV Cable System.

Ground Level - average horizontal level of the undisturbed surface of the soil prior to the trench excavation. The backfilling of the trench shall be carried out up to the Ground Level.

Nominal Operating Voltage - operational voltage to achieve the required minimum transmission capacity at the receiving substation for full load permanent operation.

Rated Electric Current (Io) - electric current for which the Cable System is designed and capable to transmit in permanent operation without any physical/mechanical or electrical degradation of the 132 kV Cable System.

Routine Test - tests made on each component of the 132 kV Cable System covered by this technical requirement, in order to confirm that the component meets the specified requirements.

Sample Test - tests made on samples of the 132 kV Cable System at a specified frequency to verify that the finished product meets the specified requirements.

Steady State Electric Current Carrying Capacity - continuous constant current (100 % load factor) carrying capacity of the 132 kV Cable System for the de facto installation conditions and operation regime.

Type Test - tests made before supplying the Cable System covered by this technical requirement, in order to demonstrate satisfactory performance characteristics to meet the intended application.

13.1.3 Applicable Standards and Recommendations

In the absence of any indication of the contrary in this Functional Specification, the design, materials, manufacture, testing and installation shall be in accordance with the latest revisions of the following standards:

Cigré TB 347:2008	Earth Potential Rises in specially bonded Screen Systems
Cigré TB 446:2011	Advanced design of metal laminated coverings: recommendation for tests, guide to use, operational feed back
Cigré TB 560:2013	Guideline to Maintaining the Integrity of XLPE Cable Accessories
DIN 4124	Excavations and trenches - Slopes, planking and strutting breadths of working spaces
DIN 8075	Polyethylene (PE) pipes- PE 80, PE 100- General quality requirements, testing
DIN VDE 0292	System for cable designation
IEC 60840	Power cables with extruded insulation and their accessories for rated voltages above 30 kV (Um = 36 kV) up to 150 kV (Um = 170 kV) – Test methods and requirements
IEC 60228	Conductors of insulated cables
IEC 60229	Electric cables - Tests on extruded oversheaths with a special protective function
IEC 60071	Insulation co-ordination
IEC 60230	Impulse tests on cables and their accessories
IEC 60287	Electric cables – Calculation of the current rating
IEC 60853	Calculation of the cyclic and emergency current rating of cables
IEC 62271-209	High-voltage switchgear and controlgear - Part 209:"Cable connections for gas-insulated metal-enclosed switchgear for rated voltages above 52 kV - Fluid-filled and extruded insulation cables - Fluid filled and dry-type cable-terminations"
IEC 60885-3	Electrical test methods for electric cables - Part 3: Test methods for partial discharge measurements on lengths of extruded power cables”
IEC 60949	Calculation of thermally permissible short-circuit currents, taking into account non-adiabatic heating effects”
IEC 60794-1-1	Optical fiber cables. Generic specification. General”

IEC 60794-1-2	Optical fiber cables. Generic specification. Basic optical cable test procedures
IEC 60793-1-1	Optical fibers. Measurement methods and test procedures. General and guidance
IEC 60811	Electric and optical fiber cables - Test methods for non-metallic materials
IEC 61753-1	Fiber optic interconnecting devices and passive components performance standard
IEC 61462	Composite hollow insulators - Pressurized and unpressurized insulators for use in electrical equipment with rated voltage greater than 1000 V - Definitions, test methods, acceptance criteria and design recommendations
IEC TS 60815-3	Selection and dimensioning of high-voltage insulators intended for use in polluted conditions - Part 3: Polymer insulators for a.c. systems”
IEC 60529	Degrees of protection provided by enclosures (IP code)
ISO 2178	Non-magnetic coatings on magnetic substrates -- Measurement of coating thickness -- Magnetic method”

The applicable standards shall be prioritized in the following order:

1. Applicable Grid Codes and local standards issued by competent Authorities
2. International Electrotechnical Commission (IEC) and the German Institute for Standardization (DIN)
3. Cigrés’ recommendations.

In case of conflict among standards, the one(s) providing the requirements which lead to most severe and onerous conditions shall prevail.

13.1.4 Cable Route

The Contractor shall optimize the Cable System connection, based on the following fundamental tenets:

- avoid as much as possible any negative environmental impacts
- foster safety and economic efficiency
- prioritize as much as possible long straight sections avoiding as much as possible cable bends and maximize the cable length between consecutive joints
- secure the shortest possible path
- avoid as much as possible any possible spatial planning constraints.

The definitive Cable System corridor and respective accessibilities shall be settled by the Contractor following the completion of Detailed Engineering. The selected Cable System corridor shall avoid any constraints to the construction and operation of the substation.

The as-installed coordinates of the final Cable System route shall be adequately documented and officially submitted to the Employer. The Employer may request further evidence that the Cable Works were undertaken in accordance with the specified.

13.2 132 kV Cable System

13.2.1 General

The 132 kV Cable System - including all accessories (joints, terminations, earthing system, etc.) - shall be made with materials of the same type as those used for the type tested cable system. The respective type test report - issued by an accredited laboratory - shall confirm the adequacy (according to all relevant standards) of the proposed 132 kV Cable System.

The quality and performance of the materials and components used in the 132 kV Cable System shall not be inferior to the quality and performance of the materials and components used in the type tested cable system.

This section addresses the fundamental requirements for the 132 kV Cable System design, manufacturing, installation and testing. The requirements hereby presented shall be considered as fundamental minimum requirements for the Detailed Engineering to be undertaken by the Contractor.

13.2.2 Electric Requirements

13.2.2.1 General

The performance requirements hereby prescribed, intend to provide guidance on the conceptual generic characteristics required for the Cable Works. During the Detailed Engineering the Contractor shall confirm data required for the design of the 132 kV Cable System. The 132 kV Cable System shall be designed to withstand the most onerous transient phenomena generated by the electric equipment in the substation.

The Contractor shall ensure that the 132 kV Cable System is adequately designed to cope with the short circuit and earth fault currents. Moreover, the Cable System shall withstand any potential electric constraints propagating from the network.

The Contractor shall design, execute and complete a 132 kV Cable System capable of delivering the minimum performance requirements described in the relevant Data Sheets included in the Employer's Requirements.

13.2.2.2 Short circuit currents

The Contractor shall confirm the maximum magnitude of the short circuit and earth fault current levels during the Detailed Engineering having in consideration the topology of the substation. The values indicated in the Data Sheets included in the Employer's Requirements are merely indicative and refer to minimum requirements.

Moreover, the Contractor shall design a suitable earthing system fully compliant with the applicable laws and regulations.

The 132 kV Cable System shall be designed, manufactured and installed to carry without any degradation the fault current - which maximum magnitude is to be confirmed during the Detailed Engineering - for the duration defined by the back-up clearance of the relevant circuit breaker.

In the event of a short circuit and earth fault currents, the temperature at any point of the 132 kV Cable System shall not exceed the maximum values prescribed and duly demonstrated by the manufacturer of the 132 kV Cable System. The short circuit capacity of the 132 kV Cable System shall be calculated assuming that the 132 kV Cable System prior to the fault is operating at full load and at the maximum allowable conductor temperature.

13.2.2.3 Electric Stress

The manufacturer of the 132 kV Cable System shall confirm the maximum allowable electric stress levels in the insulation layer calculated for the most onerous operational and transient situations. Irrespectively of the loading scenarios - full load permanent operation, daily cycles, emergency or transient conditions - the maximum permitted electric stress values confirmed and duly demonstrated by the 132 kV Cable System manufacturer shall not be exceeded.

Moreover, the insulation layer shall be dimensioned and manufactured to withstand additional stress associated either with the network operation.

The Contractor shall provide all relevant documentation necessary to fully demonstrate the Cable System ability to withstand the electric stresses under permanent full load operation or transient operation, the additional stresses associated with the network operation.

13.2.3 Thermal Requirements

The dissipation of the heat generated in the 132 kV Cable System is driven by physical and environmental constraints along the cable route, particularly the size of the troughs, spacing between the cables, temperature and thermal features of the surroundings.

At the Detailed Engineering stage, the Contractor shall develop an engineering solution capable of delivering a cable sizing suitable for the full load permanent power to be transmitted, maximum allowed temperature, maximum losses and fully compliant with the eventual thermal restrictions and depth of burial limitations prescribed by the local competent Authorities (if applicable).

The 132 kV Cable System sizing shall be based on the most onerous environmental conditions which may impact the thermal dissipation features of the cables along the complete cable route. For this purpose, the Contractor shall undertake prior to the Cable System design, the required investigations to confirm the most onerous conditions for the heat dissipation to be considered for the cable sizing.

The 132 kV Cable System manufacturing process shall not commence prior to the completion of a detailed cable sizing engineering considering the real and most onerous installation conditions (e.g., thermal resistivity and temperature) and all potential thermal constraints throughout the complete 132 kV Cable System route.

13.2.4 Mechanical Requirements

The 132 kV Cable System shall be designed and manufactured to withstand all tension, bending under tension, sidewall pressure, crush, and abrasion experienced during the subsequent installation operations.

The cable pulling shall be undertaken without infringing the cable minimum bending radius (MBR).

Moreover, the safe handling limits specified for cable parameters like the maximum pulling tension, maximum sidewall pressure and maximum crush force shall not be infringed during the cable transport, pulling and burial operations.

13.2.5 Metallic screen/sheath bonding schemes

In order to eliminate (or reduce substantially) the circulating currents in the metallic screens/sheaths, the Contractor shall design and implement a suitable bonding and earthing scheme.

For relatively short underground cable connections - for which a cross-bonding arrangement is neither economically nor technically justifiable - a Single-Point bonding scheme shall be implemented Figure 13-1.

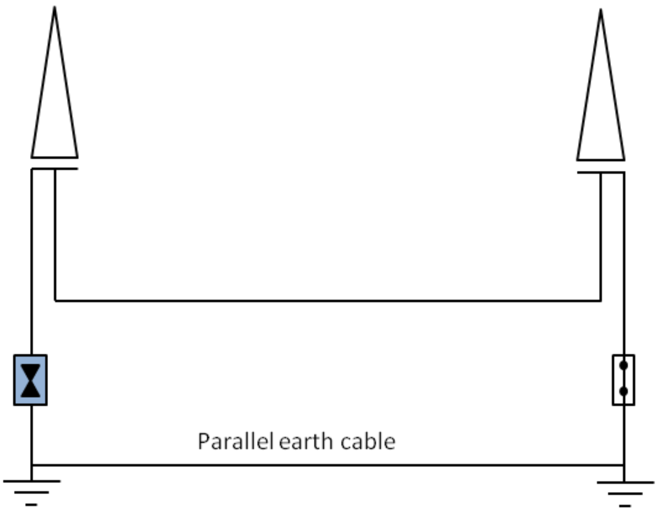

Figure 13-1 Single Point earthing scheme

Under a transient event, high voltages can be induced on the metallic screen/sheath. Since such voltage may overcome the cable outer sheath dielectric strength, the unearthed end of the cables shall be adequately protected with sheath voltage limiters (SVL).

A cross-linked polyethylene (XLPE) insulated earth cable with suitable dielectric strength and with a copper conductor cross-section capable of evacuating the zero-sequence current, shall be laid in parallel of each single point section. These cables shall be transposed at the midpoint of the single-point section and connected to the earthing systems at respective ends.

For longer connections the metallic screens/sheaths shall be arranged in a sectionalized cross bonding scheme.

The cable route is divided into multiples of major sections compromising three minor sections - ideally with equal lengths and symmetrical cable formation. At the joints connecting the minor sections, the metallic sheath/screens shall be discontinued, and cross connected with the metallic sheath/screens of the next minor section. At the ends of the major sections the cable metallic sheath/screen shall be solidly bonded and earthed.

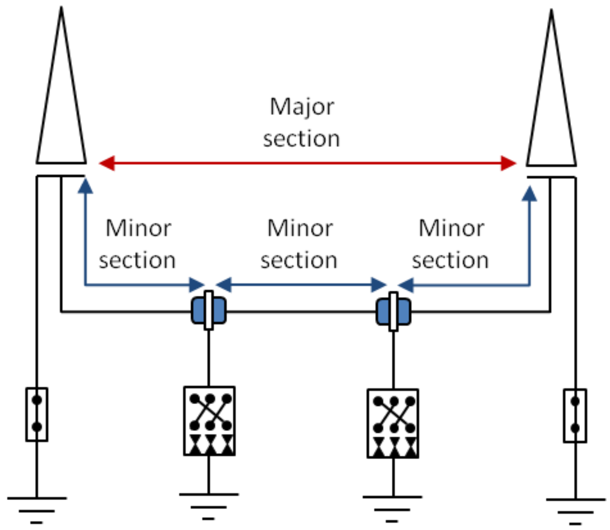

Figure 13-2 Cross bonding major section

If the cable formation is not symmetrical, e.g., horizontal or vertical flat formation, the cables shall be transposed at every joint and following a phase rotation opposite to the metallic sheath/screen rotation sequence.

In case of imbalance between minor sections and/or unsymmetrical cable formations, the Contractor shall provide evidence that despite the additional losses due to residual circulating currents, the total losses shall not exceed the maximum total losses specified for the 132 kV Cable System.

To enhance reliability and facilitate maintenance works, the Contractor shall maximize the length of the minor sections. The maximum power frequency standing voltage shall not exceed the limits enforced by the owner of the grid on which the cable link will be connected. Moreover, the maximum voltages induced in the metallic screens/sheaths due to power frequency faults or transient phenomena shall not jeopardize the integrity of the cable outer sheath.

A combination of single-point and cross-bonding schemes shall be investigated whenever the position of the joint bays undermines the effectiveness of a cross-bonding arrangement. The single-point sections shall be located at the ends of the underground cable link (Figure 13-3) and the respective maximum length shall be limited by the maximum allowed standing induced voltages enforced by the competent local Authorities or international guidelines - which shall prevail in case of lack of suitable rules and regulations from the local Authorities.

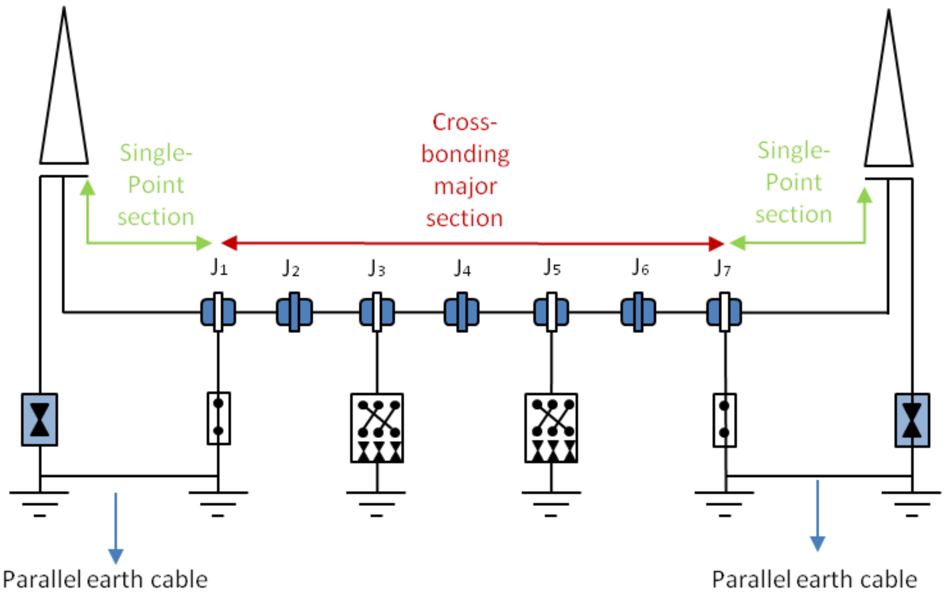

Figure 13-3 Cross bonding major section and two single point sections

13.2.6 132 kV Cable System Lifetime

The 132 kV Cable System - including cables and all accessories - shall be designed, manufactured and installed to cope with the electrical, thermal and mechanical stresses during a minimum life-time of 40 years.

13.2.7 132 kV Cable Design

13.2.7.1 Conductor

The conductor construction shall comply with IEC 60228. The conductor shall be longitudinally water blocked - filling the inter-strand spacing with suitable water blocking yarns.

13.2.7.2 Insulation including semi-conducting screens

The conductor screen shall comprise an extruded layer of thermosetting semi-conducting compound and shall be continuous and cover the whole surface area of the conductor.

A non-hygroscope semi-conducting tape shall be applied to the conductor under the extruded layer.

The conductor screen must not stick to the conductor. The inner shielding layer and the tapes (if available) must not suffer any change of functionality of the cable at the highest permissible short circuit stress.

The outer surface of conductor screen shall be cylindrical and solidly bonded to the insulation.

The insulation shall be made of Cross-Linked Polyethylene (XLPE) with suitable grade and cleanliness for a rated voltage up to 220 kV.

The insulation thickness shall be sufficient to ensure the dielectric integrity amid the electric stresses expected during normal operation, transient conditions and fault conditions.

The contact surface between the insulation and insulation screen shall be smooth and free from irregularities.

A triple extrusion process shall be used to produce in simultaneous the conductor screen, insulation and insulation screen. The three layers shall be fully bonded and concentric. The surface of the conductor shall be clean and free from any foreign particles, which may contaminate the insulation or cause a high punctual electrical field stress in the conductor screen.

The cross-linking process shall be achieved using a dry-curing process under high pressure to eliminate the formation of voids in the insulation.

The insulation raw materials shall be handled in very clean conditions to avoid contamination. Clean rooms and closed feeding systems shall be used.

A bedding of semi conductive water blocking tapes shall be applied between the insulation screen and the metallic sheath/screen.

13.2.7.3 Metallic screen/sheath

The cable shall have a metallic water impervious sheath to ensure radial water tightness. For this purpose, a longitudinally welded aluminum sheath shall be used. Alternatively, an aluminum laminate with PE copolymer longitudinally applied and folded with overlap could also be used.

The Contractor shall provide evidence - particularly through type tests - that the proposed water blocking mechanism will prevent any radial water ingress and will cope with corrosion in case of a damage in the cable outer sheath.

The aluminum sheath/foil barrier protecting the insulation screen against water ingress can also act as metallic screen for the cable if the respective cross-section is sufficient for the return of the capacitive charging current and to evacuate the required single-phase short-circuit current. If the aluminum sheath cross section is not enough to carry the required capacitive and short circuit currents, a complementary copper wire screen helically applied over the bedding/longitudinal moisture barrier that protects the insulation screen, shall be required.

The copper wires shall be helically applied and overlaid with a copper equalizing tape (minimum cross-section of 1 mm2). Moreover, the copper wires shall be free of breakages and localized wire buckling or kinks (wire kinks of less than 150° will not be acceptable). The distribution of the wires around the perimeter shall ensure coverage of at least equal 20 % and a gap of less than 4 mm between the wires.

The short-circuit capacity shall be calculated in accordance with the adiabatic method prescribed in IEC for a final temperature of 250°C and for an initial temperature of the metallic screen gauged for a conductor temperature of 90°C.

13.2.7.4 Outer sheath

The 132 kV cable shall have an outer sheath capable of withstanding friction and providing suitable protection against scratches that might occur during the cable handling and installation. Moreover, the outer sheath materials shall have adequate resistance against biological decomposition and UV radiation.

Typically, the outer sheath is made of high-density polyethylene (HDPE) with suitable mechanical and dimensional characteristics to cope with the installation conditions along the onshore cable route. The shore D hardness shall be between 55 and 61.

To enable a post-installation DC voltage sheath test, the outer sheath shall have an outer layer made of semi conductive material.

The color of the semi conductive layer extruded over the outer sheath shall be black. Subsequently, and in order to differentiate the two layers, the inner layer of the outer sheath should have a different color.

The cable outer sheath shall be sequentially marked in meters. Moreover, and as a minimum, the following details shall be marked in the cable outer sheath:

- name of the project/Client
- electric cable 132 kV
- cable type/manufacturer.

13.2.8 Cable Accessories

13.2.8.1 General

The Cable Accessories shall be designed, manufactured and installed to withstand without degradation the electrical, mechanical and thermal constraints for which the 132 kV cables were designed, manufactured and installed. Moreover, Cable Accessories shall cope with the required overloading features and stresses associated with static or transient phenomena.

The materials used must be of the same type as those used for the type tested cable system.

The Cable Accessories shall be assembled by experienced jointers holding a valid certificate issued by the manufacturer of the Cable System. The scope of the certificate shall cover the type and voltage of the cable accessory to be executed by the holder of the certificate.

All Cable Accessories included in the supplied Cable System shall be routine tested in accordance with the relevant IEC Standards and including material and dimensional verifications throughout the manufacturing process.

13.2.8.2 Outdoor Terminations

The cable terminations shall preferably be fitted with glass-fiber reinforced epoxy insulators with silicone sheds. The silicone sheds as well as all fittings shall not be affected by atmospheric or climatic conditions. It shall be ozone resistant and hydrophobic to facilitate cleaning.

The minimum Unified Specific Creepage Distance (USCD) shall be defined for the worst environmental/pollution conditions expected in the area where the 132 kV Cable System is terminated.

A suitable field grading mechanism shall maintain the electric field distribution in all cable/termination interfaces under acceptable levels.

The field grading mechanism shall be adequately designed and build-up to withstand the most severe electric stresses and temperatures for normal operation as well as for transient and fault conditions.

Moreover, the field grading shall be designed and assembled to avoid any dimensional changes, movement, or fatigue under cyclic load conditions over the required lifetime of the 132 kV Cable System.

For the design of outdoor terminations, the Contractor shall thoroughly investigate the environmental conditions and the pollution severity of the site where the cable terminations will be installed.

The design of the insulator shall be in accordance with the latest revisions of the IEC standards 61462 and TS 60815-3.

The terminations shall be filled with an insulating compound. Special attention shall be required to avoid any leakages through the bottom sealing due to heat cycle movements of the cable outer sheath.

To minimize the longitudinal movement of the outer sheath the cable shall be firmly clamped (typically every 1 m) along a sufficiently long straight section close to the entry into the termination.

The base plate of the termination shall be supported on four post insulators fixed on the steel structure in order to facilitate the periodical HV testing of the outer sheath. The base plate shall be earthed via a dedicated and adequately designed bonding lead cable.

The bonding lead cable shall be single-core type with enough cross-section to cope with the electric, mechanical and thermal constraints during the 132 kV Cable System lifetime.

Moreover, the complementary components/devices used for the earthing of the metallic screens/sheaths shall be adequately designed and assembled in order to avoid any potential overheating and degradation in the event of cable failure.

Mechanical connectors with bolt heads that shear-off with suitable torque shall be used. The connectors shall be capable of carrying the maximum electric current of the cable under 100% full load operation and short-circuits.

The Contractor shall investigate the need for corona rings. If required, the corona rings made of uncovered aluminum shall be provided.

The cable terminations shall be assembled by fitters holding a suitable and valid certification issued by the Cable System manufacturer. The assembly process shall be carried out in a controlled clean environment.

13.2.8.3 Gas Insulated Switchgear (GIS) Terminations

The GIS terminations shall be designed and manufactured in accordance with the latest revision of IEC 62271-209.

The field grading mechanism shall be adequately designed and build-up to withstand the most severe electric stresses and temperatures for normal operation as well as for transient and fault conditions.

Moreover, the field grading shall be designed and assembled to avoid any dimensional changes, movement, or fatigue under cyclic load conditions over the required lifetime of the 132 kV Cable System.

The connection of GIS terminations to gas-insulated metal enclosed switchgear shall be in accordance with IEC 60859.

The termination assembly shall have an insulation flange between the cable metallic screen and the gas-insulated metal enclosed switchgear. In case there is no transformer between the termination and the gas-insulated metal enclosed switchgear, the insulation flange shall be equipped with local surge voltage limiters (SVL) to ensure suitable protection against fast switching surges.

A minimum of three SVL spaced 120° shall connect the cable metallic sheath to the grounded metal enclosure of the GIS switchgear. The length of the connection shall not exceed 500 mm.

The size and characteristics of SVL to be provided are project specific. The Contractor shall develop a suitable concept based on the expected transient features of the equipment.

The SVL shall be designed and installed in a way to facilitate removal for cable sheath tests.

All open metallic surfaces which may incur dangerous overvoltages, shall be physically protected to avoid any risks to personnel.

The GIS terminations shall be assembled by fitters holding a suitable and valid certification issued by the Cable System manufacturer. The assembly process shall be carried out in a controlled clean environment.

13.2.8.4 Cable Joints

The cable joints shall be of prefabricated type and shall be designed and manufactured for direct buried installation with thermally stable backfill.

The Detailed Engineering to be undertaken by the Contractor shall confirm the metallic sheath/screen bonding scheme required to minimize the circulation currents. The earthing of the metallic sheath/screens of the 132 kV cables shall be made via a single-core or concentric type bonding lead cable with enough cross-section to carry the single-phase short circuit current without any electric or mechanical degradation.

The impedance of the connection between the metallic sheath and earth shall be reduced to the minimum practicable. Consequently, the length of the lead bond cables shall be as short as possible (maximum length to the earth connection: 10 m).

All complementary components/devices used for the earthing of the metallic screens/sheaths shall be adequately designed and assembled in order to avoid any potential overheating and degradation in the event of cable failure.

The insulating barrier of sectionalizing joints shall withstand without any degradation the power frequency voltages and transient impulses specified in the Data Sheets included in the Employer's Requirements.

The outer casing shall cope with the soil conditions and shall be able to protect the joint from water ingress and corrosion.

The outer enclosure shall protect the joints against third-party hazards while ensuring strict compliance with the environmental restrictions enforced by the competent Authorities.

13.2.8.5 Link Boxes

13.2.8.5.1 General

The link box is equipped with removable links which shall allow a physical/electrical separation between the cable metallic screens/sheaths and the installed local earth plane. The additional impedance introduced by the connecting leads and removable links shall be kept to the minimum practicable.

The link boxes shall be designed, manufactured to withstand the electric, mechanical and thermal constraints expected during the 132 kV Cable System lifetime. The link boxes shall withstand without physical degradation the most onerous single-phase short-circuit currents in the cable link.

The link boxes shall be made of stainless steel of adequate grade to cope with the corrosion and additional relevant environmental features for the lifetime of the 132 kV Cable System.

13.2.8.5.2 Link Boxes - Gantry Mounted

The link boxes shall be watertight (minimum IP 66) and shall be suitable for vertical mounting on the outdoor termination structure support.

A dedicated link box shall be provided for each cable termination.

The link boxes shall have a label fitted externally depicting the following information (but not limited to)

- electric hazard sign
- Client’s logo.

13.2.8.5.3 Link Boxes - Buried

The link boxes to be used for cross bonding and grounding shall be watertight (minimum IP 68) and shall be suitable for underground mounting. The materials shall be adequate for highly corrosive environments.

The link boxes shall be equipped with a grounding circuit adequately designed and assembled to ensure a reliable connection to the joint bay earthing grid. The grounding points shall be marked and easily accessible.

Additionally, the link boxes shall be equipped with easily accessible grounding balls for a safe grounding during maintenance works.

Each link box shall allow metallic sheath separation in order to allow sheath testing of the cables.

The link boxes shall have a label fitted externally depicting the following information (but not limited to)

- electric hazard sign
- Client's logo.

13.2.8.5.4 Sheath Voltage Limiters (SVL)

The sheath voltage limiters (SVL) shall be adequately designed, manufactured and assembled to protect the outer sheath of the cable against over voltages due to switching and lightning transients.

The SVL shall have a suitable Transient Overvoltage Capability (TOC) to withstand the induced voltages from the most onerous power frequency currents in the system.

The SVL shall be designed and assembled to withstand the induced voltages from the most onerous power frequency currents (short-circuit or steady-state currents) plus a margin of at least 20%. Moreover, the SVL shall withstand without degradation the maximum DC voltages used for the cable outer sheath test.

At the other end of the scale, the SLV is limited to the residual voltage due to a traveling wave from the most onerous transients in the 132 kV Cable System.

13.2.8.6 Surge Arresters

In the event of lightning strikes, and in order to protect the 132 kV cables from the subsequent overvoltages, the installation of surge arresters in parallel with the outdoor terminations should be considered.

The Contractor shall duly justify -based on the foreseen overvoltage wavefront and the end-to-end length of the 132 kV Cable System - the option for one set of surge arrester at each end of the underground span or one set of surge arrester at one end only.

For underground lines with a length exceeding 50 m, it is -in principle- recommended to use surge arresters at both ends of cable route.

13.2.8.7 Lead bond cables and parallel earth cables

The minimum copper cross section for the single core, concentric lead bond cables and parallel earth cables shall be sufficient for evacuating the required single phase short-circuit currents without any degradation of the mechanical and electrical features of the cables. The copper conductor shall be in accordance with IEC 60228 class 2 (compacted).

The XLPE insulation of the lead bond cables shall be designed and build-up to withstand without physical degradation the most onerous electrical stresses and temperature constraints during the required lifetime of the 132 kV Cable System.

The dielectric strength of the XLPE insulation of the concentric lead bonding cables shall ensure the integrity of the lead bond cables when subjected to the voltage tests specified in the Data Sheets.

13.2.9 Inspection and Tests

13.2.9.1 Type Tests

The type tests are intended to demonstrate the adequacy of the proposed 132 kV Cable System for the intended application and lifetime service.

For type tests purposes, the intended application refers to the worst foreseeable ambient thermal conditions and most onerous stress levels for the 132 kV Cable System. The type tests shall comply with IEC 60840.

The Cable System design, materials and manufacturing process shall be qualified against the intended application and required lifetime service.

All components included in the supplied 132 kV Cable System shall be type tested, namely (but not limited to):

- all cable designs to be installed along the cable route
- all types of cable joints
- all types of terminations
- earthing connections and accessories.

The manufacturing process of the components included in the 132 kV Cable System shall not commence before the successful completion of the required type tests.

Previous type tests, qualifying a particular 132 kV Cable System design, will be accepted if the applicable conditions prescribed in section 14.2 of IEC 60840 are fulfilled as well as the following conditions:

- The materials incorporated in the type tested cable system are identical to those to be incorporated in the proposed and supplied 132 kV Cable System.
- The design of the type tested cable system is identical to the proposed and supplied 132 kV Cable System.

- The electric, mechanical and thermal stresses on the type tested cable system are identical or exceed the electric, mechanical and thermal stresses foreseen for the proposed and supplied 132 kV Cable System.
- The design values for the proposed 132 kV Cable System don't exceed the design values of the type tested cable system.
- No major differences with regards to the installation, operation, repair or handling between the type tested cable system and the proposed 132 kV Cable System.
- The manufacturing site is the same and no significant modifications were introduced in the manufacturing process.

The electric type test assembly shall include all the relevant accessories included in the 132 kV Cable System. The test setup, conditions and test sequences shall be in accordance with IEC 60840. Moreover, for some tests the following conditions/methodologies shall be considered:

- Electric tests:
  - The partial discharge tests shall be performed in accordance with IEC 60885-3 and the background noise shall not exceed 2.5 pC.

13.2.9.2 Routine Tests

Routine tests shall be undertaken to verify that every Drum Length, joint, termination and all other components of the 132 kV Cable System, meet the specified requirements.

The cables shall be subjected to the routine and sample tests at the manufacturer's workshop or in authorized laboratories according to standards IEC 60060, IEC 60229, IEC 60230, IEC 60332-1, IEC 60811, IEC 60840, and IEC 60885.

The results/findings of the routine tests shall be incorporated in test reports.

As a minimum the following routine tests shall be carried out:

- dimensional verification
- Measurement of conductor DC resistance. The measured value shall not exceed the nominal value at 20°C.
- Measurement of capacitance. The measured value shall be consistent with the nominal value with a maximum variation of ±8%.
- Partial discharges. Acceptance criteria: no partial discharges.
- AC voltage withstand test.
- outer sheath test.

13.2.9.3 Post-installation Tests

As a minimum the following tests shall be carried out by the Contractor:

a) For every cable single length, an outer sheath DC test shall be performed after pulling and before the assembly of any accessories. The test shall be performed in accordance with Clause 5 of IEC 60229. A DC voltage of 10 kV shall be applied between the cable metallic screen and the ground for 1 minute.
b) Confirmation of the phase sequence
c) Measurement of the line impedance
d) Measurement of the capacitance.

In due time, the Contractor shall submit a report for each of the above-mentioned tests.

13.2.10 132 kV Cable System Installation

13.2.10.1 General

This section addresses the fundamental requirements for the 132 kV Cable System installation. The requirements hereby presented shall be considered as fundamental requirements for the Detailed Engineering to be undertaken by the Contractor.

The construction of the cable route infrastructure and subsequent cable installation shall be planned in advance in order to ensure that all the works are completed in an efficient way and with the least disruption to other construction works in the substation. Moreover, the working site shall be adequately secured and duly signed to avoid potential accidents.

13.2.10.2 Cable Route Preparation

13.2.10.2.1 Preparation Works

The Contractor shall construct all the access roads required to ensure a safe access to site for all construction machinery and transport of the Drum Lengths to the final unwinding position.

The Contractor shall ensure adequate stability of the areas on which the drum unwinding and cable pulling operations will take place.

If required for lowering the groundwater level to a level below the planned trench bottom, the Contractor shall implement the necessary provisions for water drainage along the construction corridor for the 132 kV Cable System route.

13.2.10.3 Construction Works - excavation and cable routing

13.2.10.3.1 General

The excavation of the trenches shall be planned in a way to minimize disruptions and accessibility limitations. The construction works shall be performed in accordance with the relevant Safety and Environmental legislations and relevant guidelines issued by competent Authorities.

The Contractor shall submit for the Employer's approval the work planning, detailing the intended sequence for the opening of the cable trench. Simultaneously the Contractor shall submit for the Employer approval a plan of the warning devices and safety procedures for the construction of the cable route.

In case the Contractor damages any of the existing underground utility, namely power, control and telecom cables, the Contractor shall endeavor to promptly repair the inflicted damages. Moreover, the Contractor shall be responsible for losses unleash by eventual outages resulting from the damages inflicted by the Contractor.

The cable turns throughout the cable route shall ensure a suitable bending radius (in accordance with the manufacturer requirements) for the cable during the pulling process.

The excavation works shall be carried out in strict compliance with the relevant Safety and Environmental legislations and approved HSE plan. The Contractor shall be responsible for the safety of all the personnel working or visiting the construction site.

13.2.10.3.2 Cable Routing Construction

The trench shall be adequate to tackle the mechanical constraints inherent to the cable route, namely heavy traffic, crossing existing underground infrastructures, water streams, soil erosion and landslides.

For the cable sections within the substation premises, the Contractor shall install the 132 kV Cable System in robust pre-cast concrete cable troughs. The troughs shall be adequately designed/dimensioned to avoid any mechanical constraints during the cable system installation. Moreover, the inner minimum dimensions shall in accordance with the conditions set forth in the Detailed Engineering to ensure the required electric current rating performance of the 132 kV Cable System.

Prior to the installation of the pre-cast concrete troughs, the Contractor shall backfill the bottom of the trench with a suitable bedding layer over which the troughs will be positioned. The bedding layer shall be flat and shall have enough strength to ensure a correct positioning of the troughs.

The concrete slab on top of the cable trough shall provide a robust protection of the 132 kV Cable System against the most onerous mechanical loads and environmental constraints expected during the construction works and service lifetime of the substation.

Figure 13-4shows a typical trough for two three phase circuits in flat vertical configuration.

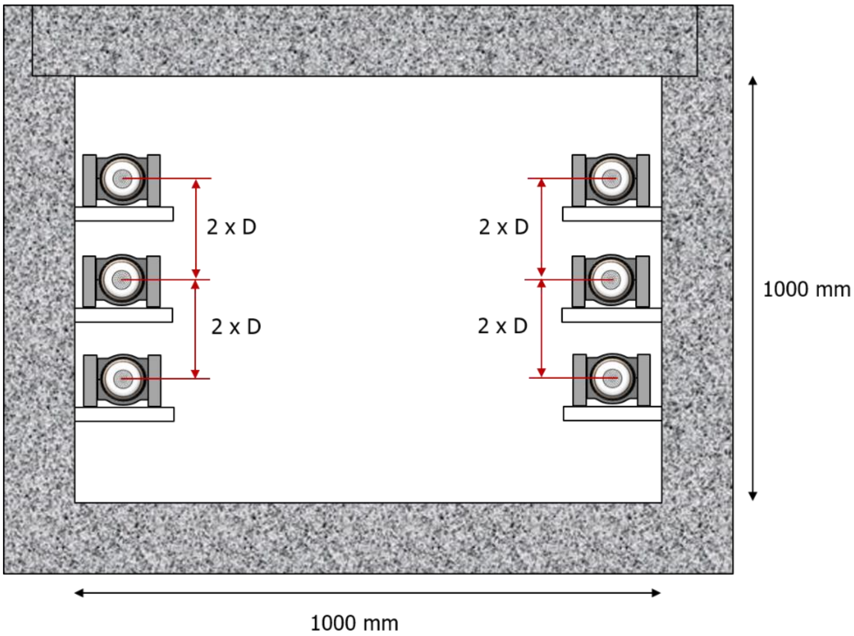

Figure 13-4 Typical cable trough for two three-phase circuits (D: outer diameter of the cable).

The Contractor's Detailed Engineering shall establish the definitive the phase/circuit separation taking into account the following fundamental aspects:

- optimization of the 132 kV Cable System sizing considering the required electric current carrying capacity, losses and the thermal constraints of the surroundings
- ensure a smooth and safe installation and repair of the 132 kV Cable System.

The Contractor is responsible for the disposal of all waste materials, and the disposal shall be performed according to the applicable local Environmental legislation.

All the works shall be performed in strict compliance with the applicable safety and environmental regulations.

13.2.10.4 Cable System Pulling Operation

The Contractor shall develop a specific concept for the pulling of the 132 kV Cable System having in consideration the specifics of the installation site and the applicable regulations prescribed by the competent consenting Authorities.

The pulling heads and ropes shall be adequately designed and installed for the expected maximum pulling forces plus a robust safety margin and to ensure a secure connection.

The winches shall have enough capacity for the maximum expected pulling forces plus a robust safety margin. Prior to the pulling works all measuring equipment and sensors shall be calibrated and the pulling force capacity verified.

The winches shall be equipped with suitable indicators for Cable System tension and length paid out. Moreover, the Cable System tension and respective time tag shall be continuously recorded and made available for the Employer representative inspection.

The Contractor shall maintain on site a suitable quantity of spare parts to minimize waiting time in case of failures.

During the pulling the Contractor shall continuously monitor the cable tension. The maximum allowable mechanical efforts prescribed by the 132 kV Cable System manufacturer shall not be exceeded.

The Contractor shall ensure that the minimum bending radius and the maximum allowable side-wall pressure specified and duly demonstrated by the manufacturer of the Cable System are not infringed during the pulling operations.

The potential utilization of powered and synchronized cable pulling machines shall be thoroughly engineered to avoid damaging the integrity of the 132 kV Cable System.

Fully functional and in good condition rollers blocks- adequately dimensioned for the physical features of the 132 kV cables - shall be firmly secured over the bottom of the troughs. The roller blocks shall be positioned with suitable intervals to avoid damages in the outer sheath of the cables during the pulling operation.

Any horizontal or vertical turns shall be performed by passing the cables through sound and fully functional corner rollers. The corner rollers shall be firmly secured to the troughs.

All types of rollers shall be made of steel or aluminum and shall ensure that the cable will roll through without sliding.

The potential utilization of powered and synchronized cable pulling machines shall be thoroughly engineered to avoid damaging the integrity of the Cable System.

13.2.10.5 Joint Bays

The position of the joint bays/pits shall be defined taking into account the following limitations:

- the maximum pulling tension and sidewall pressure allowed by the cable manufacturer
- the maximum deliverable Drum Length
- terrain features limiting the positioning of the Drum Length stand
- accessibility for cable pulling works and future repairs

- spatial and environmental constraints along the 132 kV Cable System route.

The cable joint assembly shall be carried out under controlled environment in a container specifically tailored for this function. The environment shall be free of dust and moisture.

The area for parking the container shall be adequately prepared to ensure a stable joint bay subfloor and a safe handling of the 132 kV Cable System.

For those joint bays positioned in specific locations for which the Detailed Engineering confirmed the need of earthing the metallic sheaths/screens of the cables, the Contractor shall implement a suitable earthing grid. The earthing grid shall be designed and implemented to limit the earth grounding resistance to the maximum value specified by the Detailed Engineering.

The earth grid shall be prepared prior to the construction of the joint bay subfloor.

The earthing link box shall be adequately connected to the joint bay earthing grid.

The joints/cable shall be firmly tight to a galvanized steel structure anchored to the joint bay subfloor. At least two cable clamps on each side of the joint shall be adequately positioned to mitigate any electric and mechanical constraints to the cable joints.

13.2.11 Cable System Tests on Completion

The Contractor shall carry out an outer sheath DC test in accordance with Clause 5 of IEC 60229. A DC voltage of 5 kV shall be applied between the cable metallic sheath/screen and the ground for 1 minute.

A breakdown of the outer sheath shall not be accepted, nor significant leakage currents shall occur during the test.

Within the limits of practicability, an AC resonant voltage test shall be performed as per Clause 16.3 of IEC 60840. If agreed between the Employer and the Contractor, a voltage test of U0 for 24 hours could be an alternative to the resonant test.

Acceptance criteria: no cable system (either on the cable or any relevant accessory) fail shall be observed.

In parallel with the AC resonant voltage test, a partial discharge (PD) test shall be performed to confirm the PD level for all joints and cable terminations. Acceptance criteria: no PD shall be observed over the background noise level.

All the required safety measures shall be strictly implemented and monitored.

For the PD test the cross-bonding links (if applicable) shall be put in a straight configuration, i.e., the metallic screens on each side of the joint shall be connected.

After the PD test the cross-bonding links shall be put once again in the correct position and the electric resistance of the contacts shall be measured.

13.2.12 Deliverables

The Contractor shall provide all relevant documentation required to demonstrate the proper engineering of the 132 kV Cable System design, manufacture, installation, repair and testing. All engineering documents shall be submitted to the Employer for review and comments.

All documents shall be adequately prepared and organized to allow an easy and effective utilization. The Contractor shall organize and maintain an effective filing system.

The lists of documents described in sub-sections 13.2.12.9 is not exhaustive and therefore does not release Contractor from carrying out any other engineering investigations required for a satisfactory, safe and efficient execution of the Cable Works.

13.2.12.1 Cable System Performance and Characteristics

The Contractor shall carry out studies confirming the required 132 kV Cable System performance features as well as all relevant electric parameters. Comprehensive reports detailing the calculations and all relevant investigations shall be submitted to the Employer prior to the Tests On Completion. If the studies provided by the Contractor fail in providing sound evidence that the 132 kV Cable System complies with the required performance features, the Employer is entitled to instruct the Contractor to carry out all necessary remedial measures and correct all Defects. As a minimum the Contractor shall prepare and submit to the Employer comprehensive reports addressing the following aspects:

- Cable System permanent full load electric current carrying capacity considering the multiple installation scenarios. Moreover, the electric current carrying capacity calculations shall consider the most onerous ambient conditions for the Cable System heat dissipation performance along the complete cable route. For this purpose, the Contractor shall carry out all the necessary investigations required to confirm the most onerous ambient conditions limiting the heat dissipation performance of the Cable System and subsequently the respective electric current rating capability.
- The study shall confirm that the Steady State Electric Current Carrying Capacity of the 132 kV Cable System when operated at the required operating voltage equals or exceeds the required Rated Electric Current.
- cable impedances
- cable inductance (from conductor to metallic sheath/screen) and cable capacitance (from conductor screen to insulation screen)

- electric stress along the insulation layer (from the conductor screen to the insulation screen) for different operational scenarios (continuous voltage and transients) and along the cable route (considering the multiple burial/thermal conditions along the cable route)
- earthing design, justifying the maximum distance between joints with grounded metallic sheath/screen
- studies and type test reports confirming the adequacy of the proposed Cable System to cope with the stationary and transient conditions as well as the environmental conditions along the cable route.

13.2.12.2 Cable System Manufacturing

The Contractor shall submit the traceability of the relevant raw materials required to manufacture the 132 kV Cable System.

13.2.12.3 Cable System Mechanical Performance

The Contractor shall provide all mechanical features of the 132 kV Cable System relevant for the correct handling, installation, and repair. As a minimum the Contractor shall confirm the maximum allowable values for the cable mechanical tension, minimum bending radius, sidewall pressure, crush and torsion for storing and pulling.

13.2.12.4 Cable System Route

The Contractor shall confirm the adequacy of the planned route of the 132 kV Cable System route. As a minimum the Contractor shall prepare and submit for the Employer's review and comments the following information:

- detailed plan of the Cable System route, confirming compliance with the bending radius required for the cable pulling
- drawing of the steel support for the outdoor terminations and link boxes
- drawing of the arrangement required for securing the cables in the approach to the GIS
- a cable pulling analysis based on the topography of the onshore section of the cable system route and the drum lengths.

13.2.12.5 Cable System Installation

The Contractor shall demonstrate the adequacy of the installation procedures for the installation of the 132 kV Cable System. As a minimum the Contractor shall prepare and submit for the Employer review and comments the following information:

- description of the equipment required for the cable pulling and list of personnel to be mobilized
- planning and detailed procedures for the 132 kV Cable System installation
- contingency plan detailing:

- availability of spare parts for subsequent cable repair
- mobilization in due time of a team of experienced certified jointers
- drawings of the cable trenches, joint bays, assembly procedures for cable joints and terminations.
- earthing schemes and overvoltage coordination.

13.2.12.6 Interfaces

The Contractor shall develop the required interface concepts, including all detailed studies and drawings for all the interfaces throughout the 132 kV Cable System route and for the interfaces with other equipment in the substation - particularly an interface matrix detailing the responsibility/scope in the preparation/connection of the GIS terminations.

13.2.12.7 Accessories

The Contractor shall provide all relevant documentation from the Detailed Engineering, including drawings and calculations for all types of joints, terminations and other accessories included in the 132 kV Cable System.

13.2.12.8 Spare Parts

The Contractor shall provide the required spare parts for any eventual 132 kV Cable System repair during the Cable Works and Defect Notification Period. For the spare parts described in the Data Sheets, as well as for any other component/equipment deemed to be included as spare part, the Contractor shall provide the following documentation:

- required ambient conditions and preservation methodology for all the spare parts
- list of spare parts which include components/materials with limited lifetime validity and provisions for the respective replacement in due time.

13.2.12.9 Drawings

As a minimum the Contractor shall provide the following drawings:

- earthing bonding scheme for the end-to-end 132 kV cable system
- cable joints
- joint bays
- earthing scheme for the joint bays
- drawing of the pre-cast concrete trough
- cable route plan
- cable terminations
- cable clamps
- link boxes
- earthing scheme for the cable terminations.

13.3 Medium and Low Voltage Cable Systems

This subs section covers the technical requirements of medium and low voltage cables including cable sealing ends, cable terminations and joints, cable containment and all associated equipment, complete in every respect and suitable for satisfactory operation.

Cables shall be suitable for satisfactory continuous operation at the design rating at the maximum site ambient temperature. The Contractor is responsible for providing all voltage drop and cable ampacity calculations supporting the final installed cable ratings considering derating factors such as: method of installation, ambient temperature, circuit length, grouping, etc.

13.3.1 Standards

In addition to the international standards and codes defined in the VII-3 General Technical Requirements, in VII-4 Particular Technical Requirements and in the Sections below, cables shall comply with the latest editions of the following standards as a general requirement:

IEC 60502-1	Power cables with extruded insulation and their accessories for rated volt ages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) - Part 1: Cables for rated voltages of 1 kV (Um = 1,2 kV) and 3 kV (Um = 3,6 kV)
IEC 60502-2	Power Cables with extruded insulation and their accessories for rated volt ages from 1 kV (Um=1.2 kV) up to 30kV (Um = 36kV) – Part 2: Cables for rated voltages from 6kV (Um=7.2 kV) up to 30 kV (Um = 36kV)
IEC 60502-4	Power cables with extruded insulation and their accessories for rated volt ages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) - Part 4: Test requirements on accessories for cables with rated voltages from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV)
HD 620 S2	Distribution cables with extruded insulation for rated voltages from 3,6/6 (7,2) kV up to and including 20,8/36 (42) kV
IEC 61442	Test methods for accessories for power cables with rated voltages from 6 kV (Um = 7,2 kV) up to 30 kV (Um = 36 kV)
IEC 60986	Short-circuit temperature limits of electric cables with rated voltages from 6kV (Um=7.2 kV) up to 30 kV (Um = 36kV)
IEC 60287	Electric cables - Calculation of the current rating - All relevant Parts

IEC 60332-1-2	Tests on electric and optical fiber 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
IEC 61034	Measurement of smoke density of cables burning under defined conditions - All Parts
IEC 60754-1	Test on gases evolved during combustion of materials from cables - Part 1: Determination of the halogen acid gas content
IEC 60304	Standard colors for insulation for low-frequency cables and wires
IEC 60228	Conductors of insulated cables
IEC 60229:	Tests on cable over sheaths which have a special protective function and are applied by extrusion
IEC 60811	Common test methods for insulating and sheathing materials of electric cables
IEC 61537	Cable management - Cable tray systems and cable ladder systems
EN 50575	Power, control and communication cables - Cables for general applications in construction works subject to reaction to fire requirements

13.3.2 Cable Construction Requirements

All cables provided under this Contract shall be of type and finish approved by the Employer/Engineer. All external cables shall be provided with a vermin resistant covering. In addition, all cables for external installation shall be UV resistant.

All cables shall be suitable for laying indoors, or outdoor in direct or indirect sunlight, in ducts, on cable trays and ladders, underground and in water. Cable sheaths shall be resistant to the effects of oil, bacterial action, insects, rodents and water.

All outdoor cables shall be the armored water-proof type. Single-core cables shall have an aluminum wire armor (AWA), and multi-core cables shall have a steel wire armor (SWA) unless specified differently in the data sheet.

Cable shields and armoring will normally be earthed at both ends. Single point earthing shall be provided on specific situations to eliminate to a great extent the circulating currents. In these situations, the Contractor shall develop and implement a reliable and safe concept to protect the personnel and the cable system against harmful overvoltages.

The teleprotection and 48 V DC control cables shall be designed, in co-ordination with the terminal relays, to be immune to pick up levels associated with earth faults in the station and normal operation of station equipment.

The Contractor shall provide separate cables for the following functions and for the protection systems (multi-function cables shall not be used):

- AC current transformer secondary circuits for metering and protection
- AC voltage transformer secondary circuits for metering and protection
- DC for protection, control, and indication circuits
- transducer output-metering information circuits
- 400/230 V AC for main service cables
- 400/230 V AC for building services
- supervisory control circuits.

The required technical data for the cables are specified in the Technical Data Sheets.

13.3.3 Packing and sealing Requirements

Cables shall be dispatched on drums of robust construction with hub diameter exceeding the minimum permissible bending radius recommended by the cable manufacturer. The drum shall be fully enclosed by either adjacent fitting wooden battens or continuous metallic cladding.

Both ends of the cable shall be sealed fully watertight. When requested by the user, pulling eyes shall be fitted to both ends of the cable. The pulling eye shall be directly connected to the conductor and be capable of withstanding a tensile load of 100 N/mm² of conductor area up to a maximum of the permissible pulling tension for the cable.

13.3.4 Installation Requirements

All cables shall be installed point to point as a complete single length unless the length requirement for the circuit exceeds the standard drum lengths provided by the cable manufacturer. Approved cable joints shall be used for such lengths in excess of standard drum lengths. Any such joints shall be recorded on the As-Built drawings.

Cable support and containment shall be provided in accordance with IEC 61537 for all cables to be installed under this Project.

Outdoor cables shall be installed in concrete cable channels, as defined under Civil Works Requirements. For crossing of roads, duct banks with draw pits shall be provided. Cable channels shall be provided with cable ladders for the different functions.

Outdoor cable trays/ladders exposed to sunlight shall be provided with perforated galvanized sheet steel covers. The covers shall be mounted on spacers to allow ventilation.

The Contractor shall be responsible for adequate dimensioning of the external cable trench system and cable containment to maintain the specified segregation between the different cable systems to be provided.

The following minimum segregation distances are to be maintained:

- 300 mm between low voltage power cables and control, measurement and signaling cables for voltages above 60 V
- 600 mm between medium voltage cables and control, measurement and signaling cables for voltages above 60 V.

During the installation of cables, the cable drums shall be supported on cable drum screw jacks and spindles. Cables shall be continuously pulled from the upper side of the drum in the opposite direction of travel of the direction of rolling painted in the drum's flanges. For those sections in which the cables are not pulled into PE or PVC ducts, suitable rollers shall be adequately positioned to prevent abrasion. Rollers shall be spaced between the cable drum, and within the cable trench at intervals as required to prevent cable sheath contact either with the ground or contact with sharp edges. 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 shall be covered such that no damage to the cable occurs. Should any sheath damage occur during the cable installation all cable installation activity shall immediately cease, and the Employer shall be informed. The Employer shall assess the severity of the damage and shall instruct the Contractor whether sheath repairs will be acceptable, or cable replacement shall occur. Any cable replacement deemed necessary will be at the Contractor's expense.

The Contractor shall be responsible for the dimensioning of the cable containment systems internal to each building. Internal cable containment systems shall consist of cable trays and/or ladders, and rigid conduit.

Cable containment systems shall be installed internally to each building under raised floors, above suspended ceilings, in cable cellars/vaults, concealed within the building fabric, and for surface mounted installations.

Cable containment within buildings shall maintain segregation between different systems as specified. All surface mounted installations, the three-phase cable system(s) shall be affected in galvanized rigid steel conduit

During the design process, the Contractor shall provide a cable schedule listing all cables to be provided under this Project. The cable schedule shall contain all pertinent information for each cable.

All cables shall be uniquely numbered and shall be fitted on either side of transitions through building walls or fire barriers and at each end with a metallic corrosion resistant tag embossed with a unique cable ID number. The proposed identification system shall be submitted to the Employer for approval. The individual cores must be identified by numbers or by a color code.

13.3.5 Medium Voltage Cables

13.3.5.1 Technical requirements

The Medium Voltage (MV) shall have a cross-linked polyethylene (XPLE) insulation and shall be single-core or three-core cables with copper or aluminium conductors as specified in the data sheet and simultaneously triple extruded insulation. MV cables and cable accessories shall comply with IEC 60502 2.

Operational requirements

The cable system - including cables and all accessories - shall be designed, manufactured and installed to ensure a minimum lifespan of 40 years.

Minimum requirements

Cable cores shall comprise circular stranded conductor with an extruded solid insulation. The bonding between the semiconductive layers and insulation shall be permanently strong, homogeneous and free of contaminants. The inner semiconductive layer, insulation and outer semiconductive layer shall be extruded simultaneously in a single step via a triple extrusion head. Immediately after the respective extrusion the materials shall be cross-linked.

Each core shall be provided with a copper wire screen with a copper equalizing tape. Alternatively, an aluminum layer as metallic screen is acceptable for armored cables.

Single core cables shall be provided with aluminum wire armor, three core cables shall be provided with galvanized steel wire armor.

The outer sheath shall be continuously extruded, shall contain anti-termite additive and shall consist of a flame retardant, halogen free and low smoke thermoplastic compound with the following minimum characteristics:

- flame retardant characteristics in accordance to IEC 60332-1
- low smoke density in accordance to IEC 61034-2.

The over sheath shall be provided with the following permanently legible information:

- voltage
- manufacturer
- year of manufacture
- metric marking
- cable designation.

The letters and figures shall consist of upright block characters along two or more lines, approximately equally spaced around the circumference of the cable. The maximum size of the characters shall be 13 mm and the minimum size not less than 15% of the nominal or specified external diameter of the cable or 3 mm, whichever is the greater.

The spacing between the end of one set of characters and the beginning of the next on the legend shall not exceed 150 mm. Any additional information on the sheath (e.g. the Manufacturer's name) shall not affect the spacing between repetitions of the legend.

MV cable sizing

MV cables shall be sized for the maximum load current of the connected equipment and the respective thermal performance shall be calculated assuming permanent full load operation under the most onerous environmental conditions. In case of cables for e.g. transformers with emergency loading capability, the cable shall be sized for the emergency loading capacity. In any case, the sizing of the cable shall not restrict the capability of the equipment connected.

The cable cross section shall be based on the current carrying capacity at site ambient and laying conditions in accordance with IEC 60287 and shall be not less than specified in the Data Sheet. If site ambient and laying conditions change within the route of a cable, the current carrying capacity shall be determined for each part of the route and the sizing shall be based on the most onerous laying conditions.

The short circuit capabilities of the cables shall be adequate for the prospective fault levels and fault clearing times, as defined in the Particular Technical Requirements and Data Sheets.

The three-phase short-circuit capacity shall be calculated for a final temperature of 250°C and for an initial temperature gauged for a conductor temperature of 90°C.

The single-phase short-circuit capacity shall be calculated for a final temperature of the over sheath in accordance IEC 60986.

The initial temperature in the metallic screen shall be ascertained for a conductor temperature of 90°C.

MV cable accessories

MV cable accessories shall, as a minimum, meet all the requirements of the latest edition of IEC standard 60502-4 / IEC 61442.

Outdoor termination insulators (cable sealing ends) shall be provided for external terminations. The cable sealing ends shall be fully factory tested during production. The pollution severity shall be as defined in the Particular Technical Requirements and Data Sheets. The base of the cable sealing end itself shall be insulated from supporting steelwork by mounting upon epoxy resin pedestal type insulators.

Internally within switch rooms and enclosed termination boxes of transformers, proprietary heat shrink terminations may be accepted, subject to the approval of the Employer / Engineer.

However, where MV cables terminate to equipment with plug connection, e.g. transformers with plug connector, gas insulated switchgear (GIS), proprietary separable connectors shall be used subject to the approval of the Employer / Engineer.

Grounding/Bonding

Unless specified or agreed otherwise, the cable screen and armor shall be grounded at both cable ends.

Where single point grounding of MV cables is required to meet the current rating requirement, the cables shall be bonded at the switchgear end of each circuit.

13.3.5.2 Test requirements

All routine tests on manufactured length, as stipulated in IEC 60502-2 shall be performed.

Sample tests and type tests shall be as per IEC 60502-2.

Post-installation tests as stipulated in IEC 60502-2 shall be performed.

13.3.6 Low Voltage Power and Control Cables

13.3.6.1 General Technical requirements

LV power and control cables and cable accessories shall be flame retardant and low smoke zero halogen (LSZH) and shall comply with the following standards:

IEC 60502-1	Power cables with extruded insulation and their accessories for rated volt ages from 1 kV (Um = 1,2 kV) up to 30 kV (Um = 36 kV) - Part 1: Cables for rated voltages of 1 kV (Um = 1,2 kV) and 3 kV (Um = 3,6 kV)

IEC 60331	Tests for electric cables under fire conditions (All relevant parts)
IEC 60332	Tests on electric and optical fiber cables under fire conditions
IEC 60364-4-41	Low voltage electrical installations - Part 4-41: Protection for safety - Protection against electric shock
IEC 60364-4-42	Low voltage electrical installations - Part 4-42: Protection for safety - Protection against thermal effects
IEC 60364-4-43	Low voltage electrical installations - Part 4-43: Protection for safety - Protection against overcurrent

Low voltage 0.6/1 kV power and control cables shall be single core, two, three, four, five-core or multicore cables with copper conductors. Conductors larger than 4.0 mm^2 shall be stranded.

Power cables shall be provided with color coded core insulation. The colors of the core insulation shall comply with IEC 60304. Control cables shall be provided with numbered cores.

All power and control cables shall be provided with proactive (PE) conductor. LV single core cables installed in either conduit or trunking systems within buildings shall be provided with separate earth conductors for each circuit within conduit and trunking containment systems.

LV Power and Control cables shall be provided with steel wire armor for rodent protection. Cables for DC supplies and services shall be of identical construction to that of the LV power cables. DC cables for connections between batteries, rectifiers and the DC switchgear shall be single-core power cables.

The required technical data for the LV cables is specified in the Technical Data Sheets.

13.3.6.2 Cable Sizing

The cross section of LV power and control cables shall be determined based on the following criteria:

- load current
- current carrying capacity at site ambient and laying conditions in accordance with IEC 60287
- type, characteristic and rating of protection device
- protection against electric shock in accordance with IEC 60364-4-41
- protection against thermal effects in accordance with IEC 60364-4-42
- protection against overcurrent in accordance with IEC 60364-4-43
- the voltage drop from the main LV distribution board to the point of furthest utilization for each circuit shall be maximum of 2.5% (apart from Metering and protection cables which are defined in other sections).

Cable sizing calculations and sizing tables shall be prepared by the Contractor and shall be provided to the Employer/Engineer for review on request.

The minimum cross-section for LV power cable shall be 2.5 mm^2.

13.3.6.3 Metering and protection cables

AC current and potential cables shall be multi-conductor shielded overall. The shield shall be earthed at only one end/point. All multi-core cables shall be provided with -as a minimum- two (2) spare cores.

These cables shall run direct between the outdoor equipment and the Control Building.

Metering and protection cables shall have a Power-frequency withstand voltage of 3 kV in accordance with IEC 61869.

Current transformer cables shall be of minimum cross-sectional area 4 mm^2.

Voltage transformer cables shall be of minimum cross-sectional area 2.5 mm^2.

The Contractor shall be responsible for sizing of cables to suit the burdens of the connected equipment and to ensure safe tripping of protection.

If any connections between cables from instrument transformers to the electricity meters are foreseen (such as marshalling cabinets) they shall be duly sealed.

13.3.6.4 LV control cables

All LV control cables shall be stranded conductor and shall be insulated to 0.6/1 kV.

All DC cabling between outdoor equipment and the Control Building shall be by multi-conductor cable shielded overall, routed via marshalling kiosks as required. Interconnections between outdoor equipment (interlocks, etc.) shall be made at the marshalling kiosks.

For each multicore cable 15% spare cores shall be provided.

All cabling and wiring terminated into control cubicle, relay cabinets, marshaling cabinets, etc. shall be neatly configured within the cabinet and must be accessible from the front of panels/cubicles.

13.3.6.5 ELV control, communication and signaling cables

Extra low voltage (ELV) control, communication and signaling cables shall be rated for 300/500 V and shall have an overall aluminum/polyester screen and shall contain a separate drain wire. Conductors shall be of minimum cross-sectional area of 0.75 mm^2.

Twisted pair cable with overall cable shield shall be used for communication cables. To minimize exposure to interference, the communication cables shall be isolated from power cables wherever practicable.

Twisted pair cable shall conform to EN 50288-7. Twisted pair cables shall be used for interconnection between protection signaling equipment and protection equipment and shall be suitable for carrying signals without any weakening effect over distances of about 300 m.

For each cable 15% spare conductors shall be provided.

Only armored cable shall be used in the switchyard.

Cables used for telephony shall be twisted pair and shall not be more than 0.6 mm diameter solid copper conductor, suitable for Insulation Displacement Connections (IDC).

Cables entering the Substation from outside shall be of paired construction and the entry conduits shall be non-metallic, and non-corrosive.

13.3.6.6 Heat resistant cables

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 180°C and shall comply with IEC 60331.

13.3.6.7 Fire resistant cables

Fire resistant cables shall be used wherever circuit integrity must be maintained, and cables must continue to work for a specified period of time under fire conditions for personal safety, e.g. especially for the following applications:

- fire-detection, fire-alarm, and fire-fighting-systems
- emergency and safety lighting
- systems for emergency evacuation.

Fire resistant cables shall be LSZH and fire resistant for 3 hours to IEC 60331 & IEC 60332 and shall be installed with appropriate support systems.

13.3.6.8 Cable terminations and accessories

All cables shall be terminated with the appropriate cable sealing end, termination kit, or cable gland. Catalogue information shall be submitted to the Employer for review during the design process of all cable accessories proposed. The catalogue information submitted shall be clearly highlighted to identify the precise product proposed by the Contractor.

Cable accessories shall include cable sealing ends, cable termination kits, cable glands, etc.

All cable terminations are to be prepared and neatly formed. All cable terminations are to be connected to the equipment terminals, terminal blocks, such that no strain is put on either cable termination or the equipment to which the cable is connected. Where terminations are affected in control cubicles, marshalling cabinets, etc. all cables shall be neatly loomed with sufficient slack for movement to other terminals as may be necessary.

Through joints for LV power and control cables shall be applied only in exceptional cases, subject to the approval of the Engineer. Any through joints required shall be of the heat shrink type and shall not degrade the design standards of the cable in any way.

13.3.6.9 Test requirements

Sample tests and type tests shall be as per IEC 60502-1.

All routine tests on manufactured length shall be performed as per IEC 60502-1.

13.4 Cable Containment

13.4.1 Technical requirements

Separate cable containment systems are required for the different cable systems, as identified in this specification.

The Contractor shall design and size the complete cable containment system for the Substation. Cable containment shall include cable tray, cable ladder, trunking and conduit. Cable trays and ladder shall be either medium or heavy duty listed. Cable trays and ladders shall be 'Galvanized after' and shall comply with IEC 61537.

The Contractor shall ensure that where the cable containment tray or ladders comprise of several levels that sufficient distance is provided between the layers for future access to the cables installed on each level.

The Contractor shall also ensure that sufficient clearances are maintained between different systems to comply with the segregation limits specified.

All cable containment shall be adequately supported by metallic supports of appropriate dimensions and strength. Such supports may be formed from proprietary C channel, or threaded bar entered into expanding bolts in concrete where suspension is required. The design of the cable containment system shall ensure that adequate support or suspension is provided such the manufacturer's recommended deflection is not exceeded.

All cable containment shall be hot-dip galvanized steel and shall be complete with all fittings.

Cable trays, ladders and trunking shall be provided with all necessary proprietary fittings. Field fabricated joints, T-connections, 4-way splices etc. shall not be accepted.

All cut ends on cable tray, ladders and trunking shall be treated with a minimum of 2 coats of zinc-rich paint to prevent corrosion.

- Cable trays, ladders and trunking shall be provided with earth continuity connections across each joint and shall be connected at both ends of the containment system to the nearest earth bar.
- Where building service cables are installed concealed with the building fabric high impact halogen free plastic conduit may be used. The conduit shall be provided with all necessary fittings to provide a complete containment system.

Galvanized steel conduit shall be used for all external installations.

No cables shall be drawn into any conduit system until the system is complete.

The required technical data for the cable trays is specified in the Technical Data Sheets.

13.4.2 Test requirements

- visual inspection
- galvanization test.

14 Earthing and Lightning Protection

14.1 General

This specification covers the design, manufacture, acceptance testing, supply, delivery, unloading, erection, and commissioning of the earthing and lightning protection system for the Substations, complete in every respect and suitable for satisfactory operation.

This specification shall also apply to temporary site installations.

The latest versions of the following standards shall be considered for the design, calculation and installation of the earthing and lightning protection systems:

IEC 60364	Low-voltage electrical installations (all relevant parts)
IEC 60479	Effects of current on human beings and livestock (all parts)
IEC 61936-1	Power installations exceeding 1 kV AC - Part 1: Common rules
EN 50522-2	Earthing of power installations exceeding 1 kV AC
IEC 62305	Protection against lightning (all parts)
IEEE Standard 80	Guide for safety in AC Substation grounding

The earthing system calculations shall be based upon actual soil conditions at site and the calculated short-time currents. The switchgear rating shall not be used for this calculation.

14.2 Earthing System

14.2.1 Introduction

The requirements hereinafter set with regard to the design, construction and materials relevant to the earthing system shall be read in conjunction with the paragraph(s) associated with the requirements relevant to the equipment in mention.

14.2.2 Earthing system design

The earthing system and installations shall be designed and constructed in accordance with the standards referenced within this specification and shall be in accordance with "The Guide for Safety in Alternating Current Substation Grounding" as published by the Institute of Electrical and Electronic Engineers Incorporated, Publication No. IEEE 80.

The Contractor shall present calculations to show the earthing system meets these requirements and can be shown to be safe in terms of touch, step and transferred potentials.

The design of the earthing requirements for the various voltage level switchyards/switchgears shall be considered independently. Each sub-system shall be adequately bonded together during normal system operation.

Electrical measurements of the subsoil at various depths shall be made at the site in order to determine the layered effects of the ground from which the effective ground resistivity and hence the expected resistance of the proposed earth grid system may be predicted.

The earthing grid shall be effectively protected against corrosion. Cathodic protection, if considered, may adversely affect other equipment and shall be subject to approval by the Employer/Engineer.

In actual design, the earthing system shall take the form of a combination of grids of buried conductors and earth rods driven vertically into the ground. Within the grid, conductors shall be laid in parallel lines at reasonably uniform spacing. They shall be located along rows of structures or equipment to facilitate the making of earth connections, where practical.

The main earth grid and each subsidiary earth grid shall have a cross sectional area, as required by fault currents, of not less than 0.5s duration, but in any case, not less than specified in the technical data sheet.

Connections to the grid of all non-current carrying metallic parts, which might become energized by chance, such as metal structures, building earth, equipment, earth rods, water pipes, etc. shall not be less than specified in the technical data sheets and shall be of adequate size, current-carrying capacity and mechanical ruggedness.

The spacing between conductors forming the mesh system shall be such as to limit the grid potential rise to a value that limits the touch voltage to a value not greater than the maximum tolerable touch potential, assuming a fault clearance time equal to that of the main protection equipment being provided.

Each group of earth electrodes shall be connected to the main earth grid through connections having a cross sectional area of not less than specified in the technical data sheets, which shall be protected from corrosion.

The grid shall be subdivided into a number of sections, interconnected with test links. The test links shall be accessible from above-ground.

Areas of grid where high concentrations of fault currents can appear, as at neutral earthing connections, shall have reinforced conductor sizes, where necessary, as to handle adequately the highest fault current and its duration.

In case the equipment is widely spaced in the Substation, individual local grids may be established at the various equipment locations and the local grids shall be interconnected and connected to the earthing grid. Interconnecting conductors shall not be less than the size of the conductor for main grid.

Metallic parts of all equipment, other than those forming part of an electrical circuit, shall be connected directly to the main earth system via a single conductor. The arrangement of the meshed earth system shall be such as to minimize the length of these single connections.

All non-accessible buried connections within, or to the earth grid, shall be affected by either brazing, using zinc-free brazing material with a melting point of not less than 600°C, or by approved exothermic welding.

All exposed joints shall be at a minimum height of 150 mm above floor or ground level.

Earth conductor joints that are required to be broken for testing or maintenance shall have tinned mating surfaces.

Where construction activities within the switchyard require or cause the existing earth grid to be either exposed or suffer damage, all necessary earth grid reinstatement work and any associated civil work is deemed to be within the Contractor's scope of work.

Equipotential bonding shall be undertaken to prevent the occurrence of excessive touch potentials on conductive parts of the installation which are not part of a current carrying electrical circuit.

From the point of view of the possible damage to apparatus, the earthing system shall be such as to limit voltage appearing between the Substation equipment and the main body of earth, so that insulation breakdown or burning does not occur on apparatus. For the same reason, voltage rise between earthed points in the Substation shall be kept to a minimum.

In addition, the effectiveness of any surge protection devices shall be fully realized by providing an adequate earth path. In this case the earthing system shall not only be of low resistance, but of as low reactance as practicable.

On completion of the earthing system, the Contractor shall undertake a test of the complete earthing grid of the Substation. The earth grid resistance test shall be carried out by the fall of potential method, requiring the availability of a local low voltage supply but other methods using an earth resistance megger will be acceptable in the event of a local supply being unavailable. The stand-alone earth grid resistance shall not exceed 1.0 Ω.

The resistance shall then be measured with all transmission line earth wires connected to the earthing grid. The measured earth resistance with the transmission lines connected shall not exceed 0.5 Ω.

In the event of a higher value being considered, precaution shall be taken that it does not affect the minimum pick-up currents of earth relays. A value higher than 0.5 Ω shall be subject to the approval of the Employer/Engineer.

In the event of the Substation resistance obtained with the foregoing installation being of a magnitude unacceptable to the Employer/Employer's Engineer, then - where practicable - the ground area enclosed by the earth system shall be increased by installing directly in the ground a copper conductor in the form of a ring around the site at a significant distance from the boundary fence. Alternatively, earth conductors can be directly buried radially outside the Substation perimeter fence. The use of earth plates as current carrying electrodes is not acceptable.

The test shall be repeated immediately before initial energization of the Substation. Any remedial work necessary to return the value to the original value obtained shall be deemed to be the responsibility of the Contractor.

14.2.3 Equipment earthing connections

All external metal-clad equipment in Substation switchyard shall be provided with earth bars externally installed adjacent to the equipment. The earth bars shall be used for bonding of enclosures and ancillary equipment and for the attachment of portable earths when equipment is undergoing maintenance. The earth bars shall be directly connected to the buried earth grid by a minimum of two connections.

The main members of steel structures shall be earthed by means of copper earth bonds bolted across the joints. Each steel column shall be connected to the earth grid.

Within the MV switch room, an earth bar shall be installed around the perimeter of the room. The earth bar shall be used for bonding of enclosures, internal equipment earth bars and ancillary equipment, and for the attachment of portable earths when equipment is undergoing maintenance.

The earth bar shall be directly connected to the buried earth grid by a minimum of two connections. The minimum conductor size shall be as defined in the technical data sheets

Where main LV switchgear is located internally within the control building, an earth bar directly connected to the buried earth grid shall be provided. The earth bar shall be used for bonding of enclosures, internal equipment earth bars and ancillary equipment, and for the attachment of portable earths when equipment is undergoing maintenance. The earth bar shall be directly connected to the buried earth grid by a minimum of two connections. The minimum conductor size shall be as defined in the technical data sheets.

A separate earth bar shall be provided within the control and relay room for the connection of the instrument earth bars provided within control and telecommunications equipment for the earthing of instrument cable screens.

Each instrument earth bar shall be directly connected to the buried earth grid by a single connection to prevent circulating current and noise. The minimum conductor size shall be as defined in the technical data sheets.

The maximum resistance to ground from the connection point on equipment in any facility shall not exceed 0.5 Ω, when measured by standard ground resistance measurement techniques in dry season.

All earthing conductors passing through concrete shall be installed in PVC ducts/pipe. All such cable exit/entry points shall be sealed to provide vermin, insect proof, and water-tight seal.

14.2.3.1 Earthing Conductor Connections

Earthing conductor connections shall be done by bolting and/or exothermic welding. Due care must be taken to avoid electrochemical corrosion when interconnecting different materials.

14.2.3.2 Power Transformer and Shunt Reactors

Tanks of power transformers and shunt reactor shall be connected to the earthing system at least on two diagonally opposite positions to two different points of the earth grid.

Grounded neutrals of power transformers and shunt reactors shall be connected by two insulated copper conductors to two separate earthing rods. The earthing rods shall be connected to the Earthing System at two different points of the earth grid.

14.2.3.3 Steel Structures

Steel structures shall be connected to the earth grid via two different risers to two different points of the earth grid.

14.2.3.4 Outdoor Switchgear

Besides the earth connections of the equipment, the structures shall be earthed at least on two diagonally opposite positions to two different points of the earth grid.

Earthing switches shall be connected directly to the earth grid, not via the steel structure.

14.2.3.5 Surge Arrestor

The surge arrestor earthing terminal shall be connected via a surge counter directly to the earthing grid, not via the steel structure. The connection from the earthing terminal to the surge counter must be done by insulated copper cable with adequate withstand voltage. The earthing terminal of the surge counter shall be connected to a dedicated earthing rod, which shall be interconnected with the earthing grid.

14.2.3.6 Cubicles

Control/Protection Panels, Marshalling Cubicles, Transformer Control Panels, etc. shall be connected to the Earthing System individually via two copper conductors of minimum 50 mm^2.

14.2.3.7 Cable Containment Systems

Individual sections of metallic cable trays or cable ladders must be electrically interconnected with each other by approved means (e.g., bolted connections approved for this purpose or copper cable jumpers). Minimum one bare copper earth conductor shall be run along with the cable tray or ladder and shall be connected to it visibly at intervals of maximum 20 meters. Several cable trays running along the same route shall be interconnected with each other and with the earth conductor at intervals of maximum 20 meters (common earth conductor is acceptable).

The earthing conductor must be interconnected with the earthing system at intervals, as practical, but as a minimum at both ends of the cable tray route.

14.2.3.8 Operating Areas

For outdoor operated equipment an operator platform as described in IEEE 80 shall be provided and interconnected with the earth grid and with the equipment earth connection.

14.2.3.9 Storage Tanks and Piping

As a general rule, metallic storage tanks shall be connected at two diagonal points with the earthing grid. Metallic piping shall be earthed at all service points. Flange connections shall be provided with links to ensure earthing continuity.

The rules of relevant standards and service providers shall be observed. In case rules of relevant standards and service providers and/or corrosion protection require deviations from this general rule, adequate solutions shall be proposed to ensure safety.

For earthing of trucks supplying oil, provisions shall be provided at every unloading bay for quick fixing of a flexible connection to the earth grid.

The Contractor shall prepare and provide suitable measures to protect buried pipes and other metallic parts against electro-chemical corrosion.

14.2.4 Building structural earthing

Buildings structures and structural reinforcing shall be provided with equipotential bonding as described in particular in IEC 62305-3. and other applicable IEC standards.

For potential grading and to protect against excessive contact potentials, a stranded a buried earth ring in accordance with IEC 62305-3. and other applicable IEC standards shall be provided around each of the buildings.

14.2.5 Lightning Protection System Design

For any new building structures, the Contractor shall undertake a risk assessment according to IEC 62305 and shall base the design of the lightning protection system on the results obtained.

The design, dimensioning and construction of the lightning protection system shall be in accordance with the specified standards.

A rolling sphere principle to class IV shall be applied for the design of the system, unless otherwise indicated by the afore-mentioned risk assessment.

All metallic services shall be bonded to an equipotential bonding bar. All services such as data, telecommunications etc. shall be protected by surge protective devices.

An air termination network shall be provided for each building, and for the switchyard.

The air termination network for buildings shall consist of a roof level meshed network and finials, either mounted directly to the roof surface or suspended above the roof. The air termination network for buildings shall be designed based on the rolling sphere principle.

Down conductors of sufficient quantity shall be provided for all buildings. The minimum number of down conductors is two for ancillary buildings and ten for the control building. At each building all down conductors except one shall contain readily accessible disconnecting links to facilitate testing of the effectiveness of the lightning protection system. All disconnection points shall be numbered consecutively on the drawings and shall be so labeled at the buildings and at the switchyard steel structures.

Rebar within structural columns shall be bonded to the down conductors at cast-in non-ferrous bonding connections.

Re-entrant loops shall be avoided with the air termination network and down conductor installations.

Down conductors shall be configured as a Type A system to IEC 62305 and shall terminate in pre-cast earth rod pits containing driven earth rods. The pre-cast earth rod pits shall also contain a connection between the lightning protection system and the buried earth grid.

The air termination network for the switchyard shall be based on the protective angle method and shall provide coverage for all installed equipment.

14.3 Earthing and Lightning Protection Materials

Earthing conductor materials shall be as define in the technical data sheets.

Whenever dissimilar materials are to be joined, transition plates are to be inserted as required to ensure that electrolytic action is avoided. Connections between sacrificial dissimilar metals shall be avoided wherever possible.

14.4 Test Requirements

Earthing system tests shall be carried out in accordance with IEEE 81, including the following:

- measurement of earthing resistance after installation
- measurement of earthing resistance before commissioning.

The following test requirements are stipulated regarding the lighting protection system:

- visual inspection after installation
- continuity tests after installation.

15 Lighting and Small Power Systems

15.1 General

This section introduces one of the main principles involved with substation control building and switchyard services, which is internal and external lighting design. The scope of supply and services related with the lighting supposed to be complete even if the equipment or services to be provided are not explicitly mentioned in this specification.

Detailed calculations and layouts shall be submitted for approval before any order placement or site work is undertaken.

Any exclusion to the complete and satisfactory performance of the design and installation must be clearly indicated in the offer submitted before award of the Contract. It will be otherwise assumed that everything necessary is included in the Contract price.

During the design stage, the Contractor shall submit adequate and full supporting documentation (calculations, schematics, schedules, general arrangement drawings, technical and descriptive manufacturer's data, samples of equipment, etc.) to reveal that the requirements of this specification are being fully complied with. The calculations shall identify all assumptions made and which must be agreed upon before the detailed design is finalized.

Location of the lighting equipment shall be reviewed at site before installation so that satisfactory co-ordination with pipe and ductworks, power cables and other plant and equipment shall be assured.

For plant areas where hazardous areas may exist, as defined by IEC 60079, all relevant equipment shall be rated for the respective hazardous area classification.

This specification shall also be applicable to temporary site installations.

The lighting system shall include, without being limited to the following:

- distribution boards
- cable trunking, containment systems
- luminaires
- lighting switches
- external lighting control systems
- earthing and bonding
- all standard equipment and accessories which are normally included in the supply schedule, which are not separately listed
- spare parts
- complete documentation.

15.2 Standards

Materials, workmanship and tests shall conform, at least, to the latest versions -including all relevant amendments- of the following standards:

IEC 62717	LED modules for general lighting - Performance requirements
IEC 62722	Particular requirements for LED luminaries
IEC 60061	Lamp caps and holders
IEC 60364	Low-voltage electrical installations (all relevant parts)
IEC 60598	Luminaires (all relevant parts)
IEC 61347	Lamp Control gear (all relevant parts)
IEC 62444	Cable glands for electrical installations
IEC 62560	Self-ballasted LED lamps for general lighting services
IEC 63220	LED light sources - Safety requirements
IEC 63221	LED light sources - Performance requirements
ISO 30061	Emergency lighting
EN 50171	Central safety power supply systems

The design of the electrical building services shall be in accordance with IEC 60364 - Low Voltage Electrical Installations. Individual items of equipment shall be in accordance with the latest issue of the relevant IEC Standards.

15.3 Equipment Requirements

All fixings shall be of a type approved by the Employer. All supporting metalwork used in surface installations shall be galvanized. Fixing to structural steelworks shall be with brackets or clamps, especially made to serve such a purpose. Drilling of structural steel works will not be permitted.

Switches and pushbuttons for lighting circuits shall be mounted 1300 mm above finished floor level. All lighting switches shall have a minimum continuous rating of 16A.

Luminaires shall be secured to ceilings, walls, trunking systems, roof steelwork or suspended, as required by the approved design.

Final connections to all suspended luminaires shall be by flexible cable terminated in connectors in the ceiling or junction box which shall also terminate the final sub-circuit cable. The cable length shall be such that the suspension unit supports take the full weight of the luminaires.

Where luminaires are mounted fixed on to walls or ceilings the final sub-circuit cables may be connected into the luminaires own terminal block provided that the cables are routed to avoid any heat generating components inside the luminaire. Where terminal blocks are not provided as part of the luminaire flexible cable shall be used and connected to a separate external junction box.

Explosionproof lighting fittings shall be used in the battery room.

15.4 Lighting System Particular Requirements

15.4.1 General System Requirements

The lighting system shall be designed and implemented for the following substation areas:

- indoor and outdoor lighting schemes for control buildings and indoor switch rooms under both normal and emergency (loss of AC supply) conditions
- floodlighting and emergency lighting schemes for outdoor switchyards as well as all substation doors and gate access
- access road lighting as well as any supplementary lighting for security video camera surveillance
- emergency lighting.

All exterior lighting shall be designed so that it shall be automatically switched by photo-sensitive switches (photocells) and the Contractor shall arrange that there is a time delay between the various groups of circuits being energized to compensate the switching peaks. Manual override facilities shall also be provided so that each circuit can be controlled individually.

The Lighting Uniformity describes the ratio between the minimum to average or minimum to maximum ground illuminance of the yard. The Lighting Uniformity shall be 0.4 at least.

The lighting shall be designed to provide visual performance, safety and economical usage of power.

Visual performance shall be free of excessive stroboscopic effects and flicker.

Where visual display units are to be installed, the design shall take account of the need to avoid glare which could cause fatigue to the operators.

The Contractor shall establish the parameters for the lighting design and ensure that the latest definition of maintenance factor is applied in the calculations.

This includes considering all losses associated with the luminaires including lamp lumen maintenance, anticipative switching and lighting operation. The Contractor shall assume that the luminaires will be cleaned once a year.

The design shall ensure satisfactory operation over the life of the substation.

The lighting design shall take full account of the drop-off in performance of lamps and luminaires over their expected working life and shall indicate required maintenance to maintain these minimum lighting levels.

15.4.2 Illumination levels

Minimum illumination levels shall be in accordance with the regulations of the country of the Employer, but not less than stated in Table 15-1 below. The below levels shall be based on measurements being taken after lamps have operated for not less than 100 hours. The method of measurement shall be in accordance with International Commission on Illumination (CIE) Publication No. 29. Measurements shall be taken 0.85 m above the floor level in control and relay rooms, electronic equipment rooms, and offices. Otherwise, measurements shall be taken at floor level.

Table 15-1 Typical substation illumination levels

Substation Area	**Standard illuminance (lux)**	**Limiting glare index**	**Type of control**
Indoor switch rooms	400	25	L
Control rooms	400	25	L
Telecommunication rooms	300	25	L
Battery rooms	200	25	PB
Cable tunnels and basements	50	-	L
Cable distribution room	100	-	-
Offices	500	16	L
Workshop (General)	300	22	PB/L
Entrance halls, lobbies, etc.	200	19	L
Corridors, Passageways, stairs	200	25	L
Messrooms, kitchen	200	22	L
Storerooms	100	10	L
Lavatories	200	25	L
All indoor areas not specially listed	200	25	L
Outdoor switchyard (Floodlighting)	100	-	-
Perimeter lighting	50	-	-

Substation Area	Standard illuminance (lux)	Limiting glare index	Type of control
Exterior building lighting	20	-	-
Transformers' area	100	-	PB/L/PC
Main entrance	100	-	
Roadway, Access roads, Vehicle yard and Parking	30	-	PC/L
Access ladders, stairways and plat-forms	50	-	L
Local control cabinets	200	25	L
Outdoor plant areas not especially listed	50	-	PC/L

The following symbols are used in the table:

- L Single-pole local switch
- PB Push-button for remote control
- PC Photocell.

15.4.3 Luminaires

Luminaires for interior and exterior use shall be LED type and shall be manufactured and tested in accordance with IEC 60598 or equivalent and, together with all components, shall be consistent for service and operation in the environmental and climate conditions apparent in the Project area.

Each luminaire shall be complete with lamp holders, control gear, internal wiring, fused terminal block, earth terminal and reflectors or diffusers as specified. The design of each fitting shall be such as to minimize the effect of glare, and such that the ingress of dust, flies and insects shall prevented.

Internal connections shall comprise stranded conductors not less than 0.75 mm2 covered with heat-resistant insulation to IEC 60245-3 or equivalent. All internal wiring shall be adequately se-cured inside the luminaire casing with an approved form of cleat. The finish of fittings for interior use shall have a vitreous enamel, natural aluminum or galvanized finish according to the manu-facturer's standard product.

Lamp holders shall be suitable for the lamps specified. Luminaires shall be of the type specified.

The lighting installations shall be designed to give the standards service illuminations specified in this specification.

The number of different types of luminaires shall be rationalized by the Contractor to keep the number of different types of luminaires down to a minimum.

Indoor lighting

An AC lighting system shall be used to provide an average horizontal illuminance at floor level as per Table 15-1.

On local measuring, control stands, and instrument panels 200 lux shall be provided.

Illumination shall be of uniform intensity free from glare.

Illumination levels at controls in instrument panels shall be measured in a vertical plane at the panel position.

Inside GIS switchgear rooms, high bay luminaires suitable for the height of the room shall be provided.

Stair lightings shall be positioned such to provide good visibility of the stair risers and treads and to facilitate access for maintenance/replacement.

Light fittings shall be kept free from obstructions such as cable trays and control panels. Additionally, the light fittings must not be installed below items such as cable ducts.

Where fittings are installed in areas where they it is possible to be damaged such as the basement, they shall be protected mechanically. Appropriate forms of protection include wire guards or vandal proof light fittings.

Outdoor lighting

Lighting design shall be provided for all outdoor areas, including the switchyard, transformer bays and access roads, so that the required levels of lighting will be achieved as indicated in Table 15-1.

Wherever practical light columns that can be tilted or have a mechanism that allows the light fittings to be easily lowered to ground without allowing the fittings to swing as it is being lowered, shall be used. Both the lowering mechanism and the fittings shall be easy to maintain.

All yard lighting shall be arranged by appropriate work clearances from live parts in accordance with IEC 61936. The installation and maintenance shall be possible without the need for a high voltage outage.

All light columns must be located within the direct protection zone of substation lightning protection.

Lighting shall not affect adjacent properties adversely.

The outdoor switchyard lighting fixtures shall be waterproof and dust-proof and IP66.

15.4.4 Emergency lighting

An emergency lighting system shall be provided to allow for the safe movement of personnel in the event of a failure of the normal lighting system. Emergency lighting shall also be provided at the entrances of the switchgear rooms and in the transformer areas.

The emergency lighting system shall comply with ISO 30061, IEC 60598 and with the applicable local standards.

Escape Lighting

Escape routes, exit lighting and associated signs shall be clearly marked and lit to facilitate emergency escape in safety. At least one emergency light must be visible from every point in every room. “Exit” signs shall be provided throughout the buildings, at appropriate places in the substation.

Safety Lighting

Safety lighting shall be provided for all locations with a high accident risk potential, such as e.g., electrical equipment rooms, battery rooms, etc. and for areas where work must be possible to continue in case of loss of the normal supply, such as e.g. control rooms.

Safety Lighting shall have an average emergency luminance of 50 lux.

Power source Emergency Lighting

Luminaires for escape and safety lighting shall be powered from central battery supply systems compliant with EN 50171.

Self-contained battery packed shall be used only in particular applications subject to the approval of the Employer and shall comply with IEC 60598.

The batteries shall be sized for a three-hour minimum emergency duration.

All self-contained emergency luminaires shall have a minimum guaranteed life of 4 years.

A method of testing the emergency lighting shall be provided if it is not part of a maintained system which is directly connected to the distribution boards.

The battery packs may be mounted remote if the temperatures within the luminaires will not allow the Contractor to guarantee the minimum life required.

15.4.5 Photocells

Photocells shall be mounted within a waterproof and dustproof enclosure to IP65 which shall be fully corrosion resistant.

Means shall be provided for on-site adjustment of the ambient light threshold levels at which the photocell actuates the lighting systems.

15.4.6 Lighting Switches

Switches for use in AC circuits shall be rated for 16 or 20 A and shall be single pole type provided with an earth terminal.

Switches for use in areas designated for surface installation shall be quick-make quick-break fixed grid industrial types mounted in sheet-steel weather-proof boxes with protected dolly and arranged where necessary for multi-gang switching.

Switches for use in areas designated for flush installation shall be micro-break types fixed to white plastic cover plates and mounted in galvanized steel flush type boxes.

Switches for external use shall be of the surface mounting 16 A rotary quick-make quick-break pattern housed in a cast iron galvanized weatherproof box to IP 65.

Push-button switches shall either be flush or surface types, contained in galvanized steel boxes and be single pole rated for 5 A. Push-button shall be made of non-hygroscopic material, be non-swelling and so fitted as to avoid any possibility of sticking.

The terminals for all switches shall be adequate to accommodate 2 conductors, each 2.5 mm2 in area.

Battery Rooms, shower rooms, toilets and toilet blocks shall have light switches mounted outside the entrance doors.

Light switches shall be installed such that the operating dolly shall be pushed up for OFF and down for ON. Similarly, rocker-operated switches shall be installed such that the upper portion of the rocker is pushed for OFF and the lower portion for ON.

15.4.7 Distribution Boards

The distribution boards and all component parts shall be manufactured and tested in accordance with IEC 61439 and with the requirements for Electrical Cubicles and Panels

The lighting and small power distribution boards shall be rated 230/400 V, 50 Hz. Supplies shall be taken from corresponding LV boards or safe AC supply boards.

Separate local distribution boards shall be provided depending on the service as follows:

- panel to feed all normal lighting circuits
- panel to feed all emergency lighting circuits, and
- panel to feed all AC socket outlet circuits.

The panel for normal and emergency lighting shall be equipped at least with following components:

- four-pole incoming circuit breaker with residual current protection
- single-pole outgoing circuit breakers
- three-pole outgoing circuit breakers with residual current protection
- three-phase + neutral busbar system
- earthing bar, and
- push-button, contactors, auxiliary relays time relays, etc. as necessary.

The panel for socket outlets shall be furnished with following components:

- four-pole incoming circuit breaker
- four-pole outgoing residual current circuit breakers, and
- two-pole outgoing residual current circuit breakers.

Outgoing circuits for socket outlets require residual current protection with tripping sensitivity 30 mA and air conditioning equipment with 100 mA.

Approved type labels shall be fitted externally on the front cover of each distribution board giving details of the points controlled by each circuit. The circuit list shall be typed or printed stating the location of the equipment served, rating of the protective unit and the circuit loading. The lists shall be mounted on the inside of the cover door and shall be protected by an acrylic sheet slid into a frame over the circuit list, the list and cover to be easily removable to permit circuit modifications.

Each panel shall be equipped with 20% spare feeders.

All equipment for lighting shall be suitable for 40°C ambient temperature and 100% humidity.

15.4.8 Cables

Cables shall comply with the requirements for Low Voltage Power and Control Cables. The cables for lighting systems shall be 3, or 5 cores (P+N+E and 3P+N+E). Outdoor cables shall be steel wire armored.

Cables and cable installation for emergency and safety lighting must be fire resistant.

All cables shall be protected from direct sunlight.

Cables shall run at least 150 mm clear of all plumbing and mechanical services. The space factor for cables installed in trunking or conduit shall not exceed 40%.

15.4.9 External lighting

15.4.9.1 Lighting levels

Switchyard lighting shall be sufficient to provide illumination to allow employees to move around the switchyard safely and able to see the operating equipment from ground level at night easily and clearly.

Control of this lighting shall be with multiple way switching, with each switch located as close as practical to the entry point to the substation and/or switchyard; within the area lit by the security or entry/exit lighting. The switches shall be labelled "Switchyard Lights" and must not be accessible to persons outside of the substation.

15.4.9.2 Lighting equipment

All luminaires for external lighting shall be suitable for outdoor duty and shall be adequately earthed and all earth terminations and fittings, fixing brackets and supports shall be included.

In general, such the outdoor luminaires shall emit no upward light.

15.4.9.3 External lighting poles

Lighting poles shall be of hot-dip galvanized steel of octagonal shape and shall be approved by the Employer. Poles for roadway lighting shall support the lanterns at a normal 10 m above ground level and poles for floodlighting may exceed 10 m. The maximum spacing between poles shall be 50 m. Hinged type poles for access to the light fitting shall be provided where floodlights are required to be installed at high level.

Each pole shall be equipped with a weatherproof base section of sufficient size to house an inspection trap, lockable door, fused cut-out, cable entry and terminations for both the incoming and secondary cables feeding the light source. Facilities shall be included for cable looping.

The Contractor shall ensure that each pole is provided with foundations suitable for the ground conditions existing at the site.

The substation site boundary perimeter wall/fence shall be provided with a lighting system that shall be mounted 10 m above ground level at the wall/fence line and shall be placed 1m inside the perimeter wall/fence boundary.

Due consideration must be given to outdoor lighting outside of the substation fence to avoid transfer of excessive step and touch potentials. Lighting poles for outdoor lighting outside of the substation fence shall be FRP/GRP type. The distance between lights shall provide the illumination levels specified.

All external doors of building including switch rooms and stores shall have external luminaires installed above the doors to provide illumination outside entrances. This is in addition to the requirements for any roadway or other external lighting.

15.4.9.4 Entry/Exit lighting

Sites with inadequate security or street lighting shall be equipped with automatic passive infra-red (PIR) detector-controlled entry/exit lighting.

The automatic passive infrared (PIR) detector operated lighting shall illuminate towards the gate lock or door lock, to enable them to be opened and the yard light manual control switch to be reached without using a torch or any extra equipment.

When PIR detectors are used, they shall activate the entry/exit lighting immediately and keeps it on for five (5) minutes. The PIR detector and associated lights shall be mechanically protected or mounted in a box which mechanical protection is not required.

The control switch must be located on the distribution switchboard and be labelled "Entry Lighting - Normally On".

15.4.9.5 Security lighting

Security lighting shall be operated from sunset to sunrise and in cases that the daylight shall not be sufficient to detect any possible security issue. If required, external security lights shall use pole-mounted lighting that shines light onto the exterior of the building. Lighting attached to the building shall be avoided because of insects and spider nets on the exterior of buildings, results in deduction of their visual sights and additional maintenance.

Control for this lighting shall be automatic through either time clocks or external photoelectric (PE) cells.

The bypass or override switch shall be installed in the substation to allow manual switching of the security lights for lighting operation checks. This switch shall be located on the building distribution switchboard, and it shall be labelled "Security Lighting – Normally Off".

15.5 Socket outlets, power outlets and plugs

The complete small power installation includes all power outlets, containment systems, trunking and relevant accessories.

All external outlets shall be metal-clad rated IP65.

All cables to external outlets shall be bottom entry.

A plug shall be provided for each power outlet.

Illustrations and/or Samples of all socket outlets and plugs that the Contractor proposes to use on the Project shall be submitted to the Employer for approval.

15.5.1 Socket Outlets

15 A, 230 V AC single-phase, neutral and earth socket outlets of the type commonly used as power outlet for domestic application in the country of the Employer shall be provided as follows:

- at each entrance door of a room (including cable basement if applicable) one (1) 15 A, 230 V AC socket outlet shall be provided below the lighting switch
- for each room (including cable basement if applicable), additionally one 15 A, 230 V AC double socket outlets shall be provided at strategic locations along the perimeter of the walls, with a distance of maximum 5 m between two outlets, and a minimum of two (2) per room, installed 30 cm above finished floor
- at each desk, 15 A, 230 V AC socket outlets shall be provided at convenient position and in adequate quantities as required for the equipment stationed at the location (e.g. monitors, printers, etc.) plus an adequate number of additional outlets for power supply of portable equipment, such as e.g. notebooks, mobile chargers, etc.
- at other locations where necessary, e.g. for copiers, hand tools, etc., 15 A, 230 V AC socket outlets shall be provided as required.

Socket outlets shall not be provided inside shower rooms and inside battery rooms. Socket outlets inside wet rooms, e.g. kitchens, wash rooms, etc. shall be installed with the required safety distance to water outlets.

Socket outlets installed in electrical equipment rooms, storerooms, workshops, etc. shall be industrial type with cover. Socket outlets installed in office rooms and at desks shall be robust domestic type. Socket outlets shall be of a flush fitting pattern where the wiring installation is concealed.

32 A, 230/400 V AC three-phase, neutral and earth power outlets in accordance with IEC 60309 shall be provided as follows:

- near each entrance door of switchgear rooms (except battery room), cable basements and workshops at strategic locations along the perimeter of the walls, with a distance of maximum 10 m between two outlets, and a minimum of two (2) per room, installed 130 cm above finished floor
- at any other locations where necessary, e.g. for tools.

All socket and power outlets shall be fed via Residual Current Devices (RCD). They shall have a tripping sensitivity of 30 mA and a maximum operating time of 30 ms.

15.5.2 External Power Outlets

External power outlets shall be provided for switchyards, transformer bays and other outdoor equipment (e.g. capacitors, diesel generators, etc.) to provide power for e.g. portable electrical tools, portable welding equipment, mobile oil purification plant, etc..

15.5.3 Industrial type Power Outlet Combinations

Industrial type power outlet combinations shall be provided to provide for e.g., portable electrical tools, portable welding equipment, etc. as follows:

- inside switchgear rooms with a distance of maximum 20 m between two outlet combinations, but a minimum of two (2) per switchgear room
- for switchyards at strategic locations, with a distance of maximum 50 m between two outlet combinations
- at each transformer bays and other outdoor equipment locations (e.g. capacitors, diesel generators, etc.)

Power outlet combinations shall be robust type for outdoor installation comprising the following:

- one (1) 32 A, 400 V AC three-phase, neutral and earth power outlet
- one (1) 16 A, 400 V AC three-phase, neutral and earth power outlet
- two (2) 16 A, 230 V AC single-phase, neutral and earth industrial type socket outlets
- one (1) RCD 63 A, 30 mA
- one (1) MCB 32 A, 3 pole
- one (1) MCB 16 A, 3 pole
- two (2) MCB 16 A, 1 pole.

The power outlet combinations shall be mounted on pedestals or attached to steel structures or concrete walls at a bottom height of 900 mm. When mounted externally, the power outlet combinations shall be provided with an additional galvanized sheet steel enclosure cover top, rear and sides, as additional protection against weather impact.

15.5.4 Power Connection Point

Power connection points shall be provided for connection of mobile oil purification plants and shall be installed at convenient locations as follows:

- one (1) power connection point at each power transformer bay, reactor bay, etc.
- one (1)) power connection point for every two autotransformers installed next to each other.

Power connection points shall be robust power cubicles in accordance with IEC 61439 and the general requirements for Electrical Cubicles and Cabinets, for outdoor installation comprising the following:

- galvanized sheet steel enclosure, with door, mechanically interlocked with the incoming MCB (to be opened only when MCB off)
- one (1) four pole MCB, 125 A, with RCD 300 mA
- one (1) outgoing supply terminal block 3xL/N/PE suitable for 35 mm^2 flexible cable
- one (1) cable gland for incoming supply cable
- one (1) cable entry for outgoing supply cable, which provides proper closing of the inlet in both cases, with connected and disconnected outgoing supply cable.

The power connection points shall be mounted on pedestals or attached to steel structures or concrete walls at a bottom height of 900 mm.

16 Fire Detection, Alarm and Fighting Systems

16.1 General

This section deals with the technical requirements for Fire Detection, Alarm and Fighting System to be used in the substation. This system shall be designed to comply with the requirements of ISO 7240 and EN 54 to provide early warning for personnel evacuations and to allow action to be taken to limit damage to the plant.

This system shall comprise fire detectors to be installed in the operational plant rooms, control and indicating equipment, as well as linear heat detection systems to be designed and installed in all concrete cable trenches, cable distribution rooms and tunnels and below raised floors in the Control Building, so as to provide early detection of any possible fire which might occur to the cabling system.

The substation shall be divided into zones. The number of zones and number of devices shall be determined by the Contractor in accordance with the applicable standards and regulations, as well as manufacturer's recommendations.

16.2 Standards and codes

The systems shall be based upon the standards listed below

ISO 7240	Fire detection and alarm systems - All relevant parts
EN 54	Fire detection and fire alarm systems - All relevant parts
NFPA 1	Fire Code
NFPA 10	Standard for Portable Fire Extinguishers
NFPA 11	Standard for Low-, Medium-, and High-Expansion Foam
NFPA 12	Standard on Carbon Dioxide Extinguishing Systems
NFPA 13	Standard for the Installation of Sprinkler Systems
NFPA 14	Standard for the Installation of Standpipe and Hose Systems
NFPA 15	Standard for Water Spray Fixed Systems for Fire Protection
NFPA 16	Standard for the Installation of Foam-Water Sprinkler and Foam-Water Spray Systems
NFPA 20	Standard for the Installation of Stationary Pumps for Fire Protection

NFPA 22	Standard for Water Tanks for Private Fire Protection
NFPA 24	Standard for the Installation of Private Fire Service Mains and Their Appurtenances
NFPA 25	Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems
NFPA 72	National Fire Alarm and Signaling Code
NFPA 551	Guide for the Evaluation of Fire Risk Assessments

If it is proposed to use fire safety facilities and systems for which no suitable standard exists, the Bidder shall submit full technical details and the use of such facilities and systems shall be subject to the approval of the Engineer.

16.3 Fire Detection and Alarm System Design

The fire alarm and detection system shall be of addressable type and shall comply with the requirements of the above-mentioned standards in all respects.

A complete system shall be provided with all components required for automatic operation. The fire alarm system shall include necessary interfaces to the following systems:

- extinguishing systems,
- HVAC,
- fire dampers,
- high voltage equipment
- substation control and monitoring system (SCMS).

A cause-and effect-matrix shall be provided for the event of a fire.

The fire alarm system devices shall be wired to the fire alarm control panel located adjacent to the main entrance to the substation building and shall repeat on a mimic panel in the control room.

Wiring for the fire alarm system shall be in accordance with the specified standards and it shall be surface mounted.

All devices and cables that belong to the fire alarm system and line type (linear) heat detection system shall be properly labeled.

System to be zoned, open circuit, supervised, electronically monitored type, with facilities for selective zone alarm initiation from key positions for evacuation purposes.

The control panel is to be divided into a number of zones. The number of zones required shall be the responsibility of the Contractor. Connection to the control panel with the fire alarm devices, including cabling, relay, etc. shall be provided by the Contractor.

A 'SILENCE ALARM' blue colored push button shall be incorporated in the control panel which shall silence the alarm.

A 'RESET' green colored push button shall be incorporated in the control panel which shall restore the system to normal non-alarm mode.

All rooms and areas throughout the Substation shall have a system installed which shall contain a sufficient number of detectors and manual alarm call points. In the case of fire, the fire control panel that monitors all automatic fire detectors shall generate commands to:

- shut-off ventilation and air conditioning systems and
- activate alarm bells or siren on the substation site.

In addition, the relevant alarms shall be sent to the SCADA and sound alarms shall be activated in the building/control room.

16.3.1 Fire Detection and Alarm Control Panel

The Fire Detection and Alarm Control Panel shall be of addressable type and shall comply with international standards, such as FM/UL/VdS or ether recognized approval authorities.

The control and indicating equipment panel shall be of the flush mounting pattern with the alarm and fault indication by illuminated numbered panels, cross referenced to adjacent mimic diagram.

Panel facilities to comprise:

- 'Power On' lamp
- 'Battery Fault' lamp
- 'Earth Fault' lamp
- 'System Fault' lamp
- 'Reset Alarm' push button
- 'Silence Alarm' push button
- 'Test' key switch and supervisory lamp. This test shall permit testing of zone detectors and break glass stations without activating plant alarm relays
- ‘Lamp Test' bush button
- Annunciation for fire, fault, status monitoring

The control panel shall provide:

- The required number of zone alarm and fault lamp displays for the panel shall be a minimum number of zones as determined by the Contractor.
- facilities for individual simulation of alarm and fault conditions, located inside the control panel enclosures
- output terminals for each ring wired zone sounder circuit and a supervisory trouble sounder within the control, enclosure
- monitored output terminal and the necessary control modules for repeating of all zone alarm and fault conditions to the control engineers at the Substation Control Room.

A zone legend and schematic diagram/general layout of fire alarm and detection system, as well as the line type heat detection system should be provided and installed near the respective control panel.

All outside cable trenches (troughs) installed with the line type heat detection system shall be marked in red, zone-wise for proper identification.

A separate control panel, located next to the main fire alarm control panel, shall be provided for the line type heat detection system provided for high voltage and low voltage cables in cable trenches and below raised floors.

This shall connect into the main building fire alarm control panel on a zone-by-zone basis. Fault and fire indication signals shall be sent from the line type heat detection panel to the main fire alarm panel.

A “Fire Action” signboard shall be provided on the wall in the substation control room.

16.3.2 Battery and Charger

A battery/charger unit for powering all systems components shall be provided. The battery/charger unit shall consist of a single-phase main operated battery charger unit and a standby battery, housed in a metal clad compartment separated from the associated control panel.

The battery bank shall be of a suitable (gas tight or similar) type, requiring minimal maintenance attention.

The sizes of battery and charger units shall be determined by the equipment supplier and shall allow for adequate derating of the batteries. This shall allow for the standby load, alarm load, derating for ageing, temperature derating and the non-linear standby and alarm conditions.

16.3.3 Automatic Detectors

Automatic detectors (optical and heat type) shall be suitable for a ceiling mounting box fitted with terminals and contacts. The mounting box shall be fixed in position and fully wired before the detector head is plugged in and locked into position. All detectors shall be of addressable type and shall operate on the open circuit monitored circuit principle. Detectors should not be sited within 2 m of air-conditioning supply or extract grilles and should be located away from the direction of airflow.

All detectors shall have encapsulated electronic circuitry.

The body of each detector shall have a visible red light emitting diode in the side which shall illuminate when the head is in an alarm state.

The detectors shall require no replacements after initiating an alarm to re-store it to its original quiescent condition, when the alarm condition has been reset.

All detectors shall be suitable for reliable operation within the environmental temperature and humidity ranges given in this specification.

Duct mounted smoke detectors shall be provided as required for the heating ventilation and air conditioning systems and provide alarm/fault indication on the main panel.

Thermal rate of rise type detectors shall meet the following requirements:

These shall be electronic combined rate of rise and fixed temperature type detectors complying with EN 54.

The detectors shall have an electronic temperature responsive element of heat detection and shall be suitable for operating continuously in up to 95% R.H. The rate of rise sensing circuitry shall be calibrated to respond to an increase in ambient temperature of 3°C per minute.

All cables trenches and raised floors within the Substation building shall be protected by line type heat sensing cables. These cables require are to be resistant to rodent attack and installed over the cables throughout the areas. If rodent resistant cables are not provided, protection against attack should be provided by mechanical means.

16.3.4 Manual Call Points

All manual call point units shall be of addressable type and open circuit monitored type and shall be generally flush red enamel surface pattern. Breaking the glass shall operate the contacts and raise an alarm.

All call points shall be complete with a glazed, hinged front covering fascia labeled. The glass element shall incorporate a translucent plastic coating to eliminate loose fragments of glass when broken. It shall be possible to break the glass element of station without the use of a hammer. The frangible glass elements shall be easily replaceable. Call points installed indoors shall incorporate a key test facility and outdoor units shall be weatherproof and come complete with a hammer. These shall be protected from exposure to direct sunlight.

16.3.5 Alarm Bells and Sounders

Notification of a fire shall be by either alarm bells or electronic sounders The notification device shall have a unique sound that is different from any other used on the Project.

If a similar sound is found is used on the site an electronic two tones sounder shall be used.

Bell mechanisms shall be contactless, totally enclosed type, polarized and suppressed, so that operation does not interfere with radio or television. There shall be automatic compensation for plunger wear.

Bells, when located outdoors, shall be weatherproof type suitable for mounting to surface conduit box. Elsewhere bells shall be suitable for internal ap-plication and mounting to a flush conduit box.

For the Line Type Heat Detection System, a separate sounder shall be installed just above the Heat detector cable Sensing Control Panel.

16.4 Portable Fire Extinguishers

The portable apparatus to be provided under this contract is to be used for dealing with outbreak of fire in areas where oil filled transformers protected by fixed installations as well as in electrical equipment in control and equipment rooms.

All apparatus shall be of suitable type for operation by one person and shall be easily rechargeable.

The content of extinguishers shall be non-corrosive and free of toxic gases when heated.

Equipment for dealing with oil fires shall be of foam generating type.

Portable wall mounted, hand-held extinguishers shall be of 12 and 6 kg size, with a multipurpose powder of ABC rating or carbon dioxide type

The contract shall include the supply and installation of all wall brackets and fittings for small units, as well as of wheeled trolleys for units which cannot be carried easily.

Where extinguishers are provided in external positions or other areas where they may be exposed to the weather, they shall be provided with protective cabinets. The protective cabinets shall be of red color and marked in white as 'FIRE EXTINGUISHERS' in both English and local language. The cabinet shall provide adequate protection against rain, wind blows and dust.

Where extinguishers are provided internally, they shall be wall-mounted, adjusted on the wall in a manner affording quick release from the supporting bracket.

16.5 "Wet" Firefighting System

16.5.1 General

Water based firefighting systems shall be provided for the Substation as a minimum as described herein. The firefighting system shall generally follow the NFPA codes as well as national and company specific regulations if applicable. In case of any conflict the more stringent requirement must be applied. All equipment and pumps must be approved by FM or listed by UL.

It shall be assured that a dedicated fire water supply to cover the system design flow rate is available for the facility in accordance with NFPA.

The Project shall be provided with a firefighting water storage tank.

The firefighting pumps shall be provided as a prefabricated containerized unit and shall include the following:

- electric jockey pumps (1 set - 2x100%),
- electric driven main pumps (1x100%),
- diesel engine driven main pump (1x100%), and
- expansion tank arrangement.

The fire pump container shall be furnished with a distribution and control panel for auxiliary control, ventilator fan and internal light. The panel shall be furnished with a sprinkler alarm connected to the fire alarm panel for remote supervision. It comprises the three pumps described below.

The fire alarm system shall be integrated in the operation and monitoring system. An own monitor and operation station with alarm printer shall be provided. General alarm, general fault, in operation and locked signals shall be visualized on the SCMS.

16.5.2 Firefighting water storage tank

A GRP firefighting water storage tank shall be provided, designed and manufactured in accordance with BSEN 13280. The tank shall be installed on a foundation allowing self-drain.

16.5.3 Firefighting pump system container

The firefighting pump system shall be provided as a prefabricated containerized unit for outdoor installation. The dimensions of the container shall be suitable to host the firefighting pumps, expansion tank and control panel.

The containers shall be rugged and constructed for long-term operation (> 30 years). They shall be equipped with all necessary equipment and facilities, e.g. lighting, air inlets and outlets, etc., to keep the container devices functional and operable.

Container structural components

- Supports seating underside points at the four corners
- Double acoustic door set for personal and equipment access ~1800/2400 mm (width/height) with inside panic bolts.
- Access stairways.
- Steel structures of stainless steel or adequate corrosion protection.
- Roofs consisting of two weather roofs to reduce heat loading allowing the ventilation under the outer roof.
- Walls shall be made as double wall (clearance between walls ~60 mm, filled with insulations material and min. thickness minimum 1 mm inner/outer sheet, provided that a sufficient stiffness is guaranteed by the structure of the walls.
- Floors steel construction shall be designed to withstand all anticipated loads on the structure including that of transportation of completed already installed equipment.
- Fixed points for panels/boards/etc. on walls/floors.
- Earthing connections points between the containers and the substation earthing grid (at least four connections).

The design of the container shall allow the operation without running cooling or heating under normally expected weather conditions. The utilization of a second roof (sun shield) is required.

The design of the container shall also avoid the entrance of small animals into the container. Special devices shall be provided.

It is mandatory that the complete container with all inside installed equipment shall be factory tested before shipped to site.

The design of the container shall also take into consideration the aspects related to the lifting (lifting lungs), permanent position operation requirements transport to site and permanent position operation requirements.

16.5.4 Electrical Driven Pump (Main Fire Pump)

The electrical driven fire water pump supplies the fire system with water.

The pump shall be controlled autonomously by a local control panel. The panel shall be provided with auto/manual selection.

A pressure control shall be provided in the discharge line for automatic control of the pump. The pressure sensor shall be connected to the pump control panel. In case of low pressure combined with a small time delay the pump is started. The pump can only be stopped manually at the local control panel. Running signal and fault signal shall be transmitted to the DCS for remote alarm and supervision. An alarm shall be raised when the pump is in operation.

16.5.5 Diesel Driven Fire Pump

The diesel driven fire water pump will supply the fire system with water in case no electricity is available.

The pump shall be controlled autonomously by a local control panel. The diesel motor shall start from battery powered starter. The panel shall be pro-vided with auto/manual selection.

A pressure control shall be provided in the discharge line for automatic control of the pump. The pressure sensor shall be connected to the pump control panel. The start pressure for the pump shall set to be below the start pressure of the main pump and combined with a time delay in order for the electrical driven pump to get in operation first. The pump can only be stopped manually at the local control panel. Running signal and fault signal shall be transmitted to the DCS for remote alarm and supervision. An alarm shall be raised when the pump is in operation.

16.5.6 Jockey Pump

The jockey pump shall secure pressure to the firewater system at all times.

The pump shall be controlled autonomously by a local control panel. The panel shall be provided with auto/manual selection.

A pressure control shall be provided in the discharge line for automatic control of the pump. The pressure sensor shall be connected to the jockey pump control panel. In case of low pressure, the pump shall start. When the normal pressure is obtained, and a delay timer has elapsed the pump shall stop. Running signal and fault signal shall be transmitted to the DCS for re-mote alarm and supervision. An alarm shall be raised when the pump is in operation.

16.5.7 Fire Water Demand Calculation

The water demand of the Project shall be calculated considering a worst-case scenario for a single fire event based on NFPA standards and proofed by a Fire Risk Assessment. A safety factor of approximately 1.15 shall be added. The new firefighting water storage tank, pumps and distribution system shall be designed and installed accordingly.

16.5.8 Fire Water Distribution System

All the pumps and pipework sizing is based on the fire water requirements of the Project. The pipework distribution system feeds hydrants, hose reels, and deluge systems.

A main above ground fire header shall be provided to serve strategically placed (not more than 50 m apart) outdoor hydrants and supply water to the indoor hose reel and sprinkler/spray systems. In areas where roads are crossing the main fire header, the fire header shall be underground.

The fire water distribution system shall incorporate sectionalizing valves so that a failure in any part of the system can be isolated while allowing the remainder of the system to function properly (2 way feeding).

A sufficient number of drain valves at low areas and venting valves on high areas, which allow a sectionalized flushing/drainage/venting of all water and foam pipes shall be installed.

The water distribution system is mainly an above ground system and comprises of different circuits. Shut-off valves shall be foreseen to isolate parts of the system, if and when required; however, these valves have to be 'kept and locked normally open'.

16.5.9 Function

An air/water accumulator (expansion tank arrangement) and electric jockey pumps shall have the function to maintain the water circuit pressurized compensating possible water leakages from piping arrangement. In case of an air pressurized expansion tank provision for service air pressure control arrangement or dedicated compressors shall be provided. The jockey pump is controlled by means of a pressure switch (low pressure).

In the case that the firefighting system is in operation the required delivery and pressure for the worst condition are ensured by the main duty electric pumps; diesel engine driven is stand-by, for the case of mains supply failure or extra low pressure in the network.

Starting of the main duty pumps is controlled by a pressure switch (low pressure) adjusted for a pressure value lower than of the jockey pump.

Another pressure switch controls the starting of the diesel engine driven pump in the case of failed starting of the electric pumps.

Proper starting sequence of the pumps is accomplished, also, by time delay relays.

Once started, the firefighting pumps can only be stopped manually, and a return valve shall be installed to flow the water back to the tanks.

Proper starting sequence of the pumps is accomplished by means of a suitable adjustment of the pressure switches and of the time delay relays.

The FF- system of the Project shall be complete with pump test facilities in the form a calibrated test loop around the pump set.

16.5.10 Fire Hydrants

Hydrants shall be installed at strategic locations. The quantities and types of the hydrants shall be dictated by the relevant standards (such as NFPA 24: Standard for the Installation of Private Fire Service Mains and Their Appurtenances), applicable local regulations and the relevant calculations of the Contractor, subject to the Employer's/Engineer's approval.

Fire hydrants shall be provided with a weather-cap and an epoxy or bituminous-coated shoe. The hydrants shall be set on concrete slabs.

Connections shall be mechanical joints with proper fittings.

The main hydrant valves shall be of the compression type (i.e. the water pressure shall hold the main valve closed, permitting easy maintenance of the barrel assembly from above the ground without shutting off the water supply).

All working parts shall be bronze or non-corrosive metal in accordance with the relevant standards.

All external steel surfaces shall be thoroughly cleaned to remove rust, scale etc. before applying a primer (of color in accordance with the relevant NFPA 291). All underground piping shall be provided with protective wrappings.

All other technical details with regard to hydrants shall be defined during design stage.

16.5.11 Transformer Spray water system

Fire protection for Transformers and Rectors shall be of the fixed water spray type with a minimum running pressure of 50 psi at any spray nozzle and suitable for automatic operation and manual operation by means of a deluge valve and approved detectors.

Water coverage and application should be in accordance with NFPA 15. (10.2 l/min/m2). Water storage should be sufficient to maintain a one hour of fire pump run.

All devices & pipes should be minimum 1.5 m away from the body of the transformer / reactor and 2 m. above the floor level to have clear access. All the pipe installation in front of transformer / reactor shall be easily re-movable.

The spray circuit, which operates as control circuit, is normally under pressure. High temperature causes breaking of one or more of the spray water circuit bulbs. As a result, pressure in this circuit falls, causing the pilot valve to open and consequently the water is delivered to the nozzles. This continues until the valve is closed. The water output may also be actuated by operating the manual emergency release or by a confirmed fire signal from detectors.

16.6 Inspection and Testing

16.6.1 General

Inspection and testing of fire detection and firefighting equipment, piping, valves and fittings shall comply with relevant clauses of the respective NFPA regulations in particular with NFPA 25 and with national standards of the country of the Employer.

All instruments used for the purpose of carrying out reliability, function or certification tests must have an in-date test/calibration certificate. All instruments must be recalibrated and certified in the time period regulated by the relevant standards, but not less than every six months.

16.6.2 Workshop tests

The fire detection and firefighting system shall be subjected to the following tests at the shop:

- visual inspection of all components
- functional tests of the fire alarm panel
- functional test of the complete firefighting pump system
- performance test of the firefighting pumps

16.6.3 Site tests

16.6.3.1 Fire detection system

After completion of erection all items of equipment shall be inspected and tested in order to check quality, correct operation and correct installation of the equipment. The following tests shall be performed:

- visual inspection for completeness, proper installation and consistence with installation documents
- functional test of the complete fire detection system with activation of each individual detector

16.6.3.2 Fire Fighting system

The Contractor shall perform all required acceptance tests and complete the " Material and Test Certificate" as specified in NFPA.

Before commissioning the system, the entire lines shall be flushed thoroughly under pressure through hydrants and other outlets.

Therefore, sufficient vents on high points and drains on pipe low points and system low points have to be installed.

- The flushing rates shall be as specified in NFPA.
- For purposes of flushing, suitable temporary connections may be made from a firewater tank.
- A " Material and Test Certificate" as specified in NFPA shall be supplied to the Engineer for each section of pipe tested/flushed.

The pipework shall be hydrostatically tested before trenches have been backfilled.

The allowable leakage rates shall be measured at specific test pressure points by pumping from a calibrated container.

For purposes of testing, suitable temporary connections and test pump shall be provided.

After successful hydrostatic testing and flushing of the pipes any temporary connections to the (sub-) system tested shall be removed, permanent connection shall be installed.

Performance Tests

Each firefighting pump and other fire-fighting equipment shall be Performance tested to demonstrate that the operation complies with the performance requirements and to provide base data for the assessment of performance throughout the operating life of the equipment. The extent of and procedures for performance tests shall be to the approval of the Engineer.

Unless otherwise specified the program of performance test shall include at least the following:

- Determination of maximum continuous rating,
- Determination of normally operation rating data and performances,
- Leak test, and
- Tests as recommended within NFPA 25
- Functional test of the complete firefighting pump system .

16.7 Training

Works to be done under this section include training of Employer's personnel to operate and maintain equipment efficiently and safely. The training shall be provided as classroom training and hands on training and shall include system operation, system maintenance and trouble shooting.

17 CCTV System

17.1 General

This part refers to the technical and functional requirements for the VMS (visual monitoring system), internationally also referred to as Closed Circuit Television (CCTV) systems to be used in the Substations to be refurbished under the Project.

17.1.1 Basic requirements and objectives

The objective of the CCTV system shall be this of ensuring effective surveillance of all areas of the substation (all switchyards/switchgears, the substation entrance etc.), as well as of establishing a digital storage of video for post analysis purposes.

The main objectives of the system are two folds:

- increase of safety of switching actions by visualization of the status of switching elements like disconnectors and earthing switches
- increase the security, e.g., by supervision of the substation entrance and other security critical areas.

For operation purposes the system shall provide displays on monitors located in the Substation Control Building (substation control room) for the substation operators. With data transmission over the IT Network the displays are also provided to the control rooms of the RDC.

All HV switching elements, especially all disconnectors and earthing switches shall be visualized by quick and easy action of the operators and dispatchers.

The cameras shall be positioned in such way that all switching devices, especially the disconnectors and earthing switches, can be shown by at least one camera with a pre-set sight direction and zoom ratio. The camera shall automatically pan, tilt and zoom to the pre-defined settings after the operator in the substation or a dispatcher in the RDC or BCC has selected this by an action with a minimum of steps.

17.1.2 Requirements for software licenses

All required software licenses for operation, configuration and management of all devices and systems of the closed-circuit television (CCTV) system shall be supplied.

- Software of the cameras for operation (Pan/Tilt/Zoom with pre-settings), for configuration and management
- software for access of the individual cameras from central system of the CCTV and via Internet functionality via IT-network from remote locations (e.g., RDC)

- software of the LAN switches of the CCTV system (operation, configuration, management)
- software of the CCTV central controller / camera server system (operation, operation and control of cameras, configuration and management of the system, with video analytics application software and gateway functionality for access from remote (e.g., from RDC)
- software of the digital video recorder (operation, management and configuration)
- software of the CCTV workplaces (operation, management and configuration) with HMI functionalities etc.
- anti-virus software with permanent update (update until the end of the warranty period included in the contract price), if required
- and other required operation, configuration, management and supporting software.

The following shall be fulfilled:

- The licenses shall be timely unlimited throughout the lifetime of the device or system.
- Failure rectifications and upgrades shall be implemented by the contractor until the end of the warranty period within the contracted version.
- Safety relevant failures rectification patches shall be provided until the end of the lifetime of the device or system.

17.2 Standards and Performance

All equipment to be used for the CCTV system shall be Substation-hardened and able to function under the applicable environmental conditions. In addition, all components (hardware and software) of the system shall be able to interoperate with all other systems (and/or software packages within systems) within the substation.

All components of the CCTV system shall comply with the latest versions of the following standards:

IEC 61850-3	Communication networks and systems for power utility automation - Part 3: General requirements
IEC 62599-1	Alarm systems - Part 1: Environmental test methods
IEC 62599-2	Alarm systems - Part 2: Electromagnetic compatibility - Immunity requirements for components of fire and security alarm systems
IEC 62676-1-1	Video surveillance systems for use in security applications - Part 1-1: System requirements - General
IEC 62676-3	Video surveillance systems for use in security applications - Part 3: Analog and digital video interfaces

ISO/IEC 27037	Information technology - Security techniques -Guidelines for identification, collection, acquisition and preservation of digital evidence

Moreover, the CCTV system shall be appropriately coordinated with the Substations' outdoor and indoor lighting systems.

17.3 Technical Requirements

17.3.1 Color video cameras

The cameras shall be digital CCD color video cameras with individual IP address.

The protection class of the camera housings shall be minimum IP 42 for indoor and IP66 for outdoor.

The following types of color video cameras shall be used:

- fixed perimeter cameras
- Pan/Tilt/Zoom (PTZ) type cameras
- ceiling mounted dome cameras.

All related cabling installed in the Substation switchyards shall be placed within suitable halogen free conduit to protect the cables from being damaged. The cables themselves shall be appropriately marked with the designation of the relevant camera they are connected to.

The paragraphs here below refer to the functional requirements of the aforesaid types of cameras. For all respects not addressed thereby, reference is made to the Technical Data Sheets.

17.3.1.1 Fixed perimeter cameras

An adequate number of fixed perimeter cameras shall be installed along the perimeter of the overall Substation.

The cameras themselves shall be accommodated in a weather-proof, corrosion- and vandalism-resistant housing.

The camera housing shall be supported on an appropriate steel structure support or pole. A junction box shall be used to protect any connections to the camera installed on the structure/pole and shall be mounted on the latter.

The cameras shall be positioned taking into consideration sunlight and coverage distance.

All cameras shall have wide dynamic range functionality.

17.3.1.2 PTZ cameras

The PTZ cameras shall be used in the various Substation switchyards. They shall be positioned in the switchyards to cover all critical points, such as transformers, breakers, disconnectors, earthing switches, entrances to Substation buildings etc.

Their pan, tilt and zoom range shall be chosen accordingly to serve their purpose, subject to their respective location within the overall system. The minimum requirements shall be as per the Technical Data Sheets. Each camera shall be remotely controllable by an operator being in position to pan, tilt, zoom, switch on/off etc.

Where applicable, the cameras shall be equipped with infrared illumination.

The cameras will be installed on the Substation steel-structures, buildings or poles/steel-structures erected for this purpose in specific. A junction box shall be used to protect any connections to the camera installed on the structure/pole and shall be mounted on the latter.

17.3.1.3 Thermal camera

The major equipment Autotransformers, Transformers and Shunt Reactors shall be monitored by thermal imaging camera which can measure temperature differences. The objective of these cameras will be to detected potential problems before they become costly failures, preventing downtime and enhancing worker safety.

17.3.1.4 Ceiling mounted dome cameras

The ceiling mounted dome cameras shall be used inside Substation buildings to capture any incidents that may occur.

The cameras will have a pre-set position towards for example the relevant room’s entrance door, disconnectors and earth switches, transformers, etc.

For all type of cameras, event messages in case of failure shall be configured. The CCTV system shall have the possibility of managing the following: monitoring alarms, fault messages and audio alarms.

They will have a wide dynamic range and electronic day/night function to compensate for poor light conditions. The camera housing shall be round or hemispherical and shall utilize a pan-tilt mechanism.

The cameras shall be mounted to the ceiling by means of appropriate brackets and the cables shall be routed through the bracket and installed in conduit, so they are not visible.

17.3.2 CCTV Local area network (LAN)

The CCTV system shall incorporate a local area network (LAN), fully dedicated to CCTV, consisting of a main switch (in the Substation control building) and additional switches distributed in the various Substation switchyards.

All switches shall be Substation-hardened, and they will be connected with the main switch by means of fiber optic cabling.

Within this LAN, each camera shall have each own IP (Internet Protocol) address.

The system shall allow viewing live and recorded images, as well as controlling of all controllable cameras by the authorized users present in the LAN.

17.3.3 CCTV server system

The CCTV server system, being equipped with all necessary peripherals (such as monitor, keyboard, mouse, joystick etc.), shall be capable to control all foreseen cameras and shall be expandable for future cameras.

The software used for the video display control shall offer all possibilities for matrix features, grouping cameras, programming of automatic alarm-triggered events, programming for automatic recording etc.

In addition, joystick or mouse keyboard controller shall be used for Pan, Tilt, Zoom functions.

The CCTV system shall be provided with shortcut icons which allow to easily zoom on predefined objects (e.g., Disconnectors, Transformers, gates, etc.).

The server shall ensure decoding and encoding of video and audio for storage and transmittal to a remote-control center via the telecommunication system of the Substation.

The substation CCTV system shall be suitable to easily integrated in the National central CCTV system.

17.3.4 Digital network video recording system

The video recorder shall provide the possibility for video stream and storage management.

The system shall incorporate all necessary security functions to ensure that once a video is recorded, it cannot be altered or deleted.

The system shall use video compression techniques for storing the video inputs by the cameras and shall provide sufficient storage capacity for the recordings, as per the Technical Data Sheets. The recordings shall be organized in a comprehensive data base.

17.3.5 CCTV workstations

Workstations for the CCTV system, offering full operability over the cameras installed in the buildings and throughout the Substation area, shall generally be accommodated in the relevant service room of the main Gate House. However, additional workstations shall be located in the Substation Control Building. The workstations will comprise -as a minimum- all equipment (e.g., monitors, keyboards, mouse, speakers etc.) as per the relevant Technical Data Sheets.

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Technical Requirements - Civil Works

Table of Contents

1 Design Requirements and Guidelines

1.1 Basic Instructions for Design

The civil works are predominantly driven by the requirements of the electromechanical equipment to be provided under the Contract and the conditions or specifications stipulated hereafter.

This document represents the basic specification information for calculating the lump sum price of the works concerned but should not be considered to be a complete description in every respect. Drawings which can be found in *Annexes* of the Tender Documents indicate the intended layout of the works but are not determined to be conceived as a final and dimensional reference.

The price offered shall be understood as the total sum for the complete civil preparatory works, services and installations and finishing works to suit the requirements and the functions of the works concerned.

Design and choice of construction materials shall consider and ensure the reduction of future maintenance works, and therefore, all civil elements shall be designed to minimize servicing and to result in a durable construction with a minimum design life of 40 years.

The Contractor shall prepare all necessary basic and detailed design calculations and drawings in accordance with the Contract requirements.

The Contractor shall provide adequately design foundations in accordance with international standards and ensure that the design of all structures under the Contract shall be such that differential and total settlements or other movements shall not exceed acceptable limits and full provision shall be made for all expansion and other type of joints.

Structural members subjected to flexure shall be designed to have adequate stiffness to limit deflections or any deformations that affect strength or serviceability of a structure adversely. The maximum allowable deflections of structural members shall be in accordance with the relevant design standards and the limits prescribed by the machinery manufacturers.

The dimensions of the buildings and shall be such as to provide adequate space for the safe installation, proper operation, maintenance and repair of all equipment to be accommodated in them. In existing substations, where existing control or switchgear buildings are due to be extended, adjusted and/or rearranged, under the Contract, these works are required to suit the specification and relevant equipment requirements.

In order to save energy for air conditioning, adequate thermal insulation of buildings shall be provided. The general transmission coefficient, including walls, roof, windows and doors shall be $K \leq 0.7\ W/m^2\ K$.

Suitable access to the roofs of the buildings shall be provided for maintenance and repair of any installation.

All rooms shall be provided with suitable emergency exits.

Proper access roads shall be provided to bring in all the equipment and to take it out in case of maintenance. These access roads shall be suitable for the vehicles which will be used (cars, fork-lifts, trucks/trailers, etc.) to reach up to the point of unloading/loading of the equipment.

Safe, convenient and straight forward accesses and means shall be provided so as to enable taking equipment in and out of all rooms, at all levels, using suitable stairwells, ramps and mechanical hoists. The dimensions of rooms, stairwells, doors etc. shall be designed to suit the aforementioned transport concept.

All civil designs, calculations and drawings shall be subject to approval by the Employer/Engineer before start of manufacturing and construction. All equipment and materials incorporated in the works shall be of the highest quality and subject to the Employers approval.

All roof and wall cladding systems including ventilators, openings, windows, doors, etc., shall be designed and constructed such that noise level emissions at the site boundary do not exceed 60 dBA.

Special attention has to be paid by the Contractor to the sequences of any extension works described in the electrical part of the specification. In the case of extension works inside substations, the civil works are not limited to the execution of new foundations, but are also deemed to include all necessary adjustments of existing constructions, for the necessities of the extension, various repair works, like roads, drainage, revision of fences, earthing works, etc.

1.2 Particular Architectural Requirements

The external aspects and finishing of all buildings shall be made in harmonic combination of the elevation types with the local conditions and styles. All relevant aspects shall be of the highest quality and subject to the Employer's/Engineer's approval without any cost in addition to the Contract amount.

1.3 Responsibilities of the Contractor

The Contractor shall be solely responsible in all respects for the suitability and stability of the buildings, structures and foundations.

The Contractor shall also be solely responsible for verifying the suitability of his designed foundations for the effective ground conditions.

If the soil has been excavated according to the approved design and the type of ground requires modifications in the design, these modifications shall be carried out by the Contractor without extra charge and shall be approved by the Employer/Engineer.

1.4 Codes and Standards

The civil/architectural and installation service works for buildings and structures shall be designed and constructed according to the highest quality codes/standards specified and good engineering practice.

The latest versions of all relevant laws, directives, codes, regulations and ordinances must be complied with. In particular these include, without being limited to, the following:

- EN standards/guidelines
- British/Indian Standard Codes cross referenced to equivalent international standards
- local state building regulations
- water management regulations
- workplace ordinance/guidelines
- VDE guidelines
- accident prevention regulations
- other approved standards which have the status of EN standards
- conditions, requirements and recommendations from the permits/licenses.

The metric system shall be applied.

1.5 Design Loads

The design loads to be considered for the design of buildings and structures are addressed in the following paragraphs.

1.5.1 Dead load

Dead load is defined as the weight of all permanent construction including walls, foundations, floors, roofs, ceilings, partitions, stairways, and fixed service equipment and shall be calculated according to EN 1991-1-1 or other equivalent standard.

For the substations this would include equipment, accessories, electrical and lighting conduits, switchgear related equipment, instrumentation, fireproofing, insulation, ladders, platforms and other similar items.

The gravity weight of overburden soil shall be considered as dead load, but design of switchyard foundations should consider that backfilling has not commenced prior to installation of equipment.

1.5.2 Live load

Live load is defined as the weight superimposed by the use and occupancy of the building or other structure but not permanently attached to it. For industrial design, live load can be defined as the load produced by personnel, moveable equipment, tools, and other items placed on the structure, but not permanently attached to it.

The loads assumptions / recommendations for live loads given in the table here below have been proven useful in the construction of numerous substations and shall be regarded as minimum requirements. The Engineer's consent is required in all cases for reductions of load bearing capacities and for exceeding the permissible stresses.

Table 1-1: Recommendations for live loads (kN/m^2)

	Slabs and subsidiary supports	**Main girders**	**Supports and walls**	**Foundations**
Normal floors	10	7.5	5	5
Medium intermediate floors	7.5	7.5	5	5
Gratings & light intermediate floors	5	5	5	5
Roofs	1.5	1	1	1

Areas designated for different loadings on the same floor shall be clearly and permanently marked.

1.5.3 Truck load

Structures accessible to trucks shall be designed to withstand the gravity, lateral and impact effects of truck loading. Truck loading shall be the more onerous of SLW 60 as per EN 1991-1-1, or equivalent international standards.

1.5.4 Soil load

Soil loads shall consist of lateral earth pressures. Active and passive coefficients for lateral pressures shall be obtained from the project soils report. The weight of soil shall be considered as dead load.

1.5.5 Wind and snow load

The actual wind and snow load for the calculation of buildings and structures shall be taken from the local codes and meteorological data.

1.5.6 Earthquake load

The seismic calculations of buildings and structures shall be prepared in accordance with the requirements of the relevant local standard, using data of the local authorities for the location(s) of the Project. The Bidder shall be cognizant of the potential for liquification of soil strata in the area during seismic events and make necessary consideration in the design.

1.5.7 Dynamic loads

Each structure shall be designed to withstand the effects of eventual vibration and impact to which it may be subjected. Each structure and foundation supporting equipment having significant dynamic unbalance shall be designed to resist the peak loads specified by the manufacturer.

1.5.8 Other loads - Hoists

For any hoist, the impact force shall be 20% of the lifted loads.

1.6 Design Guidelines

1.6.1 Buildings

Building foundations shall be designed according to the results of soil investigations and with the following admissible settlements:

Admissible total settlement	maximum 2 cm
Admissible differential settlement	maximum 1 cm

Cable floor shall be foreseen as necessary, requested or indicated. In any case, raised modular flooring shall be foreseen for control rooms and control equipment areas.

Provision for cooling or ventilation shall be made for every space of buildings.

Adequate number of doors and emergency exits shall be provided.

Floor slab, external walls, roofs, aluminum or metal clad walls and roofs shall be provided with adequate thermal insulation.

All buildings of the substation(s) shall be equipped with a fire alarm, detection and, if required, firefighting systems. Fire detection and alarm systems shall be designed and installed to meet the most onerous requirements of ISO 7240 or EN 54 or NFPA 72, or equivalent local or international standards.

Foundations and floor slabs shall have projecting galvanized earthing flags connected to the re-bars to enable connection to the earthing grid of the substation. The structural reinforcing bars within building columns and slabs shall be made electrically continuous.

Electrical continuity shall be assured by use of either rebar clamps or by welding across rebar sections. Rebar within any reinforced concrete structural columns shall be bonded to the lightning protection down conductors at cast-in-non-ferrous bonding connections. All steel structures shall be similarly electrically bonded and integrated into the substation earthing.

All substation´s metalwork including transformer tank, cable screens, feeder pillar, boundary fence, doors and any internal steel work shall be securely bonded together so that a good electrical connection exists between each of them and the substation earthing system.

The application of windows and glass panels as well as the general architectural concept of the building and containers are subject to the approval of the Employer/Engineer.

The following fundamental design criteria shall be strictly followed and applied:

- results of soil investigations
- approved codes and standards to be utilized in the design
- loading to be adopted for the various elements of the structure
- load factors and load combinations
- description of the design method and theories to be adopted
- calculation of the structures and general arrangement concepts.

Architectural detail drawings shall include the following:

- plans, elevations and sections detailed enough to enable construction without difficulties
- roofing and water proofing details
- doors and windows schedules
- finishing schedules
- staircase details.

1.6.2 Particular space requirements

Dimension of switchgear rooms, control rooms and all other areas shall be determined taking into consideration the equipment requirements, as identified in the relevant parts of the Contract documents.

In the switchgear rooms, control and protection areas and telecom rooms, sufficient maintenance space shall be provided between the cubicles/panels and walls, so as to allow the complete with-drawing of circuit breakers and/or, clear maintenance space for panels.

If panels have doors on the rear side, the space to the wall shall be sufficient so that, in case of emergency, the escape way is not blocked by open panel doors. The width of the escape ways shall be in accordance with IEC 60364-7-729, but not less than minimum, 0.8 m with open doors.

Pipes, lighting installations and air conditioning ducts shall be located in such a way that sufficient (shadow-free) lighting shall be provided after completion of all installations. Minimum acceptable lighting levels shall be provided in the least illuminated areas of each room.

All necessary ducting and trenching with spare capacity shall be included for the contractor for existing and future purposes.

1.6.3 Building - General

The GIS building shall be of pre-engineered steel structure. Control room building, if attached to GIS hall, shall be of pre-engineered steel structure similar to GIS hall and shall be RCC framed structure, if it is not connected with GIS hall. In case of steel control room building all walls shall be of brick masonry for the ground floor and the floor shall be of RCC. Internal access to the GIS hall from control room building shall be provided.

1.6.4 Control buildings

Where control building is foreseen to be designed and constructed for the substations, then the basic control building shall be designed and constructed by the Contractor according to the basic design indicated in the drawings attached to the Contract with necessary adjustment to accommodate all necessary equipment. The minimum requirements are outlined in the layout drawings, but the design should be in accordance with international best standards and subject to Employer approval.

All auxiliary, control, protection, telecommunication equipment which is not installed adjacent to the main switchyard equipment, shall be accommodated within appropriate rooms of the control building.

The proposed arrangement of the building can be modified by the Contractor according to the specific conditions (i.e. transport ways, arrangement of the equipment, partition of the building, etc.), subject to the Employer's/Engineer’s approval.

1.6.5 Structural description of the control buildings

Structure

For a stand-alone control building, the layout shall be, as indicated in the attached tender drawings, one or two-storey, modular system of reinforced concrete frames with block work infill and with foundations in accordance with the provision of the soil report.

The control building shall be architecturally compatible with the other facilities within the substation and assimilated to the general local environment, with the architecture subject to the approval of the Employer/Engineer.

Roof

The roof shall be of reinforced concrete. A steel structure for the support of the roof may also be acceptable but subject to approval of the Employer/Engineer, without extra cost. The roof shall be waterproof and thermally insulated, in accordance with the present specification and with the applicable international standards for this type of construction.

Doors

The doors shall be double skin insulated metal types, with the required fire resistance (for minimum 3h), large enough to pass the equipment. Double doors shall be foreseen for the MV switchgear room. For offices, archive and sanitary rooms, timber doors may be used. For exterior doors, aluminum doors are foreseen, and they shall be provided with door stoppers. All doors shall be in accordance with international standards, the highest quality and subject to Employer approval.

Cable double floor

Under the ground floor, and below equipment rooms on higher floors, a cable floor with a free height of -at least- 0.9 m, with accesses, shall be foreseen in the rooms indicated on the drawings, and/or where necessary.

Cable access room

Under the floor of the medium voltage switchgear room (this applies to both switchgear rooms located in the control building and in other buildings, as the case may be) a cable access room with a free height of -at least- 1.8 m, shall be foreseen.

Floor finishes

The following floor finishes, subject to the approval of the Employer/Engineer, shall be foreseen:

- epoxy screed (minimum 5 mm thick), with epoxy seal coat for all electrical rooms without double floor and corridors
- acid resistant ceramic floor and wall tiles to a height of 1.5 m for the battery room
- ceramic tiles throughout for sanitary facilities.
- linoleum or vinyl flooring systems for the offices, meeting rooms.

Internal walls

The internal walls shall be block work, or grade brick of the highest quality, plastered and emulsion painted. The internal wall material approval shall be subject to final approval of the Employer, without any additional cost.

Exterior walls

The exterior walls shall be cavity masonry or double-twin walls with thermal insulation, plastered and painted inside, rendered and weatherproof painted outside.

Special attention shall be paid by the Contractor so as to ensure architecturally pleasant solutions for the elevation-views of the building. Local, traditional finishing materials shall be used by the Contractor -as required- in coordination with the Employer/Engineer and subject to approval of the relevant local authorities.

Windows

The buildings shall receive aluminum-framed windows with double glazing to provide natural light in the rooms. In addition to the standard type exterior windows, if a first floor is to be provided, then in the corridor on the first level, internal fix windows shall be provided.

Access to the roof

For access to the roof, external steel service ladder with safety cage, as required by international regulations, shall be installed.

Ventilation, air-conditioning and heating

Individual split type air-conditioning systems shall be installed in the rooms. Central air-conditioning systems may be considered but shall be subject to the approval of the Employer/Engineer. The control building environment shall be cooled, heated and ventilated to suit both the conditions required for equipment, and the ambient conditions for manned operation.

Sanitary equipment

Toilet rooms shall be provided for men and ladies and disabled, with wash basins, western type WC and one Indian commode, urinals, shower, etc.

Kitchen equipment

The kitchen shall be furnished with all necessary equipment as electric cooker, microwave, fridge, wash basins, cupboards, table with chairs, all of which shall be of the highest quality and subject to the Employers approval. Please refer to the particular requirements in Chapter 2.

Furniture

Furniture shall be provided, subject to the requirements and the approval of the Employer/Engineer. This shall include at least two desks, two office tables, four swivel chairs, two visitor chairs and two cupboards for each room, i.e. the office room and the control room. All other rooms shall be provided with adequate furniture, fit to their purpose and subject to approval. Furniture requirements are elaborated in Chapter 2.

1.6.6 220kV and 132kV GIS Building

a) Material Specification

- Primary members fabricated from plates and sections with minimum yield strength of 345 Mpa or to suit design by continuous welding.
- Secondary members for Purlins and Grits shall conform to the physical specification of ASTM A570 (Grade 50) or equivalent IS/BS/international Standards having a minimum yield strength of 345 MPa. The minimum thickness of secondary members shall be 2.5mm.
- Rod / ANGLE/pipe bracing shall conform to the physical specification of relevant BS/IS/equivalent international standards of minimum 245Mpa Yield Strength.
- All hot rolled sections shall conform to the physical specifications of BS/IS/equivalent international standards. All other miscellaneous secondary members shall have minimum yield strength of 250 MPa.

1.6.6.1 Description

Primary Members

Primary structural framing shall include the transverse rigid frames, columns, corner columns, end wall wind columns and crane gantry girders and Frames at Door openings.

Secondary Members

Secondary structural framing shall include the purlins, girts, eave struts, wind bracing, flange bracing, base angles, clips, flashings and other miscellaneous structural parts. Suitable wind bracings sag rods to be reckoned while designing the structure.

Purlins

Purlins should be of pre-galvanized steel of 345 Mpa having a coating thickness of 275 gsm.

Roof Sheeting

Factory assembled 50mm thick puff (density 40kg/cu.m. +2 kg/cu m as per BS/equivalent International Standards) sandwiched panels shall be provided. These panels shall be made of puff insulation sandwiched between two high tensile steel sheets each of 0.5 mm thickness.

The material of sheets shall confirm to ASTM 792 M Grade 345 with minimum yield strength of 345 Mpa. The steel sheets shall be provided with hot dip coating of Zinc aluminum alloy (approximately 55% Al, 43.5% Zn and 1.5 % silicon) .Total mass of zinc aluminum alloy coating shall be minimum 200 gm/Sq. m inclusive of both sides. The tolerance of base metal thickness (BMT) of steel sheet shall be as per BS/IS/equivalent International Standards. After hot dip coating of Zinc aluminum alloy, the sheet shall be provided with steel primer and silicon modified polyester (SMP) paint. The total thickness of primer and paint shall be 40 microns inclusive of both sides (TCT) comprising of 20 microns of SMP paint on top surface and 10 microns of backer coat (polyester coat) on back surface over 5 microns thick primer each on both surfaces with inorganic pigments coated free from heavy metals.

Painting shall conform to BS/equivalent International Standards. In case SMP paint is not available, Super Durable Polyester paint (SDP) can also be used by the bidder without cost implication to the Employer.

Wall Panels

Wall panel material specifications shall be same as roof panels.

Sheeting fasteners

Standard fasteners shall be self-tapping zinc plated metal screws with EPDM bonded zinc plated washers. All screws shall be color coated to match roof and wall sheeting.

Sealer

This is to be applied at all side laps and end laps of roof panels and around self-flashing windows. Sealer shall be pressure sensitive elastomeric Butyl tapes. The sealer shall be non-asphaltic,

non-shrinking and non-toxic and shall be superior adhesive metals, plastics and painted at temperatures from 51°C to + 104°C.

Closures

Solid or closed cell closures matching the profiles of the panel shall be installed along the eaves, rake and other locations specified on drawings.

Flashing and trim

Flashing and/or trim shall be furnished at the rake, corners, eaves, and framed openings and wherever necessary to provide weather tightness and finished appearance. Color shall match with the color of the wall. Material shall be 26-gauge thick conforming to the physical specifications of sheeting.

Sky lights

Skylight is translucent corrugated sheets matching the profile of Roof. The translucent sheets are made from 2mm thick Polycarbonate sheets and shall provide an economic form of general-purpose day lighting. Skylights shall be provided for 5% of the roof area. Color of the panel shall be white with smooth surface finish with a light transmitting capacity of 60% ± 5%.

Gutters and downspouts

Gutters and downspouts shall be adequately designed to ensure proper roof drainage system. Material shall be same as that of sheeting.

1.6.6.2 Connections

Site connections

a) All primary bolted connections shall be provided with galvanized high strength bolts, washers, nuts conforming to specifications of relevant standards.

b) All secondary bolted connections shall be furnished with bolts, nuts, washers conforming to the specifications of grade 4.6 of relevant standard or ASTM-A307.

Shop connections

All shop connections shall be welded with appropriate arc welding process and welding shall be in accordance with relevant international standard as appropriate. The Webs should be welded on to the flanges at both the faces at top and bottom for columns, beams and crane girders. Weld material should have strength more than the parent metal.

Roof and wall bracings

Roof and wall bracings shall have minimum yield strength of 250 Mpa and shall conform to the specifications of relevant standard.

1.6.6.3 Flooring

Flooring in the GIS hall shall be as prescribed in the finishing schedule/

1.6.6.4 Walls

In the GIS building 230mm thick brick wall shall be provided up to first floor level of the control building. 50mm thick puff sandwiched panels as described above shall be provided above this brick wall. All brick walls shall be 230 mm. Mortar used for brick wall shall be of 1:4 (1 cement and 4 sand)

1.6.6.5 Roof

Roofing Panel for GIS hall: 50mm thick puff (density 40kg/cu.m.) sandwiched panels shall be provided as described in previous clauses.

1.6.6.6 Plastering

All internal walls shall have minimum 15mm thick 1:4 cement sand plaster.

1.6.6.7 External finishing

External plaster 18mm thick shall be of 1:4 cement sand plaster in two layers. External surface of the GIS buildings shall be painted with exterior paint Weather Shield Max or Excel Total All as per manufacturer’s specification.

1.6.6.8 Internal Finishing

Internal finishing shall be as prescribed in the schedule of finishes in Chapter 2, shall be of highest quality, in accordance with the most onerous international standards and subject to Employer approval.

1.6.7 Water Treatment Plant Building

The water treatment plant building shall be proved with reinforced concrete foundations and floor slab, bunded as required for fuel spillage containment. The building shall be designed to accommodate and shelter the approved water treatment plant equipment. Ambient conditions should be maintained in accordance with the operating requirements of the equipment manufacturer and finishes shall be provided in accordance with the finishing schedule.

1.6.8 Guard house

The guard house shall be located adjacent to the main substation gate. In case of secondary gates/entrances, no guard house will be provided. The minimum single storey footprint shall be 30 sq.m.

The main gate house shall be a simple one-level construction with service room, kitchen and sanitary facilities, including furniture. Air conditioning, heating and ventilation shall be provided. Structure shall be a reinforced concrete frame with block work plastered infill panels. Finishes shall be as prescribes in the schedule of finishes.

1.6.9 Outdoor foundations and structures

1.6.9.1 Transformer foundations

The main oil-filled transformers foreseen under the Contract, shall be supported on reinforced concrete foundations. In case of adjacent transformers, separation walls (firewalls) have to be provided between the foundations. Fire/blast walls shall also be provided, should the transformers be located within the fire zone for any substation building.

A rail system is to be installed such that rapid change of the transformers can be affected. Bollards to give haulage points for the transport shall be provided at suitable locations.

Provision shall be made for the catchment of oil spillage, rain and fire extinguishing water. Appropriate measures to be made to prevent pollution of the environment by discharging of ejected oily water. The foundation trays shall be provided with slope and raised borders, enclosing an oil pit in which the oil content of one transformer can be discharged in the event of an oil leakage. IEEE 980 shall be observed.

The transformers oil collecting places shall be designed to retain 1.50 times the volume of the transformer oil, latent drainage and water from the firefighting system, in the event of failure or spillage. Provision should be made for the catchment and drainage of oily water of all transformers to an underground oil sump tank (oil separator).

The transformer compound shall be of sufficient size to permit safe working and provide adequate space for installation, maintenance, removal and cooling.

The area within the enclosures shall be designed as a water retaining structure, in accordance with BS EN 1992-3. The tray shall be covered with steel grating and gravel layer. The bottom of the tray shall be sloped in order to drain the oil spillage to the pump sump foreseen in the slab.

The road immediately adjacent to the transformer, used by oil handling equipment for maintenance, will also drained to the oil separator to prevent ground pollution in the event of accidental spillage.

Connection pipe work shall be designed to ensure rapid discharge of the oil to the underground facility resistant to transformer oil at a temperature of up to 80°C.

1.6.9.2 Oil separator

The oil/water collected in the tray underneath the transformers will flow through drainage pipes to an oil separator made of reinforced concrete.

The oil separator consists of three chambers having the following functions:

- a reception chamber, in which the inflowing liquid is being settled; in this chamber water/oil emulsions start to separate.
- the collecting and oil separation chamber where the liquid is being collected and the separation of oil from water is taking place; the dimension of this chamber must be at least equal with 150% of the oil content of the largest transformer allowing for the water discharge of the fire deluge system and volume of the collecting chamber for storm and fire-fighting water. This chamber shall be equipped with an indicator/alarm system signalizing the oil content in the chamber. As needed, the oil shall be extracted by means of pumps.
- the outlet chamber, which receives the cleaned water without oil content, shall be discharged through a pipe of minimum 150 mm diameter into the storm water system of the site.

The oil separator shall be provided with openings in the cover slab and step irons into the walls for easy access into each of the three chambers. The inner surface of the structure shall be treated with oil resistant coating. The top slab as well as the cover of the openings into the slab shall be adequate for the traffic load occurring on the structure.

The design and size of the oil separator shall be in accordance with the relevant VDE technical rule (AGI J21-1) or equivalent international standards.

1.6.9.3 Outdoor foundations

The equipment or steel structure foundations shall be designed according to the relevant loads and soil characteristics, as indicated in the soil investigation report, with the application of the required safety factors. The foundations shall be arranged in a grid system. Attention has to be paid on the level of foundations. These have to comply with the drawings established for the substation in relation with the benchmarks.

The following foundations are considered in this part:

- for supporting structures of cables, etc.
- for supports of outdoor switchgear equipment, towers and gantries
- for kiosks, containers etc.
- other outdoor structure foundations not explicitly specified above
- simple slab foundation for fire water tanks.

The foundations shall be of reinforced concrete, designed and constructed according to the recommendations of the soil investigation report and the respective equipment loads. The foundations shall be designed so that the upper structures are securely supported. The foundations will have adequate dimensions to prevent settlement, overturning, or other displacement and shall withstand the calculated loading.

The overload factors for stability of the foundations (overturning, sliding, bearing and uplift) shall not be less than 2.5 for normal loading conditions and not less than 1.5 for exceptional load combinations.

The effective soil conditions occurred during the excavation/foundation works shall be checked by the Contractor's relevant engineers, recorded and compared with the previous results of the investigations. If essential differences occur, the Contractor has to inform the Employer/Engineer and to propose further measures.

Prior to concreting, the Contractor has to verify the specified soil conditions below the foundation levels by a sounding method as approved by the Employer/Engineer.

1.6.10 Fire walls

Fire walls shall be provided separating oil filled equipment, such as power transformer units, in compliance with NFPA and local codes and standards.

Fire walls must be fire resistant manufactured of concrete. with a fire rating to international standards.

Fire walls must have sufficient thickness (as outlined below) and shall be constructed continuous at all positions. Openings in external walls are not permitted or, if necessary, shall be sealed by fire protection material of equivalent fire rating.

External walls shall be fire resistant if other buildings exist in the vicinity. Internal walls shall ensure the safety of fire zones for min. 90 minutes.

Table 1-2: Requirements for fire walls

Category	Double Wall	One Wall	Slenderness
Reinforced concrete supporting wall	2x140 mm	140 mm	250 mm
Reinforced concrete non-supporting	2x100 mm	120 mm	DIN 1045

1.6.11 Cable troughs/Trenches

All cable troughs/trenches shall be of reinforced concrete. The requirements for cable troughs as detailed in VII-5 Technical Specification apply.

For outdoor trenches exposed to heavy loads (trucks), reinforced concrete covers, calculated for a live load of at least 1000 kg/m^2 shall be provided. At road crossings the truck loads imposed by SLW 60 (if not otherwise agreed with the Employer/Engineer) shall be considered.

The cable troughs/trenches shall be placed on such a level that the storm water can be discharged by natural slope, keeping the ducts always free of water.

The covers shall be of precast reinforced concrete; with suitable lifting device to suit cast-in hot dip galvanized lifting hooks, recessed into the surface of the cover.

Precast cable trenches will be considered as an alternative to in-situ, subject to the approval of the Employer/Engineer.

1.6.12 Water drainage system

1.6.12.1 General

The works comprise the following items:

- A drainage system shall be provided for the complete substation area for evacuation of rain-water from the switchyard surface, roads and paved areas, cable trenches and roof of buildings.
- An exterior perimeter open drainage system shall be provided, if requested by the Employer/Engineer, against the penetration of storm water into the substation area.
- A sewage drainage system, for the connection and discharge of domestic waters from closets, wash basins, showers, sinks, urinals and other similar appliances.

The storm water drainage system shall consist of perforated pipe drains back filled with broken stone or gravel (French drains), as well as approved, of open reinforced concrete drainage ditches and channels.

The system shall discharge the storm water outside of the substation area, as agreed with the Employer/Engineer and Authorities.

For the design of the storm water drainage systems, the following conditions have to be considered:

- Drain ditches shall be built in reinforced concrete. The sloping of open drains shall be of minimum 0.2%.
- The regulations and recommendations of the relevant local drainage standards shall be observed as agreed with the Employer/Engineer.
- The Contractor shall execute temporary channels which may be necessary to prevent flooding of the site, until permanent drains have been completed.
- The wastewater drainage system shall be discharged in a three-chamber sewage treatment plant (septic tank) constructed of reinforced concrete, adequately sized for a minimum number of 20 persons working in the station. From that point, the septic tank shall be discharge to a soak-away pit with inspection access approved by the local relevant authorities.
- In the existing substation the drainage system shall follow the constructive type of the existing system.

1.6.12.2 Design features

For purposes related to the design of drainage systems precipitation intensities prescribed by the local rules and meteorological conditions shall be considered.

The various drains within the substation shall be arranged in such a way as to avoid as far as possible any requirement for auxiliary lifting pumps.

The Contractor shall design the drainage system in order to assure a continuing and safe discharge of water from the site to external lower levels.

The Contractor shall realize also the external connection of the discharge system.

The undesirable swampy soil (if any) shall be excavated and removed from the site and the remaining soil will be adequately compacted to achieve good base for the drainage gravel layer.

The whole site will be filled by gravel, with the exception of landscaped areas, in order to create a drainage system for the substation area.

The arrangement of all drain lines, discharge headers and collectors shall suit the operational requirements. The systems shall have checking facilities to make sure that every drain component of the substation is working properly.

The pipe work for the effluent water shall be designed to withstand all adverse effects such as corrosion attacks, sand and sludge which are likely to occur under normal and emergency conditions. The material of the pipes shall be subjected to approval.

The Contractor shall supply sump pumps including discharge pipes for all pits, culverts, channels etc. if drainage by gravity cannot carry out.

The sump pumps shall be equipped with all switch and control devices including audible and optical alarms to alert personnel of the potential risk of over-flooding in the event of drainage system failures.

1.6.12.3 Materials

Quality and standards

Materials and components, which will be incorporated by the Contractor in the work or structures, shall be selected in accordance with the Employer's/Engineer's requirements and are subject to approval.

Materials shall comply with the requirements and standards acceptable to the Employer/Engineer.

Unplasticized Polyvinyl Chloride (UPVC) Pipes

UPVC pipes are to be used for water supply and storm water sewerage purposes.

Vitrified clay pipes

Vitrified clay pipes are to be used for domestic sewerage, oily water system and chemically contaminated water drains.

Requirements

The storm water drainage system collects only clean storm water which can be discharged into the storm water system of the zone. A substantially maintenance-free and operationally safe installation must be guaranteed. The surface water drainage shall include all necessary gutters, down pipes, gullies, traps, catch pits, manholes and exit as approved by the Employer/Engineer. Inspection pits/manholes shall be provided at each change of direction. The pipes and structures of the drainage system shall be placed such to withstand buoyancy.

1.6.13 Damauli Boundary Wall (Flood Retaining Wall)

At Damauli, the boundary shall be enclosed by a wall of minimum height 2.5m, suitably designed to prevent incursion by vehicle impact and protection of the plot from the 200 year flood. The wall shall be topped by a rigid frame supporting three lines of barbed wire, suitably designed to prevent intruder infiltration. The Bidder should refer to the Annex drawings to understand the design philosophy.

According to preliminary geotechnical assessment, the substation is located on the alluvial terrace. The project area is deemed to be located in the area having seismic zone factor, Z, 0.48g.

The area where the project is located is prone to a potential liquefaction effect of very high to high. The design of the flood retaining wall should respect internationally recognized codes of practice such as USACE (United States Army Corps of Engineers) Engineering Manual EM 1110-2-2502 Retaining and Flood walls.

Maximum flood with return period of 200 years shall be considered as flood event for design. For the stability considerations shall be fulfilled criterions such as:

Table 4-2

Inland Flood Wall Stability Criteria

Case No.	Loading Condition	Sliding Factor of Safety, FS	Shear Strength Test Required		Overturning Criteria Minimum Base Area in Compression		Minimum Bearing Capacity Safety Factor
			Soil Foundation	Rock Foundation[3]	Soil Foundation	Rock Foundation	
I1	Design flood	1.5	(Q &/or S)[1]	Direct shear	100%[4]	75%[4]	3.0
I2	Water to top of wall	1.33	(Q &/or S)[1]	Direct shear	75%[4]	50%[4]	2.0
I3	Earthquake	1.1	(Q)	Direct shear	Resultant within base	Resultant within base	>1.0
I4	Construction	1.33	(Q &/or S)[2]	Direct shear	75%[4]	50%[4]	2.0

Notes

1. For soil foundations which are not free draining (permeability $< 10 \times 10^{-4}$ cm/sec), analyze for both Q and S strengths and design for the worst condition. For free-draining soil foundations (permeability $> 10 \times 10^{-4}$ cm/sec), analyze for S strengths only.

2. For construction loading cases, use Q strengths when excess pore water pressure in the soil foundation is anticipated and S strengths when it is not anticipated.

3. The sliding analysis of a wall on rock should be based on the frictional resistance ($\tan \phi$) of concrete on rock or rock on rock. The values should be obtained from direct shear tests of pre-cut samples of concrete on rock and rock on rock, or direct shear tests of natural rock joints or bedding planes.

4. Less base area in compression than the minimum shown may be acceptable provided adequate safety against unacceptable differential settlement and bearing failure is obtained.

(source: EM-1110-2-2502, table 4-2, Inland Flood Wall Stability criteria)

Since the site has liquefaction susceptibility, then analysis shall be conducted at least using Seed and Idriss simplified method (ref. Chapter 5-13, EM 1110-2-2502) and application of the possible alternatives to deal with liquefaction such as changing of the proposed location (usually the best alternative but not appropriate in this case), removing and replacing the liquefiable materials, improve liquefiable materials in place. Under improvement could be applied methods such as jet grouting, stone piles or so, as well as foundation on the piles.

It is extremely important to identify liquefaction zone and possible risks.
Usage of masonry concrete retaining flood wall or cantilever or counterfort wall shall be considered by the contractor.

Contractor shall choose structural type of the retaining wall according to computations which are going to satisfy stability requirements against the imposed loads such as flood, seismic events and other loads in accordance with usual engineering practice (such as EM 1110-2-2502 code) as well as mitigating risks of liquefaction.

Use of the gabions and vegetation such as Amriso for protection against soil erosion on the slope downwards the riverbed shall be included. All proposals are subject the final approval of the Employer.

Provision shall be made for riverside access, in at least 3 No. locations.

1.6.14 Boundary Fence

Indicative drawings for the boundary fences are included in the Annexes. .All boundary fences shall have beam-type foundations shall have a free height of around 25 cm above the earth and comprise fences of rigid steel type, with a height of 2.5 m above the foundation and subject to the approval of the Employer/Engineer.

The fence shall be installed on reinforced concrete foundations -executed as cast in situ; at a minimum depth of 80 cm. The foundations themselves shall be designed so as to resist to the horizontal wind and earthquake loads.

The beam-type foundations shall have a free height of around 25 cm above the earth.

The posts shall be of steel, well-embedded in the foundation. The fence itself shall consist of sufficient rigid mesh, rigidly connected on as minimum on 3 levels. The steel construction shall be provided with corrosion-protective coating and a surface painting in color which shall be approved by the Employer/Engineer.

The fence shall be earthed and ensure continuity.

The beam-type foundations shall have a free height of around 25 cm above the earth.

Adequately sized electrically operated steel-gates for equipment and separate for persons shall be provided.

1.6.15 Roads, paving and surfacing

The internal road system shall be arranged such that a non-obstructed traffic flow is guaranteed. If necessary, the roads shall be provided with slopes, not exceeding 5%. The roads and paving shall be provided with slopes to lead the storm water to gullies and to the discharge systems.

The roads shall be provided with relevant kerbs, gutters, and storm drain system.

The following types of asphalt roads shall be provided to match existing conditions at Lekhnath but at Damauli, concrete roads shall be provided:

- The access roads, as well as the main internal road, shall be -at least- 7 m wide. Secondary roads can be as a minimum 3 m wide. The minimum radius of main roads shall be designed for heavy vehicles and trailers and shall not be less than 10 m.
- Service roads for installation and maintenance purposes shall be of at least 2.5 m width for ensuring access to the high voltage equipment, within the switchyards. The location of these roads is indicatively depicted on the respective switchyard layouts but shall be determined by the Contractor during the design stage.
- service footpaths of concrete for operation of high voltage equipment of at least 1.0 m width
- The road connections to the buildings, outdoor equipment and kiosks shall be provided by the Contractor even if they are not shown on the general layout drawing.
- The road connections from the main bridge scope of works until the site access gates are part of the scope of civil works.
- Footpaths in concrete block of 1.0 m width shall be provided around the control/switch gear building. The areas around the buildings and outdoor areas which can be used infrequently as lay down areas for small loads, parking areas, etc. shall be paved with interlocking concrete blocks.
- Parking areas shall be provided near the control building and near the guard house.
- Road signs, traffic signs and road surface marking shall be provided, as per the local authority requirements for traffic in industrial areas.

For dimensioning the roads, the actual heavy traffic loads have to be considered. However, as a minimum, the specific standard load of the truck SLW /60 shall be taken into consideration.

Due attention shall be paid to the delivery and removal of power transformers by large cranes or hydraulic jacks.

In the existing substation, the internal road system shall be rearranged so that no obstructions shall occur in the operation phase of the substation.

In the areas of the switchyards not covered by buildings, foundations, structures, roads, paving, plants etc., after the evacuation of the vegetal strata, the surface shall be adequately compacted, and weed-killer suppressant membrane shall be applied.

The outdoor switchyard area shall be filled to the final elevation by a minimum of 200 mm thick layer of gravel and as required by approved grounding requirements.

1.6.16 Landscaping

The free area of land inside of the substation where no roads or gravel is provided, and in compliance with the grounding requirements, shall be landscaped using low to medium-high growing plants and grass. Plantations shall be provided along the main roads and the building. The adopted landscaping approach shall be such so as to avoid hinderances in operation and maintenance of the substation. The landscaping is subject to the approval of the Employer/Engineer.

1.6.17 HVAC and heating system works

Air-Conditioning and ventilation systems shall be provided as defined in VII-1 Scope and shall be selected, calculated, designed, manufactured, executed and tested in conformity with the latest issues of the relevant and internationally recognized codes and standards such as well as all local laws and regulations.

Calculation of heat loads and losses, cooling loads, ventilation and air flow requirements shall be made in accordance with the ASHRAE Standard for Cooling Load Calculation. Commercially available cooling load design programs may be used for load calculation and the results of the calculation process shall be submitted.

For the design, the following room conditions shall be considered as a minimum but shall also be confirmed by the Contractor against the requirements of the respective equipment contained within each room:

Table 1-3: Room conditions for design of HVAC and heating systems

Inside	Min. °C	Max. °C	Humidity %	Unit Capacity %
Switchgear rooms	+20	+28	50% ±10%	3 x 50
Control, relay and office rooms	+20	+25	50% ±10%	3 x 50
Toilets, corridors	+20	+25	n.a	2 x 100
Store Work Shops	+20	+30	n.a	1 x 100

Air-conditioned areas shall be kept at a slight positive pressure in the building to prevent the Infiltration of humid, dust-laden air into the building. However, the battery room, kitchen and sanitary rooms shall have slight negative pressure.

For battery rooms, the conditions should be controlled to ensure temperature control within the optimum performance conditions advised by the manufacturer. Ventilation requirements must follow IEC 62485-1/2.

Air filters shall be provided for air inlets with filter efficiency as follows:

- 85% for control rooms, electronic rooms and offices
- 75% for switchgear rooms and other rooms

1.6.18 Water supply system

The water supply system works include:

- the connection of the internal network to an approved new well source on the site or to an outside source and a storage tank
- the water supply network systems inside of the site
- a drinking water storage tank with capacity as defined in VII-1 Scope.

2 Particular Technical Requirements

2.1 General

The specifications and methods of construction for civil works are specified hereinafter. The Contractor has to follow these requirements and shall conform thereto. In addition, the Contractor shall submit his own proposals for specifications of items not covered by this document and shall be of the highest quality and subject to approval of the Employer.

No work will be regarded as complete, until the Contractor has removed from the site all rubbish and unused materials and has properly dressed and finished all the grounds to the final approved levels and to the full satisfaction of the Employer.

2.2 Site Facilities for the Employer and the Engineer

The Contractor shall provide, in addition to site facilities for Contractor's own staff, separate site facilities for the Employer and the Engineer, in accordance with the Contract.

2.3 Responsibilities of the Contractor

The Contractor shall be solely and, in all respects, responsible for the suitability and stability of the buildings and foundations.

The Contractor shall also be the solely responsible for verifying the suitability of the foundations he designed, considering the effective ground conditions. When the soil has been excavated according to the approved design and it is identified that the type of ground requires modifications in the design, these modifications shall be carried out by the Contractor without extra charge. These works shall be subject to approval by the Employer/Engineer.

The construction work referred hereto shall be performed in such a manner that high standards of quality and function are achieved.

2.3.1 Setting out of the work

The Contractor shall set out the work and shall be solely responsible for the accuracy of the setting out work. He is also responsible for the maintenance of existing and provision of all necessary survey marks.

2.3.2 Materials

All material used in the works shall be new and of best quality of their respective kinds. The materials shall comply with the requirements of the latest edition of the relevant standards.

2.3.3 Workmanship

All workmanship shall be of the highest standard and shall be performed by competent personnel skilled in their respective jobs.

2.3.4 Samples

Samples, when approved, shall be regarded as the acceptable standard. Any material or workmanship subsequently not complying with the samples shall be rejected and replaced by the Contractor. Sample storage boxes shall be provided by the Contractor free of cost.

2.3.5 Tests

Whenever considered necessary by the Contractor/Employer/Engineer, Inspectors may be sent to manufacturer`s or sub-contractor`s facilities in order to test materials or supervise their manufacture.

When specified or requested, the Contractor shall obtain from the manufacturer certificates of test, showing that the materials have been tested in accordance with this specification and the relevant standards.

2.3.6 Prevention of damage

The Contractor shall take all necessary and reasonable precaution during the execution of the works to prevent damage to land, fences, channels, roads, buildings, services on and/or adjacent to the site.

2.3.7 Safety precautions

Wherever works are to be constructed in the vicinity of existing electrical installations, overhead power lines, power cables or any other electrical equipment in operation, the Contractor shall be responsible for ascertaining the necessary precautions and safety measures, as required by the rules and regulations of the relevant local authorities. In addition, the environmental, social, health and safety requirements contained in the Contract shall be closely adhered to.

2.3.8 Cleanliness of site

The Contractor shall at all times maintain the site in a clean condition, and all rubbish, debris etc. shall be collected and disposed as foreseen by the local applicable regulations, in the Contract and/or as requested by the Employer/Engineer.

2.3.9 Offices, stores, workshops, accommodation

The areas to be used by the Contractor for offices, stores, accommodation, workshops etc., as well as free outdoor plot areas for storage of materials shall be approved by the Employer/Engineer but are the sole responsibility of the Contractor.

2.3.10 Sanitary facilities

The Contractor shall be responsible for providing suitable and adequate temporary sanitary facilities for his site staff, as approved by the Employer/Engineer.

2.3.11 Health

The Contractor shall take of all necessary health measures, for his staff, as required by the works and by the statutory provisions of the local health authorities and safety, health and environmental requirements of the Contract.

2.3.12 Water and electricity supply

The Contractor shall be responsible for supplying all temporary water and electricity required for the execution of his works. He should give notice and pay all fees, as required by the relevant local authorities for such supplies and services.

The Employer will give all necessary assistance for electricity connections. Should a temporary supply from utility source be unavailable, the Contractor shall, at no additional cost to the Employer, supply from diesel generator so as to meet the site needs.

2.3.13 Temporary roads and fences

The Contractor shall provide the temporary roads outside and inside of the site and temporary security fences around the site.

2.3.14 Overall and detailed schedules

The Contractor shall prepare overall and detailed schedules for civil works and submit them for approval. The detailed schedule for civil works shall be in accordance with the relevant provisions of the General and Particular Conditions of the Contract.

2.3.15 Supervision

The Contractor shall provide adequate and qualified supervision for all civil works and the works of his subcontractors.

2.3.16 Inclement weather

No additional payment will be made to the Contractor for works due to inclement weather conditions.

2.4 Site Services during Construction

2.4.1 General

Site services such as Contractor’s temporary site buildings, site fire protection, site access control and security, temporary latrines and ablutions, as well as temporary electricity and water supplies are within the Contractor’s responsibility.

2.4.2 Site preparatory works

The Contractor shall clear all materials, debris etc. from the areas required for the temporary and permanent works and accesses. All trees and vegetation, including rubbish and objectionable materials shall be felled, stumped, stacked, burned or disposed of. Unless otherwise stated, holes and cavities resulting from the clearing, grubbing, de-grumping and de-rooting shall be back-filled with acceptable materials and compacted to the density of the adjacent areas.

Materials removed during clearing operations shall be burned, buried in disposal areas or other-wise disposed of, as approved by the Employer/Engineer and in accordance with the relevant local laws and regulations and requirements of the Contract.

Any excavation of cable trenches or foundations near existing services shall be made by hand and not by mechanical excavator.

2.4.3 Site clearance and demolition works

Site clearance and demolition works comprise the removal and disposal of bushes, existing struc-tures and foundations and of all other obstructions on the substation site, access roads, as well as the back filling of existing pits, trenches, channels etc.

Before submitting his bid, the Bidder is given the opportunity to visit the sites, inspect and exam-ine the extent and nature of the various works which are included in the scope of supplies and services.

Demolishing, taking away and storage of existing structures (if any) shall be performed by the Contractor. It is within the scope of the Contractor to plan, follow-up, execute and supervise these demolishing works.

2.4.4 Topographic survey

2.4.4.1 General

The Contractor shall carry out all the necessary surveying works in order to:

- obtain (if available) maps of the construction and surrounding areas
- propose and install new transferred benchmarks (TBM); their level and grid coordinates shall be related to the existing reference system
- conduct spot level topographic survey of the development area and adjacent prominent surface boundaries as well as the access roads
- present all survey data in digital format for processing and detailed maps developments
- produce CAD adaptable and editable maps, natural ground profiles and survey data files of all surveyed items
- produce a survey report of resources, procedures, site and office works and data acquisition, data processing and presentation
- prepare necessary supporting survey data in support of construction permit applications.

The survey shall include all buildings and structures in the substation area (e.g. foundations, fences, overhead power lines, roads, tracks, finished grade, paving, buried services etc.). Furthermore, all pipelines and cables shall be taken up together with any location of equipment installed.

The required accuracy in elevations shall be ±10 mm relative to the existing benchmarks.

The benchmarks shall be secured and marked in such a manner so as to ensure that they:

- can be found at any time
- will not be destroyed by the ongoing construction activities
- can be constantly used for reference and check measurements.

2.4.4.2 Preliminary site survey report

The results of the survey shall be reported by means of the Preliminary Site Survey Report, which shall be submitted by the Contractor. This shall include:

- an executive summary stating the objectives of the survey and containing a brief description of the work undertaken, as well as the major conclusions
- description of the survey work, referring to the method applied, equipment used, work organization, field operation, data processing, interpretation and presentation of the results
- a site survey plan on a scale of 1:500.

2.4.4.3 Final site survey report

Within 2 weeks after the receipt of the Employer's/Engineer's comments on the preliminary report, the Contractor shall submit the Final Site Survey Report.

For the final report the Contractor shall also provide all the survey data in a digital format. In addition, the Contractor shall provide the software necessary to gain access to the data in digital format, as well as the information with regard to the minimum technical requirements of the computer workstation to be used for such a purpose.

2.4.5 Geotechnical investigations

2.4.5.1 General

The extent of the subsoil investigations shall be such as to permit the satisfactory determination of the geotechnical conditions and to allow reasonable foundation proposals. All subsoil investigations and reporting shall be performed by a recognized and approved geotechnical subcontractor, and conducted in accordance with the most onerous of International Standards including USCS, Eurocodes, BS and IS.

The Contractor is responsible for:

- carrying out his own investigation for design purposes
- the correctness of the results of his investigation
- the selection of proper foundations.

2.4.5.2 Scope

The purpose of the site investigations is to accurately capture, sample and in-situ test within the substation areas, including site reconnaissance, site geology, site previous utilization history and above ground and subsurface conditions.

The Contractor shall comply with all local laws, rules and regulations for the relevant works. The investigation procedure shall be governed by the latest editions of relevant recognized international standards and codes.

The anticipated work activities related with the site geotechnical investigations comprise, without being limited to, the following items:

- conduct site reconnaissance, in-situ geophysical and geotechnical exploration including open trial pits, boring, in-situ borehole and open pit testing, piezometer installation, as per planned exploration program
- collect disturbed and undisturbed soil samples and extract water samples from boreholes and open trial pits

- select proper collected samples and perform geotechnical lab tests to classify soils and assess their geotechnical behavior
- compile in-situ data collection, in-situ test results, lab test results and desk studies accounts
- produce a comprehensive factual report of resources, procedures, obtained data, site works and lab tests, desk study, data processing and conclusions/recommendations
- liaise with topographic survey for interchange of information to be introduced on topographic survey maps or to obtain topographic survey information useful in setting out site investigation works.

2.4.5.3 Field works

Boreholes

Exploratory boreholes shall be sunk at the locations approved by the Employer/Engineer. The boreholes shall be 12 cm in diameter.

The depth of boreholes shall not be less than 10 m unless rock is encountered, in which case the thickness shall be proved to be greater than 1.5 m. Where weak soils are encountered, boreholes shall be continued down to a load bearing stratum with a minimum thickness of 3 m, proved.

The boreholes shall be drilled by trained drillers under the direct supervision of the Contractor, according to the established instructions and specifications. Casing shall be used, where necessary, to prevent the collapse of the borehole wall.

An appropriate boring method with continuous recovery of soil samples shall be used. Disturbed and undisturbed samples shall be collected for visual examination and laboratory testing.

The soil stratifications encountered in the boreholes shall be logged during drilling and the borehole logs shall include at least the following information:

- the soil stratification
- the number, depth and type of soil samples
- the corrected penetration resistance
- the groundwater level
- the grain size distribution
- the index and engineering properties of representative samples collected from different strata
- the SPT values
- the drilling method, coring, casing.

Standard penetration tests (SPT)

Down to the depth of drilling, SPT shall be performed in the boreholes at 1.5 m intervals, in both cohesive and non-cohesive soils.

Sampling

During SPT at 1.5 m intervals, disturbed samples shall be collected and submitted in polyethylene bags with proper identification.

Undisturbed samples shall be collected for cohesive soils at 1.5 m intervals. A thin-walled sample tube of an internal diameter of 63.5 mm and length of 610 mm shall be pressed into the cohesive soils by means of hydraulic pressure produced by the drilling rig. The undisturbed samples shall be trimmed and scaled with non-shrinkage wax at both ends and clearly labeled. Disturbed and undisturbed soil samples shall be sent for laboratory tests.

Groundwater level measurement

The water level in each borehole shall be recorded before commencement and after completion of drilling when the water level has settled. The depth of the borehole and the casing (if any) shall be also recorded.

Cone penetration tests (CPT)

CPT shall be carried out as a second method of soil investigation (after borehole sinking) at the locations required and approved by the Employer/Engineer.

CPT shall be carried out using static penetro-meters (Dutch cone test apparatus) for determination of the soil type, density and consistency.

The results of the CPT shall be presented in the borehole log sheets.

Test (trial) pits (TP)

Test or trial pits down to 1.5 m shall be used as a third method of soil investigation in order to visually identify the top strata and its sequence as well as to proof suitability of dredgers. The Contractor shall obtain at least one disturbed and one undisturbed sample of each stratum encountered.

The description of the encountered strata and of the strata sequence, accompanied by colored photographs, shall be specified in the soil investigation report.

General soil characteristics

A general soil/subsoil description shall be made for the investigation, comprising:

- soil conditions at the surface
- expected soil conditions below the surface (slopes etc.)

- inclination of the ground surface, inclination and orientation of cracks and fissures, as well as their stratification, evaluation of slope stability in case there is a potential for sliding.

This information shall be provided to the Employer/Engineer through intermediate reports, to enable him to give instructions for more intensive or additional investigations, if necessary.

The minimum number of boreholes/soundings/trial pits for each site (substation) is given in the below mentioned table:

Table 2-1: Minimum number of boreholes/soundings/trial pits for each site

	Borings	**Cone Penetration Tests (CPT)**	**Trial Pits (TP)**
Switchyard zones	4	4	4
Gantries	4	4	
Power Transformer	2	2	
Control building	2	2	

However, the final number of boreholes will be agreed between the Contractor and the Employer/Engineer.

2.4.5.4 Laboratory tests

Natural moisture content

Tests to determine that natural moisture content (natural water content) and the in-situ wet and dry densities shall be performed on undisturbed samples.

Atterberg limit tests

Tests to determine the liquid limit and the plastic limit shall be performed on representative cohesive soil samples collected from different strata. The Liquidity Index/Consistency Index shall be determined.

Grain size distribution tests

The specific gravity and the grain size distribution of representative soil samples collected from different strata shall be determined with standard sieves and a hydrometer.

Grain size distribution curves with classification (as per USCS, Unified Soil Classification System) of representative samples shall be specified in the soil investigation report.

Unconfined compression tests

Unconfined compression tests shall be performed with a constant strain rate on representative undisturbed specimens with a diameter of 3.56 cm. Stress-strain diagrams of these shall be attached to the soil investigation report.

Consolidation tests

With a 1:1 load increment ratio and 24-hour duration for each increment, standard consolidation tests shall be performed on 2.54 cm thick, representative undisturbed specimens with a diameter of 5.08 cm.

Chemical analyses

The groundwater and the soil shall be analyzed and classified with regard to their aggressive action on concrete. The classification shall comply with DIN EN 4030-1 or another equivalent international standard. The results and recommendations shall be part of the soil test report.

The chemical analyses shall determine the sulfate and chloride contents as a minimum as well as the pH value.

Electrical resistivity tests

Electrical resistivity tests shall be made for a minimum of 8 samples and shall be sufficient to permit calculations to be undertaken to meet the requirements.

2.4.5.5 Objectives of geotechnical investigations

The report generated after the execution of the geotechnical investigations shall contain, without being limited to, the following:

- description of the scope of work carried out
  This shall include:
  - work program
  - methods and systems (equipment) used
  - works carried out (field investigations and laboratory tests).
- layout location plan of soil investigations
  This plan shall depict:
  - the area
  - the general layout plan
  - locations of boreholes, soundings, trial pits and plate tests (if any) carried out
  - comprehensive map surrounds.
- logs, tables
  The subsurface conditions, for example the sequence of the strata, the nature and properties of the individual strata as well as the groundwater conditions shall be determined and described in the borehole logs. The results of the laboratory tests and the diagrams of the test results shall be included in the report.

- borehole logs, trial pit logs and surroundings logs

  These shall include:
  - actual ground level and reference to the local Datum
  - description and limits of various soil layers
  - samples taken
  - SPT results
  - water levels
  - depth of borehole/pit/sounding.
- soil profiles (cross-sections)

  The results of the subsoil investigations shall (in addition to the borehole logs) also be shown in the form of cross-sectional drawings with a vertical scale of 1:100 showing, for example, the following:
  - actual ground level and at the points of investigations
  - results of boreholes including standard penetration test (SPT) graphs
  - trial pit profiles
  - CPT diagrams
  - proposed foundation levels
  - limit lines of soil layers (soil strata)
  - groundwater level
  - legend (key).
- soil classification

  The soils shall be classified according to USCS or BS 3882 or DIN 18196 standards, relevant IS standards, and the most onerous, therefore.
- groundwater classification

  After the chemical analysis, the groundwater shall be classified according to its aggressive action on concrete. The classification shall comply with ASTM standards or equivalent codes.
- foundation proposal

  Admissible bearing pressures of different types of foundations and levels shall be advised. Type and engineering values of proposed pile foundations - if necessary - shall be given. Explanation for recommended soil improvement methods shall be made. Geotechnical restrictions of earth work (cut and fill, slopes, etc.) shall be advised. Recommendations for foundations shall be derived from the in-situ investigations and from the laboratory tests.

A comprehensive investigation report shall be produced in two stages, as per the following paragraphs.

2.4.5.6 Draft report

Within six weeks of completion of the soil investigation field work, the Contractor shall submit the draft report to the Employer/Engineer for comments and approval. The draft report shall be complete and shall contain all information mentioned above.

2.4.5.7 Final report

A final revision of the report in mention shall be issued after incorporation or satisfactory addressing of all comments and requirements on behalf of the Employer/Engineer.

All report deliverables, documentation, maps and drawings shall be compatible with the current versions of M/S Office suite and CAD systems. Data to be interchanged with topographic surveyor shall be in electronic format, suitable for further electronic processing.

2.5 Earthworks and Excavation

2.5.1 General

This section covers all the necessary work of the excavating, importing, placing, disposal and compaction of earth, retaining walls, and slope protection works, as required by these specifications and the drawings submitted along with the Tender Documents, for the proper execution of the works.

The Bidder is expected, before submitting his bid, to visit the site and familiarize himself with the ground conditions on the site, the nature of the soil to be excavated, obstructions which may be encountered within the limits of the excavation, the possibility of flooding etc. In this context, no claims will be accepted after award of the Contract in this regard.

The site shall be excavated, filled and graded to the required leveling, which shall be established by the Contractor taking into account:

- the results of the topographical surveys performed by the Contractor
- the protection against flooding of areas.

The quantity of imported filling from borrow pits shall be kept to a minimum.

2.5.2 Water removal

Removal of water during and after excavation is included in the Contractor's scope. The Contractor shall provide all facilities and take any action is necessary to keep the excavation clear of water, at all times of the execution. Disposal of water shall be in accordance with all Environmental requirements of the Contract.

2.5.3 Topsoil removal

The first earthworks operation shall be the removal of topsoil, to a depth as agreed with the Employer/Engineer. The topsoil shall be kept separate from other material and stock-piled for re-use on the site in the landscaped areas, if required. If not, it shall be disposed by the Contractor.

Disposal of waste material shall be in accordance with all Environmental requirements of the Contract

2.5.4 Execution of excavations

The works shall be excavated either by hand or by use of mechanical excavating equipment.

Excavation by hand shall be required close to existing installations and/or underground services.

The contractor shall carry out earth- and rockwork for the works defined hereafter:

- clearing and grubbing
- excavation of topsoil
- open cut excavation
- backfilling and compacting
- safety precautions during earthwork
- underground excavation (if required)
- leveling and grading
- replacement of material
- creation of permanent drainage and external discharge system
- trench excavation for service lines
- embankment excavation and filling works in the areas of retaining walls (if any)
- manual excavations, where mechanical equipment cannot be used.

2.5.4.1 Safety precaution

The Contractor shall be responsible for all necessary safety measures according to the provisions of local and international regulations.

Proper strutting, sheeting and bracing, including re-arrangement of the installations, when necessary, stabilization and protection of slopes, methods of excavation to reduce risks of slides etc. shall be considered by the Contractor.

2.5.4.2 Over excavation

If somewhere, and for any reason, excavations are executed beyond the established lines and without the Employer's/Engineer's previous approval, the Contractor shall -at his own expenses- backfill with approved material (including required compaction) or with lean concrete with the volume corresponding to this of the over-excavation.

2.5.4.3 Stockpiles and disposal

Excavated material from the works which has been selected by the Employer/Engineer for re-use shall be placed immediately in its final position, if possible. Otherwise, it may be stockpiled or deposited on site, as directed by the Employer/Engineer.

The Contractor shall not have the right either to additional payment or to claim because of work involved in stockpiling materials, re-use of materials or for carting to the waste disposal areas. Soil unfit for re-use shall be removed to sites approved by the Employer. The excavated material which will not be used for backfilling works shall be removed from the site by the Contractor at a disposal area, in accordance with local laws and regulations and instructions of the Authorities. This clause is valid also for the debris resulting from any demolition works.

2.5.4.4 Back filling and fill material

The material for filling shall be made with natural material free from mud, silt, vegetable or other soft or injurious matter. The Contractor shall inform the Employer/Engineer of the source or borrow pit from which he proposes to obtain the material.

As soon as possible after the permanent works are sufficiently hard and have been inspected and approved, backfill shall be placed where necessary and thoroughly consolidated in layers not exceeding 200 mm in depth.

If during the execution of the excavation, due to delay because of floods, bad weather, slips, etc., any sand, mud, weeds or other materials will be deposited or accumulated on the excavated areas, such materials shall be removed by the Contractor at his own cost.

The Contractor shall provide pumping to keep the whole of the works, including the deepest foundations, free from water.

The positions of all temporary sumps shall be approved by the Employer/Engineer. No sumps shall be permitted within the area of the foundations of the permanent work.

Due notice shall be given by the Contractor when he considers that any excavation beds have been properly and finally prepared, so that the Employer/Engineer may arrange to make the necessary inspection.

The fill materials shall be examined by the Contractor and approved by the Employer/Engineer. Here below, the various categories of fill material are listed.

Select fill

The intention is to use select fill below structures, roads, parking areas etc. Select fill shall be well graded, non-cohesive and nearly silt free, salt free and free of organic matter.

The material shall be of such nature and character that it can be compacted to the specified densities. It shall be free of plastic clays, of all materials subject to decay, decomposition or dissolution or other materials which will corrode piping or other metal.

Ordinary fill

The intention is to use ordinary fill for non-built areas. Ordinary fill shall be natural inorganic soil. The salt content shall not be greater than 5% and the organic matter shall be less than 3%.

Special fill

The intention is to use special fill as, for example, sub-base material for open-air switchgear areas, buildings and roads. Special fill material shall be gravel or crushed rock.

Density requirements, as per tests according to the modified AASHTO (American Association of State Highway and Transportation Officials)

180 Method D or equivalent, at optimum moisture content, shall be as follows:

- under buildings and structure foundations and slabs 97%
- under roadways and parking areas 95%
- under transformers and other major foundations 97%
- embankments 95%.

2.5.4.5 Placing and compacting

The filling shall be placed in layers not exceeding 200 mm in depth and the surface of each layer shall be given a slight fall to allow natural drainage.

Each layer shall be compacted at optimum moisture content by eight (8) tone smooth wheel rollers, or equivalent vibrating roller, or other approved means.

Subsequent layers shall not be placed and compacted until the previous layer has been compacted as specified and accepted by the Employer/Engineer.

Filling material that does not contain sufficient moisture to achieve the required degree of compaction shall be sprayed with water until compaction can proceed at optimum moisture content.

2.5.4.6 Excavations for ducts, pits, trenches, foundations, drainage, discharge facilities, etc.

Excavation shall be taken out to the minimum sizes necessary for the proper construction of the works. The excavation shall not be kept open for periods longer than necessary and reasonably required for the construction of the works.

The Contractor shall take all precautions necessary to ensure that the bottoms of excavation are protected from deterioration and contamination and that the excavation is carried out in such a manner that adjacent foundations, pipes, etc. are not undermined, damaged or weakened. Any excavation taken out below the proper level without approval shall be made good at the expense of the Contractor using lean concrete.

The Contractor shall be responsible for the stability of the steep sides of excavations and shall provide and install all timbering and shoring necessary to ensure stability.

Shoring shall not be removed until the possibility of damaging of the works by earth pressure has asset.

The bottoms of all excavations shall be properly trimmed and leveled, inspected and approved by the Employer/Engineer before placing of concrete.

2.6 Site Finishing

2.6.1 Weed killer

Weed killer of an approved type, suitable for local conditions, shall be spread over areas to be covered by site surfacing before such surfacing is laid. The weed killer shall be of type which does not cause corrosion of metals and shall be used strictly in accordance with the manufacturer's instructions. A weed suppressant membrane should also be incorporated in the design for pervious areas.

2.6.2 Switchyard surfacing

Switchyard surfacing shall consist of 200 mm clean, hard, natural, gravel or crushed stone graded from 20 to 40 mm.

The gravel/crushed stone shall be free from dust, in order to avoid that dusty gravel retains the moisture for a long time increasing the time duration during which it is less effective

It shall be uniformly spread after installation of service and cable earth strips, electrical equipment etc.

The site shall be provided with both uphill and downhill retaining walls (if necessary). The natural stones shall be procured from possible existing sources but with adequate suitable geological formations.

The use of a natural stone or reinforced concrete retaining wall as a basic solution shall be designed, calculated and measured according to the effective approved standards/rules and these shall be subject to the Employer's approval. The free surface of the wall should have a planar set stratification provided with fine skinny joints.

The rainwater from the back side of the wall shall be drained by storm water overflow openings distributed at regular distances on the wall face.

2.7 Road Works and Surfacing

2.7.1 General

This section contains the requirements for the construction of the roads and pathways.

Culverts, pipe drains, ducts and other services shall be completed under and alongside roads. The Contractor shall take all necessary precautions to prevent damage to completed or partially completed services until the roads and paths have been completed.
Slopes, ditches, drainage channels, discharge structures etc. shall be suitably designed and executed ensure the drainage of all storm water and to avoid possible damages to the road foundations.

All designs should be in accordance with all relevant international standards including US, Eurocode, BS, IS and the most onerous thereof.

The access roads belong also to the road works and their position, along with the exact positioning of the main entrance to the site, will be settled during the design stage. However, no claims on behalf of the Contractor on such a basis will be accepted.

2.7.2 Sub-base

Sub-base material shall be crushed rock or other approved local material having suitable properties and in accordance with the following grading:

Table 2-2: Grading for sub-base material

BS (British Standard) Sieve (or equivalent) Mm	**Percentage by Weight Passing**
75	100
37.5	85-100
10	45-100
5	25-85
0.6	8-45
0.075	0-10

The sub-base shall be compacted by approved plant to a dry density which shall not be less than 98% relative compaction.

Wet mix base material shall consist of crushed gravel or crushed rock and shall be suitably proportioned to be in accordance with the following grading:

Table 2-3: Grading for wet mix material

BS (British Standard) Sieve mm (or equivalent)	Percentage by Weight Passing
50	100
37.5	90-100
20	60-80
10	40-60
5.00	25-40
2.36	15-30
0.600	8-22
0.075	0-8

The base shall be compacted by approved plant to a dry density which shall be not less than 98% relative compaction.

The final surface shall be shaped and finished true to line and level within a tolerance of ±10 mm to the levels.

2.7.3 Road base

Wet mix road base material shall be crushed and mixed by an approved plant. Water for adjusting the moisture content shall be added at the mixer. If required, the moisture content shall be adjusted to allow for evaporation loss during transportation. After mixing the material shall be removed from the mixer and transported to the placing location without delay.

The compaction procedure and plant shall be proved by trials at the commencement of the Works. The weight, type and number of passes of compaction plant shall be varied to determine the optimum compaction.

The road base shall achieve a minimum dry density of 98% or modified Proctor density of 97% according to the relevant standard.

2.7.4 Hard shoulders

The material used for any hard shoulders (for the access road(s)) shall comply with the relevant standards.

2.7.5 Bitumen macadam

Aggregate shall be hard, clean, durable crushed rock or gravel and sand, all in accordance with approved standards and shall be obtained from an approved source which shall not include quarries containing significant proportions of weathered, decomposed or extensively fractured materials.

The Contractor shall propose certain source(s) and samples shall be obtained for testing before obtaining aggregate. Laboratory tests shall be made at regular intervals to confirm the suitability of aggregate.

Table 2-4: Aggregate quality (table 1 of 2)

	Wearing Course	**Base Course**
Aggregate crushing value	20%	25%
Flakiness index	25%	30%
Elongation index	25%	30%
Water absorption	2%	2%

Coarse aggregate may contain up to 15% of pieces with one uncrushed face in each grading size.

Table 2-5: Aggregate quality (table 2 of 2)

Test Sieve (mm) % by weight passing	**Grading (20 mm nominal size)**
28	100
20	95-100
14	70-90
10	55-75
6.3	40-60
3.35	25-40
1.18	15-30
0.075	2-6

Bitumen shall be of Grade 60/70 penetration.

2.7.6 Final surfacing

The Bitumen Macadam binder course shall be kept clean and uncontaminated so long as it remains uncovered by a wearing course.

Should the binder course become contaminated, the Contractor shall take the appropriate measures for cleaning it, to the full satisfaction of the Employer/Engineer.

2.7.7 Interlocking paving blocks

Footpaths and areas to be paved with interlocking concrete blocks shall be excavated and placed with 300 mm depth of compacted material at the exact levels and falls required for the finished work.

If parts of the base are found to be unstable, the Contractor shall excavate further to a firm bed and fill with layers of thoroughly compacted fine crushed rock or aggregate. The upper surface of the base shall reflect the exact profile, fall or contour of the final paving as irregularities shall not be compensated for by varying the depth of sand bedding.

A stable edge shall be provided to retain the paving units and sand bedding by means of concrete edging. The sand bedding shall be a fine, well graded sand in a dry to moist condition and laid to a thickness of 50 mm.

The paving blocks shall be laid in accordance with the manufacturer’s instructions and shall be compacted at completion.

The interlocking block shall be a minimum of 80 mm thick and the concrete quality shall be approved by the Employer/Engineer.

2.7.8 Foundations

The foundations shall be performed according to the requirements of the specific, applicable loads and the findings of the soil investigation’s report. Special measures have to be taken if the results of soil and laboratory tests prove chemically aggressive conditions.

Foundations for electrical equipment shall be reinforced concrete.

The soil conditions met during the foundation works are to be checked by the Contractor's soil engineer, recorded and compared with the previous results of the investigations. If essential differences occur, the Contractor shall inform the Employer/Engineer and shall propose further measures.

Prior to pouring of concrete, the Contractor shall verify the specified soil conditions below the foundation level by sounding.

Especially with regard to the extension works in existing substations, the Contractor will be responsible for obtaining all necessary information on the type and design of the existing foundations and considering it for his own design.

The bid shall include for foundations to any modular fire pump house and associated foundations for fire-fighting storage tank.

2.7.9 Drainage of foundation pits

During the foundation works, the excavated areas, foundation levels and pits shall be kept free of water.

2.7.10 Waterproofing

The necessary measures shall be taken so as to protect the structures against water action, e.g. in accordance with EN 1992-1-1 (Euro code 2).

2.7.11 Pit-wall stability

The excavated pit sides, walls or slopes shall be stable and established with respect to safety regulations.

2.7.12 Settlement and expansion joints

Permanent or working joints are to be arranged in such a way that stresses and strains caused by settlements, temperature, differential settlement, etc. do not adversely affect the structures. The settlement joints shall run through the complete structure down to foundation level, the expansion joints however shall stop on the top level of foundations. The joint width shall be at least 2 cm.

Settlements of all relevant structures shall be measured, recorded and shown in diagrams according to recognized standards.

2.7.13 Foundations at different depths

Foundations at different levels shall be based beyond a load spread angle of 30° (against the horizontal).

2.7.14 Safety against uplift

For all parts of the structures extending into the ground water table, safety against uplift has to be guaranteed during all execution stages.

2.7.15 Shallow foundations

For shallow foundations, the latest editions of the following standards shall apply:

EN 1992-1-1	Euro code 2: Design of concrete structures - Part 1-1: General rules and rules for buildings
EN 1997-1	Euro code 7: Geotechnical design - Part 1: General rules

Equivalent British and Indian Standards will also be considered but the most onerous thereof shall apply.

The excavation for the foundations shall be done by machines if the underground is not disturbed by this procedure. In any case, the last 20 cm above the foundation level shall be excavated by hand.

2.7.16 Soil replacement

If unsuitable soils are encountered below the foundation level, they shall be replaced by suitable layer-wise compacted material down to the bearing soil. This statement is especially typical for the swampy areas.

Attention has to be paid by the Contractor regarding the design of foundations to be executed in filled areas of the site. The allowable pressures on the soil are generally lower and do not achieve the resistance of undisturbed soils (such as in the cut areas). This is especially critical in downhill areas.

2.7.17 Piling works

This paragraph regards the requirements for the materials, the installation and the realization of bored cast-in-place concrete piles with grouting at the base and driven cast-in-place piles.

The piling works (if any) and its design shall be in accordance with the latest editions of the following standards:

EN 1536	Execution of special geotechnical work - Bored piles
EN 12699	Execution of special geotechnical works - Displacement piles.

Equivalent British and Indian Standards will also be considered but the most onerous thereof shall apply.

2.7.18 Waterproofing systems

The civil works include all necessary waterproofing works including, but not being limited to, tanking systems, treatment of horizontal and vertical surfaces, joints, -including roofs- together with the related protection works of the water proofing.

2.8 Concrete Works

2.8.1 Standards

In general, the concrete works shall be based on Euro code 1, 2 and 4, the provisions of the EN standards or equivalent local rules, standards and regulations. IS standards may also be considered but in general, the most onerous International Standards shall apply.

2.8.2 Materials for concrete

All materials used for concrete and reinforced concrete structures shall be of the best quality, free from defects that can undermine the strength and duration of service of the works. The materials furnished must at least comply with the agreed standards and with all requirements described in these technical requirements.

All materials shall be stored and handled in a manner that will prevent contamination and/or deterioration. Deteriorated and/or contaminated material shall not be used for the concrete and shall be removed from the site at the expense of the Contractor.

2.8.2.1 Cement

The cement used for concrete, reinforced concrete, mortar, grout and plaster works shall be a moderate sulfate resisting Portland cement in accordance with DIN 1164, EN 197-1, or another equivalent standard. Mixes prepared with an alternative of ordinary Portland cement may be considered by the Employer/Engineer but similar resistance to chemical attack must be demonstrated and approved.

All deliveries of cement to the concrete supplier shall be accompanied by a certified mill test report and shall include all of the physical and chemical properties.

The manufacturer's test certificate will normally be accepted as proof of compliance with these requirements but in case the Employer/Engineer requires it, confirmatory tests shall be conducted by a recognized quality control organization, at Contractor’s cost.

The following information shall be provided for the cement which is intended for delivery to site: date of manufacture, date of original loading, destinations end-route and date of unloading, intended date of delivery to site.

Cement which has been manufactured longer than 3 months before the proposed date of delivery to the site shall be inspected, sampled and tested for approval purposes before delivery to the site.

The Contractor shall obtain and provide to the Employer/Engineer the manufacturer’s Bulk Average Test Certificate for each consignment of cement to the works.

Samples shall be taken from each consignment of cement and tested as directed by the Employer/Engineer in an approved independent laboratory.

All bagged cement shall be stored in a weatherproof building which shall be kept clean at all times.

Cement shall be adequately protected against rain, humidity and dewfall, and all charging and discharging points shall be properly sealed.

2.8.2.2 Water

Water for preparing concrete and mortar shall be clean, fresh and free from organic and/or inorganic matter in solution or suspension in such amounts that may impair the strength or durability of the concrete. Water may be obtained from local sources after comprehensive testing and analysis of samples. No seawater or water from excavations shall be used. Water shall be stored in clean containers.

2.8.2.3 Aggregates

Materials used as aggregate shall be obtained from a source known to produce aggregates satisfactory for concrete and shall be chemically inert, strong, hard and durable, of limited porosity and free from adhering coats, clay lumps and organic impurities that may impair the strength or durability of the concrete. Aggregates shall comply with and be tested in accordance with the requirements of the relevant standards.

2.8.2.4 Concrete additives

Concrete additives approved by the Employer/Engineer can be used to improve consistency, workability, quality and strength of the concrete. Unless otherwise agreed, additives must comply with an approved standard.

Plasticizers are intended to reduce bleeding of free water at the surface. It shall only be used after the written approval of the Employer/Engineer and in accordance with the manufacturer's instructions.

2.8.3 Concrete mixes

2.8.3.1 General description and proportions and mixing

The mix proportions shall be determined by proper mix design, based on the requirements for strength, workability and the particular site in which the concrete is to be placed. The mix design shall be carried out by the Contractor's responsible specialist and shall be subject to approval.

The following table lists the various concrete classes.

Table 2-6: Concrete Classification

Concrete Class	Cube strength at 28 days in MPa	water/cement ratio	Max. nominal aggregate size in mm	Min. cement content in Kg/m^3
C 16/20	20	-	25	280
C 35/45	45	0.40	20	380
C 40/50	50	0.40	20	400

Or equivalent M classification for all of above.

Concrete aggregates and cement shall be proportioned and batched by weight. Water and liquid additives shall be proportioned.

2.8.3.2 Trial mixes

Before concreting commences, the Contractor shall, at his own expense, make trial mixes to determine the mix proportions required to produce the strengths specified for each class of concrete and for each degree of workability required to allow placing, transporting and compacting of the concrete with the equipment he proposes to use in any particular situation.

Only materials which the Contractor intends to use for concreting (including all admixtures) shall be used in the trial mixes.

Test cubes from trial mixes shall be made and tested in accordance with approved standards.

All trial mixes and cube testing shall be undertaken at a certified laboratory approved by the Employer/Engineer,

The appropriate strength requirements may be considered to be satisfied if none of the strengths of the cubes is below the required characteristic strength (as per *Table 2-6: Concrete Classification*) and if the average strength of nine cubes is not less than recommended by the standards.

2.8.3.3 Consistency of concrete

The amount of water used in the concrete shall be adjusted as required to ensure such a consistency that it can be readily transported, placed and compacted without segregation of the materials or bleeding of free water at the surface. Addition of water to compensate for stiffening of the concrete before placing shall not be permitted. Consistency of the concrete shall be checked by slump tests.

2.8.3.4 Mixing of concrete

The cement and aggregate shall be thoroughly mixed in a batch-type pull mill mixer. The capacity of the mixer shall not be less than 2.5 m^3 and the total capacity of the batching mixing plant shall be such to accommodate the various concrete quantities to be cast in a continuous way.

The water shall not be added until all the aggregate and cement are in the drum. Mixing shall continue until the concrete is uniform in color and for not less than 1 minute after all the materials and water are in the drum.

Partly set or excessively wet concrete shall not be used. No concrete shall be mixed by hand.

2.8.3.5 Strength of concrete

Testing of fresh concrete will be conducted by means of test cubes.

All test cubes shall be made and tested for compressive strength in accordance with concrete testing method as per the following standards:

EN 12350-1	Testing fresh concrete - Part 1: Sampling
EN 12350-6	Testing fresh concrete - Part 6: Density

Equivalent British and Indian Standards will also be considered but the most onerous thereof shall apply.

The minimum required strength for different classes of concrete is as shown in *Table 2-6: Concrete Classification*.

One (1) set of test cubes, or test cylinders, shall be tested for 100 m^3 of concrete. One set consists of three cubes or cylinders.

A minimum of seven (7) test cubes shall be made on each concreting day (from the same mix) and for at least each 40 m^3 of concrete mixed.

For columns, beams and cantilevers, seven (7) cubes for every 15 m^3 of concrete poured shall be taken.

The molds for the test cubes shall be made of steel. Tests shall be carried out in an approved laboratory.

The strength level of each type concrete will be evaluated separately, and the concrete strength will be considered satisfactory if any individual strength test result, as defined above, is greater than 85% of the specific minimum cube strength (characteristic strength).

If the results are less than those specified, the Employer/Engineer shall be entitled to suspend all concreting work and order further tests.

Any concrete found not to comply with these specifications shall be broken out and replaced to the satisfaction of the Employer/Engineer.

The Contractor shall pay all costs incurred in making, curing, delivering and testing of concrete cubes.

All test cubes will be tested at a certified laboratory using calibrated equipment.

2.8.3.6 Transport of concrete

Immediately after mixing, the concrete shall be conveyed to the place of use as rapidly as possible using methods which will prevent the segregation, loss or contamination of materials. The concrete shall be placed and compacted within 90 minutes of the addition of water to the mix. Any concrete left unplaced after this time shall be rejected and removed from the site.

2.8.4 Concreting operations

2.8.4.1 Inspection prior to concreting

All concreting methods shall be subject to the approval of the Employer/Engineer.

Concrete placing shall not be started until the Employer/Engineer has approved all preparation of forms, reinforcement, joints and all mixing, conveying, spreading, curing, finishing and protection equipment.

2.8.4.2 Placing of concrete

Concrete shall be placed in the forms as close as possible to its final position, in a single operation to the full thickness of slabs and beams and shall be placed in horizontal layers, not exceeding 2.5 m height, in a single pour in walls, columns and similar members.

The Contractor shall organize the pouring of concrete in such a manner that once concreting of a section has started the operation shall be continuous. Each operation shall be completed prior to a stoppage.

The temperature of concrete shall not exceed 30°C, measured at discharge into the works. Concrete shall not be placed when the ambient temperature is above 37°C and it is rising.

Where specified on the drawings, construction, expansion or contraction joints shall be provided and the concrete shall be poured continuously between two adjacent joints. No other joints apart from those that may be shown on the drawings shall be permitted. Stoppage (cold) joints formed between two concreting operations separated by more than 6 hours' time shall be subjected to the same treatment as the construction joints. Where the design requires a water retaining or water excluding structure, proprietary water bars shall be adopted in all joints.

Concrete shall not be dropped into place from a height exceeding 2 m. Chutes -subject to Employer's/Engineer's approval- shall be used for any concrete to be fed from a height exceeding 2 m.

Concrete which has partially been hardened shall not be exposed to injurious vibration or shock, except for controlled re-vibration where specified. When concreting of a certain large structural element is specified strictly as to be poured continuously, then the concreting operations shall be organized for day and night working, in long shifts, as necessary.

2.8.4.3 Compaction and mechanical vibration of concrete

As concrete is being placed, it shall be compacted by mechanical vibrators, to obtain a dense material, free from honeycombing, water and air holes. For compacting the concrete, internal vibrators shall be used, operating within a range of 5000 to 10000 cycles per minute.

The Contractor shall ensure that the vibrators are used in such a manner that the reinforcement is not displaced, the formwork not damaged, and no segregation caused, but complete compaction of the concrete is achieved.

2.8.5 Construction joints

The number of construction joints shall be kept as low as possible, in consistence with reasonable precautions against shrinkage. Concreting should be carried out continuously up to construction joints.

Where it is necessary to introduce construction joints, careful consideration should be given to their exact location, which should be indicated on the drawings. Alternatively, the location of joints should be subjected to agreement between the Employer/Engineer and the Contractor before any work commences.

Construction joints should be at right angles to the general direction of the member and should take due account of shear and other stresses.

Immediately prior to recommencement of concreting on a joint, the surface of the concrete against which new concrete will be cast should be free from laitance and should be roughened to the extent that the largest aggregate is exposed but not disturbed. Care should be taken that the joint surface is clean immediately before the fresh concrete is placed against it.

Particular care should be taken in the placing of the new concrete close to the joint. This concrete should be particularly well compacted and if possible, a vibrator shall be used.

A record shall be kept on site of the time and date of placing the concrete in each section of the work.

2.8.6 Expansion and contraction joints

The expansion joints, contraction joints and other permanent structure joints shall be provided in positions as shown in the drawings.

Joints shall be straight and vertical, except where otherwise specified and concrete surfaces on both sides of the joint shall be flushed. Where necessary, water stops of a type approved by the Employer/Engineer shall be embedded in the concrete. The water stop shall be made of high-quality material which must obtain its resilience through the service life of the structure for the double function of movement and sealing.

To ensure a good tightness with or without movement of the joints, the water stop should be provided with anchor parts. The complete works of fixed and welded connections must be carried out strictly in accordance with the manufacturer's instructions.

2.8.7 Concreting at night

When approval is given to carry out concreting operations (under control of the Employer/Engineer) at night or in places where daylight is excluded, the Contractor has to provide adequate lighting at all points of mixing, transportation and placing of concrete.

2.8.8 Concreting in high ambient temperature

The temperature of the mixed concrete shall not exceed 30°C. The Contractor shall take special measures in the mixing, placing and curing of concrete. These measures shall include the shading of aggregates, spraying of aggregates with water, cooling of the mix constituents (introduction of ice to the mixing water) and reduction of transportation time to the minimum.

During placing, suitable measures shall be provided to prevent premature setting of concrete placed in contact with hot surfaces. All concreting areas, formwork and reinforcement shall be shielded from the direct rays of the sun and sprayed with water when necessary.

2.8.9 Protective measures for concrete

The minimum concrete cover shall be as follows:

- concrete parts above ground (external surface) 50 mm
- concrete exposed to underground and groundwater 75 mm
- slabs (internal) 30 mm
- beams and coils (internal) 40 mm

Immediately after the compaction of the concrete has been finished, the Contractor shall ensure adequate protection from the weather. The concrete surface shall be covered with a layer of sacking, canvas, straw mats or similar absorbent material, special protection sprays kept constantly moist for at least 7 days.

Curing compounds or other methods of preventing evaporation may be used if approved by the Employer/Employer's Representative.

Where formwork cannot be removed within 24 hours after placing the concrete, the formwork shall be kept shaded from the direct rays of the sun and shall be sprayed with water.

Where large sections of concrete are poured, special precautions to the approval of the Employer/Employer's Representative shall be taken to reduce and dissipate the heat generated by the setting and hardening of the concrete (e.g. built-in cooling water pipe system).

The minimum amount of reinforcement shall be present to prevent shrinking cracks.

No load of any kind shall be allowed on concrete which has not properly set and the Contractor shall prevent any load to be imposed on the concrete structures until it has been declared by the Employer/Engineer to be ready to carry loads.

2.8.10 Repair of damaged or defective concrete

Concrete which has completed its final setting shall be inspected by the Employer/Engineer and any cracks, honeycomb areas, segregations, etc. shall be marked. No repairs shall be carried out until directed by the Employer/Engineer. Repairs shall be performed using approved proprietary repair mortars in accordance with manufacturer's instructions.

2.8.11 Protection of concrete surfaces

The concrete face shall have the finish indicated in these technical specifications or in the relevant drawings.

All surfaces which may come into contact with oil or oily water shall be adequately protected (paint, etc.). The finished surface of all concrete work shall be sound and free from defects. No plastering, cement wash or mortar shall be applied to cover defective concrete faces. The repair works shall be executed to the approval of the Employer/Engineer.

All concrete surfaces of cable basements and the like which are endangered by ground water shall receive a water proofing membrane of approved type with protection board against the soil.

All concrete in contact with soil shall receive a bituminous coating of at least two layers.

2.8.12 Reinforcing steel

Reinforcing steel, complying with Euro code 2 shall be used in reinforced concrete.

2.8.12.1 Reinforcement supports

Reinforcement supports shall include all spacers, chairs, ties, slab bolster, clips, chair bars, and other devices for properly assembling, placing, spacing, supporting, and fastening the reinforcement.

Spacers shall be cast from concrete of the same quality as that in which they will be embedded.

Concrete block spacers shall be cast in metal molds with an approved means of separating blocks and of ensuring that the blocks are of the proper size.

2.8.12.2 Certificates of steel reinforcement

Each consignment of steel reinforcement shall be accompanied by a test certificate from the manufacturer showing that the steel has been tested and analyzed and the date of such tests and analyses and that such tests and analyses comply in all respects with the applicable standards.

2.8.12.3 Rejection of reinforcement steel

The Employer/Engineer will reject any reinforcement steel as the result of any failed test therefore not withstanding the manufacturer's certificates.

2.8.13 Finishing of concrete

All exterior corners (angles of 90° or less) of reinforced concrete shall be chamfered (25 mm x 25 mm).

The top or final surface of all concrete works shall be finished by screening, floating, troweling, grinding, tooling as approved by the Employer/Engineer.

Dry cement or cement and sand shall not be used to dry excess water on the concrete surface.

Floors and slabs, which are required to be finished smooth, shall be troweled just before the setting of the concrete.

Screening shall be executed by moving a straight edge or template by hand or by mechanical means immediately after compaction of the concrete.

Floating shall follow screening but shall not be started until some stiffening of the concrete has taken place.

With regard to troweling, where specified as necessary, the floating shall be followed by finishing until a smooth surface free from defects is obtained.

Where specified, the methods to produce the desired surface shall be approved by the Employer/Engineer. The grinding and/or tooling shall not start until the concrete has hardened sufficiently to prevent dislodgment of the aggregate.

Wherever possible, all chiseling works shall be carried out with mechanical devices.

2.8.14 Formwork

2.8.14.1 Design and construction of formwork

With regard to the type of formwork, its stability and the support framing used, the relevant EN standards or the most onerous of BS or IS standards shall be observed.

The formwork and the supporting structure shall be dimensioned so as to be able to withstand all vertical and horizontal forces safely.

Supporting structures shall be sufficiently rigid to maintain the forms in their correct position and to be true to shape and dimensions so that the final concrete is within the limits of the dimensional tolerances.

2.8.14.2 Materials for formwork

Forms shall be constructed from steel or from sound timber, well-seasoned and free from shakes. Plywood lining for forms shall be of timber which is resin bonded and water repellent.

For HV equipment foundations, steel forms shall be used.

Formwork surfaces in contact with concrete shall be free from adhering grout, projecting nails, splits or other defects.

Joints shall be sufficiently tight to prevent the leakage of cement grout. Connections shall be constructed to permit easy removal of the shuttering and shall be either nailed, screwed, bolted, or otherwise secured so as to be strong enough to retain the correct shape during consolidation of the concrete.

The fair faced concrete facades have to be to the satisfaction of the Employer/Engineer. The concrete surface for facades has to be absolutely free of stains and all efforts have to be taken in this direction.

2.8.14.3 Preparation and inspection of formwork

Before concrete is placed, all formworks shall be inspected to see if it is built according to the approved plans and to see if it has been cleaned and is free from sawdust, shavings, dust, mud, earth or other contamination and properly oiled. Contact surfaces of panels shall be treated with a suitable release agent (e.g. non-staining mineral oil) where applicable. Surfaces which are not oiled shall be wetted thoroughly to prevent warping.

2.8.14.4 Erection and placing of formwork

All formworks shall be erected and placed in accordance with the construction drawings approved by the Employer/Engineer. Shuttering shall be true to line and braced and strutted to prevent deformation underweight and pressure of the wet concrete, live loads, wind and other forces. The deflections shall not exceed 3 mm.

Formwork for walls and elsewhere shall be arranged for a maximum concreting height of 2.5 m in a single pour. Where necessary, panel openings are to be provided in the forms for cleaning, inspection, access of vibrators, etc.

All formworks will be inspected and approved by the Employer/Engineer before concrete placing commences but this shall not relieve the Contractor of any of his responsibilities under the contract.

2.8.14.5 Removal of formwork

Formwork shall not be removed until the concrete has sufficient strength to carry its own weight plus any constructional or designed loads likely to be applied with a normal factor of safety. It shall be removed in such a manner that no shock or injury shall result to the concrete.

Before removal of the formwork, the concrete shall be examined, and removal shall proceed only under due guidance and supervision.

Indicative hardening periods for concrete for soffit formwork are as follows:

Soffit formwork to slabs	8 days
Soffit formwork to beams	10 days

Indicative hardening periods for concrete for vertical formwork to columns are as follows:

Walls and large beams	24 hours
Props to slabs	14 days
Props to beams	21 days

Extreme care shall be taken to avoid chipping of corners during removal of formwork.

2.9 Fences and Gates

2.9.1 Perimeter fences

Fences around the perimeter of the substation site (property borders) shall be provided. Indicative drawings are provided in the Annexes.

The fences shall be connected to the earthing systems of the substation and continuity should be demonstrated between all posts panels and frames. Consideration of continuity should also be given at gates and openings.

The fence shall be of rigid, galvanized steel with posts at maximum 2.5 m intervals. The concrete foundation, reaching in depth at least 80 cm, shall have an over ground part with height of at least 25 cm.

From this level (25 cm) up to the top of the fence (2.5 m), there shall fixed galvanized steel, made of flat bars to the posts, connected at -minimum- 3 levels. The steel part of the fence construction shall be provided with corrosion protection and surface painting, as instructed by the Employer/Engineer.

Modification of fences around the perimeter of existing substation sites, shall be extended by the Contractor according to the requirements of the Employer/Engineer, and shall match the existing construction.

All perimeter fences and gates shall be of the highest quality and subject to the approval of the Employer, without additional cost.

2.9.2 Internal fences (if any)

Internal fences shall be materialized by means of welded wire panels, of minimum height of 2 m and mesh size of 50x50 mm. The mesh shall be made of galvanized coated steel and the wire diameter shall be 6 mm supported by reinforced concrete foundations. The fence panel frames shall be made of L profiles of minimum size of 50 mm.

Chain link fences with height of approximately 2 m, made of plastic-coated galvanized steel wire, shall be erected on 0.20 m high perimeter beam, made in steel or reinforced concrete and provided with adequate reinforced concrete foundations according to the Contractor´s design.

The internal fences shall be connected to the earthing system.

2.9.3 Gates

The entrance gates shall be mechanically operated sliding gates with barrier, of an opening of at least 6.00 m. A separate personnel door shall be provided near the guard house.

The height of the gate shall correspond to the height of the adjacent perimeter fences.

The gate shall comply with international accepted standards and shall be constructed of plastic-coated galvanized chain link mesh on a plastic coated galvanized RHS or tubular steel frame.

Gate posts shall be made of plastic coated galvanized RHS section and set in concrete in the ground. Gate hinges (pivots) shall be heavily galvanized and plastic coated.

The gate shall be provided with locks.

The gate and associated structures shall be connected to the earthing system.

All gates shall be subject to the approval of the Employer/Engineer.

2.10 Drainage

2.10.1 Introduction

The sites shall be provided with adequate provisions so as to prohibit storm water from entering to the site. The external drain shall consist of open trapezoidal channels with stone pitching against the erosion effects of the flowing water. At the entrances, the drainage shall be executed by means of embedded pipes.

The details regarding the discharge of water at the exterior of the substation are subject to the Employer's/Engineer's approval.

2.10.2 Work execution

The site drainage works have to be executed in harmonic combination with drying up works of the eventual wet areas of the site.

For trench excavation, slope safety and stability and refilling, please refer to the relevant paragraphs of this document.

For pipe laying and backfilling the requirements of the pipe manufacturer, EN 1610 or equivalent shall be considered.

The design of the pipes shall be based on the maximum combination of loadings (external and internal) and shall be applied systematically for the whole pipeline. This program shall be subject to approval prior to execution of the works.

Independently of any groundwater lowering measures which may be necessary, the bottom of the trench shall be kept free of water to permit satisfactory excavation, placing and compaction. Buoyancy effects on the pipes are strictly to be avoided during the construction period.

Appropriate precautions (e.g. filters) shall be taken to prevent earth from entering the drain pipe. Mechanical filter stability is to be ensured for all adjacent layers.

The below mentioned activities are subject to approval.

2.10.2.1 Preparation of the trench bottom

The dimensions and shape of the trench bottom shall be designed to suit the required working space and type of pipe bedding. Trench bottom material must not be loosened. It must be protected against digging up, washing and scouring. Any cohesive bottom soil which becomes loosened, or it is swampy must be removed down to the depth of disturbance before pipes are laid and must be replaced by gravel soil or special approved pipe bedding. Non-cohesive soil shall be compacted by layer wise tamping or vibrating.

2.10.2.2 Bedding of pipes

The pipes may be bedded on:

- Type A existing soil
- Type B a bed of placed sand or gravel sand
- Type C concrete support
- Type D concrete enclosure
- Type E special forms of construction

Type A, Bedding on existing soil

Assuming that the soil encountered at the pipe bottom is suitable, is workable by hand, has a minimum bearing capacity of 15 N/cm^2 and has at least medium to stiff consistency or medium density, the following instructions must be observed:

- The bedding in the natural soil shall be performed so that it corresponds to the surface of the pipe. In the cross-sectional area this applies for a supported segment of the circumference of the pipe corresponding at least to a bearing angle of 90° (related to the center line of the pipe and in accordance with the design and calculation).
- The natural density of the subsoil shall not be disturbed (loosened).
- The bedding must be executed in such a way that the pipe is completely and uniformly supported throughout its length.

Where the trench bottom is of sand, the bearing surface shall be contoured from the undisturbed soil to suit the shape of the outside of the pipe before the pipe is laid, so as to ensure that when laid the pipe is firmly supported over its entire length.

For pipes of cast iron, plastics and steel of all nominal bores and or pipes of concrete, reinforced concrete, stoneware and reinforced concrete pressure pipes up to and including nominal DN 600, a firm support can be obtained by placing the pipe on the carefully leveled bottom of the trench, provided that material is packed and compacted beneath the pipe to ensure uniform load-bearing support. If these requirements cannot be satisfied the following methods of bedding shall be executed.

Type B, Bedding on a gravel layer

If the soil encountered is not suitable as immediate pipe bedding, a layer of "select fill" has to be placed under the pipe. This layer has to satisfy the following conditions:

The sand or fine gravel used must be well graded. In the case of natural material, the maximum particle size is 30 mm. In the case of crushed stone material, the maximum particle size is 15 mm.

The thickness of the bedding below the lowest point of the pipe must be at least 10 cm + 1/10 of the pipe nominal bore.

After placing, the bedding must be compacted by suitable equipment so that the pipe rests firmly on the bedding over the entire prescribed bearing angle (90°).

Type C, Concrete Support

If the material of the trench bottom is unsuitable for forming a gravel bedding, if the bottom is steeply inclined or if there is a risk of sand being washed out by drainage effects or if local loads require it, the pipes shall be fully bedded on concrete.

The minimum thickness of concrete bedding shall be 5 cm + 1/10 of the pipe nominal bore, with a minimum value of 10 cm.

The surface of the concrete bedding shall be shaped to suit the outside of the pipe so that when laid the pipe rests firmly over the prescribed bearing angle. Bedding concrete can be placed after aligning of the pipe. If it is placed before the pipe is installed, the pipes must be laid in a fresh layer of mortar.

Type D, Concrete Enclosure

In order to increase the load-bearing capacity of pipes, a full concrete enclosure may be provided on some locations / crossing of roads / ducts etc. In designing the cover (static calculation), it is important to consider whether the concrete will be cast against the undisturbed soil or, for example, against sheet piling; the later extraction of sheet piling has an adverse effect upon the relieving action of the horizontal earth pressure.

The minimum concrete quality for pipe enclosure is B15. Construction joints should be bridged by short reinforcing bars.

It may be advantageous to subdivide the concrete enclosure by suitably spaced concrete joints at the pipe connections.

2.10.2.3 Penetration of pipes through buildings and structures

The penetration of pipes through buildings, shafts, thrust blocks and other structures or the transition from the pipes to any structure must be designed in such a way that differential settlements do not occur or cannot cause leakage or damage. Such penetrations or transitions shall be designed to be flexible by rocker pipes or other arrangements, if not otherwise approved by the Employer/Engineer.

2.10.2.4 Supporting and anchoring

Pipes laid in groundwater shall be secured against uplift by anchoring or additional loads, if their dead-weight is not sufficient. If branches, bends, transition pieces, closures and the like are incorporated in pressure pipelines in such a way that they do not transmit longitudinal force, they shall be so secured that these forces are resisted.

Thrust blocks and other fixing structures are to be arranged in such a way that the ends of the reinforced/pre-stressed concrete or other pipelines remain without being subject to all forces and displacement.

Bend structures are to be calculated as gravity structures. The pipeline forces have to be transmitted by bottom friction from this gravity structure into the ground. Horizontal active and passive earth pressure may not be taken into consideration.

2.10.2.5 Special measures for aggressive water and soils

In the presence of aggressive water or soils, in addition to the use of pipes made from especially resistant materials, it is important that the surfaces of pipes and joints are protected by special precautions.

2.10.2.6 Test for water resistance

The pipes shall be tested for water resistance before being backfilled. The regulations of the manufacturer or referred to in this technical requirement shall be used as the basis for the test.

2.10.2.7 Embedding and backfilling of pipes

Until final acceptance and fill, the Contractor shall protect pipes, trench and inspection pits from damage and obstructions.

Embedding of pipes and backfilling shall not be commenced until pipe joints and supports are capable of being loaded by overburden and other forces which occur during backfilling. Embedding and backfilling shall be done in accordance with the respective parts of this specification. This especially applies to the suitability of fill materials, compaction requirements and quality assurance (internal control and independent spot check). The number of independent spot checks is limited to one check per 3 km trench length, at least three checks, being performed.

The number of tests can be increased by the Employer/Engineer if the results are doubtful. The costs for this are to be included in the lump sum price.

For embedding of the pipes, material according to paragraph shall be used. The maximum particle size is limited to 30 mm for embedding. Bedding material is to be deposited on both sides of the pipe up to a height of 30 cm above the pipe crown in layers and shall be compacted as for 'select fill'.

Under-packing and compaction shall be carried out with the greatest possible care; only hand tamping using flat tampers or light mechanical compaction equipment shall be employed. Under-packing shall be carried out simultaneously from both sides, in order to prevent displacement of the pipe. Any external protection (coating) provided on the pipeline shall not be damaged.

Backfilling and placing of fill over pipes must be carried out in layers, materials used and compaction to be chosen in conformity with the drawings or to correspond to the subsequent use of the areas above the pipeline. The thickness of the layers and the compaction equipment shall be such that the stability of the pipeline is not prejudiced. In addition, the compaction equipment shall be selected to suit the ground conditions and trench supports. The fill material and fill procedure shall be as defined for “select fill” if not explicitly specified otherwise.

The use of heavy tamping and vibrating appliances where the pipe cover is less than 1 m is not permitted.

Flexible pipes, as e.g. glass fiber reinforced plastic pipes, shall be designed taking into account soil mechanical and foundation engineering aspects. All relevant checks and calculations have to be made following at least two different internationally recognized design methods/standards.

The pipe bedding and pipe zone shall be compacted to at least 90% of modified proctor density (or 80% relative density if proctor density cannot be determined).

Where required, suitably sized concrete thrust blocks shall be incorporated in pressure pipelines. Thrust blocks shall be cast against undisturbed soil.

2.10.3 Structures of the drainage system

2.10.3.1 Shafts and manholes

Manholes shall be provided at each inlet to the drainage system at each change in gradient or direction, and at maximum intervals of 30 m. The diameter of manhole should be chosen as a function of the pipe cross-section. Either prefabricated or cast-in-situ concrete manholes may be used.

Cast-in-situ concrete shafts shall meet the requirements set out in paragraph *2.8. Concrete Works*.

Manholes on foul water, oily water and chemically contaminated water drains shall be rendered internally on all faces using anti-corrosive resin mastic. All manholes shall have step irons. Concrete and mortar benching will be formed at the base of each manhole formed in a way to ensure smooth uninhibited internal flow.

Manhole covers and frames shall be heavy duty type, except where flush with paved surfaces, where they shall be ductile iron and be of sufficient strength for the duty to which they will be subjected.

2.10.3.2 Oil-separator and mud trap

Oil polluted sewage shall be led through mud traps and oil separators installed immediately outside the building before entering the sanitary sewage system.

The oil-separators shall comply with approved standards and shall be equipped with automatic closing acoustical and optical alarm, and local indication of oil to be separated. The materials shall be of cast iron and precast concrete pipes.

2.10.3.3 Pump stations

Pump stations may be required for collection of clean drain, stormwater from building roofs and paved areas and cleaned sanitary sewage. They shall be constructed of cast-in-situ concrete and mainly buried into the soil. The top slabs shall not be subject to traffic loads and shall therefore be surrounded by steel railing.

2.10.3.4 Open channels

Open channels may be required for collection of drain, storm water. They shall be constructed of cast-in-situ concrete and mainly buried into the soil. The top slabs shall not be subject to traffic loads and shall therefore be surrounded by steel railing.

2.10.4 Accessories

2.10.4.1 Covers, trash gratings

Shaft and manhole covers shall be made from cast iron and reinforced concrete, of watertight construction, with and without dirt traps, to suit local requirements. Shaft and pit covers shall have a test load suited to the traffic conditions. The dimensions of trash gratings shall be those determined by proper structural design. Trash gratings shall be of cast steel.

2.10.4.2 Step irons

Only corrosion-protected or stainless-steel materials may be used. Where shafts are constructed of reinforced concrete, the step spacing shall be 33.3 cm. Climbing irons shall be staggered, maintaining a horizontal axial spacing of 30 cm.

2.10.4.3 Pumps and valves

Drainage and stormwater can be very corrosive and abrasive in certain cases. This must be taken into consideration when selecting the appropriate construction material.

Furthermore, the design of the pump must be taken into consideration so that the pumps are able to operate with the minimum of maintenance due to their location and the operating procedure.

For basement and low points drainage, the pumps shall be effluent sump pumps with submersible motor in wet installation.

Workshop and site tests shall be carried out as laid down in the appropriate section and in the accordance with the relevant standards and codes.

Any other standards can be accepted provided they are equal or better than the specified codes and standards.

2.10.5 Tests

The main test shall be carried out at a test pressure which is greater than nominal pressure. If a line cannot be tested under pressure in one operation, then it shall be tested by lengths (partial length testing).

The value of test pressure shall be determined as follows:

- for pipes with a permissible operating pressure of up to 10 bar ($10\ kN/cm^2$): 1.5 x nominal pressure
- for lines with a permissible operating pressure above 10 bar ($10\ kN/cm^2$): nominal pressure + 5 bar ($5\ kN/cm^2$).

Testing shall not be repeated until all defects have been rectified. When the pipeline, anchorage and pipe joints are inspected, it should not be possible to detect any evidence of lack of water resistance and/or changes in position.

Before backfilling of the trench, the approval of the Employer shall be obtained.

Pressure lines for water supply purposes shall be carefully cleaned, vented, washed out and sterilized before being brought into service.

For the pressure test of drainage lines, the requirements of the relevant standards shall be complied with.

A test report on each internal pressure test shall be supplied to the Employer/Engineer without special request.

2.11 Cable Troughs, Ducts and Trays

The requirements of VII-5 Technical Specification shall apply as a general requirement.

2.11.1 General

Ducts are required for installation of all buried cables. All cable ducts shall be constructed of cast-in-situ reinforced concrete in accordance with the specifications of concrete works.

2.11.2 Outdoor troughs and ducts

The network of switchyard ducts consists of:

- main cable troughs and ducts with free dimensions of 1000 x 1000 mm
- terminal troughs and trenches with free dimensions of 800 x 800 mm, to distribute the cables into the equipment foundations.

Outdoor Troughs shall have concrete covers with maximal weight of 50 kg.

2.11.3 Indoor ducts

Trenches inside of building shall be of the open type covered by checkered steel plates (6 mm thick as a minimum).

2.11.4 Cable trays

Cables in control buildings shall be laid on adequate metallic cable trays and they shall be properly fixed. The fixing clamps shall be adequately sized to withstand the short-circuit and shall not have sharp hedges to prevent the cut of the cables due to vibrations. The metallic cable trays shall be adequately grounded.

2.12 Structural Steel

2.12.1 General

Structural steel shall conform to the latest editions of Euro code 3, ISO 10721 or another equivalent standard.

All specified steel structures, except where otherwise required, shall be hot-dip galvanized.

The minimum weight of galvanizing coat shall be:

- 900 g/m² on steel sections 5 mm thick and over
- 600 g/m² on steel sections 2 – 5 mm thick.

Bolts and nuts shall conform to approved standards.

All welding joints shall conform to approved standards.

Allowable deflections for steel structures shall not exceed the following values:

1. Deflection on beams and girders due to live load
   - length / 240: for cantilevers
   - span / 360: for beams carrying plaster or other brittle finish
   - span / 300: for all other beams
2. Horizontal deflection of columns due to live and wind loads
   - height / 500: for tops of columns in single-story buildings
   - height of story / 500: in each story of a building with more than one story
3. Monorail and hoist beams
   - span / 600: for vertical deflection, unless more strict criteria are requested by the manufacturer.

4. Grating and floor plate under live load
   - span / 300: measured with respect of the support, but not more than 6 mm elements
5. Steel stairs
   - tread width = minimum 250 mm
   - riser height = maximum 190 mm
   - where a stair height exceeds 16 risers, each flight shall be equal and separated by a landing.
   - stair tread width = minimum 1000 mm for secondary stairs and 1200 mm for main stairs.
   - minimum headroom of stairs shall be 2300 mm.
   - the stairs shall be provided with a light-weight weather protection.

All structural steel works shall be protected from damage during handling, transporting, unloading and storage. The Contractor shall be responsible for the correct positioning and correct levels of structures in relation to the relevant drawing.

2.12.2 Design characteristics

If not otherwise approved, site joints for the structure shall be bolted and not welded. The construction methods shall be such as to permit easy erection and shall conform to the stipulation given in other parts of these specifications.

Maximum dimensions and weight of the structure elements will be limited by the local transport conditions which should be investigated and verified by Contractor.

2.12.3 Materials

Structural steel primer paints shall be those of a recognized manufacturer experienced in coatings. The type of paint shall be submitted to the Employer for approval prior to use.

All other materials not specifically described but required for a complete and proper installation of structural steel, shall be new, free from rust and subject to approval by the Employer/Engineer.

2.12.3.1 Surface conditions

Prior to installation of the work of this subsection, installed work of all other subsections must be carefully inspected and it must be verified that all such work is complete up to the point where this installation may properly be initiated.

It shall be verified that structural steel may be fabricated and erected in agreement with the original design, the approved drawings and related standards.

2.13 Non-Structural Steelwork

This portion of the scope includes all labor, materials, equipment and services required to complete all steel work shown on drawings and as specified herein, including, but not being limited to, the following items:

- anchor bolts, leveling plates and slim packs with complete instructions and templates to facilitate installation
- base plates, columns, beams, girders, bracing, hangers, and related connections (bolted and welded)
- floor plating
- supports for equipment or elements from other supplies
- corrosion, protection
- temporary erection bracings and supports
- miscellaneous steel structures (like ladders, rails, etc.)
- Unless specifically excluded, furnishing and installing of all structural steel work indicated on the drawings, specified or obviously needed to make the work of substation complete.
- All ferrous materials, their dimensions, forms, weights, tolerances chemical and mechanical properties, shall comply with the relevant standards or approved equivalents.
- All work shall be carried out in accordance with the requirements of the drawings and the specification. All parts in the assembly shall fit accurately together and corresponding parts should preferably be interchangeable. Forced correction to fit the member together will not be allowed.
- The Contractor shall submit to the Employer/Engineer for approval the country of origin and manufacturer of the steel he proposes to supply.
- All steel shall be carefully stored and handled so that pieces are not subjected to excessive stress or damage. Steelwork shall be stored on site such that it will be free from earth and dirt and will be properly drained.
- The Contractor shall be responsible for the correctness of his shop details and site connections.
- All steelworks shall be smooth, un-deformed, straight and free from cracks, twists and burrs.
- In the event of damage, immediately all repairs and replacement necessary shall be undertaken by the Contractor, subject to the approval by the Employer/Engineer and at no additional cost to the Employer.

2.14 Grouting Works

2.14.1 General

Non-shrinking grout will be used as support for the heavy steel structure base plates.

All types of grouts to be used in these works shall comply with the relevant standards.

A grout is regarded as "non-shrinking" if, after hardening over a period of 28 days during which the test specimens have been completely protected against drying and evaporation, its volume is still not less than the initial volume.

2.14.2 Mixing

Ready-to-use grouting material and water shall be used. Materials shall be mixed in accordance with the manufacturer's requirements.

2.14.3 Preparation

All defective concrete, laitance, dirt, oil, grease and loose material shall be removed from the concrete foundation until sound, clean concrete is obtained. The surface of the concrete shall be left reasonably rough but not so rough as to interfere with proper placing of the grout.

2.15 Finishing Works

2.15.1 General

With regard to the finishing works, please refer to the following table. However, this table is not deemed to necessarily be exhaustive or fully applicable to the Project. All finishes shall be of the highest international standards and subject to approval of the Employer. Any buildings or rooms not included, or any other special items shall be agreed upon between the Contractor and the Employer/Engineer. All materials are also subject to prior approval by the Employer/Engineer.

Table 2-7: Floor finishes per type of room

Type of room	**Floor finishes (typical)**
switchgear rooms	epoxy screed (trowel applied minimum 5 mm thick) and epoxy seal coat
toilets mess room	glazed non-slip fully vitrified ceramic tiles
offices	heavy duty tiles
corridors, stairs, landings	vitrified ceramic tiles (floor tiles with epoxy grout)
battery rooms	acid/lye resistant ceramic tiles, plaster and acid / lye resistant paint
control room, relay rooms, electrical equip-	heavy duty PVC tiles on false floor
Workshop/storage rooms	Ceramic tiles
instrument/electrical workrooms	heavy duty PVC / rubber backed tiles

False ceilings shall be provided to all areas of the control building except for battery rooms, switchgear rooms, welfare areas, stores and workshops. The ceiling system shall have fire resistant, sound absorbing and thermal insulation characteristics. Ceiling panels shall be mineral board with the dimensions of 600mm x 600mm. They shall conform to BS8290 and non-combustible class 0 to parts 1 and 4 of BS 476. The suspension system shall be of sufficient strength and rigidity and aluminum frames shall support each panel which shall be secured with locking clips to the grid. Rod hangers shall be galvanized steel of 4 mm diameter (minimum). Power driven fasteners shall be used for fixing the rod hangers in the reinforced concrete ceiling.

2.15.2 Typical internal wall finishes

Plaster (or similar approved) and outdoor quality emulsion paint shall be used. In the control rooms, MV/ LV switchgear rooms, LVAC rooms, computer rooms, restroom, administration areas, offices and similar rooms, corridors, instrument and electrical workrooms, mechanical workroom and storeroom. Acid resistant plaster and paint shall be used in the battery room.

Skirting shall be provided from the same material as the floor finish.

All materials are subject to the approval of the Employer/Engineer.

2.15.3 Fair faced block work, cement wash, paint

HVAC mechanical plant rooms, stores and workshop.

All materials are subject to the approval of the Employer/Engineer.

2.15.4 Glazed ceramic tiles plaster and paint above

Glazed ceramic tiles up to a level of 2.3 m and plaster and paint above this level shall be applied in toilets, washrooms, locker rooms and kitchen.

All materials are subject to the approval of the Employer/Engineer.

2.15.5 Acid/lye resistant tiles, plaster and acid / lye resistant paint

Acid/lye resistant tiles, (plaster and acid / lye resistant paint) up to a level of 1.2 m shall be applied in the battery room. Skirting shall be provided at the base of all tiled or plaster finished walls.

All materials are subject to the approval of the Employer/Engineer.

2.16 Masonry

2.16.1 General

This portion of the works regards the performance of all kinds of masonry work in accordance with the static analysis and as per the approved working drawings. The requirements of Euro code 6 or equivalent shall be observed.

Particular attention shall be paid to the surface protection measures specified here below.

2.16.2 Material

The various materials to be used for masonry work comprises the following items:

- clay bricks and sand/limestone
- solid or hollow concrete blocks
- blocks, stones and wall boards made of cellular concrete blocks
- light weight concrete blocks and wall boards
- gypsum plaster boards
- natural stones
- any other type of blocks and stone artificially produced
- insulating and filling material
- binding agents
- metal accessories.

The material above shall be generally standardized as specified hereafter.

2.16.3 Execution

Masonry work, bedding bricks, blocks and boards etc. shall be executed in mortar to form a homogeneous mass and to bond them in such a manner that point, or other loads and stresses are dispersed and distributed through the mass without the structure tending to disintegrate.

Block work partitions less than 200 mm in thickness shall be solid block and strengthen around all openings by reinforced concrete frame of 200 mm width (as a minimum) and in the same thickness of the wall.

Block work more than 3 m in height shall be reinforced with reinforced concrete stiffening framework comprising 200x300 mm verticals at 4 m centers and 200x300 mm horizontals at mid-height or at every 3 m in case wall height is bigger than 6 m. Block walls will rise by a maximum of 5 course over 24 hours.

Solid block works shall be provided wherever service pipes, cables etc. are passing in wall (e.g. auxiliary electrical rooms, bath rooms, kitchens, etc.).

2.16.4 Construction during hot weather

The presence of water in mortar is necessary for the setting action to take place. Precaution shall therefore be taken to prevent the work drying too quickly, especially in hot weather. All bricks, blocks and boards shall be saturated before bedding, except during frost, to prevent them absorbing the moisture from the mortar, and also to remove all loose dust from the surface in contact with the mortar.

Brickwork and/or block/board work which has not been thoroughly wetted can be detected by a thin crack between the brick/block/board and the mortar joint. Such work shall be pulled down and rebuilt. All masonry work shall be suspended during extreme weather unless adequately protected.

Block work under the ground slab, retaining walls and around foundations shall be, as a minimum, 200 mm thick.

2.16.5 Auxiliary work

Unless otherwise requested, all and any kind of work, materials, services, safety measures etc., as well as all tests and samples required for the completion of the work, shall be included in the offer. Among others they shall include the following services:

- provision and walling-up of all scaffolding holes and supports for beams, girders and ceilings
- walling-in or grouting of girder and beam heads and other structural members
- provision of slots, grooves, small openings and the like
- provision of the scaffolding also for use by others and of the covers/enclosures of openings beyond the period during which these are required for Contractor's own use.

2.16.6 Tests and properties

The minimum number of tests shall be as follows:

- two (2) compressive tests of soil block for load bearing walls per 200 m2 of bearing block walls
- three (3) compressive tests of each type of material as mentioned above
- three (3) compressive tests of each kind of mortar to be used.

Quality assurance

Blocks and stones shall be hard, of the selected quality, reasonable in size and shape. The strength of the blocks and stones shall be according to the static requirements, but not less than the below mentioned:

- fill in block work 5 N/mm^2
- fill in bricks 10 N/ mm^2

▪ non-bearing wall blocks (Hollow type) (average)	5 N/ mm^2
▪ non-bearing wall bricks	10 N/ mm^2
▪ load-bearing wall blocks (Solid blocks)	8 N/ mm^2
▪ load-bearing wall bricks	15 N/ mm^2
▪ face bricks	15 N/ mm^2
▪ sand lime bricks	15 N/ mm^2.

2.16.7 Mortar

Mortar for block work shall be cement mortar in the proportions 1:3 to 1:4 (Portland cement to sand). All mortar shall be mixed in a power-driven mixer and in addition, all materials shall be screened before mixing to remove lumps. Mortar whether with or without plasticizer shall be mixed only in sufficient quantity for the work immediately in hand and no partly set mortar shall be used.

2.16.8 Reinforcement and fixing accessories

2.16.8.1 Reinforcement

Horizontal reinforcement to brick or block work is called for. It shall be in high tensile galvanized steel mesh 6 cm wide for 10 cm walls and 12 cm wide for 20 cm walls. The reinforcement shall be laid in as long lengths as practicable without laps and be installed on every second course.

Where joints are necessary, the lengths shall be lapped not less than 30 cm, except at corners or junctions where the lap shall be equal to the width of the reinforcement and the reinforcement in one wall bent over that in the other.

Galvanized lugs shall be provided between columns and each third course of block work. In case of double skin walls, galvanized mild steel wall ties shall be spaced at 90 cm horizontally and at each 45 cm or equivalent, to suit the block size.

All materials are subject to the approval of the Employer/Engineer.

2.16.8.2 Dampcourses

Dampcourses shall be laid on and bedded in a bed of 1:4 cement mortar in as long lengths as practicable. Where joints have to be made, they must be lapped at least 20 cm in the runs and for full width on corners and the meeting surfaces sealed with an adequate application of black bituminous water-proofing paste.

At ground floor levels, the damp-proof course for a wall shall extend to the full width. The vertical damp-proof course at reveals shall extend the full width of the return.

Damp-proofing under floor slabs shall be one-layer self-adhesive bituminous membrane, 3 mm thickness, polyester reinforced applied on bituminous primer over the blinding concrete and protected from top by minimum of 50 mm thickness cement sand screed.

All materials are subject to the approval of the Employer/Engineer.

2.16.9 Dimensions of masonry walls

The thickness of walls, all exclusively to be constructed as double skin walls, shall be designed and constructed -including the insulation boards- to meet at least a heat transmission coefficient of U = 0.70 W/(m^2*K).

2.17 Wall Covering

Wall coverings are to match the function of the rooms and wall areas concerned.

A high standard shall be applied to the choice of materials, in particular for the control rooms.

The cleanliness aspect -with a view to removal of dirt- is of outmost importance.

All materials are subject to the approval of the Employer/Engineer.

2.18 Rendering

All rendering work shall be protected from direct sunlight during execution and curing.

The Contractor shall ensure that all surrounding building work and paving is protected from cement splashes.

All electrical conduits and other services shall be fixed in position, and when necessary, securely fixed in chases and recesses, before the execution of any rendering or other similar work.

2.19 Corrosion Protection of Steel and Ironwork

2.19.1 Galvanizing

All steel and ironwork shall be hot dip galvanized and/or painted as determined by the Employer/Engineer. Site drilling or cutting of steel will be generally not permitted.

2.19.2 Shop painting

With the exception of steelworks which is to be encased in concrete or galvanized, all surfaces of steelworks shall be shot blasted to a commercial gray finish to a profile height of 40 microns minimum.

All surfaces of steelworks shall then be painted with one Epoxy metallic zinc holding primer of an approved type and make, within one hour after shot blasting.

All surfaces of steelworks which will be not accessible after fabrication of the steelwork, such as back angles etc., shall then be painted with two coats of red lead and two coats of Iron Oxide paint.

All areas of painted surfaces shall be made good of any damage occurred during stockpiling and delivery to site prior to erection.

2.19.3 Site painting

All materials shall be the best of their respective type and shall be supplied from an approved Manufacturer and suitable for the climatic conditions of site.

All materials shall be delivered direct from the manufacturer on to the site in sealed containers on which maker's name and brand are clearly displayed and shall be stored to comply with all requirements for the preservation of the paints.

If any of the painting work deteriorates from any cause other than by mechanical damage by others the Contractor shall thoroughly remove the damaged paint work and repaint the area affected in accordance with these specifications and to the satisfaction of the Employer/Engineer.

A color schedule for all painting works will be made available to the Contractor prior to commencement of the works and subject to approval of the Employer/Engineer.

2.20 Raised Modular Floors

Full access raised, easily removable, modular floor, comprised of 800x800 mm (or 600x600 mm) panels shall be used, as determined by the Employer/Engineer.

The props shall be of rust proof material, with screw device for level adjustment. The panels shall be of galvanized steel with a core of processed timber. The surface covering of the panels shall be PVC tiles. The underside and edges of the panels shall be fire resistant meeting the requirements of BS 6266 or another equivalent standard. Panel lifting devices are included in the scope of supply of the Contractor.

All materials are subject to the approval of the Employer/Engineer.

2.21 Floor Coverings and Screeds

2.21.1 Floor coverings

Floor coverings shall be constructed with the desired slope or completely level. All pretreatment of the base, e.g. application of damp-proof membranes or insulating coats and adherent coatings is to be carried out in such a way as to avoid any deficiencies or damage. Openings shall be edged with suitable sections.

2.21.2 Screeds

Screeds shall be constructed in the necessary quality for the application concerned. All necessary measures are to be taken to guard against over-rapid drying out. The minimum thickness is 50 mm. Edgings shall be made with properly fixed steel angles.

2.22 General Requirements of Roofs

The roof construction is to be such that, with due allowance for the climatic conditions and with the intended use of the rooms taken into account, no damp will penetrate into the materials used. All roofs must have a minimum sound absorbing index of 20 dB (A) and a maximum heat transmission coefficient of 0.57 W/m^2°C. Appropriate insulation materials will have to be used to achieve these figures.

All roof penetrations are to be made with metal surrounds and bonded flanges and are to be sealed.

For coverings, insulated corrugated steel plates are preferred.

The roof waterproofing shall comprise of 4 mm thick APP bitumen membrane with non-woven polyester reinforcement of minimum 260 g/m^2. torch applied laid over foam concrete (minimum density 1200 kg/m^3.) cast to slopes, with extruded polystyrene insulation board of minimum density 35 kg/m^3 and separation layer followed by mortar and concrete tiles.

2.22.1 Roofing membrane

The roofing membrane shall be a 4 mm thick APP bituminous reinforced membrane, with a minimum reinforcement of 260 g/m^2. It shall be stable non-woven polyester, finished on both sides with a macro perforated torch off film, allowing laying by torch. The laps are to be fully torched and seamed.

2.22.2 Separation layer

A 1000 g/m^2 geo textile separation layer such as Terram, Typar or equivalent.

2.22.3 Insulation board

The insulation boards to be used shall be extruded polystyrene, 35 kg/m^3 density.

2.22.4 Primer

The primer to be used shall comply with all respect to ASTM D 41 and shall be applied at a minimum rate of 250-300 g/m^2.

2.22.5 Rainwater outlets

They shall consist of a prefabricated flange and a welded pipe, flange dimension exceeding 120 mm from edge of pipe opening. Pipe shall be of a diameter and a length adapted to the roof condition. Outlets shall be UV-resistant PVC or aluminum, subject to the Employers/Engineer's approval. All flanges shall be primed on both faces before insertion in the roofing built-up. Bottom of the pipe shall be sealed to the downpipe entry.

2.22.6 Flashing

Aluminum flashing 1mm thick profiled to cover the water proofing termination and receive sealant to prevent ingress of water into the termination groove.

2.22.7 Roof tiles

Proprietary concrete roof tiles of size 400x400x40 mm shall be laid over geo-textile membrane on a bed of 20 mm sand cement mortar.

2.22.8 Storage

All materials shall be stored in dry area, out of direct sunlight and according to manufacturer's instructions (correct rolls position, maximum load and stacking allowed). In the opinion of the Employer/Engineer, if the stored materials are damaged or otherwise rendered unusable due to inadequate and poor storage, they shall be removed from site as instructed and replaced at no extra cost to the Employer.

2.22.9 Installation

The installation shall be by approved applicators, authorized by the manufacturer of the waterproofing system. The tiles shall be laid on a bed of 4 cm thick cement sand mortar with appropriate expansion joints.

2.22.10 Tests

All materials to be supplied and installed shall be in accordance with the stated standards and manufacturer’s instructions. All roofs protected by waterproofing membranes shall undergo a water test to verify leaks.

All down pipes and spouts shall be closed and the whole roof shall be filled with water up to 50 mm deep at the lowest level. The water shall remain on the roof for at least 3 consecutive days.

Evaporations due to temperature and sun radiation shall every day be refilled again. Any water leakage observed during such period has to be repaired and the water test repeated until complete water tightness has been proofed. Protection layers on the roof shall be placed only after successful performance of this water test.

2.23 Doors and Windows

2.23.1 Doors

2.23.1.1 Aluminum doors

Aluminum frames shall be provided for exterior doors.

All doors shall be installed by manufacturer or his authorized representative, and shall be set plumb, square, level and true to line. Frames shall be set and securely anchored to the structure. Aluminum surfaces in contact with mortar, concrete or other masonry materials shall be provided with one heavy brush coat of bituminous paint.

Sections of aluminum extruded box profiles shall not be less than 50 mm deep and 2 mm thick. Aluminum alloys shall be of uniform quality, free from defects impairing strength and durability with regularity of surfaces and accuracy of right angles. Glass panels in the door shall be placed as approved by the Employer in the doors and windows schedule.

2.23.1.2 Steel doors

Fire-rated steel internal doors shall comply with the requirements of NFPA 80 or equivalent. The doors frames and shutters shall be galvanized by hot dip process. Injected polyurethane insulation or equivalent non-combustible material shall cover the whole interior area of the door.

Doors shall be protected by the application of 3 coats of an approved epoxy paint system. All doors shall have an all-around smoke seal strip and in addition external doors shall have an integrated weather strip. Thickness of steel door shutter (skin) shall be minimum 1.5mm and that of frame profile shall be minimum 2 mm. The thickness of door shutter shall be minimum 44 mm. Fixing of the door frame shall be by stainless steel anchors of diameter 12 mm. Any void between wall and frame is to be filled with non-shrink cement grout. Joints of door frames to walls shall be fire sealed.

2.23.1.3 Wooden doors

Wooden doors may be considered for the toilets, pantry, cupboards and partition doors in non-equipment areas which do not need the extended fire rating of steel doors. Frames shall be re-bated, rounded, molded and grooved.

The frames shall be fixed in by metal anchors, secured to a timber sub-frame and screwed to surrounds. Screws holes shall be plugged. Architraves shall be molded and shall be greater in thickness than any skirting that abuts them. They shall not be installed until after the wall cover-ings have been formed. Flush doors shall be solid cored.

Skeleton-framed flush doors will not be accepted but proprietary makes of cellular cored doors may be used if approved by the Employer/Engineer. Doors shall be painted or with an exposed hardwood veneer subject to the approval of the Employer/Engineer,

2.23.1.4 Hardware

Hardware for all doors shall be furnished and installed by the door manufacturer. All locks shall require different keys, and three keys shall be furnished for each lock. Hardware for aluminum doors and windows shall, as a rule, be of stainless steel. A master-key system shall be proposed for all locks and shall be subject to the approval of the Employer/Engineer.

2.23.2 Windows

Window frames shall be of UPVC and of high quality, only at thew approval of the Employer. Sections shall not be less than 50 mm deep and 2 mm thick. .

The manufacturer should be approved by the Employer and demonstrate an accepted product for incorporation in the substation, all windows shall be installed by the manufacturer, and shall be set plumb, square, level and true to line. Frames shall be set and securely anchored to the structure. .

Hardware for all windows shall be furnished and installed by the window manufacturer.

The windows strips in the switchgear room shall be installed on the level of + 2.0 m. The same principle is valid for all other areas where cabinets are installed.

2.23.3 Glazing

Clear safety toughened glass 8 mm thick of an approved manufacturer shall be used for doors.

For windows only double glazing shall be used.

2.24 Water Supply System and Plumbing

2.24.1 General description

The water supply system required for the substations shall include:

- construction of a new well on the site with connection to the storage tank. The capacity shall be sufficient to satisfy all potable, domestic and firefighting requirements.
- If a separate firefighting water tank is foreseen in other parts of the specification, then the contractor should include for a reinforced concrete flat slab to accommodate that isolated tank.
- A main storage tank with capacity as defined in VII-1 Scope shall be installed. The main tank shall be provided with a water inlet to allow refill of the tank from outside of the building. A smaller tank (200l) shall be installed on the top of the control building (under the roof). The tank has to be protected and insulated against sunshine heating effects.
- The smaller tank shall be automatically filled by a pump from the main tank. The pump motor shall be controlled by a water level-controlled switch in the smaller tank.
- all pipelines, connections pumps and associated works for the satisfactory operation of the water supply system
- internal connections for the sanitary installations
- The main pipe supplying water to control building and the main water tank shall be PVC lining carbon steel pipe (ø ½”). All valves shall be made of cast iron or bronze.
- The fittings shall include toilet paper roll holders, soap dispensers, etc.
- The internal supply network from the main tank shall be connected to the public water supply network.

The following points shall be supplied by drinking water:

- toilets and battery room wash basins
- toilet urinals
- closets
- kitchen
- battery room.

Water pipes within buildings will generally be of copper or galvanized steel. PVC pipes may be used for cold water lines only, subject to approval of the Employer/Engineer. PVC pipes shall conform to approved class and manufacture and shall be jointed and fixed to walls using the correct fittings and fixings as supplied or specified by the manufacturer.

2.24.2 Lavatory basins

Lavatory basins in the sanitary and battery rooms shall be white ceramic, with mirrors, to be approved by the Employer/Engineer before purchase or fixing in the works.

2.24.3 WCs and cisterns

Unless otherwise agreed or directed, water closet pans shall be of western type, white ceramic or metal. Flushing cisterns can be of white ceramic metal. All materials shall be approved by the Employer/Engineer before purchase or fixing in the works.

2.24.4 Urinals

The urinal shall be white ceramic provided with automatic flushing cisterns.

2.24.5 Wastewater system

The wastewater from kitchen, sink, battery room wash basin, urinal, exterior tips, and all rainwater pipes shall be connected by drainpipes to septic tanks outside of the substation buildings.

2.25 Painting (Except Steel Surfaces)

2.25.1 Paints

The Contractor shall submit for approval the name of the manufacturer proposed to be used. Only paints suitable for the climatic conditions of the site shall be used.

All materials shall be delivered to site in sealed containers on which the maker's name, specification and date of manufacture are clearly displayed and shall be stored to comply with the requirements for the preservation of the paints. Only colors and undercoats approved by the Employer/Engineer shall be used.

2.25.2 Application

Application of paint shall be by brush or roller, as approved or directed by the Employer/Engineer. The treatment to be given to the different surfaces shall be specified by the Contractor.

All paint shall be applied in accordance with the manufacturer's instructions and shall not be diluted in any way unless specifically stated or agreed by the Employer/Engineer. No external paint work shall be carried out during high winds and rains or other unfavorable weather conditions.

All rubbish and debris shall be removed, and floors swept and dampened before painting commences. Door, furniture, light switch covers, and the like shall be removed, and surrounding surfaces covered with canvas or other approved protection.

Newly painted surfaces shall be protected against contamination by dust or other causes.

2.26 Drinking Water Tanks

The Contractor shall provide permanent underground, reinforced concrete water tanks. The volume of the tank shall be as defined in VII-1 Scope and it shall be provided with:

- adequate supply inlets and entrances with tight covers
- water level indicator
- slope and pit for cleaning operations
- pumping installations in the internal network
- adequate surface protection.

For the proper function of the internal drinking water network, smaller tank (of 1-2 m^3) shall be installed below the roof.

2.27 Furniture

All furniture shall be fabricated with the best quality and subject to the Employers approval. Natural and synthetic materials and workmanship shall be of the high standard. They shall be suited for to the climatic conditions in the area as well as durability against normal everyday use in a substation environment.

The following are the minimum basic standards however they are not limited to be applied for material and workmanship:

Work Surfaces
Three-layer chipboard with a compressed surface, with RAL-quality-mark, with melamine resin coating and with the color's selection by the Employer. All materials shall be of high quality and subject to approval of the Employer. Cable magazines shall be provided to suit the Employers approval.

Form of Work Surfaces
Length edges rounded 180-degree, side edges flat (covered by the leg frame). Minimum 25mm thickness, with machine molds.

Connecting Elements
Connecting elements shall be made of wood, with a synthetic surface, painted matching the work surfaces.

Supporting Elements

4-leg-frame made of oval steel tubes partly C legs stove-enameled, with traverses in the length direction, sides of the work surfaces enclosed by the leg frame, legs with screws for height adjustment.

Traverses concealed directly under the work surfaces, serving also as support for the work surfaces.

Cable Magazine

Horizontal: Retractable cable magazine of the front side below the work surface, made of steel, stove-enameled

Vertical: Retractable cable magazine in the legs of the frame.

Drawers and Panels

The edges of the drawer fronts are rounded and extend on the side towards the knee space of the desk.

The drawer fronts are generally screwed to the drawer and not welded to the drawer. All drawers will generally be provided with slotted sides. All drawers shall have sides of the same height. The height of the drawers is achieved by the drawer fronts available in different height, which provides maximal flexibility for changes.

Drawer Support shall be steel on telescopic rails, fully extendable with nylon-covered ball bearing rolls and nylon-rolls.

Generally, each drawer shall be provided with a central locking device (push cylindrical lock).

Shelving

Two types of shelving shall be provided.

Type 1 is 800mm deep, heavy duty modular galvanized steel framed shelf, compliant with FEM regulation 10.2.06 (Federation of European Material Handlers) or equivalent standard.

Type 2 is 600mm deep, medium duty pre-galvanized steel modular shelving tested and approved with FEM (Federation of European Material Handlers) norms or equivalent standard.

Furniture Manufacturers

The Contractor shall select the furniture from well-established manufacturers who are demonstrated to provide furniture of the highest international quality. Manufacturers and selected furniture shall be subject to the approval of the Employer.

Minimum furniture and interiors requirements.

The listings below are to be guideline for minimum requirements only. Details are to be finalized as per the approved interior design. Areas not mentioned in the schedule shall be suitably furnished for the normal use intended, of the highest quality and subject to the approval of the Employer.

Damauli two-storey Control Building	
	Furnishings (minimum)
Ground Floor	
Store	Type 1 Steel modular shelving, full height, minimum 6m total length
Cleaning Room	No furnishings
Office	▪ 1x hard wood desk minimum 1.5 x 1.2m with drawers on both sides and laminated top ▪ 1x side table 1,500 x 700 mm with drawers (matching the desk) ▪ 2x high backed executive adjustable swivel chair ▪ 2x visitor chairs ▪ 1x 4 drawer filing cabinets ▪ Type 2 full height steel modular shelving, minimum 1.2m length ▪ wall boards
AC/DC Rectifi-ers	No furnishings
Battery	No furnishings
Workshop	Type 1 Steel modular shelving, full height, minimum 6m total length
Toilets	▪ Fitted toilet/bathroom as specified ▪ 1x illuminated wall mirror above each sink
Changing Rooms	▪ 1No. wooden surface bench in each changing area ▪ 1No storage unit incorporating 5No. lockable storage cubicles for each changing area.
First Floor	
Storeroom	No furnishings
Office/Archive	▪ 1x hard wood desk minimum 1.5 x 1.2m with drawers on both sides and laminated top ▪ 1x side table 1,500 x 700 mm with drawers (matching the desk) ▪ 2x high backed executive adjustable swivel chair ▪ 2x visitor chairs ▪ 1x 4 drawer filing cabinets ▪ Type 2 full height steel modular shelving, minimum 1.2m length ▪ wall boards

Damauli two-storey Control Building	
	Furnishings (minimum)
Control Room	▪ 1x hard wood desk with drawers and laminated top, sized to suit the layout of the control room monitors and computers/printers etc., all to an approved layout ▪ 1x high backed executive adjustable swivel chair provided at each monitor ▪ 3x visitor chairs ▪ 1x 4 drawer filing cabinets ▪ Type 2 full height steel modular shelving, minimum 1.2m length ▪ Wallboards, including laminated and framed SLD for substation ▪ steel wall mounted key box, minimum capacity 90 keys
SCADA /RTU room	No furnishings
Metering	No furnishings
PLC Telecom	No furnishings
220kV Protec-tion	No furnishings
Tea/Kitchen	Fitted kitchen as per specification with work surfaces and cup-boards (both above and below the surface) to three sides of the room with as a minimum ▪ 3No. wooden surface bar type kitchen stools ▪ stainless steel sink and draining board provided with mixer tap. Integrated 4 ring electric hob ▪ 1000w microwave oven ▪ integrated refrigerator minimum 145litre capacity
Toilets	▪ Fitted toilet/bathroom as specified ▪ 1x illuminated wall mirror above each sink
Meeting Room	1No. Hardwood meeting table provided with 8No. Meeting room chairs
Guard House	▪ 1x hard wood desk minimum 1.5 x 1.2m with drawers on both sides and laminated top ▪ 1x side table 1,500 x 700 mm with drawers (matching the desk) ▪ 2x high backed executive adjustable swivel chair ▪ steel wall mounted key box, minimum capacity 90 keys ▪ wall board

Damauli two-storey Control Building	
	Furnishings (minimum)
Lekhnath Two-storey Control Building	
	Furnishings (minimum)
Ground Floor	
Store	Type 1 Steel modular shelving, full height, minimum 4m total length
33kV Room	No furnishings
Battery rooms	No furnishings
Office	▪ 1x hard wood desk minimum 1.5 x 1.2m with drawers on both sides and laminated top ▪ 1x side table 1,500 x 700 mm with drawers (matching the desk) ▪ 2x high backed executive adjustable swivel chair ▪ 2x visitor chairs ▪ 1x 4 drawer filing cabinets ▪ Type 2 full height steel modular shelving, minimum 1.2m length ▪ wall boards
AC/DC Rectifi-ers	No furnishings
Workshop	Type 1 Steel modular shelving, full height, minimum 4m total length
Changing Area	▪ 1No. wooden surface bench in each changing area ▪ 1No storage unit incorporating 5No. lockable storage cubicles for each changing area
Toilets	▪ Fitted toilet/bathroom as specified ▪ 1x illuminated wall mirror above each sink
First Floor	
Office/Archive	▪ 1x hard wood desk minimum 1.5 x 1.2m with drawers on both sides and laminated top ▪ 1x side table 1,500 x 700 mm with drawers (matching the desk) ▪ 2x high backed executive adjustable swivel chair ▪ 2x visitor chairs ▪ 1x 4 drawer filing cabinets ▪ Type 2 full height steel modular shelving, minimum 1.2m length ▪ wall boards

Damauli two-storey Control Building	
	Furnishings (minimum)
Control Room	▪ 1x hard wood desk with drawers and laminated top, sized to suit the layout of the control room monitors and computers/printers etc., all to an approved layout ▪ 1x high backed executive adjustable swivel chair provided at each monitor ▪ 3x visitor chairs ▪ 1x 4 drawer filing cabinets ▪ Type 2 full height steel modular shelving, minimum 1.2m length ▪ Wallboards, including laminated and framed SLD for substation ▪ steel wall mounted key box, minimum capacity 90 keys
SCADA /RTU room	No furnishings
Metering	No furnishings
PLC Telecom	No furnishings
220kV Protection	No furnishings
Tea/Kitchen	Fitted kitchen as per specification with work surfaces and cupboards (both above and below the surface) to three sides of the room with as a minimum ▪ 3No. wooden surface bar type kitchen stools ▪ stainless steel sink and draining board provided with mixer tap ▪ Integrated 4 ring electric hob ▪ 1000w microwave oven ▪ integrated refrigerator minimum 145litre capacity
Toilets	▪ Fitted toilet/bathroom as specified ▪ 1x illuminated wall mirror above each sink
Meeting Room	1No. Hardwood meeting table provided with 12No. Meeting room chairs

VII-7.1

Specifications for Environmental, Social, Health and Safety Management (ESHS) of the Works

Specifications for Environmental, Social, Health and Safety Management (ESHS) of the Works

Throughout the ESHS Specifications, a reference to the Conditions of Contract (CC) means a reference to both the General Conditions of Contract and the Particular Conditions of Contract. Readers should apply due care, when referring to a specific Clause or Sub-Clause, and:

a) Read first the Clause or Sub-Clause text from the General Conditions of Contract

b) Then check whether this text has been amended by the Particular Conditions of Contract, and if so, to which extent.

As per CC Sub-Clause 1.5, when interpreting the Contract, the terms of the Particular Conditions of Contract prevail over those found in the General Conditions of Contract.

Any term in these ESHS Specifications which is identical to a term in the Conditions of Contract shall have the same meaning as the one defined in the Conditions of Contract.

Any term in capital letters in these ESHS Specifications is defined in CC Sub-Clause 1.1 – Definitions.

Table of Contents

A. Environmental, Social, Health and Safety Management

1. Responsibilities and liabilities	1.1. In conjunction with his obligations defined under the Contract, the Contractor will plan, execute and document construction works pursuant to the present Environment, Social, Health and Safety specifications (ESHS). 1.2. The Contractor is liable for all damages to the environment and people caused by the execution of the works or the methods used for execution, unless it is established that the execution or methods were necessary, according to the provisions of the Contract or an Engineer's instruction. 1.3. Under the Contract and as introduced by the present ESHS Specifications, the term "Project Area" means: a) The land where work will be carried out; or b) The land necessary for the implantation of construction facilities (work camp, workshops, offices, storage areas, concrete production plants) and including special access roads; or c) Quarries for aggregates, rock material and riprap; or d) Borrow areas for sand and other selected material; or e) Stockpiling areas for backfill material or other demolition rubble; or f) Any other location, specifically designated in the Contract as a Project Area. The term "Project Area" encompasses any individual Project Area or all Project Areas. For the sake of clarity, Project Area is a different concept than Site under CC Sub-Clause 1.1.6.7. Project Area defines an area within which the Contractor is to comply with environmental, social, health and safety obligations defined in the present ESHS Specifications. Site is the places where the Permanent Works are to be executed and to which Plant and Materials are to be delivered, and where right of access to, and possession of, is to be given by the Employer to the Contractor. The Employer is under no similar obligation for any area located outside the Site, even if within the Project Area, where access is at Contractor's risk.

	In term of physical footprint, the CC Sub-Clause 1.1.6.7 Site is included in the Project Area. The Project Area is then of greater geographical extent than the Site. 1.4. The ESHS Specifications refer to: a) Protection of the natural environment (water, air, soil, vegetation, biological diversity) in areas within any Project Area and its surroundings, i.e. including but not limited to access roads, quarries, borrow areas, stock-piling of backfill material, camps or storage areas; b) Health and safety conditions to be maintained for the Contractor's personnel and any other person present on the Project Areas, or along access routes; c) Working practices and the protection of people and populations living near the Project Area but exposed to the general disturbance caused by works. 1.5. Subcontractors The Contractor shall ensure that all Subcontractors and Suppliers (in particular those for major supply items) are familiar with the ESHS requirements and guidelines valid on Site and Project Area. 1.6. Applicable regulations The Contractor must identify all applicable laws, permits and regulations in relation to the protection of the environment (water, air, soils, noise, vibration, vegetation, fauna, flora, waste, groundwater) and, pursuant to Clauses 4 and 6 of the CC, the protection of people (labor law, indigenous populations, standards on occupational exposure, other). The Contractor must list all texts, standards and other regulatory limitations in its Project Area Environmental and Social Management Plan (PA-ESMP as specified in ESHS Specifications Sub-Clause 2.1) and specify the means taken for compliance.
2. ESHS Planning Documents	2.1. The Contractor prepares and ensures prior validation by the Engineer, implementation and regular update of the Project Area Environmental and Social Management Plan (PA-ESMP), which includes Health and Safety aspects. 2.2. The PA-ESMP represents the unique reference document in which the Contractor defines in detail all organizational and technical provisions implemented to satisfy the obligations of the present ESHS Specifications. 2.3. The Contractor defines in the PA-ESMP the number, the locations and the type of Project Area as defined in ESHS Specifications Sub-Clause 1.3. For each Project Area,

	unless otherwise agreed by the Engineer, the Contractor establishes site specific management strategies and implementation and monitoring plans (Site-ESMP) to manage and monitor Environmental, Social, Health and Safety (ESHS) risks, depending on the type, scope and risks of the project and as assessed in the project´s Environmental and Social Impact Assessment (ESIA). These sub-plans shall be included in the PA-ESMP and include: • e.g. Health and Safety Plan • e.g. Traffic Management Plan (to ensure safety of local communities from construction traffic) • e.g. Water Resource Protection Plan (to prevent contamination of drinking water) • e.g. Boundary Marking and Protection Strategy (for mobilization and construction to prevent offsite adverse impacts) • e.g. Biodiversity Action Plan • e.g. Worksite Management Plan • e.g. Site Emergency Plan • e.g. Accommodation Plan • e.g. Waste Management Plan • e.g. Hazardous Materials Management Plan • e.g. Specific mitigation plan for endangered species in the wider area • e.g. Emergency plan • e.g. Community Interaction plan 2.4. The PA-ESMP (and the sub-plans) are structured according to the plan specified in Appendix 1 of the present ESHS Specifications. 2.5. PA-ESMP covers the entire period from the Contract Agreement signature date to the date of issue of the Performance Certificate by the Engineer. 2.6. Unless agreed otherwise by the Engineer, the PA-ESMP is written in the language of communication defined under Sub-Clause 1.4 of the CC. 2.7. The first draft version of the PA-ESMP is to be provided by the Contractor to the Engineer within 28 days from the date of execution of the Contract Agreement. 2.8. The Contractor shall proceed in accordance with the program, subject to the Engineer's approval of the PA-ESMP. The Employer's Personnel shall be entitled to rely upon the program when planning their activities. 2.9. No physical work or activity shall commence on any Project Area until such time when the PA-ESMP, and the

	annexed Site-ESMP corresponding to the Project Area, are approved by the Engineer. 2.10. During the execution of the works, whenever instructed by the Engineer, the PA-ESMP will be updated by the Contractor and reissued to the Engineer. The revised version shall highlight the new elements incorporated in the document. Such approval shall only be withheld if the PA-ESMP shows substantial deficits. 2.11. Related to the PA-ESMP, the Contractor will be responsible for: a) communicating the contents of the ESMPs to their Subcontractors and Suppliers (in particular those for major supply items) and workers and training them to ensure that they understand their respective responsibilities b) ensuring that adequate resources are mobilized to implement the specific Plans, including input from any specialist resources necessary to ensure effective planning and implementation of measures c) ensuring that the procedures established in the PA-ESMPs are complied with by their workers and Suppliers (in particular those for major supply items) d) implementing effective monitoring measures listed in the PA-ESMP to ensure that the effectiveness of the activities are assessed and any issues are promptly detected and addressed e) ensuring that lessons are learned and corrective actions are taken f) keeping the Engineer fully informed of any Project Area ESHS issues.
3. Management of Non-Conformities	3.1. In application of Clause 5, non-conformities detected during inspections carried out by the Engineer are subject to a process adapted to the severity of the situation. The non-conformities will be defined as deviations from the requirements of the applicable regulations, the present ESHS Specifications, the ESMP, and the Worksite - ESMP. Non-conformities are divided into 4 categories as follows: a) Notification of observation of minor non-conformities. The non-conformity results in a notification to the Contractor’s Representative, followed-up by a signed notification of observation prepared by the Engineer. The multiplication of notifications of observation at the Project Area, or absence of corrective actions by the

	Contractor, can result in the severity of the non-conformity being raised to that of level 1. b) Level 1 non-conformity: Non-conformities that do not represent a serious immediate risk for health, environment, social or safety. The non-conformity is the subject of a report addressed to the Contractor and which shall be resolved within five (5) days. The Contractor addresses to the Engineer a report explaining how the non-conformity has been corrected. Further to an inspection and a favorable evaluation of effectiveness of the corrective action, the Engineer signs a close-out report for the non-conformity. In all cases where a non-conformity of level 1 is not resolved within one (1) month, the severity of the non-conformity is raised to level 2. c) Level 2 non-conformities: applies to all non-conformities that represent a risk with major consequences to health and/or the environment, social or safety. The same procedure as for level 1 non-conformities is applied. Corrective action shall be taken by the Contractor within three (3) days. The Contractor addresses a report explaining the corrective actions implemented. All level 2 non-conformities, which are not resolved within one (1) month, are raised to level 3. d) Level 3 non-conformities: applies to all non-conformities that have resulted in damage to health or the environment, or which represent a high safety hazard or high social risk. The highest levels of the Contractor's and Engineer's hierarchies present in the Employer's country are informed immediately and the Contractor has twenty-four (24) hours to bring the situation under control. Pursuant to Clause 14.6 of the Particular Conditions of Contract (PC), a level 3 non-conformity results in the staged reduction of interim payments until the non-conformity has been resolved. Following the resolution of the Level 3 non-conformity the reduction(s) will be included in the next Interim Payment Certificate for payment. No interest will be paid on any reductions or suspended payment amounts. If the situation requires, and in pursuance to Clause 8.8 of the PC, the Engineer can order the suspension of work until the resolution of the non-conformity.
4. Resources allocated to ESHS management	4.1. ESHS supervisors and managers a) Pursuant to Sub-Section Specifications (c) Personnel Requirements, Sub-Clause 4.18 of the CC and in addition to the provisions of Sub-Clause 6.7 of the CC, the

	Contractor appoints at one or several competent Environment, Social, Health and Safety manager in charge of implementing the present ESHS Specifications. b) The appointment of the ESHS Manager shall include specific instruction to enforce regulations and delegated authority to take any action, measure or to issue instructions regarding their enforcement. All staff and labor within the Project Area shall be made aware of the name and authority of the ESHS managers and supervisors. c) The ESHS manager holds the power within the Contractor's organization to suspend the works if considered necessary in the event of severe non-conformities, and allocate all resources, personnel and equipment required to take any corrective action considered necessary. The ESHS Manager speaks fluently the language of communication of the Contract, and the official language of the Employer's country, if the language of communication of the Contract is not the official language. d) If so required in accordance with Sub-Section Specifications (c) Personnel Requirements, ESHS supervisors represent the ESHS Manager within work teams. Their role is to ensure that the works are carried out pursuant to the present ESHS Specifications and notify the ESHS Manager of any detected non-conformities. 4.2. Personnel in charge of relations with external stakeholders a) If so required in accordance with Sub-Section Specifications (c) Personnel Requirements, the Contractor appoints an External Stakeholders Relations Manager responsible for relations local communities, administrative authorities, and representatives of economic activities located within one hour travel from the Project Area. In smaller projects, the person responsible for relations with external stakeholders can also be the ESHS Manager appointed under Sub-Clause 4.1.a) of the ESHS Specifications, providing that the latter speaks the local population language fluently. b) If so required in accordance with Sub-Section Specifications (c) Personnel Requirements, the Contractor shall appoint several subject specific Community Liaison Officers.

	c) Personnel in charge of relations with external stakeholders will be based on or near the Project Area on a permanent basis. d) Administrations and local authorities will be informed of the existence of this person as of the start of works and will be provided with telephone contact details so as to be able to contact this person if a problem arises during the execution of works, or concerning the behavior of the Contractor's Personnel, inside or outside the Project Area. 4.3. The team, including the ESHS supervisors and manager, and the person in charge of relations with external stakeholders, will be equipped with the necessary resources to operate independently and get to all location of the Project Area without delay. Commensurate with the size and location of the project, this may include: a) A 4WD vehicle (unless otherwise instructed by the Engineer) and the necessary operating budget; b) A complete IT workstation: computer, printer, Internet access; c) Field equipment: GPS, digital camera; d) One communication equipment per person adapted to the context (mobile phone, satellite phone, or, should coverage not be adequate, a long-range two-way radio). e) Lists of equipment will be maintained on site for inspection by Employer.
5. Inspections	5.1. The ESHS Manager will carry out an ESHS inspection of the facilities and Project Area on a weekly basis. A written report of reasonable length will be drafted for each weekly inspection, in a format approved by the Engineer, addressing non-conformities detected on the Project Area as specified in the present ESHS Specifications. 5.2. Any non-conformity shall be immediately addressed by corrective actions, which will be mentioned in the reports to the Engineer. 5.3. Each non-conformity will be documented by a digital photograph with captions to provide a visual illustration, explicitly indicating the location, date of inspection and the non-conformity in question.
6. Reporting	6.1. The Contractor includes a summary of ESHS activities implemented in relation to the execution of the works during the reporting period in the monthly Progress Report

	(as specified in Sub-Clause 4.21 of the CC) to the Engineer. The Contractor shall report on compliance with applicable laws, permits and regulations and the project related ESHS requirements. E.G. key issues shall include: monitoring results, covering amongst other issues, safety issues, incidents/accidents, need for corrective measures, conflicts amongst construction workforce or with local residents, grievances of workforce or stakeholders, any other details related to the social and environmental management and performance. Issues related to Subcontractors and Suppliers (in particular those for major supply items) shall also be included. 6.2. The ESHS progress report is written exclusively in the language of communication defined under Sub-Clause 1.4 of the CC. 6.3. Specific reporting requirements related to Health and Safety are detailed in the respective section (e.g. Health and Safety, accident reporting)
7. Code of Conduct	7.1. A Code of Conduct is established by the Contractor for the Project Areas, addressing the following: safety rules, zero tolerance for substance abuse (as defined in Clause 41 of these ESHS specifications), environmental sensitivity of areas around the Project Areas, the dangers of STDs and HIV/AIDS, gender issues (in particular sexual harassment) and respect for the beliefs and customs of the populations and community relations in general (drawing special attention to the risks of prostitution and human trafficking). 7.2. The rules are clearly displayed at the different Project Areas and posted in the Contractor's vehicles and machinery driving cabs. 7.3. The rules confirm the Contractor's commitment to implementing the ESHS provisions provided for in the Contract. 7.4. New Contractor's Personnel and existing Contractor's Personnel are made aware and acknowledge their understanding of the rules of procedure and the associated provisions. Rules of procedure document are initialed by all Contractors' Personnel prior to the start of any physical work at any Project Area. 7.5. Pursuant to Sub-Clauses 6.9 and 6.11 of the CC, the rules of procedure include a list of acts considered as serious misconduct and which must result in dismissal from any Project Area by the Contractor, or by the Engineer if the Contractor is not acting in due course, should a Contractor's Personnel repeatedly commit an offence of serious

	misconduct despite awareness of the rules of procedure, and this is without prejudice to any legal action by any public authority for non-compliance with applicable regulations: a) Drunkenness during working hours, leading to risks for the safety of local inhabitants, customers, users and personnel; b) Punishable statements or attitudes, and sexual harassment in particular; c) Violent behavior; d) Intentional damage to the assets and interests of others, or the environment; e) Repeated negligence or imprudence leading to damage or prejudice to the environment, the population or properties, particularly breaching provisions intended to prevent the spreading of STD and AIDS; f) Drug use; g) Possession and/or consumption of meat or any other part of an endangered animal or plant as defined in the Washington convention (CITES) and national regulations. h) Entering property of neighboring people without permission of the landowners or those cultivating/renting the land. 7.6. Serious misconduct, such as organization of sex trade (pimping), committing pedophilia, physical aggression, drug trafficking, deliberate and severe pollution, trading and/or trafficking in all or part of protected species, shall lead to immediate dismissal as of the first report of misconduct is detected, in application of the rules of procedure and labor laws. 7.7. The Contractor establishes a record for each case of serious misconduct, and a copy will be provided to the Contractor's Personnel in question, indicating all action taken to terminate the misconduct by the Contractor's Personnel in question and to bring the attention of other Contractor's Personnel to the type of incident detected. This record will be provided to the Engineer as an attachment to the ESHS progress report (see ESHS Specifications Sub-Clause 6.1.). 7.8. The Contractor shall without delay inform the Engineer who in case of serious misconduct shall immediately inform the Employer.

8. ESHS Training	8.1. The Contractor prepares a training program adequate for the works to be performed within the Project Areas and the personnel engaged in the works. 8.2. The Contractor ensures that Employees with direct responsibility for activities relevant to the Project's ESHS performance are adequately qualified and trained so that they have the knowledge and skills necessary to perform their work. 8.3. Training sessions are two-fold: introductory sessions for starting work at the Project Area, and technical training as required in relation to the execution of the works. Starting work sessions are organized for each Contractor's Personnel and shall cover as a minimum: a) Rules of procedure; b) Safety rules on Project Areas; c) Protection of areas adjacent to Project Area; d) Risks relating to sexually transmitted diseases (Sub-Clause 6.7 of the CC), prostitution, human trafficking, and sexual harassment; e) Basic health: combating malaria (if prevalent) and waterborne diseases, improving hygiene; f) HIV/AIDS sensitization training, g) Gender sensitization; h) Emergency response procedures or evacuation; i) Community relations training for workers interacting with local communities; j) Communication of the contents of the Employment, Training and Worksite Management Plans to workers and all Subcontractors and Suppliers (in particular those for major supply items) and training them to ensure they understand their responsibilities with respect to employment, training and worksite management, incident reporting and response. k) Health and Safety awareness training l) The Contractor shall be responsible for informing all workers of the Worker Grievance Mechanism at the time of hiring 8.4. The Contractor shall ensure that adequate resources are mobilized for these trainings, including input from any specialist resources necessary to ensure effective

	planning and implementation of measures and that trainings are delivered in a timely manner. 8.5. Technical training: a) Training in the skills needed for tasks requiring a work permit (see ESHS Specifications Clause 27) b) Training in first aid and transporting the injured c) If applicable: appropriate driving skills d) If applicable: the Contractor establishes and implements a transparent and binding Local Workforce and Supplier Training plan to enhance the capabilities of local people and companies, with a view to increasing local content e) a matrix of training requirements showing the training frequency and interval between refresher courses and covering: 8.6. The Contractor details in the training program the actions and ESHS training for all Subcontractors and Suppliers (in particular those for major supply items) or personnel of a joint venture when applicable. 8.7. The Contractor prepares an awareness program for local communities on the risks of prostitution, human trafficking and other forms of illegal trafficking. 8.8. The Contractor shall develop means of confirming that the training system is effective.
9. Standards	9.1. The Contractor complies with all applicable norms, standards and discharge limit values defined in the national regulations of the Employer's country regulations and pursuant to Sub-Clause 1.6 of the present ESHS Specifications. 9.2. The Contractor complies with norms, standards and discharge limit values recommended by the specialized international organizations affiliated to the United Nations, as described in ESHS Specifications 9.3 below. In the event of discrepancies in between international standards and national regulations, the Contractor shall comply with the most stringent requirements. 9.3. The specialized international organizations affiliated to the United Nations referred to in ESHS Specifications Sub-Clause 9.2 include: a) World Bank, including the IFC and its Environmental, Health and Safety guidelines available from http://www.ifc.org/ehsguidelines;

	For matters not addressed in the above mentioned IFC document, the most stringent of the norms, standards and discharge limit values of the following institutions shall apply: a) World Health Organization (WHO); b) International Labor Organization (ILO) in particular in pursuance to Clauses 6.20, 6.21, 6.23 and 6.24 of the PC (Part B); c) International Maritime Organization (IMO).

Note to “4. Resources allocated to ESHS management” Personnel Requirements

The Bidder must demonstrate that it has the personnel for the key positions that meet the following requirements:

ESHS Manager

The Contractor’s ESHS Manager shall be responsible for the development and implementation of the project- and site-specific HSE Management Plan, including Occupational Health and Safety.

The ESHS Manager will work closely with the Contractor’s Project Manager, advising on the performance of the contractors’ (including all subcontractors) compliance with the requirements as provided in the ESMMP and Biodiversity Action Plan (BAP) and set site specific the Health, Safety and Environment Management Plan (HSEMP).

The ESHS Manager shall also ensure that all environmental and social as well as occupational health and safety requirements stipulated in the ESMMP, BAP and site specific HSEMP, together with the relevant local laws and regulations and the standards as listed above, are adhered to by the project team/personnel and shall ensure compliance with the same by subcontractors and suppliers.

The ESHS Manager shall be experienced in OHS- on construction sites, especially related to construction of Substations.

Years of professional experience: 15 or more years.

Construction HSE Manager

The Construction HSE Manager shall be responsible for the day-to-day implementation of ESMS elements, occupational health and safety management measures and the relevant activities on construction sites. He shall be reporting to the Construction Site Manager and the ESHS Manager. This person shall be establishing regular E&S Performance Reports and shall be in addition reporting on any HSE issues when these occur. Construction HSE Manager shall be fluent in local language (Nepalese)

Years of professional experience: 7 or more years.

Social and Environmental Expert

Contractor's Social and Environmental Expert shall be responsible for the communication and interaction with stakeholders, local communities, and Project Affected People. This expert shall supervise implementation of all mitigation / compensation measures defined by the site-specific HSEMP related to the social environment. This shall be done in compliance with the Project's Resettlement Action Plan (RAP) which is prepared by the Implementation Consultant in line with requirements of national and international standards and is implemented by NEA.

Moreover, Contractor's Social and Environmental Expert shall supervise the implementation of overall environmental and social mitigation activities defined by the site-specific HSEMP, provide environmental and social administrative support for the Construction HSE Manager, coordinate and maintain the preparation of environmental and social plans, procedures, work instructions etc., to be defined also for the management of emergency cases; manage and audit the personnel, ensuring they have been inducted to adequate training measures; establish an inspection / audit scheme and review the results of inspections / audits; and identify any issues and deficiencies, to be brought to the attention of Contractor's Project Manager.

Requirements for this expert include: University degree in anthropology / sociology or related disciplines; Experience with conducting environmental & social risk assessments, preferably with a focus on the power / transmission sector. Excellent communication and reporting skills; fluent in English and Nepalese language.

Years of professional experience: 7 or more years.

B. Environmental and Social Management and Monitoring Plan

	This section is herewith enclosed as Appendix 3.

C. Health and Safety

	This section is herewith enclosed as Appendix 3.

D. Local labor and relations with local communities

	This section is herewith enclosed as Appendix 3.

Appendix 1

Example for the Contents of a PA-ESMP

1. Environmental policy	• Declaration of ESHS policy signed by the Managing director of the Contractor and clearly defining the commitment of the Contractor in terms of (i) ESHS management for its construction sites and (ii) compliance with the ESHS Specifications of the Contract.
2. PA-ESMP	• Target and content of the Project Area Environmental and Social Management Plan (including Health and Safety) • Preparation and updating schedule • Quality assurance and validation
3. ESHS resources	• Human resources: - ESHS manager - ESHS supervisors - Person in charge of relations with stakeholders - Medical personnel • Logistics & communications: - ESHS vehicles - IT stations - In situ noise, air and water measuring equipment - Analysis laboratory used • Reporting: - Weekly inspections - Monthly - Accident/ Incident
4. ESHS regulations	• Definition of standards for the applicable national ESHS regulations and the ESHS recommendations of institutions affiliated to the United Nations (WHO, ILO, IMO, IFC), applicable to the execution of works: - Environment..... - Noise and Vibration Soil Erosion - Air Quality - Solid Waste - Hazardous Materials - Wastewater Discharges - Contaminated Land - Occupational Health and Safety - Community Health and Safety - General Site Hazards - Disease Prevention - Traffic Safety - Discharge standards - Minimum wage - Day and/or night traffic restrictions - Other • Definition of ESHS standards for the industry applied

5. ESHS operational inspection resources	• Site tracking procedure: - Frequency - Personnel - Assessment criteria • Non-conformity handling and detection procedure: - Distribution of information - Notification depending on the level of importance allocated to non-conformities - Tracking of the closing of the non-conformity • Management of data on tracking and non-conformities : - Archiving - Use as a performance indicator
6. Project Areas	• Description of Project Areas (as per definition in ESHS Specifications Sub-Clause 1.3: - Number - Location on a topographical map - Activities - Opening & closing schedule - Access • Reference to the Appendix: a Site-ESMP for each Project Area.
7. Health and safety plan	• Identification and characterization of health and safety risks, including the exposure of personnel to chemicals, biological hazards and radiation. • Description of working methods to minimize hazards and control risks. • List of the types of work for which a work permit is required • Personal protection equipment • Presentation of the medical facilities at Project Areas: - Healthcare center, medical equipment and allocation of medical staff - Medical treatments that can be carried out on site - Ambulance, communications - Referring hospital • Evacuation procedure for medical emergencies • Description of the internal organization and action to be taken in the event of an accident or incident
8. Training plan	• Basic training for non-qualified staff • Health and Safety inductions • Health & safety training
9. Labor Conditions	• Description of Human Resource Policy for construction works of direct and indirect workers
10. Local Recruitment	• Local labor requirements: - Job descriptions and the levels of qualifications required - Recruitment procedure and deployment schedule - Initial training to be provided by the Contractor for each job description

	• Location and management of the local recruitment office(s)
11. Project machinery and vehicle traffic	• Description of the fleet of vehicles/machinery used for the execution of the works and emission levels and safety requirements • Deployment (Project Area & schedule) and maintenance sites for each vehicle and machine • Mapping of itineraries, travel times, and areas where speeds are limited • Dust suppression: - Mapping or road sections where dust reduction initiatives apply - Water points identified or to be created for refueling tanker trucks - Capacity of the tanker trucks used and calculation of the number of trucks required - Width of the track to determine if one watering run or equivalent is adequate (narrow track) or if two runs are required (wide track) - Number of watering or equivalent operations proposed per day depending on the climate
12. Dangerous substances	• Inventory of dangerous substances per Project Area and per period • Transport and storage conditions and chemical incompatibility
13. Effluents	• Characterization of effluents discharged to the receiving environment • Facilities for the treatment or pre-treatment of effluents including sufficient run-off • Measures for reducing the sediment content of rainwater run-off • Measures for monitoring the efficiency and performance of facilities for reducing sediment content of rainwater run-off • Resources and methods for monitoring effluent and rainwater runoff quality
14. Noise and vibrations	• Estimation of the frequencies, duration, days of the week and noise levels per Project Area
15. Waste	• Inventory of waste per Project Area and per period • Collection, intermediate storage, handling and treatment methods for ordinary or inert waste • Storage and handling methods for dangerous waste
16. Clearing and revegetation	• Methods & schedule for clearing vegetation and earthwork activities • Methods, species and schedule for the revegetation of Project Areas disturbed by the works
17. Biodiversity	• Schedule for adequate fauna and flora management

	• Measures for minimizing impact on fauna and flora species based on the Contracting Authority procedures • Measures for monitoring the efficiency and performance of the plan in place • Measures for limiting IAS • Measures for monitoring the efficiency and performance of the plan in place
18. Prevention of erosion	• Location of zones suffering from erosion • Methods and schedule for the implementation of anti-erosive actions, including topsoil storage
19. Documentation of site condition	• List and cover of viewpoints • Imaging method • Archiving photographs
20. Rehabilitation	• Method and schedule for Project Area rehabilitation
21. Appendices	• Site-ESMPs (number and location specified in Section 6 "Project Areas" above): - Marking out of the Project Area perimeter on a map - Definition of zones for vegetation clearing, zones for the storage of usable timber, zones for burning of green waste - Definition of on-site activities: construction, storage areas, accommodation areas, offices, workshops, concrete making units - Layout of activity areas on the Project Area: construction works, production/operation areas, rehabilitation and closure - Zones for the storage of topsoil, spoil from earthworks, materials - Access routes and checkpoints - Project Area occupancy schedule - Organization of Project Area preparation - Liquid discharge outlet points - Proposed sampling points for monitoring water quality - Atmospheric emission outlet points - Location of the storage site for dangerous products - Location and mapping of waste treatment facilities when handled by an external service provider - Any other information relating to the environmental management of the Project Area • Emergency plan - Description of facilities - Characterization of hazards - Emergency situations - Organization structure - roles and responsibilities - Emergency procedures - Human and material resources - Triggering of the plan - Reporting

Appendix 2
Properties rendering a product dangerous

1. Explosive	substances and preparations which could explode in the presence of a flame or which are more sensitive to impacts and friction than dinitrobenzene.
2. Combustive	substances and preparations which, when in contact with other substances, particularly inflammable substances, undergo strongly exothermic reactions.
3. Easily inflammable	substances and preparations (i) in liquid phase (including extremely inflammable liquids), with a flash point below 21°C, or which can heat up to the extent of spontaneous combustion in ambient air; or (ii) in solid phase, which can burst into flames easily in the brief presence of a source of inflammation and which will continue to burn after the removal of the source of inflammation or (iii) in gaseous phase, which are inflammable in air at normal pressure; or (iv) – which, when in contact with moist air or water, produce dangerous quantities of gases which are easily inflammable.
4. Inflammable	liquid substances and preparations, with a flash point equal to or above 21°C and less than or equal to 55°C.
5. Irritant	non-corrosive substances and preparations which, when in immediate, extended or repeated contact with the skin and mucosa, can cause inflammation.
6. Harmful	substances and preparations which, in case of inhaling, swallowing or cutaneous penetration, can lead to risks of limited severity.
7. Toxic	substances and preparations (including highly toxic substances and preparations), which, in case of inhaling, swallowing or cutaneous penetration, can lead to serious, acute or chronic risks, and even death.
8. Carcinogenic	substances and preparations which, in case of inhaling, swallowing or cutaneous penetration, can lead to or increase the frequency of cancer.
9. Corrosive	substances and preparations which, in case of contact with living tissues, can destroy the latter.
10. Infectious	substances containing viable micro-organisms or their toxins, for which it is known or we have good reasons to believe that they cause disease in humans or other living organisms.
11. Harmful to reproduction function	substances and preparations which, in case of inhaling, swallowing or cutaneous penetration, can induce or increase the frequency of undesirable non-hereditary effects in offspring or have a negative effect on reproductive functions and abilities.

12. Mutagenic	substances and preparations which, in case of inhaling, swallowing or cutaneous penetration, can lead to hereditary genetic disorders or increase the frequency of these disorders.
13. React with water	substances and preparations which, in case of contact with water, air or an acid, release a toxic or highly toxic gas.
14. Sensitivising	substances and preparations which, in case of inhaling or cutaneous penetration, can lead to a hypersensitation, so that renewed exposure to the substance or preparation will cause characteristic harmful effects. This property can only be considered if test methods are available.
15. Ecotoxic	substances and preparations with inherent or potential immediate or deferred risks for one or several environmental components.
16. Dangerous for the environment	substances and preparations which are likely, after elimination, to lead to another substance, by any means, e.g. a lixiviation product, with one of the above characteristics.

Appendix 3
Environmental and Social Management and Monitoring Plan

Environmental and Social Management and Monitoring Plan

Lekhnath-Damauli 220kV Transmission Line Project, Nepal

Package A Transmission Line

8 February 2022

Project No.: 0529927

VII-7.2

Environmental and Social Management and Monitoring Plan (ESMMP)

Environmental and Social Management and Monitoring Plan

Lekhnath-Damauli 220kV Transmission Line Project, Nepal – Package B Substations

8 February 2022

Project No.: 0529927

The business of sustainability

Signature Page

8 February 2022

Environmental and Social Management and Monitoring Plan

Lekhnath-Damauli 220kV Transmission Line Project, Nepal – Package B Substations

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Acronyms and Abbreviations

AP	Angle Point
APLIC	Avian Power Line Interaction Committee
BAP	Biodiversity Action Plan
CDC	Compensation Determination Committee
CF	Community Forest
CFUG	Community Forest Users' Groups
DFO	Division Forest Office
E&S	Environmental and Social
EBRD	European Bank for Reconstruction and Development
ECoW	Ecological Clerks of Work
EHS	Environmental, Health, and Safety
EMF	Electro-Magnetic Field
EPRP	Emergency Preparedness and Response Plan
ERM	Environmental Resource Management GmbH
ESHS	Environmental, Social, Health, and Safety
ESIA	Environmental and Social Impact Assessment
ESMMP	Environmental and Social Management and Monitoring Plan
ESSD	Environmental and Social Studies Department
FPIC	Free, Prior and Informed Consent
GBV	Gender-based Violence
HPP	Hydro Power Plant
IC	Implementation Consultant
IEE	Initial Environmental Examination
IFC	International Finance Corporation
ILO	International Labour Organization
IP	Indigenous Peoples
KfW	German Development Bank *Kreditanstalt für Wiederaufbau*
LDTLP	Lekhnath-Damauli 220 kV Transmission Line Project
LRP	Livelihood Restoration Plan
MCC	Millennium Challenge Corporation
MoFSC	Ministry of Forests and Soil Conservation
NEA	Nepal Electricity Authority
NR	Nepali Rupee (currency)
NTFPs	Non-timber forest products
OHL	Overhead Line
OHS	Occupational Health and Safety
OMCN	Office of the Millennium Challenge Nepal
PAP	Project Affected Person
PPE	Personal Protective Equipment

PS	Performance Standards
Ramsar	Convention on Wetlands
RAP	Resettlement Action Plan
RPF	Resettlement Policy Framework
RoW	Right of Way
SEP	Stakeholder Engagement Plan
TL	Transmission Line
ToF	Trees Outside of Forest
USD	United States Dollar (currency)
WMP	Waste Management Plan

EXECUTIVE SUMMARY

This Executive Summary presents the Environmental and Social Management and Monitoring Plan (ESMMP) for the proposed Lekhnath-Damauli 220kV Transmission Line (TL) Project. This ESMMP covers the Damauli Substation (Package B), and the ESMMP Package A covers the TL.. The ESMMP provides the purpose, project information, key environmental and social (E&S) impacts and determines mitigation and monitoring approaches. The text of the ESMMP will be for the entire Project and therefore be the same for Package A and B, but the mitigation and monitoring measures will be tailored to the development and operation of each individual package.

The purpose of the ESMMP is to provide the framework of management plans and monitoring regimes by describing in detail the important environmental mitigation measures identified during the impact assessment studies, necessary management plans, responsibilities, and monitoring procedures. The ESMMP addresses the anticipated E&S project impacts, and provides measures to avoid, minimise or compensate adverse impacts on the environment and the quality of life of impacted communities.

The developer of the Project will construct a 42 km 220 kV double circuit line between Lekhnath and Damauli, a connection from the new Damauli Substation to the 220 kV TL from the Tanahu Hydropower plant to Bharatpur (Package A), a new substation near Damauli, as well as an expansion of the existing substation at Lekhnath (Package B). The Project developed by NEA is part of Nepal’s strategy to overcome the continuing power shortages and satisfy the growing demand of electricity. The TL will serve as the power evacuation route for the Tanahu Hydropower Project. The proposed route was determined through the process of line route optimisation. An Alternative Analysis of three alternative routes was carried out. For the final routing of the TL, potential E&S impacts have been considered by the technical planner. The proposed towers are between 29 m and 44 m in height. The provisional right of way (RoW) under the TL will be 30 m - 40 m in total.

Key potential E&S impacts associated with the proposed Project are related to land acquisition, economic and physical displacement, disturbance of fauna especially avifauna, deforestation, soil erosion as well as potential risks during construction such as occupational health and safety (including Covid-19 risks), waste generation, fugitive dust and other emissions (eg. from vehicle traffic, land clearing activities), noise from heavy equipment and truck traffic, hazardous materials and oil spills associated with operation and fuelling activities, the amount of raw material needed (leading to mining for sand or gravel from riverbeds), landslides caused by access road construction and impact on community safety (including Covid-19 risks).

The ESMMP includes measures to protect the environment, especially regarding biodiversity, workers and communities’ health and safety, as well as labour aspects and relations with local communities. Land acquisition and resettlement aspects will be addressed by a separate Resettlement Action Plan (RAP).

The overall responsibility for implementation of a given measure always rests with Nepal Electricity Authority (NEA); the specific implementation of ESMMP items is then (usually, though not always) undertaken by the contractors who construct the Project. All contractors must adopt and comply with the policies and plans required as part of this ESMMP.

A Biodiversity Action Plan has been developed, determining the Project’s mitigation strategy and biodiversity commitments to mitigate and manage biodiversity impacts, including conservation action. A plantation program will be carried out as compensation of trees cleared by the Project. The plantation sites will be determined consulting with the Ministry of Forests and Soil Conservation, the Division Forest Office and Project Affected Community Forest Users’ Groups. The separate RAP will address land compensation in accordance with the rates determined by the Compensation Determination Committee. The RAP does not cover construction-related losses and damages, which will be compensated by the contractor as part of this ESMMP.

A Stakeholder Engagement Plan and Grievance Mechanism including Free Prior Informed Consent (FPIC) requirements for the engagement with Indigenous People (IP) are established for the Project in case affected persons have concerns regarding the Project, including the implementation of the ESMMP. Complaints are expected to be addressed and resolved in a timely manner.

The ESMMP provides a monitoring procedure to ensure that construction and operation of the proposed Project remain compliant with performance standards, guidelines and safeguards established by the lender, as well as national legislation. A key objective of the monitoring is to identify any unanticipated changes by the Project and to identify environmental, health and safety issues before they become significant and to take remedial action.

A cost estimate is stated in this ESMMP for mitigation measures, this includes cost estimates that are stated in the Updated IEE, 2020.

1. INTRODUCTION

Environmental Resources Management Germany (ERM, the Consultant) was appointed by KfW Development Bank (KfW, the Client) to prepare an Environmental and Social (E&S) Gap Closing for the proposed Lekhnath-Damauli 220kV Transmission Line Project (LDTLP, the Project).

The Project is being developed by the Nepal Electricity Authority (NEA, the Project Developer). The Project is part of Nepal's strategy to overcome the continuing power shortages and satisfy the growing demand of electricity. The Transmission Line (TL) will serve as the power evacuation route for the Tanahu Hydropower Project. Fichtner Germany supports NEA as an Implementation Consultant (IC).

The Project is located in the Kaski and Tanahu Districts and consists of the following components:

Package A

- Lekhnath - Damauli 220 kV Double Circuit TL;
- Tie in of loop-in-loop-out (LILO) connection of Tanahu Hydro 220 kV TL into new Damauli Substation (Tanahu TL under-construction, separate financing); and
- Tie in of LILO connection of Old Damauli - Bharatpur 132 kV TL into new Damauli substation.

Package B

- 220 kV GIS extension at existing Lekhnath substation; and
- New 220/132kV GIS Damauli Substation.

This ESMMP is only applicable for Package B. For Package A a separate ESMMP has been developed. The text of the ESMMP will be for the entire Project and therefore be the same for Package A and B, but the mitigation and monitoring measures will be tailored to the development and operation of each individual package.

The existing Initial Environmental Examinations (IEEs) are the basis for the approval by the Nepali Ministry of Energy under Nepali laws. The Environmental and Social Studies Department (ESSD) at NEA is responsible for conducting the IEEs for this Project.

So far, the following documents have been submitted:

- IEE, prepared by NEA's ESSD, November 2017;
- Updated IEE, prepared by NEA's ESSD, November 2019; and
- Updated IEE, prepared by NEA's ESSD, January 2020.

The first IEE drafted in 2017 served as the basis for the Gap Analysis against International Standards. Based on changes in the technical planning, such as the new location of the Damauli Substation the IEE has been updated. According to the planning on which the IEE 2017 is based, the substation has been planned at Belbas of Byas Municipality. In the Updated IEE from November 2019, the new substation is proposed in Khairbote of Byas Municipality. Due to further changes in the technical planning, the IEE was updated again in January 2020. Land acquisition for the Damauli Substation is a time-taking process, and is still going on due to pending case at court.

The ERM assignment includes, besides this Environmental and Social Management and Monitoring Plan (ESMMP) the preparation of the following documents:

- Rapid Assessment for the New Damauli Substation;
- Biodiversity Assessment;
- Biodiversity Action Plan (BAP);
- Gap closing IEE Addendum Report;
- Project-specific Environmental and Social Management System (ESMS);

- Updated Stakeholder Engagement Plan (SEP), including Free Prior Informed Consent (FPIC) requirements and Grievance Mechanism.

A Resettlement Action Plan (RAP) will be developed by the IC based on the Resettlement Policy Framework (RPF), which was developed by ERM as part of a previous assignment and received NEA/KfW approval in 2018.

2. PURPOSE OF THE ESMMP

ESMMP is a fundamental component of an Environmental and Social Impact Assessment (ESIA), since its purpose is to provide the framework of management plans and monitoring regimes that will deliver the commitments, and to ensure these can be implemented practically speaking. This ESMMP describes in detail the important environmental mitigation measures identified during the impact assessment study, necessary management plans, responsibilities, and monitoring.

The broad purpose of the ESMMP is:

- To provide a structured list of actions to be undertaken during project implementation to ensure that E&S risks identified during the assessment process are addressed to international good practice and standards; and
- To provide assurance to third parties, that their requirements, with respect to E&S performance, will be met.

The specific objectives of this ESMMP are:

- To provide an institutional mechanism with well-defined roles and responsibilities for ensuring that measures identified are implemented;
- To minimise any adverse environmental, social and health and safety impacts resulting from the project activities by implementing all suggested mitigation measures identified through the process;
- To prevent or compensate for any loss of the affected persons;
- To conduct project activities in accordance with relevant Nepali Laws and the international guidelines;
- To prevent environmental degradation resulting from cumulative impacts;
- To ensure the ESMMP is feasible and cost-efficient; and
- To ensure all stakeholders concerns are addressed.

The overall responsibility for implementation of a given measure always rests with NEA; the specific implementation of ESMMP items is then (usually, though not always) undertaken by the contractors who construct the Project. All contractors must adopt and comply with the policies and plans required as part of this ESMMP.

3. DEVELOPMENT OF THE ESMMP

The existing Initial Environmental Examinations (IEEs) are the basis for the approval by the Nepali Ministry of Energy. However, the national IEE documents do not provide sufficient details to cover the E&S requirements of the World Bank Group and the German Development Bank *Kreditanstalt für Wiederaufbau* (KfW). Several reports were prepared by ERM to close this gap. Therefore, this ESMMP includes all mitigation measures stated in the IEEs combined with the measures from the gap closing documentation:

- IEE, prepared by NEA's ESSD, November 2017;
- Updated IEE, prepared by NEA's ESSD, November 2019;
- Updated IEE, prepared by NEA's ESSD, January 2020;
- Rapid Assessment for New Damauli Substation, prepared by ERM, 2021;
- Biodiversity Report and BAP, prepared by ERM, 2021; and
- Gap closing Addendum Report, prepared by ERM, 2021.

4. LEGISLATION AND REGULATIONS

4.1 Nepalese Legislation

For this Project, the relevant Nepalese legislation is applicable. A list of the relevant regulations and other relevant instruments and guidelines is presented below.

- Policies and Plans:
  - National Bio-Diversity Strategy and Action Plan (2014-2020);
  - National Climate Change Policy 2076 (2019);
  - National Policy on Land Acquisition, Compensation and Resettlement (2015);
  - Land Use Policy 2072 (2015);
  - National Forest Policy 2075 (2019).
- Acts:
  - Land Acquisition Act (1977);
  - Soil and Watershed Conservation Act, 2039 (1982);
  - Water Resource Act, 2049 (1992);
  - Electricity Act, 2049 (1992);
  - Forest Act, 2049 (1992);
  - Labour Act, 2074 (2017);
  - Environment Protection Act, 2076 (2019);
  - Local Government Operation Act (2017);
  - Child Labour (Prohibition and Regulation) Act, 2056 (2000);
  - Control of International Trade of Endangered Wild Fauna and Flora Act, 2073 (2017);
  - Solid Waste Management Act, 2068 (2011).
- Rules and Regulations:
  - Electricity Rules, 2050 (1993);
  - Environment Protection Rules, 2075 (2020);
  - Water Resources Rules, 2054 (1997);
  - Forest Rules, 2051 (1995);
  - Labour Rules, 2075 (2018);
  - Solid Waste Management Rules, 2070 (2013);
  - Contribution Based Social Security Regulation (2018);
  - Electricity Regulatory Commission Rules, 2075 (2018).
- Guidelines:
  - National EIA Guidelines, 2050, (1993);
  - EIA Guidelines for Forestry Sector, 2052 (1995);
  - Forest Production, Collection & Sales Distribution Guidelines, 2073 (2016);
  - Community Forest Guidelines, 2071 (2014);

- Community Forest Inventory Guidelines (2005);
- Working Procedure with Standards for the Use of National Forest Land for National Priority Project, 2076 (2019).

- Conventions:
  - Convention on Biological Diversity (1992);
  - Convention on International Trade of Endangered Species of Wild Fauna and Flora (CITES)(1973);
  - Convention on Wetlands of International Importance (Ramsar Convention);
  - International Labor Organization (ILO) Convention of Indigenous and Tribal Peoples, 1989 (No. 169).

4.2 International Standards

For this Project, the Bank's (KfW) Sustainability Guidelines[1] are applicable. This means that the application of the following sets of policies and guidelines are required:

- IFC Performance Standards (PS), 2012:
  - PS1 - Assessment and Management of E&S Risks and Impacts;
  - PS2 - Labour and Working Conditions;
  - PS3 - Resource Efficiency and Pollution Prevention;
  - PS4 - Community Health, Safety, and Security;
  - PS5 - Land Acquisition and Involuntary Resettlement;
  - PS6 - Biodiversity Conservation and Sustainable Management of Living Natural Resources;
  - PS7 - Indigenous Peoples;
  - PS8 - Cultural Heritage.
- IFC/World Bank General Environmental, Health, and Safety (EHS) Guidelines, 2007[2];
- IFC/World Bank Environmental, Health, and Safety Guidelines for Electric Power Transmission and Distribution, 2007[3];
- Human Rights Principles outlined in the BMZ Strategy "*Human Rights in German Development Policy*"[4] and specified in the BMZ Guidelines on Incorporating Human Rights Standards and Principles, Including Gender, in Programme Proposals for Bilateral German Technical and Financial Cooperation, 2013;
- Core Labour Standards of the International Labour Organisation (ILO)[5];

[1] KfW (2021) Sustainability Guidelines. Available at: https://www.kfw.de/About-KfW/Service/Download-Center/Konzernthemen/Nachhaltigkeit/Richtlinien/
[2] IFC/World Bank (2007) Environmental, Health, and Safety General Guidelines. Available at: https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/ehs-guidelines.
[3] IFC/World Bank (2007) Environmental, Health, and Safety Guidelines for Electric Power Transmission and Distribution. Available at: https://www.ifc.org/wps/wcm/connect/7b65ce6b-129d-4634-99dc-12f85c0674b3/Final%2B-%2BElectric%2BTransmission%2Band%2BDistribution.pdf?MOD=AJPERES&CVID=jqeI4Rs&id=1323162154847.
[4] BMZ (2013) Human Rights in German Development Policy. Available at: https://www.bmz.de/resource/blob/70448/14b3b6b3fe59eab4dcc05efe266e57b4/guidelines-human-rights-bilateral-cooperation.
[5] Core Labour Standards of the International Labour Organisation. Available at: https://www.ilo.org/global/standards/introduction-to-international-labour-standards/conventions-and-recommendations/lang--en/index.htm on July 2021.

- the UN Basic Principles and Guidelines on Development-based Evictions and Displacement, namely §§ 42, 49, 52, 54 and 60)[6] and guidance provided within the IFC (2002)[7] Handbook for Preparing a Resettlement Action Plan and World Bank (2004) Involuntary Resettlement Sourcebook[8]; and
- FAO Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests (VGGT), 2012[9].

[6] https://www.ohchr.org/Documents/Issues/Housing/Guidelines_en.pdf
[7] ttps://www.ifc.org/wps/wcm/connect/22ad720048855b25880cda6a6515bb18/ResettlementHandbook.PDF?MOD=AJPERES&CACHEID¬=22ad720048855b25880cda6a6515bb18
[8] http://documents.worldbank.org/curated/en/206671468782373680/pdf/301180v110PAPE1ettlement0sourcebook.pdf
[9]FAO (2012) Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests. Available at: http://www.fao.org/docrep/016/i2801e/i2801e.pdf

5. PROJECT DESCRIPTION

5.1 Project Overview

The Project developed by the NEA is part of Nepal's strategy to overcome the continuing power shortages and satisfy the growing demand of electricity. The TL will serve as the power evacuation route for the Tanahu Hydropower Project. It relates to the construction of a new substation (Damauli Substation) and the expansion of an existing substation (Lekhnath Substation), which will be linked by a double circuit TL. The main components of the Project are:

Package A

- Construction of 42 km 220 kV Double Circuit TL between Lekhnath - Damauli;
- Tie in of loop-in-loop-out (LILO) connection of Tanahu Hydro 220 kV TL into new Damauli Substation (Tanahu TL under-construction, separate financing); and
- Tie in of LILO connection of Old Damauli - Bharatpur 132 kV TL into new Damauli Substation.

Package B

- 220 kV GIS extension at existing Lekhnath Substation (on land which already belongs to NEA); and
- New 220/132kV GIS Damauli Substation.

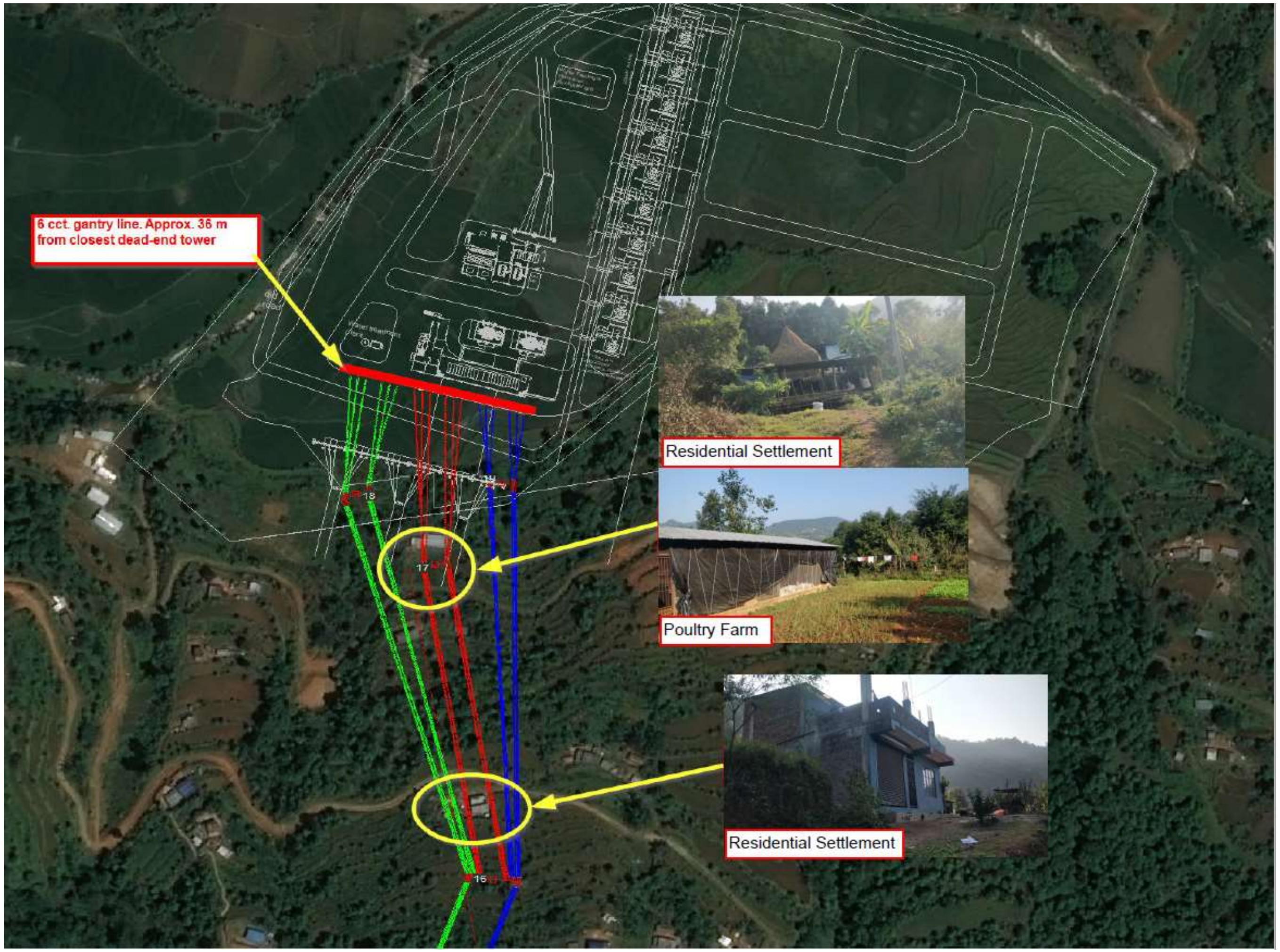
The Project is located in the Kaski and Tanahu Districts of Province No. 4 in the Gandaki Zone of the central part of Nepal.

The currently proposed TL has a length of about 42 km. The proposed route starts at the existing substation of Lekhnath, near Pokhara, and terminates at the proposed Damauli Substation in the Byas Municipality of Tanahu District.

The majority of the proposed TL will be a double/four circuit with two separate aluminium conductor steel reinforced (ACSR) per phase. The proposed towers are between 29 m and 44 m in height. The provisional right of way (RoW) under the TL will be 15 m either side of the centre line (30 m in total). For the multi-circuit line from AP44 to the new Damauli Substation, the RoW will be 20 m either side of the centre line (40m in total).

Developing the Project will require expanding some foot trail and feeder roads in order facilitate the transport and placement of towers.

The approximate size of the Damauli Substation will be 7 ha. A overview is shown in Figure 5-1. The resettlement issue shown in the Figure will be covered in the separate RAP and is not part of the ESMMP for Package B.



Source: Fichtner (2021)

Figure 5-1 Project Overview

5.2 Construction Planning

The implementation of the proposed project comprises construction of the foundation for and erection of towers, wire stringing, testing and commissioning of the line. The estimated period of project completion is two years. According to the Updated IEE for the Project (NEA ESSD, January 2020), the following key phases are envisaged.

Preliminary Works

Preliminary works for the TL consist of contract award, the detail design study and mobilisation of the contractors. The detail design study will carry out the detailed route survey, spotting the tower locations, preparation of longitudinal profiles, geological field test and laboratory testing, tower design etc. To achieve effective tower footing resistance, earth resistance will also be measured at each tower site.

Land Acquisition and Resettlement

Once the Contractor is selected, the final line profile/design will be determined. This includes the necessary line routing, which needs to be approved by NEA, IC and KfW. After the design of the tower locations is finalised, the required land will be acquired by NEA as per the Land Acquisition Act (2034 B.S.), the requirements stipulated in the RPF (2018) and concretised in the RAP developed and supported by the IC in coordination with Compensation Determination Committee (CDC). Based on the final design to be developed by the Contractor the Interim RAP will be prepared. For the Interim RAP a Social Survey and Census of PAPs will be made. The census will be accompanied by an inventory of lost assets and a detailed land measurement survey to determine all houses/structures in the RoW and land ownership of tower foundations and access roads that will have a permanent impact on land, which cannot be fully restored to prior condition. Overspanning of private lands in the RoW will be compensated as well.

The design of the substation site is already finalised. Out of the 84 plots of the Damauli Substation, all owners have already claimed and received the compensation, except for only two plots belonging to one person. These plots remain to be compensated because the case is currently pending at court.

The impacts that were not avoided and not compensated during the prior RAP implementation, will need to be compensated by the Contractor (according to RAP entitlements).

Forest and Land Clearance

The trees will be felled for the tower foundation and under the RoW in coordination with the Division Forest Office (DFO) and other stakeholders. Loss of crops will be compensated.

Extension at Lekhnath Substation

At Lekhnath substation, the new 220 kV switchgear will be connected to the existing 132 kV AIS outdoor switchyard by means of 220/132/11 kV single-phase auto-transformers, and the existing 132 kV yard will be extended accordingly.

Damauli Substation Construction

In Damauli, a new 132kV switchyard shall be constructed together with the 220kV substation. An indoor, double bus bar system SF6 Gas Insulated Switchgear (GIS) type has been selected for both substations. Construction of the new substation at Damauli will include civil works for ground elevation, boundary wall, control building, office/staff quarter buildings and line bay foundation. Following completion of the main civils works, the transformers and equipment will be transported to the sites and installed. The level of the substation will be raised by about 2 m for purpose of flood protection; for this a quantity of minimum 20,000 m³ of filling material will be needed. Additional permanent and stabilised access roads will be needed to enable the transport, storage and management of the soil at the substation site. Also, the transportation traffic through the villages will increase.

Tower Foundations

The construction of tower foundations will be undertaken by manual labour assisted by the mechanical equipment wherever possible. The mechanical plant will be limited to small demountable steel skid framed concrete mixers, air compressors, air drills/chisels and tamping/compaction tools. Excavation and the concreting of the tower foundations will be carried out as per the design requirements and after necessary curing, the foundations will be backfilled with suitable material. The average area required for each tower foundation is 15m x 15m (0.0225ha).

Erection of Towers

Galvanised steel lattice towers, manufactured offsite at a centralised factory, will be transported to the individual tower locations and are assembled and erected manually by employing pulleys, winches, etc. into the tower foundations.

Insulator Fittings, Conductor and Ground Wire Stringing

Conductors, optical ground wire (OPGW), ground wires, insulators and necessary accessories will be transported manually to the tower locations. Stringing of conductors, OPGW and extra high strength wire will be carried out with the help of a tension machine and other pulling devices as per the design requirements.

Access Roads

Primary site access for the substation construction will be gained from Byas through Belbas road. The TL and its foundation construction sites will be accessed from Prithvi Highway and its various feeder roads that pass near the settlements along the alignment. Existing feeder roads and tracks will be used for construction and maintenance where available. The construction material up to the nearest road head will be carried where possible by vehicle and later transported manually up to the individual tower locations. Various options for access road types have been identified by the IC[10]:

- Sections of existing public roads to be used (without enlargement or other modification);
- Existing roads not maintained by local authorities (which may need upgrade and stabilisation works);
- Existing community tracks (which will need to be enlarged and stabilised, thus creating E&S impacts);
- Proposed new access tracks which can be restored to natural condition after construction;
- Proposed new access tracks which will require cutting of slopes or terraces and cannot be restored to natural condition and thus need to be stabilised with roadside stabilisation, erosion protection and drainage to prevent degradation and negative environmental impacts; and
- Tower locations that cannot be accessed by road and need to be accessed by animal, cable, or aerial (e.g. helicopter) transport. This category also includes tower locations where the construction of access roads would cause excessive environmental damage.

Dumping Site

Since the construction of TL towers requires clearing and excavation of fairly small areas at tower locations, construction work will not require soil dumping sites. According to the IEE project description, the soil will be filled up and compacted in the tower base area. Similarly, soil generated

[10] Internal Document on Mitigation measures for access roads prepared by Fichtner, ERM received 17.11.2021.

from the substation during construction will be used for levelling of the access road and river protection work near the substation. However, attention must be paid to avoid erosions caused by access road development and soil disturbance. Adequate mitigation measures to address this issue are listed in Chapter9.

Construction Materials

The materials required for civil construction works related to the TL, switching station and substation will be:

- Steel reinforcement;
- Cement;
- Coarse aggregate;
- Fine aggregates (sand);
- Batteries; and
- Admixtures, etc.

Steel reinforcing bars and cement may be acquired from local manufacturers or may also be imported. Coarse aggregates will be produced at site from excavated materials or purchased from the local market. Likewise, fine aggregates will be collected from existing major quarries and the excavated foundation material will be used as a backfill material required for the foundation construction. Amounts required of each material are presented in Table 5-1.

Table 5-1 Construction Materials Quantities of the Project

Description	Unit	Quantity
Coarse aggregates	m^3	4,588
Total Reinforced Steel Quantity	Tons	460
Total Cement Quantity	Bags	47,120
Total Fine Aggregates	m^3	2,356
Filling Material	m^3	20,000

Source: NEA, Updated IEE 2020

5.3 Requirement of Workforce

During the construction period of the Project, altogether approximately 350 people will be employed including 265 unskilled, 60 semi-skilled and 25 skilled personnel. The requirement of the workforce will be from start to end of the construction stage. Most of the unskilled manpower will be hired locally as per available skill and experiences.

5.4 Project Schedule

The estimated completion period of the project is 24 months, including 6 months pre-construction and 18 months construction and commissioning. According to the IEE project description, the construction work will primarily be carried out during the dry season when ground conditions are essentially dry and river flows low to allow easy movement of materials and placement of towers. However, it should be noted that a document from the IC[11] including mitigation measures states that culverts and bridges shall be installed for the purpose of crossing existing watercourses. The locations and types of culverts and bridges shall be proposed by the Contractor and approved by NEA and the IC. Construction activities during the monsoon season will primarily be restricted to stringing of

[11] Internal Document on Mitigation measures for access roads prepared by Fichtner, ERM received 17.11.2021.

conductors, although this activity may also be restricted by the adverse weather conditions. The construction work of the switching station and substation will be conducted throughout the year.

6. ROLES AND RESPONSIBILITIES

6.1 Nepal Electricity Authority

NEA has the overall responsibility for E&S management during the planning, construction and operation phase of the Project. This role includes the following responsibilities:

- Ensuring compliance with all relevant national legislation, as well as with the environmental controls and mitigation measures contained in this ESMMP;
- Ensuring that the design and planning is in compliance with national requirements and aligned with international Standard / Best practice;
- Ensuring that the relevant mitigation measures during construction are part of contractor's contract;
- Monitoring the performance of contractors and sub-contractors used for providing workforce, supplies and services; and
- Acting as point of contact for consultation and feedback to stakeholders and the public (stakeholder engagement).

NEA ESSD

The Environment and Social Studies Department (ESSD) of NEA executes all activities related to the environmental aspects of project studies, design, construction and operation by NEA. Being the concerned department, ESSD had prepared the IEE reports of this Project.

NEA Environmental Management Unit

An **Environmental Management Unit** will be formed, responsible for managing and implementing mitigation measures and monitoring on behalf of the Project. The Environmental Management Unit will prepare and disseminate monthly reports containing information on the implementation status of the measures and monitoring results.

For the implementation of the E&S measures specially trained staff has to be employed (ESMS Manager, Occupational Health and Safety (OHS) Expert, Environmental Expert, Social Expert (e.g. Community Liaison Officer). Staff involved in the management and implementation of the E&S measures during construction and operation need to be especially trained for ESMMP implementation (capacity building).

Environmental Management and Grievances Redress Unit (NEA / NEA ESSD)

NEA will establish an **Environmental Management and Grievances Redress Unit** under the Project organisational setup. This Unit will be under direct supervision of the **Project Manager Office (PMO)** and will have three sections, namely

- Land Acquisition and Rehabilitation Section (LARS);
- Project Information Centre (PIC);
- Mitigation Implementation Section (MIS).

LARS will be responsible for the implementation of land acquisition and rehabilitation program, whereas public disclosure activities will be conducted through PIC supported by IC. The MIS will implement mitigation measures proposed in the ESMMP. The MIS will coordinate the work district level agencies such as District Forest Office, District Development Committee, and District Land Revenue and others.

6.2 Contractor

Construction Contractors are required to fulfil the Environment, Social, Health and Safety (ESHS) requirements as set out in this ESMMP and to ensure that their sub-contractors fulfil the ESMMP. This typically includes tasks before and during construction and rehabilitation of work areas after construction:

- Conduct internal monitoring and on-site audits to verify implementation of the ESMMP and report on findings to NEA.
- Communicate any environmental issues and incidents to NEA immediately.
- Training of the construction workers to raise awareness in the fields of E&S topics and in general implementation of this ESMMP.
- Ensure that workers comply with all OHS requirements e.g. safety working at height, wearing of PPE etc.
- Conduct Stakeholder Engagement, including FPIC requirements.
- Establish a Grievance Mechanism and implementation of corrective actions.

6.3 Implementation Consultant

The Implementation Consultant (IC, Engineer) is responsible for managing engineering activities in close cooperation with NEA. This includes technical, managerial and supervisory activities as well as provision of necessary guidance during all project phases. The project implementation has three (3) different phases. The IC supports NEA in all three of them:

- **Procurement Phase:** comprises all tasks until award of a contract, such as review services, the preparation of tender documents while considering the E&S aspects, conduct the tender process, including tender evaluation and assistance for the award of contract(s).
- **Implementation Phase:** comprises all tasks related to design audit, site supervision, testing, handing over, reviewing, updating, monitoring and reporting activities related to the E&S concerns of the Project. Main tasks related to E&S aspects will be the
    - Support NEA in implementing the ESMMP and any sub-plans, including the interim and final RAP, the SEP, to achieve FPIC, the BAP etc;
    - Attendance at any consultation meetings held by NEA or other responsible agencies with the PAP and attendance at any key milestone resettlement related activities (e.g. during the physical resettlement period (if any), etc.);
    - Monitoring and reporting on implementation of the ESMS / ESMMP (including any updates), including preparing and summarising reports on construction-related E&S aspects;
    - Continuous updating and preparing of final RAP inter alia to record the final compensation entitlements and payments made to each PAP household and provide actionable details of any livelihood initiatives and implementation arrangements which require follow-on action;
    - Monitoring, following-up and resolving any complaints or grievances in relation to construction health and safety, labour conditions or environmental pollution, land issues, disturbance of population, etc. while considering as well the available Grievance Redress Mechanism (GRM); and
    - Monitoring E&S success indicators.

- **Post-construction Phase:** comprises tasks related to services rendered during the Defects Liability Period (assumed to be 24 months) and related reporting activities to the Project completion and E&S concerns of the Project.

6.4 Other Stakeholders

A tree plantation program will be carried out as compensation of trees cleared by the Project. The plantation sites will be determined consulting with the Ministry of Forests and Soil Conservation (MoFSC), the Division Forest Office and Project Affected Community Forest Users' Groups (CFUGs).

Land compensation will be given in accordance with the rates determined by the Compensation Determination Committee (CDC). The district-level CDC was established under Section 13 (2) of the Land Acquisition Act, 2034 (1977) to determine replacement value and compensation rates for property acquired under the Act.

6.5 Agencies Responsible for Implementation and E&S Monitoring

The overall responsibility for implementation of a given measure rests with NEA as the Project Proponent; the specific implementation of ESMMP items is then (usually, though not always) undertaken by the contractors who construct the Project. The division of responsibilities for each individual mitigation measure is defined in the Tables below in Chapter **Error! Reference source not found.**. All contractors must adopt and comply with the policies and plans required as part of this ESMMP.

Ministry of Energy, Water Resources and Irrigation (MoEWRI) and the Department of Electricity Development (DoED) will be responsible for monitoring. However, NEA will have the prime responsibility for carrying out the monitoring activities. NEA ESSD will be responsible for pre-construction and construction phase monitoring of the Project. EMU comprising the staff from NEA ESSD will be established for the construction phase of monitoring of the project. The EMU will be responsible for compliance and impact monitoring works.

7. STAKEHOLDER ENGAGEMENT

NEA, supported by the IC, will ensure that the local communities are informed at an early stage about the planned Project, timelines, expected impacts and communication channels and will assign personnel in charge of the engagement with stakeholders. NEA will also seek for feedback from the communities about the Project. As part of its community liaison process, NEA will initiate and implement a Grievance Mechanism to ensure that all stakeholder comments, suggestions and objections are captured and considered. It will allow the affected community and the workers to express their concerns and any complaints directly to NEA. Contact details and information on the procedure, including grievance form, will be distributed to the local communities. It is envisaged that grievances will be responded to within 20 working days after receipt.

All comments and complaints will be investigated by NEA, and if necessary appropriate action will be conducted. Records of all complaints and actions will be maintained on site.

The SEP and, thus, the engagement process will aim to achieve FPIC from Indigenous Peoples (IP) affected by the Project through good faith negotiation between the Project proponent and the Affected Communities of IPs. ERM developed a SEP for this Project in 2017.[12] The SEP needs to be updated when necessary, since Stakeholder Engagement will be continued throughout the Project life cycle.

The Contractor is responsible for Worker's Grievance Mechanism and communication with PAP's during construction works.

[12] Stakeholder Engagement Plan for the Lekhnath Damauli Transmission Line Project, Nepal (2017)

8. SUMMARY OF MAIN E&S PROJECT IMPACTS

Key potential impacts associated with the proposed expansion of substation and development of a new substation and proposed mitigation measures during construction and operation of the Project are provided in Chapter 9. The Contractor will be responsible for implementing mitigation measures as required in the ESMMP. For the construction and operation of the two substations, the following key impacts are expected or can potentially occur:

- **Potential land use impacts**
  - Land will be temporarily and permanently acquired; and
  - Land acquisition will generate economic and physical displacement (loss of structure, loss of crops, and loss of livelihood).
- **Potential impacts during construction**
  - Construction site waste generation;
  - Soil erosion from material sourcing areas, site preparation activities and development of access roads;
  - Fugitive dust and other emissions (e.g. from vehicle traffic, land clearing activities and materials stockpiles);
  - Noise from heavy equipment and truck traffic;
  - Potential for hazardous materials and oil spills associated with heavy equipment operation and fuelling activities;
  - Potential landslides caused by access road construction;
  - Raw material demand increases risk for potential (illegal) mining for sand or gravel from riverbeds as well as impact on quarries (E&S management required);
  - Occupational Health and Safety (OHS) risk also in regard to workers' accommodation (including risks of Covid-19);
  - Community Safety (increased traffic, construction site, risks of Covid-19);
  - Potential impacts of the Project on biodiversity receptors
    - Habitat loss and degradation within the Project Area (including for new access roads);
    - Species loss – flora removal from vegetation clearance;
    - Species loss - fauna mortality due to direct loss or injury from vehicle or machinery strike or as a result of poaching by the construction workforce;
    - Disturbance and displacement of fauna; and
    - Loss of ecosystem services.
- **Potential impacts during operation**[13]
  - Adverse health impacts from electromagnetic fields (EMF);
  - Acoustic noise for sensitive receptors near substations especially during night time; and
  - Waste management risks.

[13] Operational phase includes operation of the TL and respective maintenance.

9. E&S MANAGEMENT AND MONITORING PLAN

9.1 Mitigation Measures of the Damauli Substation

Overall, in addition to paying adequate compensation rates for loss of land, assets and business, the Project needs to ensure the following requirements are met:

- All requirements regarding resettlement and livelihood restoration as described in the Resettlement Policy Framework (RPF) (ERM 2018);
- For the Damauli substation out of 84 plots of the substation, all owners have already claimed and received the compensation except only two plots belonging to one person. These plots remain to be compensated because the case is currently pending at court;
- Registration Tax or Land Transfer Tax from owners to NEA was paid by NEA. In addition, the Capital gain Tax was paid by NEA while acquiring the land. The compensation procedure did not consider full replacement costs as real estate transfer tax for buying new land was reportedly not included. On the other hand, an additional sum to the land compensation costs will be/were paid, considering the crops value for a 5-year period[14]. It is recommended that the Project Implementation Consultant, who is in charge of RAP preparation, seeks clarification whether the additional amount paid compensates for the omitted transfer tax;
- Potential noise impacts from the substation on nearby receptors need to be modelled and appropriate mitigation measures need to be implemented as per construction standard;
- Potential trainings and other livelihood restoration measures (i.e. skills training, agricultural training, agricultural input provision) need to be conducted (described below in the Tables); and
- Three old trees on the substation site need to be protected (if possible regarding substation safety and security restrictions) and the recreational area need to be kept accessible for people (not fenced).

Furthermore, a new hydrological analysis study, including a flood risk assessment of the Damauli Substation by NEA shows that an increase of the substation platform elevation is required to protect it against potential flood.

9.2 Overview of ESMMP for the Project

This document determines the ESMMP. The ESMMP captures the typical E&S impacts and associated mitigation measures that need to be considered at the Project development and operation. The ESMP includes also respective monitoring procedures and means of verification. NEA - together with the contractors and other involved entities - shall use this document as guidance.

The ESMMP is divided into the ESMMP for the design/planning, construction and operational phase for the development of the TL. The ESMMP follows the structure of the KfW standard bidding documents :

- A – General Requirements for ESHS Management,
- B – Protection of Environment;
- C – Workers Health & Safety; and
- D – Labour and Relations with Local Communities.

However, Section A – General Requirements for ESHS Management are identical for all projects and are therefore unrevised included in the KfW standard bidding documents. Thus, this ESMMP only includes the Sections B – D.

[14] Only annual crops are grown on the substation site.

An ESMS with the supporting management plans as listed in Table 9-1 should be prepared. However, further plans may be needed.

Table 9-1 Required Supporting Management Plans and Responsibilities

Plans	Phase	Responsibility
Biodiversity Action Plan (BAP) (existing)	Construction	NEA (prepared by ERM)
	Operation	
Chance Finds Procedure	Construction	Contractor
Community Health and Safety Management Plan	Construction	Contractor
	Operation	NEA
Contract Management Plan	Construction	NEA
Earthworks, Erosion and Reinstatement Management Plan	Construction	Contractor
Emergency Preparedness and Response Plan (EPRP)	Construction	Contractor
	Operation	NEA
Environmental, Health & Safety (EHS) Policy	Construction	Contractor
	Operation	NEA
Grievance Mechanism	Construction	NEA
	Operation	
Workers and Community Grievances	Construction	Contractor
Human Resources Management Plan	Construction	Contractor
	Operation	NEA
Resettlement Policy Framework (RPF) (existing)	Before Construction	NEA (prepared by ERM)
Resettlement Action Plan (RAP) and Livelihood Restoration Plan (LRP)	Construction	Implementation Consultant
	Operation	
Stakeholder Engagement Plan (SEP) (existing)	Construction	NEA (prepared by ERM)
	Operation	
Traffic Management Plan	Construction	Contractor
Vehicle Machinery and Inspection Programme	Construction	Contractor
Water Management Plan	Construction	Contractor
Waste Management Plan (WMP)	Construction	Contractor
	Operation	NEA

9.3 ESMMP for the Project – Design/Planning Phase

The following Table 9-2 shows the measures required to be implemented during the design/planning phase as well as prior to start of construction. In this phase NEA, the Contractor as well as the IC are each responsible for the implementation of certain measures as indicated in the table.

Table 9-2 ESMMP for the Project – Design/Planning Phase

No.[15]	Item	Mitigation, Management and Enhancement Measures	Responsible[16]	Timeline	Means of Verification	Monitoring Procedure	Source
B.	**Protection of the Environment**						
B.10.	Protection of adjacent areas	Quantify the required water amounts, water sources and the availability of water in terms of the volume that can be provided from the watercourses envisaged as water source. Permits will be obtained prior to usage of any water resources. Nearby water users (communities) will be engaged in order to not affect their water availability. Downstream impacts on residents to be considered.	Contractor	Prior to construction	Development of Water Management Plan Water permit obtained	Regular monitoring of adjacent natural resources By IC	Standard / Best practice
B.11.	Selection of borrow areas, backfill material stockpile sites and access road	Approve quarries and borrow pits with appropriate E&S certification (eg. no gravel abstraction from river) for construction. Prepare IEE/EIA for quarry/borrow area for approval by Ministry of Environment.	Contractor	Prior to construction	IEE/EIA Permit	Permit review By IC Final approval By NEA	Standard / Best practice
		In the detailed design phase, prepare access road maps detailing the proposed access routes. The various access types shall be identified and mapped showing length and terrain features. The types of new access tracks to be constructed shall be shown on maps.	Contractor	During design, prior to construction	Review Written approval	Review By IC Final approval By NEA	Internal Document prepared by IC, received 17.11.2021

15 Numbering is not continuous because it refers to the items of KfW standard bidding documents.

16 In case several entities are responsible for implementation, a lead entity is defined in this format: **Lead Entity**.

No.[15]	Item	Mitigation, Management and Enhancement Measures	Responsible[16]	Timeline	Means of Verification	Monitoring Procedure	Source
		Type(s) of Contractor's heavy machinery which shall traverse the access routes shall be indicated and will also be included in the Traffic Management Plan. Access maps shall be submitted together with the final detailed routing design (at least 12 months before the physical construction commencement date). Appropriate measures such as avoidance of tree cutting, avoidance of agriculture areas, and avoidance of impacts on communities shall be implemented in design phase. If land needs to be acquired it has to be included in the RAP. If private lands are traversed by temporary access roads, compensations have to be paid to land users. For a detailed approach for identifying access road types and details to be included follow the instruction in Appendix A.					
		The Contractor is required to minimise the need for new access roads by: ■ Using existing roads as much as possible; ■ Create short 'finger' roads from existing roads to tower locations instead of long roads along the line route where possible; and ■ Consider alternate means of transportation described earlier instead of constructing long roads through forested hilly/mountainous areas. Selection criteria for types of access roads in order of priority are defined in Appendix A.	Contractor	During design	Review Written approval	Review By IC Final approval By NEA	Internal Document prepared by IC, received 17.11.2021

No.[15]	Item	Mitigation, Management and Enhancement Measures	Responsible[16]	Timeline	Means of Verification	Monitoring Procedure	Source
		Once the access maps have been approved, the Contractor shall not make use of any other access routes without the prior approval of NEA and IC.	Contractor	During design	Review Written approval	Review By IC Final approval By NEA	Internal Document prepared by IC, received 17.11.2021
		Culverts and bridges shall be installed for the purpose of crossing existing watercourses. Culverts shall also be installed where required for effective drainage systems. The locations and types of culverts and bridges shall be proposed by the Contractor and approved by NEA.	Contractor	Prior construction	Observations on site	Review By IC Final approval By NEA	Internal Document prepared by IC, received 17.11.2021
B.12.	Pollution prevention	Develop an Emergency Preparedness and Response Plan (EPRP) for spill containment and clean-up, engineering contingencies, collisions, natural hazards and other emergencies to include: ■ The emergency response in the event of spills, fire, accidents, earthquakes, floods; ■ Procedure for staff and subcontractors to report any incidents; and ■ Emergency response training; ■ Emergency communication procedure. Ensure PCBs are not used in substation transformers or other project facilities or equipment. Ensure processes, equipment and systems do not use chlorofluorocarbons (CFCs), including halon, and their use, if any, in existing processes and systems should be phased out and to be disposed of in a	Contractor	Prior to construction	Review Written approval	Review By IC Final approval By NEA	Standard / Best practice

No.[15]	Item	Mitigation, Management and Enhancement Measures	Responsible[16]	Timeline	Means of Verification	Monitoring Procedure	Source
		manner consistent with the requirements of the Government.					
B.13.	Noise and vibration	Potential noise impacts from the substation on nearby receptors need to be modelled and appropriate mitigation measures need to be implemented as per construction standard.	Contractor	Prior to construction	Review Written approval	Review By IC Final approval By NEA	Standard / Best practice
		Develop a Vehicle Machinery and Inspection Programme of own and subcontractor / third party trucks and other machinery. This should be dealt with according to specific H&S procedures of the Contractor.	Contractor	Prior to construction	Review Written approval	Review By IC Final approval By NEA	Standard / Best practice
B.16.	Waste Management	Develop an effective Waste Management Plan (WMP) to ensure that all wastes (hazardous, non-hazardous, wastewater) are disposed of in an environmentally sound manner. This plan shall describe procedures to ensure that waste generation is minimised, transportation is monitored, storage is safe and disposal methods are sound and do not cause negative impacts to the environment or communities.	Contractor	Prior to construction	Review Written approval	Review By IC Final approval By NEA	IEE Nov 2017, A IEE Nov 2019, A IEE Jan 2020, A
C.	**Health and Safety**						
C.22.	Health and Safety Plan	Develop occupational H&S plans and procedures and/or update the existing documents in line with Project standards as required. Develop Community Health and Safety Management Plan.	Contractor	Prior to construction	H&S Plans and Procedures in place Community Health and Safety Management Plan	Review By IC Final approval By NEA	Standard / Best practice
C.31.	Emergency scenarios prevention	Take the necessary measures to ensure that pollution to air, water or land is prevented or, where this is not possible, reduced and	Contractor	Prior to construction	Review Written approval	Review By IC	Standard / Best practice

No.[15]	Item	Mitigation, Management and Enhancement Measures	Responsible[16]	Timeline	Means of Verification	Monitoring Procedure	Source
		mitigated as far as practicable during the construction phase. In doing so the Contractor will need to develop a EPRP which clearly outlines the measures for managing e.g. atmospheric emissions and dust, e.g. noise and vibrations, e.g. waste (specified in ESHS Specifications including 15 and 16 below). Please provide specific details on how to handle for example the following aspects: a) liquid effluents b) air emissions and dust c) noise and vibration management d) vehicle and equipment maintenance and selection e) fuel, oil and chemical storage and handling Develop an EPRP for spill containment and clean-up, engineering contingencies, collisions, natural hazards and other emergencies to include: ■ The emergency response in the event of spills, fire, accidents, earthquakes, floods; ■ Procedure for staff and subcontractors to report any incidents; ■ Emergency response training; ■ Emergency communication procedure.				Final approval By NEA	
C.40.	Hygiene, accommodation and food	Provide adequate accommodation for workers, in line with international Standard / Best practice. Develop a Worker Accommodation Plan as per IFC/EBRD Guidelines on Worker	Contractor	Prior to construction	Accommodation to meet international standards Worker Accommodation	Campsite inspection prior to accommodation of the workers. By IC	Standard / Best practice

No.[15]	Item	Mitigation, Management and Enhancement Measures	Responsible[16]	Timeline	Means of Verification	Monitoring Procedure	Source
		Accommodation[17], whenever planning to establish a labour camp/colony. The Worker Accommodation Plan shall also include risks and mitigation linked with gender-based violence and trafficking in persons, as well as communicable diseases, for sexually transmitted diseases and pandemic diseases such as Covid-19.			Plan and Monitoring Checklist		
D.	**Labour and relations with local communities**						
D.42.	Labour conditions	Adopt and implement human resources policies and procedures consistent with the requirements of national labour laws, IFC PS 2 and the ILO Conventions. Provide workers with documented information that are clear and understandable, regarding their rights under national labour and employment law and any applicable collective agreements, upon beginning working relationships and when any material changes occur. Ensure wage rates are not be lower than established for the sector where the work is carried out or for a similar industry. There should be no wage disparity (for similar work and skill levels) between males and females, or migrant workers and local workers. Ensure Contractor and any subcontractor will not interfere with workers' rights to form or join a workers' organisation.	Contractor	Prior to construction	Human Resources Management Plan Sample contract Worker Accommodation Plan and Monitoring Checklist Audit	Review By IC Final approval By NEA	Standard / Best practice

[17] IFC/EBRD (2009) Guidelines on Worker Accommodation. Available at: https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/publications/publications_gpn_workersaccommodation

No.[15]	Item	Mitigation, Management and Enhancement Measures	Responsible[16]	Timeline	Means of Verification	Monitoring Procedure	Source
		The Contractors engaged for the Project (including supply chain) will not use child or forced labour, or discriminate against vulnerable groups. Ensure all workers have the same rights and are treated equally. These measures will be laid out in Human Resources Management Plan. The Project will audit contractors to ensure they are abiding by the Human Resources Management Plan. Failure to meet these standards will result in consequences up to and including termination of contract, to be decided on a case-by-case basis.					
D.43.	Local recruitment	Ensure that the assigned contractor gives capable members, as well as unskilled labour of the affected communities and villages priority in recruitment, throughout the construction and operation phases of the Project. The assigned contractor will prioritise the procurement of goods, construction materials and services from within the affected District, or in case this is not possible, preference should be given to suppliers within the Region.	Contractor	Prior to construction	Local procurement and employment rules and records Appropriate code of conduct	Review By IC Final approval By NEA	Standard / Best practice
D.47.	Community interaction	Update the existing Stakeholder Engagement Plan[18] (SEP), including FPIC requirements throughout the project life cycle, designed to support the development of strong, constructive and responsive relationships, which includes inter alia:	**NEA**, Contractor	Prior to construction	SEP developed Grievance mechanism and grievance log	Monitoring of effected works By IC	Standard / Best practice

[18] Stakeholder Engagement Plan of the Lekhnath-Damauli Transmission Line Project, Nepal (2017)

No.[15]	Item	Mitigation, Management and Enhancement Measures	Responsible[16]	Timeline	Means of Verification	Monitoring Procedure	Source
		■ Endorsement and implementation of a SEP; ■ Implementation of a grievance mechanism so that communities can share their concerns; and ■ Consultation to inform local communities of the risks of trespassing onto sites.			Public awareness programme and documentation		
		Pending Resettlement and Land Acquisition issues, will be addressed in the Resettlement Action Plan and Livelihood Restoration Plan (RAP and LRP). All details are provided in the RPF and the RAP.	IC	Prior to construction	RAP and LRP SEP Grievance mechanism	RAP and LRP Implementation and Completion Audits By IC Final approval By NEA	Standard / Best practice
		Ensure that the RAP and LRP includes consideration of permanent loss of livelihoods, and develop and implement a Livelihood Restoration Plan for all affected households. This should include compensation for loss of land (preference to like for like else cash compensation), compensation for crops and trees (based on replacement value) as well as development of alternative livelihood strategies if replacement land cannot be provided. The Livelihood Restoration Plan should include consideration of land users and owners. The LRP should include identification of potential LRP implementation partners ie. NGOS, government bodies, cooperatives etc.	IC	Prior to construction	RAP and LRP	RAP and LRP Implementation and Completion Audits. By IC Final approval By NEA	IEE Nov 2017, C IEE Nov 2019, C IEE Jan 2020, C
		Undertake stakeholder engagement in a timely manner to inform people about the construction and operation activities	**NEA**, Contractor	Prior to construction	RAP and LRP	RAP and LRP Implementation and Completion Audits.	IEE Nov 2017, C IEE Nov 2019, C

No.[15]	Item	Mitigation, Management and Enhancement Measures	Responsible[16]	Timeline	Means of Verification	Monitoring Procedure	Source
		including the timing of such activities and restrictions on land use. Implement a grievance mechanism so that communities can share their concerns regarding the Project and if activities are having significant negative impacts on livelihoods. Transition Allowances and other forms of allowances – land development, land improvement, transportation etc.				By IC Final approval By NEA	IEE Jan 2020, C
		The RAP and LRP also cover impacts on Indigenous Peoples (IP) including impacts on land under traditional ownership or customary use of IPs, natural resources, cultural sites, and physical displacement.	IC	Prior to construction	RAP and LRP SEP Grievance mechanism	RAP and LRP Implementation and Completion Audits By IC Final approval By NEA	Standard / Best practice
		Effective gender mainstreaming and integration of consistent gender perspective in all Project activities. This relates to both labour management and community health and safety. Promotion of opportunities, growth, gender equality and positive gender dynamics, recognising different needs and impacts for men and women, as well as management and mitigation of adverse gender risks such as gender-based violence (GBV), including sexual harassment and bullying. The Contractor will develop awareness training for workers, to integrate gender issues into overall project E&S management, ensuring workers understand code of conduct expectations and required compliance. This includes but is not limited to:	Contractor	Prior to construction	Human Resources Management Plan Code of Conduct	Review of Human Resources Management Plan and Code of Conduct Interviews Review of grievance log By NEA	Standard / Best practice

No.[15]	Item	Mitigation, Management and Enhancement Measures	Responsible[16]	Timeline	Means of Verification	Monitoring Procedure	Source
		■ A Human Resources Management Plan and Code of Conduct, which includes fair treatment, equal opportunities without discrimination based on political affiliations, age, sex, race, ethnicity and sexual orientation, as well as no tolerance for any form of sexual harassment, discrimination, bullying or violence; ■ Associated provisions in the Plan and Code of Conduct concerning employment and workforce behaviour (including but not limited to safety rules, zero tolerance for substance abuse, environmental sensitivity and stewardship for the Project area, acknowledgment of the dangers of sexually transmissible diseases and HIV/AIDS, respect for the beliefs and customs of the populations and community relations in general). ■					
D.49.	Land acquisition and land take	Compensation will be provided to PAPs for standing crops at FRC. Compensation to be provided to owner of crops, trees and assets and not land owner necessarily.	**<u>NEA,</u>** CDC	Prior to construction	RAP and LRP	RAP and LRP Implementation and Completion Audits By IC Final approval By NEA	IEE Nov 2017, C IEE Nov 2019, C IEE Jan 2020, C
		Compensation for the hindrance due to use of land, agricultural extension program, livelihood skill training programs, maximise job opportunities.	NEA	Prior to construction	RAP	RAP and LRP Implementation and Completion Audits By IC Final approval	IEE Nov 2017, C IEE Nov 2019, C IEE Jan 2020, C

No.[15]	Item	Mitigation, Management and Enhancement Measures	Responsible[16]	Timeline	Means of Verification	Monitoring Procedure	Source
						By NEA	
D.50.	Traffic management	Develop a Traffic Management Plan, including but not limited to: ■ Speed limits (of approximately 30 km/h or less depending on the risk analysis to be conducted by the Contractor) when travelling through communities by all Project related traffic and signalisation; ■ Driver qualifications and selection (e.g. defensive driving courses, accident history and 'practical' interviews to test skills); ■ Driver education and training (awareness raising, information on required standards and review of incidents); ■ Vehicle inspection and maintenance (in line with manufacture requirements for vehicle roadworthiness and Project standards); ■ Accident/ incident reporting and investigation; ■ Passing spaces on narrow village road; ■ Cover of trucks when transporting sand to prevent dust; and ■ Road damages and degradation to be reinstated, time planning etc. Undertake consultation with communities along key transport routes to inform them about the potential for increased traffic movements prior to any changes and train them on road safety awareness. A grievance procedure shall be established whereby any complaints by neighbours or	Contractor	Prior to construction	Traffic Management Plan development disclosed to local authorities Records of Public Awareness Sessions and Documentation. EPRP Grievance mechanism logbook Training records	Review By IC Final approval By NEA	Standard / Best practice

No.[15]	Item	Mitigation, Management and Enhancement Measures	Responsible[16]	Timeline	Means of Verification	Monitoring Procedure	Source
		affected parties related to road traffic can be submitted, recorded and responded to.					
D.51.	Fossils/ Archaeological Chance Finds	Obtain clearance by competent authority. Develop a Chance Finds Procedure taking into account local legislation. The Chance Finds Procedure will include: ■ Training of all site personnel in the recognition and proper handling and custody of archaeological finds; ■ Establishment of protocols for responding to chance finds including cessation of works for finds and notification of NEA, who will advise the appropriate authorities (Antiquity Department, see Antiquities Act); and ■ Expedited procedures for evaluation and treatment of significant chance finds in order to limit impacts to important resources while limiting construction delays.	Contractor	Prior to construction	A Chance Finds Procedure is in place and approved by NEA management Contractor and employees are familiar with the Chance Finds Procedures	Review By IC Final approval By NEA	Standard / Best practice

9.4 ESMMP for the Project – Construction Phase

The following Table 9-3 shows the measures required to be implemented during the construction phase. In this phase mainly the Contractor is responsible for the implementation of the measures as indicated in the table.

Table 9-3 ESMMP for the Project – Construction Phase

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
B.	**Protection of the Environment**						
B.10.	Protection of adjacent areas	Implement a Water Management Plan, which should also cover the protection of the nearby creek of the substation Damauli. See B.18 Biodiversity for further details.	Contractor	During construction	Observations on site	Observations during construction By ECoW	BAP, 2021
		Re-vegetation, slope maintenance will be carried out in the disturbed areas to avoid erosion. Bioengineering with combination of retaining structures will be done as per the requirement.	Contractor	During construction	Observations/ visual inspection on site	Regular monitoring By IC	IEE Nov 2017, A IEE Nov 2019, A IEE Jan 2020, A
B.11.	Selection of borrow areas, backfill material stockpile sites and access road	Use only approved quarries and borrow pits with appropriate E&S certification (eg. no gravel abstraction from river).	Contractor	During construction	E&S audit at quarries	Regular site inspection By IC	Standard / Best practice

[19] Numbering is not continuous because it refers to the items of KfW standard bidding documents.

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		After obtaining permission for the construction of access roads, the Contractor shall undertake all necessary measures to make the access suitable for use and shall take all precautions to avoid damage to existing properties. The access tracks shall be constructed in such a way as to minimise damage to property, land, crops, and vegetation and shall be adequately drained to prevent washouts or soil erosion. Ensure slope stabilisation, replanting, erosion prevention, drainage measures, dust prevention etc are required, which shall be defined in an approved Earthwork, Erosion and Reinstatement Management Plan.	Contractor	During construction	Observations on site	Regular monitoring By IC	Internal Document prepared by IC, received 17.11.2021
		Once the access maps have been approved, the Contractor shall not make use of any other access routes without the prior approval of NEA and IC.	Contractor	During construction	Observations on site	Regular monitoring By IC	Internal Document prepared by IC, received 17.11.2021
		Brought filling material for construction of platform shall be stored in designated storage areas to be used for site reinstatement after completion of construction. Topsoil layer shall be removed and stored separately from subsoil. Procedures for transport and storage of excavated material and site reinstatement shall be defined in an approved Earthwork, Erosion and Reinstatement Management Plan.	Contractor	During construction	Earthwork, Erosion and Reinstatement Management Plan Observations on site	Regular monitoring By IC	Internal Document prepared by IC, received 17.11.2021
		Any residual material shall be disposed of in accordance with approved Waste Management Plan (WMP) after completion of the construction.	Contractor	During construction	Observations on site	Regular monitoring By IC	Internal Document prepared by IC, received 17.11.2021

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		Disposal or storage of excavated soil on the slopes above or below access roads shall be strictly prohibited. Appropriate safety measures (e.g. anchored barriers) shall be installed below excavation sites to prevent accidental rockfall down the slopes.					
		The access tracks shall be constructed in such a way as to minimise damage to property, land, crops, and vegetation and shall be adequately drained to prevent washouts or soil erosion. All watercourses shall be crossed by means of bridges or culverts covered with stone material and suitable grading. Drainage shall be provided by swales and appropriately placed culverts. Access route maps shall include location of all bridges, culverts, and swales. The drainage systems and surface of new access tracks for the duration of the works (and leave the measures in place for the time after works e.g. erosion prevention measures, drainage etc.) shall continuously be maintained.	Contractor	During construction	Observations on site	Regular monitoring By IC	Internal Document prepared by IC, received 17.11.2021
		Culverts and bridges shall be installed for the purpose of crossing existing watercourses. Culverts shall also be installed where required for effective drainage systems. The locations and types of culverts and bridges shall be proposed by the Contractor and approved by NEA/IC.	Contractor	During construction	Observations on site	Regular monitoring By IC	Internal Document prepared by IC, received 17.11.2021
B.12.	Pollution prevention	Take the necessary measures to ensure that pollution to air, water or land is prevented or, where this is not possible, reduced and mitigated as far as practicable during the construction phase. In doing so the Contractor will need to develop a EPRP which clearly	Contractor	During construction	Ensure that potential pollutants are not stored and handled within 50 m of sensitive	Regular monitoring Review of grievance records By IC	Standard / Best practice

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		outlines the measures for managing e.g. atmospheric emissions and dust, e.g. noise and vibrations, e.g. waste (specified in ESHS Specifications including 14, 15 and 16 below). Please provide specific details on how to handle for example the following aspects: ■ liquid effluents; ■ air emissions and dust; ■ noise and vibration management; ■ vehicle and equipment maintenance and selection; and ■ fuel, oil and chemical storage and handling. Ensure all works carried out minimise pollution risk (e.g. liquid effluents, air emissions, noise and vibration management, vehicle and equipment maintenance and selection, fuel, oil and chemical storage and handling) including the whole duration of the Project.			receptors (particularly watercourses)		
B.13.	Effluents	Ensure appropriate containment and storage of construction wastewater, including sanitary water. No untreated effluent is discharged. All platforms where generators, hydrocarbon storage tanks and refuelling stations are installed have impervious and chemical resistant surfaces are drained separately and equipped with an oil removal treatment (oil-water-separator) to prevent pollution. Discharges shall be in line with local and international standards.	Contractor	During construction	No untreated wastewater discharge	Regular monitoring Review of grievance records By IC	Standard / Best practice

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		No effluent is discharged into water courses (streams, rivers, ponds, lakes etc.) or to the ground surface or infiltrated into subsoils, without prior treatment and without monitoring quality of the treatment's performance to guarantee the absence of pollution in the effluent. Effluent discharge and flow rates into natural water bodies will be managed to control erosion/sediment freight. Ensure workers and subcontractors are prohibited from bathing or washing clothes and vehicles/equipment in rivers or watercourses.					
B.14.	Air emissions and dust	Water spraying will be done to control dust pollution. See also IFC General EHS Guidelines (1.1 Air Emissions and Ambient Air Quality).	Contractor	During construction	Community Health and Safety Management Plan Grievance log No complaint	Regular monitoring Review of grievance records By IC	Standard / Best practice
B.15.	Noise and vibration	Regular maintenance will be done for all equipment as per manufacturer's specifications. Implement a Vehicle Machinery and Inspection Programme of own and Contractor/third party trucks and other machinery Noise prevention and mitigation measures should be applied where predicted or measured noise impacts from the construction exceed the applicable noise level guideline at the most sensitive point of reception. Locate stationary equipment (such as power generators and compressors) as far as possible from nearby receptors (e.g. worker	Contractor	During construction	Inspection log books for vehicles and machinery. Confirmed through regular inspections and monitoring reports.	Regular monitoring Review of grievance records By IC	IEE Nov 2017, A IEE Nov 2019, A IEE Jan 2020, A Standard / Best practice

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		resting areas, populated areas and environmentally sensitive areas). Equipment known to emit noise strongly in one direction, whenever possible, will be orientated so that the noise is directed away from sensitive receptors Standard noise abatement equipment shall be fitted to equipment by the Contractor, used and maintained in accordance with manufacturers' instructions. Working hours will be limited in sensitive areas (e.g. near settlements). Ensure that construction activities are only undertaken during the day and local communities are informed of the construction schedule to comply with National Ambient Noise Standards/ IFC standards (i.e. the threshold value of noise for day time in Industrial/commercial area is 70 dB(A) and that of in Residential/ Institutional/Educational area is 55 dB(A) respectively. Plan high noise generating works (e.g. pile driving, blasting, rock clearing, drilling, percussion drilling) in line with national regulations. Ear mufflers or plugs will be provided to labour force working in the areas susceptible to noise pollution. For guidance please follow the IFC EHS Guidelines for Noise management.20					

[20] IFC (2007) Environmental, Health, and Safety (EHS) General Guidelines: Noise Management.
Available at: https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/ehs-guidelines

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
B.16.	Waste Management	Implement an effective Waste Management Plan (WMP) to ensure that all wastes (hazardous, non-hazardous, waste water) are all disposed of in a sound manner. This plan shall describe procedures to ensure that waste generation is minimised, transportation is monitored, storage is safe and disposal methods are sound and do not cause negative impacts to the environment or communities. Good construction practices and site management will be adopted to avoid impacting soil and ground water, and pollution of water bodies. Waste oils and chemicals will be collected and stored in suitable storage tanks and disposed of by a certified company. Fuel and hazardous chemical storage areas shall not be allowed within 30m of a minor watercourse, within 100m of a major watercourse, within a floodplain or where there is the potential for spilled fuel to enter groundwater. Provide training for the workers in order to ensure adequate waste management. Establish and maintain a waste register. This register will record all waste management operations: production, collection, transport, treatment. It will be available as of the Contractors mobilisation to any Project Area. Waste shall be categorised according to the following definitions:	Contractor	During construction	WMP exists and employees are aware Observations on site Training records Monitoring records Grievance mechanism logbook	Regular monitoring Review of grievance and training records By IC	IEE Nov 2017, A IEE Nov 2019, A IEE Jan 2020, A Standard / Best practice

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		a) Non-hazardous solid waste generated at construction and decommissioning sites includes excess fill materials from grading and excavation activities, scrap wood and metals, and small concrete spills. Other non-hazardous solid wastes include office, kitchen, and dormitory wastes when these types of operations are part of construction project activities. b) Hazardous solid waste includes contaminated soils, which could potentially be encountered on-site due to previous land use activities, or small amounts of machinery maintenance materials, such as oily rags, used oil filters, and used oil, as well as spill clean-up materials from oil and fuel spills. c) Hazardous liquid waste includes effluents and waste material containing "free liquids" (e.g. used cutting oil or wastewater mixed with oil after cleaning machinery).					
B.17.	Vegetation clearance	■ Ensure measures concerning vegetation clearing are implemented, such as but not limited to: ■ Vegetation clearing using chemicals is not permitted; ■ Vegetation clearing using bulldozer is not permitted in zones less than 30 m from areas designated as sensitive by the Engineer, where only manual clearing is authorised; ■ Where it is not possible to restrict the timing of construction practices, vegetation shall be removed outside the breeding period so that works can carry on into this period unhindered; ■ Unless otherwise specified in the Contract or if otherwise instructed by the NEA/IC, burning vegetation is not	Contractor	During construction	Observations on site	Observations during construction By ECoW	Standard / Best practice

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		permitted. Green waste can be burnt with prior approval from NEA/IC regarding the location, method and schedule; ■ The collection of wild plants is prohibited; ■ Lighting fires in work areas is prohibited unless specifically authorised by NEA.					
B.18.	Biodiversity	Project workers will strictly be prevented from hunting and poaching and any other kind of illegal activities related to hunting and poaching.	Contractor	During construction	Observations	Observations during construction By ECoW	IEE Nov 2017, B IEE Nov 2019, B IEE Jan 2020, B
		Ensure that all personnel are informed and aware of the importance to protect species, habitats, fauna and flora and are informed about wildlife encounter procedures. Information and awareness training is documented. a) The Contractor´s personnel shall not approach, injure, hunt, capture, possess, feed, transport, rear or trade wild animals and/or collect birds' eggs on the Project Areas; b) The Contractor´s personnel shall avoid where possible breeding, feeding and nesting sites of endangered species; c) The Contractor personnel shall not collect flora or fauna species on the Project Areas; d) The Contractor shall report any sighting or finding of dead wildlife killed by the works to NEA/IC immediately; e) The Contractor shall protect excavations with temporary fencing to prevent injury to animals;	Contractor	During construction	Observations	Observations during construction By ECoW	Standard / Best practice

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		f) The Contractor shall release any trapped uninjured animals immediately; g) The Contractor shall report injured endangered and/or larger animals to NEA/IC who will inform the appropriate Environmental Authority; h) The Contractor shall not disturb natural habitats outside the Project Areas; i) The Contractor shall only use designated roads or paths and abide by speed limits; j) The Contractor shall not start forest fires; and k) The Contractor shall not introduce Invasive Alien Species (IAS)					
		If vegetation clearance takes place within the bird breeding season (October – April), trees will be checked for nests of raptors or other large birds prior to felling. If active nests are identified, an exclusion zone will be established around the nest to avoid disturbance until the young have fledged.	**NEA**, Contractor	During construction	Observations/ records kept	Quarterly reporting during construction By ECoW	BAP, 2021
		Three old trees on the substation site need to be protected (if possible regarding substation safety and security restrictions) and the recreational area need to be kept accessible for people (not fenced).	**NEA**, Contractor	During construction	Observations	Observations during construction By ECoW	Rapid Assessment for New Damauli Substation, 2021
		Construction will avoid unnecessary machinery disturbances and lighting.	Contractor	During construction	Observations	Observations during construction By ECoW	IEE Jan 2020, B
		Construction camps and lay-down areas will be not be located in forest areas and sensitive habitats.	Contractor	During construction	Observations	Observations during construction By ECoW	BAP, 2021

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
B.19.	Erosion control measures	Cut off drains and soakaways will be installed on access tracks on steep slopes to minimise sediment run off in the watersheds of the Pokhara Valley lakes and Madi River Valley.	Contractor	During construction	Observations	Observations during construction By ECoW	BAP, 2021
B.20.	Site rehabilitation	Compensation planting requirements will be updated following the completion of construction to include all trees felled for the Project (substation).	**NEA**, MoFSC, DFOs, Contractor	During construction	Records of trees felled	Observations during construction DFO with oversight from **NEA**	BAP, 2021
		Planting trees on substation site to reduce visual impacts if security distances allow such.	NEA	During construction	Records of planted trees	Observation By ECoW	Standard / Best practice
C.	**Health and Safety**						
C.22.	Health and Safety Plan	Implement occupational H&S plans and procedures and updated as required. It will include mandatory health and safety training for workers and contractors. Training attendance will be recorded. Implement Community Health and Safety Management Plan.	Contractor	During construction	H&S Plans and Procedures in place Training records Community Health and Safety Management Plan	Regular monitoring By IC	Standard / Best practice
		Ensure prevention measures are in place for managing OHS risk of working on live power lines. For guidance see IFC (2007) EHS Guidelines for Electric Power Transmission and Distribution[21]	Contractor	During construction	H&S Plans and Procedures in place	Regular monitoring By IC	Standard / Best practice

[21] Available at: https://www.ifc.org/wps/wcm/connect/7b65ce6b-129d-4634-99dc-12f85c0674b3/Final%2B-%2BElectric%2BTransmission%2Band%2BDistribution.pdf?MOD=AJPERES&CVID=jqeI4Rs&id=1323162154847

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		Workers may be exposed to occupational hazards from contact with live power lines during construction, maintenance, and operation activities. Prevention and control measures associated with live power lines include eg.: ■ Only allowing trained and certified workers to install, maintain, or repair electrical equipment; ■ Deactivating and properly grounding live power distribution lines before work is performed on, or in close proximity, to the lines; ■ Ensuring that live-wire work is conducted by trained workers with strict adherence to specific safety and insulation standards. Qualified or trained employees working on transmission or distribution systems should be able to achieve the following[22]. a) Distinguish live parts from other parts of the electrical system; b) Determine the voltage of live parts; c) Understand the minimum approach distances outlined for specific live line voltages; d) Ensure proper use of special safety equipment and procedures when working near or on exposed energised parts of an electrical system; ■ Workers should not approach an exposed energised or conductive part even if properly trained unless:					

[22] Further information is available from the Occupational Safety and Health Administration (OSHA). Available at: https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.950

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		a) The worker is properly insulated from the energised part with gloves or other approved insulation; or, b) The energised part is properly insulated from the worker and any other conductive object; or c) The worker is properly isolated and insulated from any other conductive object (live-line work). ■ Where maintenance and operation is required within minimum setback distances, specific training, safety measures, personal safety devices, and other precautions should be defined in a health and safety plan. (Table 2 in Section 2.2 of the IFC EHS Guidelines provides recommended minimum safety setbacks for workers); ■ Workers not directly associated with power transmission and distribution activities who are operating around power lines or power substations should adhere to local legislation, standards, and guidelines relating to minimum approach distances for excavations, tools, vehicles, pruning, and other activities; ■ Minimum hot stick distances may only be reduced provided that the distance remaining is greater than the distance between the energised part and a grounded surface.					
		Ensure prevention measures are in place for managing OHS risk of working at height on poles and structures. For guidance see IFC	Contractor	During construction	H&S Plans and Procedures in place	Regular monitoring By IC	Standard / Best practice

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		(2007) EHS Guidelines for Electric Power Transmission and Distribution[23] Workers may be exposed to occupational hazards when working at elevation during construction, maintenance, and operation activities. Prevention and control measures for working at height include eg.: ■ Testing structures for integrity prior to undertaking work; ■ Implementation of a fall protection program that includes training in climbing techniques and use of fall protection measures, inspection, maintenance, and replacement of fall protection equipment, and rescue of fall-arrested workers, among others; ■ Establishment of criteria for use of 100 percent fall protection (typically when working over 2 meters above the working surface, but sometimes extended to 7 meters, depending on the activity). The fall protection system should be appropriate for the tower structure and necessary movements, including ascent, descent, and moving from point to point; ■ Installation of fixtures on tower components to facilitate the use of fall protection systems; ■ Provision of an adequate work-positioning device system for workers. Connectors on positioning systems should be compatible with the tower components to which they are attached;					

[23] Available at: https://www.ifc.org/wps/wcm/connect/7b65ce6b-129d-4634-99dc-12f85c0674b3/Final%2B-%2BElectric%2BTransmission%2Band%2BDistribution.pdf?MOD=AJPERES&CVID=jqeI4Rs&id=1323162154847

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		■ Hoisting equipment should be properly rated and maintained and hoist operators properly trained; ■ Safety belts should be of not less than 16 millimetres (mm) (5/8 inch) two-in-one nylon or material of equivalent strength. Rope safety belts should be replaced before signs of aging or fraying of fibres become evident; ■ When operating power tools at height, workers should use a second (backup) safety strap; ■ Signs and other obstructions should be removed from poles or structures prior to undertaking work; ■ An approved tool bag should be used for raising or lowering tools or materials to workers on structures.					
C.24.	Accident reporting	Ensure all H&S related incidents (e.g. observations, accidents) on site are recorded and followed up properly.	Contractor	During construction	Incident recording process in place	Check incident/accident records By IC	Standard / Best practice
C.28.	Personal protective equipment	Provide PPE such as helmets, ear mufflers or plugs, safety boots and other safety equipment to the construction workers.	Contractor	During construction	Records of accidents Documentation of safety training for staff	Regular monitoring By IC	IEE Nov 2017, C IEE Nov 2019, C IEE Jan 2020, C
C.31.	Emergency scenarios prevention	Implementation of an EPRP for spill containment and clean-up, engineering contingencies, collisions, natural hazards and other emergencies to include: ■ The emergency response in the event of spills, fire, accidents, earthquakes, floods;	NEA	During construction	EPRP in been formally approved by NEA management	Regular monitoring By IC	Standard / Best practice

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		■ Procedure for staff and subcontractors to report any incidents; ■ Emergency response training; ■ Emergency communication procedure.					
C.33.	First-aid	Provide workers with primary health care and basic first aid at construction camps / worksites. Agreements should be entered into with health care facilities around emergency care.	Contractor	During construction	Suitable first aid kits on site Ensure the presence of first aid helpers in all shifts First aid certificates	Regular monitoring of first aid kits Review of first aider certificates Review of number of first aiders required by local legislation By IC	Standard / Best practice
C.37.	Access to health care	Ensure the workforce has access to primary healthcare on site, providing prescriptions and vaccinations	Contractor	During construction	Healthcare available on site Medical surveillance records	Regular monitoring By IC	Standard / Best practice
C.40.	Hygiene, accommo-dation and food	Provide adequate accommodation for workers, in line with international Standard / Best practice. Implement a Worker Accommodation Plan as per IFC/EBRD Guidelines on Worker Accommodation[24], whenever planning to establish a labour camp/colony. The Worker Accommodation Plan should also include	Contractor	During construction	Worker Accommodation Plan and Monitoring Checklist	Regular monitoring By IC	Standard / Best practice

[24] IFC/EBRD (2009) Guidelines on Worker Accommodation. Available at: https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/publications/publications_gpn_workersaccommodation

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		risks and mitigation linked with gender-based violence and trafficking in persons.					
		Avoid increasing local demand for firewood and timber, provide kerosene/LPG to the extent possible to project workers staying at temporary/permanent labour camps. If the use of alternative fuel is not possible, haphazard collection of fuel wood from the nearby forest will be controlled in coordination with the Forest User Groups, Sub-Division Forest Office and DFOs.	NEA, MoFSC, DFOs, **Contractor**	During construction	Observations	Observations during construction by ECoW	IEE Nov 2017, B IEE Nov 2019, B IEE Jan 2020, B BAP, 2021
		Establish guidelines in a Workers Code of Conduct for engagement with communities to limit and prevent transmission of disease. Ensure regular health screening will be provided for all employees (including contractors and subcontractors). This will be undertaken at least every six months and will be undertaken by the Projects in-country medical personnel. The contractors will make all necessary efforts to avoid possible community exposure to health and safety risks, including developing a Health and Safety Management Plan. All employees including employees of contractors and subcontractors should undergo pre-employment screening which will include testing for Tuberculosis and other communicable diseases and voluntary testing for sexually transmitted diseases. No worker will be denied employment on the basis of the testing (as long as they are fit to work), but in the case of TB will need to commence	Contractor	During construction	Workers Code of Conduct Health screenings for employees Disease control strategies Training records Community Health and Safety Management Plan	Regular monitoring By IC	Standard / Best practice

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		treatment and be non-infectious before taking up their post.					
		Develop disease control strategies including environmental controls and implementing health awareness training (including HIV/AIDS awareness), to be provided to all employees covering good health practices, health risks and preventive measures for diseases to be aware of, including pandemic diseases like Covid-19.	Contractor	During construction	Records of health awareness training (including HIV/AIDS and Covid-19) and attendance documentation	Review By IC	Standard / Best practice
		Ensure measures are in place to minimise the chances and contain the spread of the Covid-19 virus as a result of the movement of workers. Ensure project sites are prepared for an outbreak, and develop and practice contingency plans so that personnel know what to do if an outbreak occurs and how treatment will be provided. Follow the World Bank Group Guidance for EHS Response to Covid-19[25] and IFC Interim Advice for IFC Clients on supporting Workers in the Context of Covid-19[26].	Contractor	During construction	Records of Contingency Planning for Project Site Observations	Review By IC	Standard / Best practice
D.	**Labour and relations with local communities**						
D.42.	Labour conditions	Adopt and implement human resources policies and procedures. Consistent with the requirements of national labour laws, IFC PS 2 and the ILO Conventions. Provide workers with documented information that are clear and understandable, regarding	Contractor	During construction	Human Resources Management Plan Sample contract	Review of Inspection reports (also from labour authorities) By IC	Standard / Best practice

25 Available at: https://www.worldbank.org/en/who-we-are/news/coronavirus-covid19

26 Available at: https://www.ifc.org/wps/wcm/connect/b27193d8-b024-4830-83cf-f93e931b240a/Tip+Sheet_Interim+Advice_Supporting+Workers_COVID19_April2020.pdf?MOD=AJPERES&CVID=n9s.6RO

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		their rights under national labour and employment law and any applicable collective agreements, upon beginning working relationships and when any material changes occur. Ensure wage rates are not be lower than established for the sector where the work is carried out or for a similar industry. There should be no wage disparity (for similar work and skill levels) between males and females, or migrant workers and local workers. Ensure Contractor and any subcontractor will not interfere with workers' rights to form or join a workers' organisation. The Project (including supply chain) will not use child or forced labour, or discriminate against vulnerable groups. These measures will be laid out in Human Resources Management Plan. The Project will audit contractors to ensure they are abiding by the Human Resources Management Plan. Failure to meet these standards will result in consequences up to and including termination of contract, to be decided on a case-by-case basis.			Worker Accommodation Plan and Monitoring Checklist Audit		

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		Establish a worker grievance mechanism for directly employed, contractors and subcontractors of the Project. It will be publicly advertised to the workforce. It will be easily accessible by workers, free of retaliation and should allow anonymous complaints to be raised and addressed.	Contractor	During construction	Grievance mechanism for workers in place and grievances recorded Training records	Review of grievance register Review of training records By IC	Standard / Best practice
		Ensure no child or forced labour to be used in the Project supply chain, at a minimum by first tier suppliers and contractors.	Contractor	During construction	Requirement to be set out in supply contract documents Supply contract	Review of requirements By IC	Standard / Best practice
		Give capable members, as well as unskilled labour of the affected communities and villages priority in recruitment, throughout the construction and operation phases of the Project. The assigned contractor will prioritise the procurement of goods, construction materials, filling material and services from within the affected District, or in case this is not possible, preference should be given to suppliers within the Region.	Contractor	During construction	Local Procurement and Employment Records Ensure that appropriate code of conduct will be adopted.	Review procurement and employment rules and records Review of grievance register By IC	Standard / Best practice
D.43.	Local recruitment	Ensure local communities are preferred for the supply of goods and services to the Project and Project personnel, where appropriate.	Contractor	During construction	Local Procurement and Employment Records	Review procurement and employment rules and records Review of grievance register By IC	Standard / Best practice

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
D.47.	Community interaction	Implement Stakeholder engagement throughout the project life cycle based on Project SEP, designed to support the development of strong, constructive and responsive relationships, which includes inter alia: ▪ Endorsement and implementation a SEP; ▪ Implement a grievance mechanism so that communities can share their concerns; and ▪ Consultation to inform local communities of the risks of trespassing onto sites. Stakeholder engagement will take place in a timely manner to inform people about the construction activities, construction sites including the timing of such activities and restrictions on land use.	**NEA**, Contractor	During construction	SEP Grievance mechanism and grievance log Minutes of Meetings Public awareness programme and documentation	Quarterly Reporting during construction Logs to date and grievances treated Minutes of consultation meetings By IC	Standard / Best practice
		Assign an ESHS person with respective community liaison tasks as well as public outreach activities, such as sign posts, flyers etc. In addition, the Contractor needs to have in place a Contractor-GRM to resolve construction-related grievances, especially with PAPs.	Contractor	During construction	Records of engagement activities Grievance mechanism	Review By IC	Standard / Best practice
D.48.	Damage to people and property	Inform local communities of the risks of trespassing onto sites, the meaning of signs, dangers of playing on or near equipment or entering fenced areas. Records of the meeting and attendees should be kept.	**NEA,** Contractor	During construction	SEP Community Health and Safety Management Plan	Regular monitoring By IC	Standard / Best practice

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
					Adequate storage of materials and equipment		
		Ensure that warning signs are put up around work fronts and construction sites advising people of the risks associated with trespass. All signs should be in diagram form to ensure those with low levels of literacy understand the signs. Ensure that there is adequate fencing around lay down yards and other similar facilities to minimise the risk of trespass. Fencing will be checked daily to ensure that it is in good condition and to look for any signs of entry. Materials and equipment will be stored in such a way that it is only accessible by authorised staff. Ensure adequate compensation in case of accidents.	Contractor	During construction	Community Health and Safety Management Plan Warning signs at construction sites, near equipment or fenced areas Adequate fencing Adequate storage of materials and equipment	Regular monitoring By IC	Standard / Best practice
		The Contractor will implement awareness training for workers, to integrate gender issues into overall project E&S management, ensuring workers understand code of conduct expectations and required compliance. This includes but is not limited to: ■ A Human Resources Management Plan and Code of Conduct, which includes fair treatment, equal opportunities without discrimination based on political affiliations, age, sex, race, ethnicity and sexual orientation, as well as no tolerance for any form of sexual harassment, discrimination, bullying or violence;	Contractor	During construction	Human Resources Management Plan Code of Conduct	Review of Human Resources Management Plan and Code of Conduct Interviews Review of grievance log By NEA	Standard / Best practice

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		■ Associated provisions in the Plan and Code of Conduct concerning employment and workforce behaviour (including but not limited to safety rules, zero tolerance for substance abuse, environmental sensitivity and stewardship for the Project area, acknowledgment of the dangers of sexually transmissible diseases and HIV/AIDS, respect for the beliefs and customs of the populations and community relations in general); ■ Worker awareness training for transmissible diseases and GBV; ■ Implementation of policies to ensure gender equality in opportunities, skill-building and training as part of livelihood programs; ■ Implementation of an accessible grievance mechanism and reporting process for sexual harassment, exploitation, abuse and GBV provide appropriate actions in case of reported incidents; and Provisions for prevention and management of related community health and safety issues as they may arise.					
		Temporary impacts resulting from construction-related losses and damages require to be carefully assessed and addressed in line with national laws and IFC PS 5. The contractor is required to plan its activities in ways to avoid damaging property and/or activities that could significantly reduce the income sources of people during construction activities. Where damages deliberately or accidentally do occur, the contractor will be required to repair any	Contractor	Prior to construction	RAP SEP Grievance mechanism	Final approval By IC	Standard / Best practice

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		physical damages to private property to its former condition immediately upon completion of civil works and at his own cost. Compensation must be paid at replacement cost value for permanent impacts as well as for all temporary disturbances e.g. damages to crops, prepared soil, etc. during construction. All other affected assets that will be encountered during corridor preparation or construction will also have to be compensated by the construction contractor. This could be illustrated in a tabular format such as the following:					

Type of loss / impact	Description	Category of project affected persons	Number of affected individuals / HHs	Entitlements	Responsibility
Permanent damages to (or losses of) any assets (land, structures, crops, trees, etc.) during construction	Damages or losses that may occur as a result of construction related activities, which were not previously foreseen and compensated.	Persons using any of the affected assets with or without legal basis	Any persons whose land/assets are damaged or who experience losses resulting from construction activities	• Repairs of any damages to assets and restoration to their former condition; OR • Cash compensation for any affected assets (crops, trees, structures, etc.) at full replacement cost.	Construction contractors

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
D.49.	Land acquisition and land take	Compensation will be provided to PAPs for standing crops at FRC. Compensation to be provided to owner of crops, trees and assets and not land owner necessarily.	**NEA**, CDC	During construction	RAP and LRP	RAP and LRP Implementation and Completion Audits By IC Final approval	IEE Nov 2017, C IEE Nov 2019, C IEE Jan 2020, C

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
						By NEA	
		Compensation for the hindrance due to use of land, agricultural extension program, livelihood skill training programs, maximise job opportunities.	NEA	During construction	RAP	RAP and LRP Implementation and Completion Audits By IC Final approval By NEA	IEE Nov 2017, C IEE Nov 2019, C IEE Jan 2020, C
D.50.	Traffic management	Implement the Traffic Management Plan. Undertake consultation with communities along key transport routes to inform them about the potential for increased traffic movements prior to any changes and train them on road safety awareness. Implement the EPRP, including training on workers on how to control and mitigate any unexpected situations, including spills or road accidents. A grievance procedure shall be established whereby any complaints by neighbours or affected parties related to road traffic can be submitted, recorded and responded to.	Contractor	During construction	Traffic Management Plan disclosed to local authorities Public Awareness Sessions and Documentation EPRP Grievance mechanism Training records	Review of training records Inspection if traffic routes Review of grievance register By IC	Standard / Best practice
D.51.	Fossils/ Archaeo-logical Chance Finds	Implement Chance Finds Procedure taking into account local legislation.	Contractor	During construction	A Chance Finds Procedure is in place and approved by NEA management Training records	Regular monitoring By IC	Standard / Best practice

No.[19]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
					Records about chance finds		

9.5 ESMMP for the Project – Operational Phase

The following Table 9-4 shows the measures required to be implemented during the operational phase. In this phase NEA is responsible for the implementation of the measures as indicated in the table.

Table 9-4 ESMMP for the Project – Operational Phase

No.[27]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
B.	**Protection of the Environment**						
B.12.	Pollution prevention	Ensure all works carried out minimise pollution risk (e.g. liquid effluents, air emissions, noise and vibration management, vehicle and equipment maintenance and selection, fuel, oil and chemical storage and handling) including the whole duration of the Project.	NEA	During operation	Ensure that potential pollutants are not stored and handled within 50 m of sensitive receptors (particularly watercourses).	Regular site inspection Review of grievance records By NEA	Standard / Best practice
		In order to avoid any leakage of SF6, handling of SF6 during transport to site, initial filling and maintenance of the gas insulated station will be undertaken only by the GIS manufacturer or mandated specialised companies.	NEA	During operation	Supply and maintenance contract.	Supply and maintenance contract	Standard / Best practice
B.16.	Waste Management	Implement an effective Waste Management Plan (WMP) to ensure that all wastes (hazardous, non-hazardous, waste water) are all disposed of in a sound manner. This plan shall describe procedures to ensure that waste generation is minimised, transportation is monitored, storage is safe and disposal methods are sound and do not cause negative impacts to the environment or communities.	NEA	During operation	WMP Observation on site	(external) Monitoring and progress controls By NEA	Standard / Best practice

[27] Numbering is not continuous because it refers to the items of KfW standard bidding documents.

No.[27]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		Establish and maintain a waste register. This register will record all waste management operations: production, collection, transport, treatment. It will be available as of the Contractors mobilisation to any Project Area. Waste shall be categorised according to the following definitions: a) Non-hazardous solid waste generated at construction and decommissioning sites includes excess fill materials from grading and excavation activities, scrap wood and metals, and small concrete spills. Other non-hazardous solid wastes include office, kitchen, and dormitory wastes when these types of operations are part of construction project activities. b) Hazardous solid waste includes contaminated soils, which could potentially be encountered on-site due to previous land use activities, or small amounts of machinery maintenance materials, such as oily rags, used oil filters, and used oil, as well as spill clean-up materials from oil and fuel spills. c) Hazardous liquid waste includes effluents and waste material containing "free liquids" (e.g. used cutting oil or wastewater mixed with oil after cleaning machinery). Garbage and solid wastes generated in the Project area will, where practicable, be converted into compost. Where this is not possible, it will be buried in designed landfill areas.					

No.[27]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		Good site management will be adopted to avoid impacting soil and ground water, and pollution of water bodies from accidental spills from fuels and lubricants etc.					
B.17.	Vegetation clearing	Ensure that no chemicals/pesticides are used, burning of vegetation is restricted.	NEA	During operation	Observations on site	Site inspection prior to commencement of activities By NEA	Standard / Best practice
C.	**Health and Safety**						
C.22.	Health and Safety Plan	Implement occupational H&S plans and procedures and updated as required. It will include mandatory health and safety training for workers and contractors. Training attendance will be recorded and monitored by the Project. Implement Community Health and Safety Management Plan.	NEA	During operation	H&S Plans and Procedures in place Training records Community Health and Safety Management Plan	Monitoring and progress controls By NEA	Standard / Best practice
		Ensure prevention measures are in place for managing OHS risk of working on live power lines. For guidance see IFC (2007) EHS Guidelines for Electric Power Transmission and Distribution[28] Workers may be exposed to occupational hazards from contact with live power lines during construction, maintenance, and operation activities. Prevention and control	Contractor	During construction	H&S Plans and Procedures in place Training records	Regular monitoring By IC	Standard / Best practice

[28] Available at: https://www.ifc.org/wps/wcm/connect/7b65ce6b-129d-4634-99dc-12f85c0674b3/Final%2B-%2BElectric%2BTransmission%2Band%2BDistribution.pdf?MOD=AJPERES&CVID=jqeI4Rs&id=1323162154847

No.[27]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		measures associated with live power lines include: ■ Only allowing trained and certified workers to install, maintain, or repair electrical equipment; ■ Deactivating and properly grounding live power distribution lines before work is performed on, or in close proximity, to the lines; ■ Ensuring that live-wire work is conducted by trained workers with strict adherence to specific safety and insulation standards. Qualified or trained employees working on transmission or distribution systems should be able to achieve the following[29]. e) Distinguish live parts from other parts of the electrical system; f) Determine the voltage of live parts; g) Understand the minimum approach distances outlined for specific live line voltages; h) Ensure proper use of special safety equipment and procedures when working near or on exposed energised parts of an electrical system; ■ Workers should not approach an exposed energised or conductive part even if properly trained unless: d) The worker is properly insulated from the energised part with gloves or other approved insulation; or,					

[29] Further information is available from the Occupational Safety and Health Administration (OSHA). Available at: https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.950

No.[27]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		e) The energised part is properly insulated from the worker and any other conductive object; or f) The worker is properly isolated and insulated from any other conductive object (live-line work). ■ Where maintenance and operation is required within minimum setback distances, specific training, safety measures, personal safety devices, and other precautions should be defined in a health and safety plan. (Table 2 in Section 2.2 of the IFC EHS Guidelines provides recommended minimum safety setbacks for workers); ■ Workers not directly associated with power transmission and distribution activities who are operating around power lines or power substations should adhere to local legislation, standards, and guidelines relating to minimum approach distances for excavations, tools, vehicles, pruning, and other activities; and ■ Minimum hot stick distances may only be reduced provided that the distance remaining is greater than the distance between the energised part and a grounded surface.					
		Ensure prevention measures are in place for managing OHS risk of working at height on poles and structures. For guidance see IFC (2007) EHS Guidelines for Electric Power Transmission and Distribution[30]	Contractor	During construction	H&S Plans and Procedures in place	Regular monitoring By IC	Standard / Best practice

[30] Available at: https://www.ifc.org/wps/wcm/connect/7b65ce6b-129d-4634-99dc-12f85c0674b3/Final%2B-%2BElectric%2BTransmission%2Band%2BDistribution.pdf?MOD=AJPERES&CVID=jqeI4Rs&id=1323162154847

No.[27]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		Workers may be exposed to occupational hazards when working at elevation during construction, maintenance, and operation activities. Prevention and control measures for working at height include: ■ Testing structures for integrity prior to undertaking work; ■ Implementation of a fall protection program that includes training in climbing techniques and use of fall protection measures, inspection, maintenance, and replacement of fall protection equipment, and rescue of fall-arrested workers, among others; ■ Establishment of criteria for use of 100 percent fall protection (typically when working over 2 meters above the working surface, but sometimes extended to 7 meters, depending on the activity). The fall protection system should be appropriate for the tower structure and necessary movements, including ascent, descent, and moving from point to point; ■ Installation of fixtures on tower components to facilitate the use of fall protection systems; ■ Provision of an adequate work-positioning device system for workers. Connectors on positioning systems should be compatible with the tower components to which they are attached; ■ Hoisting equipment should be properly rated and maintained and hoist operators properly trained; ■ Safety belts should be of not less than 16 millimetres (mm) (5/8 inch) two-in-					

No.[27]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		one nylon or material of equivalent strength. Rope safety belts should be replaced before signs of aging or fraying of fibres become evident; ■ When operating power tools at height, workers should use a second (backup) safety strap; ■ Signs and other obstructions should be removed from poles or structures prior to undertaking work; and ■ An approved tool bag should be used for raising or lowering tools or materials to workers on structures.					
C.24.	Accident reporting	Ensure all H&S related incidents (e.g. observations, accidents) on site are recorded and followed up properly.	NEA	During operation	Incident recording process in place	Check incident/accident records By NEA	Standard / Best practice
C.31.	Emergency scenarios prevention	Implement an EPRP for spill containment and clean-up, engineering contingencies, collisions, natural hazards and other emergencies to include: ■ The emergency response in the event of spills, fire, accidents, earthquakes, floods; ■ Procedure for staff and subcontractors to report any incidents; ■ Emergency response training; ■ Emergency communication procedure.	NEA	During operation	EPRP in been formally approved by NEA management.	Monitoring and progress controls By NEA	Standard / Best practice
D.	**Labour and relations with local communities**						
		Establish a worker grievance mechanism for directly employed, contractors and subcontractors of the Project. It will be publicly advertised to the workforce. It will be easily accessible by workers, free of	NEA	During operation	Grievance mechanism for workers	Monitoring and progress controls By NEA	Standard / Best practice

No.[27]	Item	Mitigation, Management and Enhancement Measures	Responsible	Timeline	Means of Verification	Monitoring Procedure	Source
		retaliation and should allow anonymous complaints to be raised and addressed.					
D.47.	Community interaction	Implement Stakeholder engagement throughout the project life cycle, designed to support the development of strong, constructive and responsive relationships, which includes inter alia: ■ Endorsement and implementation of a SEP; ■ Implementation of a grievance mechanism so that communities can share their concerns; and ■ Consultation to inform local communities of the risks of trespassing onto sites.	NEA	During operation	SEP Grievance mechanism and grievance log Public awareness programme and documentation	Monitoring and progress controls Logs to date and grievances treated By NEA	Standard / Best practice

10. MITIGATION AND COMPENSATION COSTS

This chapter presents a rough estimate of the mitigation and compensation costs, calculated for the following measures:

- Physical Impact Measures;
  - **River Training Structures;**
  - **Culvert for Chaabdi Khola;**
- Land Acquisition and Structure Loss.

Mitigation measures presented in the ESMMP (eg. development of Management Plans etc.), which are deemed as Standard / Best practice have not been considered in this calculation.

Physical Impact Measures

The Updated IEE, 2020 has calculated cost estimates for mitigation measures of physical impacts[31]. AP 43 and Damauli substation need protection from flooding. To access the New Damauli Substation from the access road, crossing on Chaabdi river is necessary. A culvert is proposed in the IEE.

Table 10-1 Costs for Flooding/ Landslide Risk Mitigation Measures at Damauli Substation

Mitigation Measures	Indicative Budget (USD)[32]
River training structures	45,700
Culvert for Chaabdi Khola (near substation)	1,000
Total	**46,700**

Source: NEA, Updated IEE 2020

Land Acquisition and Displacement

The Updated IEE, 2020 has calculated cost estimates for land acquisition and displacement mitigation measures For Package B as well as trainings is outlined in Table 10-2.

[31] Since the updated of the IEE 2020, minor modifications in the detailed design may imply changes in the costing.
[32] The IEE originally stated the cost in Nepalese rupees. The ESMMP gives the costs all in USD.
The following exchange rate was used: 1 NPR = 0.0083 USD.

Table 10-2 Costs for Compensation and Social Enhancement Measures

Mitigation Measures	Indicative Budget (USD)[33]
Compensation for land	999,950
Compensation for structure	3,700
Compensation for crops loss	9,300
Safety training*	-
Displacement and transportation cost*	-
Farming training, skill development and social awareness program*	-
Total	**1,012,950**

** Costs combined for Package A and Package B, have been considered in the ESMMP for the TL.*

Source: NEA, Updated IEE 2020

The costs in the above Table 10-2 cover the compensation costs according to the design included in the IEE. Since the design has changed afterwards, the RAP will include cost estimations for land acquisition and displacement mitigation measures based on the revised design of the substation, which may differ from the above mentioned figures.

[33] The IEE originally stated the cost in Nepalese rupees. The ESMMP gives the costs all in USD.
The following exchange rate was used: 1 NPR = 0.0083 USD.

11. REFERENCES

ERM (2021) Biodiversity Action Plan for Lekhnath-Damauli 220kV Transmission Line Project.

GoN/MoFSC, 2014. Nepal Biodiversity Strategy and Action Plan 2014-2020. Government of Nepal, Ministry of Forests and Soil Conservation, Kathmandu, Nepal.

IFC (2020) Interim Advice for IFC Clients on supporting Workers in the Context of Covid-19.

IFC/EBRD (2009) Guidelines on Worker Accommodation.

IFC/WBG (2007) EHS Guidelines for Electric Power Transmission & Distribution.

IUCN Nepal, (2008). Conservation for livelihoods: promoting biodiversity conservation, environmental justice and sustainable livelihoods in Nepal: IUCN Nepal intersessional plan (2009-2012).

IUCN (2012). The art of implementation: gender strategies transforming national and regional climate change decision making.

KfW Development Bank (2021). Sustainability Guideline. Assessment and management of Environmental, Social, and Climate Aspects: Principles and Procedures.

National Planning Commission, Government of Nepal (2015). Nature Conservation. National Strategic Framework for Sustainable Development (2015-2030).

Nepal Electricity Authority Environment and Social Studies Department (2017) Initial Environmental Examination of Lekhnath-Damauli 220kV Transmission Line Project.

Nepal Electricity Authority Environment and Social Studies Department (2019) Updated Initial Environmental Examination of Lekhnath-Damauli 220kV Transmission Line Project.

Nepal Electricity Authority Environment and Social Studies Department (2020) Updated Initial Environmental Examination of Lekhnath-Damauli 220kV Transmission Line Project.

Patricia Moore and Firuza Pastakia, eds. (2007). Environmental Justice and Rural Communities: Studies from India and Nepal. IUCN, Bangkok, Thailand and Gland, Switzerland. pp. 115.

World Bank Group (2020) Guidance for EHS Response to COVID-19.

APPENDIX A INTERNAL NOTE PREPARED BY FICHTER 2021

Access roads

The Contractor shall at an early stage of the Contract assess the line route and prepare access road maps detailing the proposed access routes to all towers of the line for Employer's/Engineer's review and approval.

The various access types shall be identified and mapped (showing length and terrain features):

sections of existing public roads to be used (without enlargement or other modification)

existing roads not maintained by local authorities (which may need upgrade and stabilization works)

Existing community tracks (which will need to be enlarged and stabilized, thus creating environmental and social impacts)

proposed new access tracks which can be restored to natural condition after construction

Proposed new access tracks which will require cutting of slopes or terraces and cannot be restored to natural condition and thus need to be stabilized with roadside stabilization, erosion protection and drainage to prevent degradation and negative environmental impacts.

Tower locations that cannot be accessed by road and need to be accessed by animal, cable, or aerial (e.g. helicopter) transport. This category also includes tower locations where the construction of access roads would require excessive environmental damage.

The types of new access tracks to be constructed shall be shown on maps. Type(s) of Contractor's heavy machinery which shall traverse the access routes shall also be indicated.

Access maps shall be submitted together with the final detailed routing design (at least 12 months before the physical construction commencement date). The maps will also show the following details:

Locations for storage of topsoil

Locations for storage of excavated material (undersoil)

Laydown areas for material and work equipment storage

Workers camps

Locations of the work areas required for positioning of the stringing equipment

Access to the work areas required for positioning of the stringing equipment

Once the access maps have been approved, the Contractor shall not make use of any other access routes without the prior approval of the Employer and Engineer.

The Contractor is also required to assist the Employer in the implementation of the Resettlement Action Plan. The envisaged assistance mainly consists of accurate identification of all private properties that will be affected by the construction activities, including modification of existing and construction of new access roads. Further details and detailed procedures are provided in the Project ESMP.

After obtaining permission for the construction of access roads, the Contractor shall undertake all necessary measures to make the access suitable for use and shall take all precautions to avoid damage to existing properties.

The Contractor is required to minimise the need for new access roads by:

using existing roads as much as possible
create short ‘finger’ roads from existing roads to tower locations instead of long roads along the line route where possible
consider alternate means of transportation described earlier instead of constructing long roads through forested hilly/mountainous areas.

Selection criteria for types of access roads in order of priority shall be as follows:

1. Existing roads (without the need for modifications)

Any damages to existing roads shall be fully rehabilitated so that condition of the roads is equal to that at the start of the Project. Environmental and social impacts shall be avoided.

2. Existing roads with modifications

Necessary modifications (e.g. widening, side stabilisation) shall be shown on access maps and shall be the subject of the Employer’s/Engineer’s approval. The Contractor is responsible for maintenance of the roads during construction and reparation of any damages. Environmental and social impacts shall be avoided where possible or minimised.

3. New access roads on flat terrain

All new access roads required over reasonably firm and level terrain shall be located, where possible, within the OHL easement (RoW). The Contractor is responsible for restoration of affected ground to initial condition before handing over. If traversing agricultural lands all losses shall be compensated until the full restoration of the productive capacity of the land (if temporary impact). If permanent impact, the lands shall be acquired and PAPs compensated for permanent losses. Cutting of trees for new access roads shall be avoided where possible or minimized.

4. New Access roads in hilly terrain

Adjustment of access road geometry to existing terrain features is of crucial importance. Cutting into steep slopes (which might lead to slope destabilization and cannot be restored to natural condition) shall be avoided as much as possible. Where this cannot be avoided, alternative means of access shall be considered (e.g. aerial or animal transport). In case alternative transport is not a feasible option, adequate slope stabilization measures (retaining walls, roadside stabilization, drainage, or other measures as appropriate) shall be installed during construction of the access roads. These measures shall be designed as permanent structures with consideration of long-term impacts. Necessary maintenance measures shall be included in the Operations and Maintenance Manual. Identification and installation of appropriate erosion prevention measures is the sole responsibility of the Contractor and shall be monitored by the Employer /Engineer.

The Contractor shall endeavour to minimise the environmental and social impacts by implementing the following:

Measures to avoid environmental and social impacts

Appropriate measures such as avoidance of tree cutting, avoidance of agriculture areas shall be implemented in design phase.

Measures to mitigate environmental and social impacts

Measures to mitigate environmental and social impacts shall be implemented for the remaining/residual environmental and social impacts. Some examples of appropriate measures are listed below. For detailed requirements reference shall be made to Environmental and Social Management Plan (ESMP).

Excavated material shall be stored in designated storage areas to be used for site reinstatement after completion of construction.

Topsoil layer shall be removed and stored separately from undersoil.

Procedures for transport and storage of excavated material and site reinstatement shall be defined in approved CESMP.

Any residual material shall be disposed of in accordance with approved Waste Management Plan after completion of the construction.

Disposal or storage of excavated soil on the slopes above or below access roads shall be strictly prohibited. Appropriate safety measures (e.g. anchored barriers) shall be installed below excavation sites to prevent accidental rockfall down the slopes.

The access tracks shall be constructed in such a way as to minimize damage to property, land, crops, and vegetation and shall be adequately drained to prevent washouts or soil erosion.

All watercourses shall be crossed by means of bridges or culverts covered with stone material and suitable grading. Drainage shall be provided by swales and appropriately placed culverts. Access route maps shall include location of all bridges, culverts, and swales.

The Contractor shall continuously maintain the drainage systems and surface of new access tracks for the duration of the works (and leave the measures in place for the time after works e.g. erosion prevention measures, drainage etc.).

Replantation of access roads that will not be used for maintenance shall be considered especially in forest areas or not-cultivated slopes. If located in RoW this can be done with low growing bushes and grass to stabilize slopes.

4.1.1 Use of existing roads without the need for modifications

Where Contractor uses existing roads maintained by the local authorities, he shall ensure that the drains (culverts) are properly maintained, protected and/or reinforced. Drains shall not be blocked for the duration of the Contract. Any damage to the road surface, drainage facilities, or any road accessories (e.g. signs, markings) caused by the Contractor shall be urgently repaired.

When the Contractor has approval to use existing community roads which are not maintained by local authorities, he shall get the consent from the concerned local community and shall maintain the road during the construction period to such a standard that its use by the customary traffic is not impeded in any way. This requirement also applies to roads described in 4.1.2.

All existing roads shall be restored at least to a condition equal to that before the construction activities commenced. Such restoration shall be completed before the issue of the Taking-Over Certificate. This requirement also applies to roads described in 4.1.2.

Specific procedures for use of existing roads, including measures for minimizing disruption to local communities shall be defined in approved Traffic Management Plan.

4.1.2 Use of existing roads/tracks with modifications

Widening or any other modification (e.g. stabilisation, installation of drainage systems) of existing access roads/tracks may only be done with Employer's/Engineer's approval.

Widening of existing access tracks will almost invariably impact the properties of local residents e.g. agriculture areas, forest areas etc. The Contractor will need to get consent for widening and upgrade of the tracks and all affected assets will need to be compensated. The terrain needed for widening of access roads shall have to be acquired and be part of the Resettlement Action Plan (RAP). Modifications (e.g. drainages, retaining walls) shall be suitable for long term use.

4.1.3 New Access Roads Construction

The land needed for new access roads will have to be acquired from private owners or allocated by the responsible government organizations / municipalities. The land acquisition will be part of the RAP. Houses shall be avoided, thus preventing any additional physical displacement by way of construction of access roads.

The first earthworks operation shall be the removal and separation of topsoil. Topsoil shall be kept separate from other material and stock-piled for site reinstatement.

Access roads shall be made in two layers (load bearing and cover layer) with a minimum width of 3.0 m or maximum vehicle width plus 0.5m. The load bearing layer and cover layer shall be made for heavy transports with a maximum axle load of 12 t and a maximum total weight of 60 t.

Load-bearing layer shall be based on a surface with in-situ value of California Bearing Ratio (CBR) of at least 7%. In poor soil areas where this CBR value cannot be achieved at shallow excavation depth, replacement of soil layer (ca 1m thickness) with crushed rock, or alternative method of soil reinforcement shall be considered.

Proper turning angles and light slopes shall be provided for safe turning and access for heavy vehicles. The safety of the access roads shall additionally be ensured by means of side protections (safety barriers) above dangerous slopes. Passing places shall be incorporated where necessary to ensure safe operation of the access road.

During heavy rains and adverse weather conditions the viability and practicability of access roads must be guaranteed. For loose and unsustainable clay, marl, loam or soggy soil layers, the use of a geotextile is recommended to avoid an entry of fine-grain components in the base and to stabilize the subsoil.

During the construction of the access roads, the Contractor shall grade and slope the roads to prevent any unnecessary water flow across the road and to minimize soil erosion. Appropriate measures shall be provided to ensure continuity of flows of existing watercourses (e.g. by installation of culverts) and surface run-off. Surface protection and erosion mitigation measures (drainage, stone pitching, gabions, etc.) shall be installed.

4.1.4 Access Roads Maintenance

Contractor shall be responsible for maintaining all new (maintenance requirements for existing roads are specified in 4.1.1) access roads in usable condition for the duration of the Contract. Usable condition is to be understood as safely passable for all 4WD vehicles and fully loaded construction machinery.

In particularly difficult terrain, and with agreement of the Employer/Engineer, limited usability roads- defined as safely passable for 4WD vehicles with use of gear reduction system and partially loaded construction vehicles - may be accepted. In such cases, limited usability sections of the access roads shall be clearly marked with appropriate safety warnings.

Care shall be taken to ensure the roads are free from ice and mud during wet seasons. Drainage systems must be regularly inspected and cleared from any blockages.

In case the roads are damaged or considered unsafe after heavy rainstorms, access to hazardous sections of the roads shall be prevented by means of temporary barriers until corrective works are completed and appropriate road condition restored.

Local population shall not be put to any inconvenience in gaining safe and timely access to their properties.

All necessary measures connected with the access, transport and maintenance are Contractor's responsibility. These measures shall include, but not be limited to:

provision of all necessary means of transport, preparation of access roads and tracks associated with levelling, gravelling, safety measures, bridges, culverts etc.

clearing and establishing of storage facilities, traffic control, making good of damages, as well as obtaining necessary approvals from authorities where applicable

regular maintenance of access roads, including installed stabilisation and erosion protection facilities (e.g. drainage swales, retaining walls).

4.1.5 Culverts and Bridges

Culverts and bridges shall be installed for the purpose of crossing existing watercourses. Culverts shall also be installed where required for effective drainage systems.

The locations and types of culverts and bridges shall be proposed by the Contractor and approved by the Employer/Engineer.

4.1.6 Reinstatement of new access roads

After completion of the works, access roads shall be reinstated, and the topsoil placed in its original position to ensure full reinstatement of the area to the original / natural condition. Same requirement also applies to the storage areas used for excavated materials and topsoil, as well as all platforms used for stringing equipment.

Reinstatement of access roads and other listed areas shall be the responsibility of the Contractor. A method statement and programme for reinstatement works shall be submitted to Employer/Engineer for approval.

Reinstatement works, shall include all necessary actions such as soil restoration (backfilling and compaction), topsoil restoration and preparation for hydro-seeding and planting of shrubs and trees to a standard at least equal to the condition of the site prior to construction.

The sequence of work shall ensure establishment of all native plant species to achieve successful replanting at site.

Ruts and scars shall be removed, damage to ditches, terraces, roads, and other features of the land shall be corrected, and the land shall be restored to its original condition.

All such work shall be completed to the full satisfaction of the Employer/Engineer and the relevant regulatory authorities before the issue of the Taking-Over Certificate.

4.1.7 Access Roads Adaptation for Long-Term Use

In case the Employer indicates that any access road(s) should be preserved for OHL maintenance or full area reinstatement is not possible for any other reason, the Contractor shall propose, for Employer's/Engineer's approval, any additional measures necessary for adaptation of the roads for long-term use and prevention of long-term erosion as appropriate. These roads and associated adaptation measures shall be considered a part of the Permanent Works as defined by the Clause 1.1.5.4 of the GCC.

Based on assessment of the needs for future maintenance access and assessment of the local geotechnical and hydrological conditions, additional works shall be executed to ensure safe use and durability of access roads which shall be preserved beyond Project completion. Such works shall typically include, but are not limited, to:

widening of the road to 4.0m
widening and further compaction of the load-bearing layer
replacement and compaction of the cover layer (gravel or crushed rock)
Increase of the thickness of the cover layer to min. 40 cm
upgrade of the drainage system (e.g. underground pipe installation, geotextile and riprap lining, culverts)
installation of permanent safety features (e.g. signs, fences, safety barriers) as required by the Employer
installation of long-term erosion protection systems (e.g. erosion mats, retaining structures).

Other appropriate actions as may be required on site-specific basis.

The compaction procedure and plant shall be proved by trials at the commencement of the works. The weight, type, and number of passes of compaction plant shall be varied to determine the optimum compaction.

Long-term stability of earth retaining structures shall be confirmed by an appropriate geotechnical design method prepared by the Contractor and approved by the Employer/Engineer.

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VII-8

Technical Data Sheets

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Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
1	**220 kV Air Insulated Switchgear (AIS)**			
1.1	**220 kV Capacitive Voltage Transformer**			
1.1.1	Manufacturer	-	-	
1.1.2	Place of manufacture	-	-	
1.1.3	Model designation	-	-	
1.1.4	Applicable standard	-	IEC 60071-1	
			IEC 60071-2	
			IEC 61869-1	
			IEC 61869-5	
			IEC 60358-1	
			IEC 60529	
			IEC 60815	
1.1.5	Type	-	outdoor, capacitor type	
1.1.6	Highest voltage for equipment U_m	kV	245	
1.1.7	Rated primary voltage	kV	220 / √3	
1.1.8	Number of secondary windings		3	
1.1.9	• for protection	-	combined	
1.1.10	• for measurement	-	combined	
1.1.11	• for metering	-	1	
1.1.12	Rated secondary voltage:			
1.1.13	• protection winding	V	110 / √3	
1.1.14	• measurement winding	V	110 / √3	
1.1.15	• metering winding	V	110 / √3	
1.1.16	Accuracy class for protection	-	3P	
1.1.17	Accuracy class for measurement	-	0.5	
1.1.18	Accuracy class for metering	-	0.2S	
1.1.19	Total rated burden secondary windings	VA	3 x 50	
1.1.20	Type of insulators	-	silicon	
1.1.21	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
1.1.22	Rated lightning impulse withstand voltage	kV_{peak}	1050	
1.1.23	Rated power frequency withstand voltage	kV_{rms}	460	
1.1.24	Tests according to *VII-5 Technical Specification*	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
1.2	**220 kV Lightning Arrester and Discharge Counter**			
1.2.1	Manufacturer	-	-	
1.2.2	Place of manufacture	-	-	
1.2.3	Model designation	-	-	
1.2.4	Applicable standard	-	IEC 60071-1	
			IEC 60071-2	
			IEC 60099-4	
			IEC 60099-5	
			IEC 60529	
			IEC 60815	
1.2.5	Type	-	Outdoor, silicon-housed	
1.2.6	System data:			
1.2.7	• Nominal system voltage	kV	220	
1.2.8	• Highest system voltage	kV	245	
1.2.9	• System frequency	Hz	50	
1.2.10	Rated voltage U_r	kV	180	
1.2.11	Maximum continuous operating voltage U_c	kV	144	
1.2.12	Rated discharge current	kA	10 / 20 subject to calculation	
1.2.13	Thermal energy rating	kJ/kV	10	
1.2.14	Separate earthing rod per SA, 150 mm^2	yes/no	yes	
1.2.15	Discharge Counter:			
1.2.16	Manufacturer	-		
1.2.17	Model designation	-		
1.2.18	Display	-		
1.2.19	Number of impulses	yes/no	yes	
1.2.20	Leakage current measurement, total current	yes/no	yes	
1.2.21	Protection class	-	IP55 W	
1.2.22	Number of counters per three (3) 1-ph arresters	-	3	
1.2.23	Tests according to *VII-5 Technical Specification*	yes/no	yes	
1.3	**220 kV Post Insulator**			
1.3.1	Manufacturer	-		
1.3.2	Place of manufacture	-		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
1.3.3	Type	-	outdoor, silicon	
1.3.4	Applicable standard	-	IEC 60071-1	
			IEC 60071-2	
			IEC 60168	
			IEC 60273	
			IEC 60815	
			IEC 61952	
			IEC 62217	
			IEC 62231-1	
			IEC 61462	
			IEC 62772	
1.3.5	Model designation	-		
1.3.6	IEC post insulator designation	-		
1.3.7	System nominal voltage	kV	220	
1.3.8	Highest voltage of equipment	kV	245	
1.3.9	Rated lightning impulse withstand voltage, dry	kV_{peak}	1050	
1.3.10	Rated switching impulse withstand voltage, wet	kV_{peak}	460	
1.3.11	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
1.3.12	Minimum failing load, bending	kN		
1.3.13	Tests according to *VII-5 Technical Specification*	yes/no	yes	
1.4	**220 kV Insulator String**			
1.4.1	Insulator units			
1.4.2	Applicable standard	-	IEC 60071-1	
			IEC 60071-2	
			IEC 60120	
			IEC 60383-1	
			IEC 60383-2	
			IEC 60305	
			IEC 60372	
			IEC 60815	
			IEC 61109	
			IEC 61466	
1.4.3	Manufacturer	-		
1.4.4	Type	-		
1.4.5	Insulating body material	-	silicon	
1.4.6	Rated electromechanical or mechanical strength	kN		
1.4.7	Max. shed diameter	mm		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
1.4.8	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
1.4.9	Tests according to *VII-5 Technical Specification*	yes/no	yes	
1.5	**220 kV Insulator String**			
1.5.1	Manufacturer	-		
1.5.2	Place of manufacture	-		
1.5.3	Type	-		
1.5.4	Insulating body material	-	silicon	
1.5.5	Applicable standard	-	IEC 60071-1, IEC 60071-2 IEC 60120, IEC 60383-1, IEC 60383-2, IEC 60305, IEC 60372, IEC 60815, IEC 61109, IEC 61466	
1.5.6	Rated electromechanical or mechanical strength	kN		
1.5.7	Max. shed diameter	mm		
1.5.8	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
1.5.9	Tests according to *VII-5 Technical Specification*	yes/no	yes	
1.6	**220 kV Tubular Busbar**			
1.6.1	Applicable standard	-	DIN 43670	
			DIN 46276-1	
			EN 755-1	
			EN 755-2	
			EN 755-7	
1.6.2	Manufacturer	-		
1.6.3	Place of manufacture	-		
1.6.4	Type	-		
1.6.5	Type for road crossings or other special purposes	-		
1.6.6	Rated current	A	4000	
1.6.7	Rated short time current (3s)	kA	≥ 40	
1.6.8	Cross-section	mm^2	-	
1.6.9	Tubular type:	-	Aluminum	
1.6.11	Overall diameter	mm	≥250	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
1.6.12	Internal diameter	mm	-	
1.6.13	Tube weight	kg/m	-	
1.6.14	Theoretical breaking force	kN	-	
1.6.15	Ohmic resistance at 20°C	Ω/km	-	
1.6.16	Tests according to *VII-5 Technical Specification*	yes/no	yes	
1.7	**220 kV Conductor**			
1.7.1	Applicable standard	-	IEC 60104	
			IEC 61089	
			IEC 61232	
			IEC 62004	
1.7.2	Manufacturer	-	-	
1.7.3	Place of manufacture	-	-	
1.7.4	Type	-	-	
1.7.5	Rated current	A	-	
1.7.6	Rated short time current (3s)	kA	≥ 40	
1.7.7	Total cross-section	mm^2	-	
1.7.8	Number of strands x diameter:		-	
1.7.9	Aluminum	#/mm	-	
1.7.10	Steel	#/mm	-	
1.7.11	Overall diameter	mm	-	
1.7.12	Conductor weight	kg/m	-	
1.7.13	Theoretical breaking force	kN	-	
1.7.14	Ohmic resistance at 20°C	Ω/km	-	
1.7.15	Tests according to *VII-5 Technical Specification*	yes/no	yes	
1.8	**220 kV Clamps/dead-end joints (to be filled in separately for each type)**			
1.8.1	Manufacturers	-		
	Type	-		
	Cross-section	mm^2		
	Rated current	A	4000	
1.8.2	Busbar	A	4000	
1.8.3	Connections	A	4000	
1.8.4	Tests according to *VII-5 Technical Specification*	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
1.9	**Steel Structures**			
1.9.1	Manufacturer	-		
	Place of manufacture	-		
	Applicable standard	-		
	Material	-		
1.9.2	Factor of safety in calculation	-		
1.9.3	Galvanization thickness:			
1.9.4	Steel sections thicker than 5 mm	µm		
1.9.5	Steel sections 2 mm-5 mm	µm		
1.9.6	Bolts and nuts	µm		
1.9.7	Bolts and nuts:			
1.9.8	Securing with plain and spring washers	yes/no		
1.9.9	Minimum quality	-		
1.9.10	Tests according to *VII-5 Technical Specification*	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
2	**132 kV Air Insulated Switchgear (AIS)**			
2.1	**132 kV Circuit Breaker**			
2.1.1	Manufacturer	-		
2.1.2	Place of manufacture	-		
2.1.3	Model designation	-		
2.1.4	Applicable standard	-	IEC 62271-1, IEC 62271-100, IEC 62271-110, IEC 62271-310	
2.1.5	Circuit breaker type	-	Outdoor SF_6	
2.1.6	Type of operation		three phase / three phase operated	
2.1.7	Operating mechanism:		three-phase	
2.1.8	Incomer / coupler bay	-	three-phase	
2.1.9	OHL bay	-	single-phase	
2.1.10	Electrical endurance class		E2	
2.1.11	Mechanical endurance class		M2	
2.1.12	On line monitoring	yes/no	no	
2.1.13	Point-on-wave controller	yes/no	no	
2.1.14	Number of poles	-	3	
2.1.15	Nominal voltage	kV	132	
2.1.16	Rated voltage U_r	kV	145	
2.1.17	Rated frequency	Hz	50	
2.1.18	Rated short-duration power frequency withstand voltage:	kV_{rms}	275	
2.1.19	Rated lightning impulse withstand voltage:	kV_{peak}	650	
2.1.20	Rated continuous current	A	2000	
2.1.21	Rated short-time breaking current	kA	31.5	
2.1.22	First-pole-to-clear factor	-	1.3	
2.1.23	Making current peak	kA	80	
2.1.24	DC time constant of the rated short-circuit breaking current	ms	60	
2.1.25	Duration of short circuit	s	3	
2.1.26	Rated break time	ms	≤40	
2.1.27	Rated closing time	ms	≤75	
2.1.28	Rated opening time	ms	≤30	
2.1.29	Number of tripping coils	-	2	
2.1.30	Number of closing coils	-	1	
2.1.31	Rated operating sequence (three-phase auto reclosing)	-	O-0.3 s-CO-3 min-CO	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
2.1.32	Type of operating mechanism	-	spring operated	
2.1.33	Insulators	-	silicon	
2.1.34	Minimum unified specific creepage distance (USCD)	mm/kV	43.3	
2.1.35	Temperature operating range	ºC	-25 - +40	
2.1.36	Rated ice thickness	mm	N/A	
2.1.37	Degree of protection of operating mechanism	-	IP55	
2.1.38	Motor rated voltage	V DC	110	
2.1.39	Operating coils rated voltage	V DC	110	
2.1.40	Number of auxiliary contacts (NO/NC)	-		
2.1.41	Number of spare auxiliary contacts	%	15 (as a minimum 3 NO and 3 NC)	
2.1.42	Rated voltage of heater	V AC	230	
2.1.43	Autoreclosing for the line feeders	-	N/A	
2.1.44	Gas pressure alarm blocking	MPa		
2.1.45	Tests according to *VII-5 Technical Specification*	yes/no	yes	
2.2	**132kV Disconnector with earthing switch**			
2.2.1	**Center Break Disconnector with earthing switch**			
2.2.1.1	Manufacturer	-		
2.2.1.2	Place of manufacture	-		
2.2.1.3	Model designation	-		
2.2.1.4	Applicable standard	-	IEC 60071, IEC 62271-1, IEC 62271-102	
2.2.1.5	Type of operation	-	two-columns rotary, three-phase by common operating mechanism	
2.2.1.6	Type	-	outdoor	
2.2.1.7	Bus transfer capability	A	1200	
2.2.1.8	Electrical endurance class		E0	
2.2.1.9	Mechanical endurance class		M2	
2.2.1.10	Number of poles	-	3	
2.2.1.11	Nominal voltage	kV	132	
2.2.1.12	Rated voltage U_r	kV	145	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
2.2.1.13	Rated continuous current	A	2000	
2.2.1.14	Rated frequency	Hz	50	
2.2.1.15	Rated short-time withstand current	kA	31.5	
2.2.1.16	Rated duration of short circuit	s	3	
2.2.1.17	Rated peak withstand current / short circuit making current of earthing switch	kA	80	
2.2.1.18	Rated short-duration power frequency withstand voltage:	-	-	
2.2.1.19	Phase-to-earth and between the phases	kV_{rms}	275	
2.2.1.20	Across the open isolating distance	kV_{rms}	315	
2.2.1.21	Rated lightning impulse withstand voltage:	-	-	
2.2.1.22	Phase-to-earth and between the phases	kV_{peak}	650	
2.2.1.23	Across the open isolating distance	kV_{peak}	750	
2.2.1.24	Insulators	-	silicon	
2.2.1.25	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
2.2.1.26	Temperature operating range	ºC	-25 - +40	
2.2.1.27	Rated ice thickness	mm	N/A	
2.2.1.28	Type of operating mechanism	-	motor operated / manually in case of emergency	
2.2.1.29	Degree of protection of operating mechanism	-	IP 55	
2.2.1.30	Drive rated voltage	V DC	110	
2.2.1.31	Heaters rated voltage	V AC	230	
2.2.1.32	Number of auxiliary contacts (NO/NC)	-		
2.2.1.33	Number of spare auxiliary contacts	%	15 (as a minimum 3 NO and 3 NC)	
2.2.1.34	Number of earthing switches	-	1	
2.2.1.35	Earthing switches induced current and voltage class	-	B	
2.2.1.36	Operating mechanism of earthing switches	-	motor operated / manually in case of emergency	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
2.2.1.37	Tests according to *VII-5 Technical Specification*	yes/no	yes	
2.2.2	**Pantograph Disconnector with earthing switch**			
2.2.2.1	Manufacturer	-		
2.2.2.2	Place of manufacture	-		
2.2.2.3	Model designation	-		
2.2.2.4	Applicable standard	-	IEC 60071, IEC 62271-1, IEC 62271-102	
2.2.2.5	Type of operation	-	pantograph, single phase / three-phase by common operating mechanism	
2.2.2.6	Type	-	outdoor	
2.2.2.7	Bus transfer capability	A	1200	
2.2.2.8	Electrical endurance class		E0	
2.2.2.9	Mechanical endurance class		M2	
2.2.2.10	Number of poles	-	3	
2.2.2.11	Nominal voltage	kV	132	
2.2.2.12	Rated voltage U_r	kV	145	
2.2.2.13	Rated continuous current	A	2000	
2.2.2.14	Rated frequency	Hz	50	
2.2.2.15	Rated short-time withstand current	kA	31.5	
2.2.2.16	Rated duration of short circuit	s	3	
2.2.2.17	Rated peak withstand current / short circuit making current of earthing switch	kA	80	
2.2.2.18	Rated short-duration power frequency withstand voltage:	-	-	
2.2.2.19	Phase-to-earth and between the phases	kV_{rms}	275	
2.2.2.20	Across the open isolating distance	kV_{rms}	315	
2.2.2.21	Rated lightning impulse withstand voltage:	-	-	
2.2.2.22	Phase-to-earth and between the phases	kV_{peak}	650	
2.2.2.23	Across the open isolating distance	kV_{peak}	750	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
2.2.2.24	Insulators	-	silicon	
2.2.2.25	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
2.2.2.26	Temperature operating range	ºC	-25 - +40	
2.2.2.27	Rated ice thickness	mm	N/A	
2.2.2.28	Type of operating mechanism	-	motor operated / manually in case of emergency	
2.2.2.29	Degree of protection of operating mechanism	-	IP55	
2.2.2.30	Drive rated voltage	V DC	110	
2.2.2.31	Heaters rated voltage	V AC	230	
2.2.2.32	Number of auxiliary contacts (NO/NC)	-		
2.2.2.33	Number of spare auxiliary contacts	%	15 (as a minimum 3 NO and 3 NC)	
2.2.2.34	Number of earthing switches	-	1	
2.2.2.35	Earthing switches induced current and voltage class	-	B	
2.2.2.36	Operating mechanism of earthing switches	-	motor operated / manually in case of emergency	
2.2.2.37	Tests according to *VII-5 Technical Specification*	yes/no	yes	
2.3	**132 kV Current Transformer**			
2.3.1	Manufacturer	-		
2.3.2	Model designation			
2.3.3	Place of manufacture	-		
2.3.4	Applicable standard	-	IEC 61869-1	
			IEC 61869-2	
	Type	-	Outdoor	
	Nominal voltage	kV	132	
	Rated voltage	kV	145	
	Rated short-time current	kA	31.5	
	Duration of short circuit	s	3	
2.3.5	Rated peak withstand current	kA_{peak}	80	
2.3.6	Type of insulators	-	silicon	
2.3.7	Rated extended primary current in percentage of rated primary current	%	120	
	Rated primary current			

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
2.3.8	• for measuring/metering/prot.	A	1250-1500-2000	
	• for busbar protection	A	2000	
2.3.9	Number of cores:			
2.3.10	• for measuring	-	1	
2.3.11	• for metering	-	1	
2.3.12	• for protection	-	3	
2.3.13	Rated secondary current:			
2.3.14	• for measuring	A	1	
2.3.15	• for metering	A	1	
2.3.16	• for protection	A	1	
2.3.17	Accuracy class:			
2.3.18	• for measuring	-	0.5 M	
2.3.19	• for metering		0.2S	
2.3.20	• for protection	-	5P 20	
2.3.21	Rated burden:			
2.3.22	• for measuring core	VA	15	
2.3.23	• for metering core	VA	15	
2.3.24	• for protection cores	VA	30	
2.3.25	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
2.3.26	Rated lightning impulse withstand voltage	kV_{peak}	650	
2.3.27	Rated short-duration power frequency withstand voltage	kV_{rms}	275	
2.3.28	Tests according to *VII-5 Technical Specification*	yes/no	yes	
2.4	**132 kV Capacitive Voltage Transformer**			
2.4.1	Manufacturer	-	-	
2.4.2	Place of manufacture	-	-	
2.4.3	Model designation	-	-	
2.4.4	Applicable standard	-	IEC 60071-1	
			IEC 60071-2	
			IEC 61869-1	
			IEC 61869-5	
			IEC 60358-1	
			IEC 60529	
			IEC 60815	
2.4.5	Type	-	outdoor, capacitor type	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
2.4.6	Highest voltage for equipment U_m	kV	145	
2.4.7	Rated primary voltage	kV	132 / √3	
2.4.8	Number of secondary windings		3	
2.4.9	• for protection	-	combined	
2.4.10	• for measurement	-	combined	
2.4.11	• for metering	-	1	
2.4.12	Rated secondary voltage:			
2.4.13	• protection winding	V	110 / √3	
2.4.14	• measurement winding	V	110 / √3	
2.4.15	• metering winding	V	110 / √3	
2.4.16	Accuracy class for protection	-	3P	
2.4.17	Accuracy class for measurement	-	0.5	
2.4.18	Accuracy class for metering	-	0.2S	
2.4.19	Total rated burden secondary windings	VA	3 x 50	
2.4.20	Type of insulators	-	silicon	
2.4.21	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
2.4.22	Rated lightning impulse withstand voltage	kV_{peak}	650	
2.4.23	Rated power frequency withstand voltage	kV_{rms}	275	
2.4.24	Tests according to *VII-5 Technical Specification*	yes/no	yes	
2.5	**132kV Lightning Arrester and Discharge Counter**			
2.5.1	Manufacturer	-	-	
2.5.2	Place of manufacture	-	-	
2.5.3	Model designation	-	-	
2.5.4	Applicable standard	-	IEC 60071-1	
			IEC 60071-2	
			IEC 60099-4	
			IEC 60099-5	
			IEC 60529	
			IEC 60815	
2.5.5	Type	-	Outdoor, silicon-housed	
2.5.6	System data:			
2.5.7	• Nominal system voltage	kV	132	
2.5.8	• Highest system voltage	kV	145	
2.5.9	• System frequency	Hz	50	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
2.5.10	Rated voltage U_r	kV	108	
2.5.11	Maximum continuous operating voltage U_c	kV	86	
2.5.12	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
2.5.13	Rated discharge current	kA	10 / 20 subject to calculation	
2.5.14	Thermal energy rating	kJ/kV	10	
2.5.15	Separate earthing rod per SA, 150 mm^2	yes/no	yes	
2.5.16	Discharge Counter:			
2.5.17	Manufacturer	-		
2.5.18	Model designation	-		
2.5.19	Display	-		
2.5.20	Number of impulses	yes/no	yes	
2.5.21	Leakage current measurement, total current	yes/no	yes	
2.5.22	Protection class	-	IP 55 W	
2.5.23	Number of counters per three (3) 1-ph arresters	-	3	
2.5.24	Tests according to *VII-5 Technical Specification*	yes/no	yes	
2.6	**132 kV Post Insulator**			
2.6.1	Manufacturer	-		
2.6.2	Place of manufacture	-		
2.6.3	Type	-	outdoor, porcelain/silicon	
2.6.4	Applicable standard	-	IEC 60071-1	
			IEC 60071-2	
			IEC 60168	
			IEC 60273	
			IEC 60815	
			IEC 61952	
			IEC 62217	
			IEC 62231-1	
			IEC 61462	
			IEC 62772	
2.6.5	Model designation	-		
2.6.6	Number of stacks	-	single	
2.6.7	IEC post insulator designation	-		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
2.6.8	System nominal voltage	kV	132	
2.6.9	Highest voltage of equipment	kV	145	
2.6.10	Rated lightning impulse withstand voltage, dry	kV_{peak}	650	
2.6.11	Rated switching impulse withstand voltage, wet	kV_{peak}	275	
2.6.12	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
2.6.13	Minimum failing load, bending	kN		
2.6.14	Tests according to *VII-5 Technical Specification*	yes/no	yes	
2.7	**132 kV Insulator String**			
2.7.1	Insulator units			
2.7.2	Applicable standard	-	IEC 60071-1	
			IEC 60071-2	
			IEC 60120	
			IEC 60383-1	
			IEC 60383-2	
			IEC 60305	
			IEC 60372	
			IEC 60815	
			IEC 61109	
			IEC 61466	
2.7.3	Manufacturer	-		
2.7.4	Type	-		
2.7.5	Insulating body material	-	silicon	
2.7.6	Rated electromechanical or mechanical strength	kN		
2.7.7	Max. shed diameter	mm		
2.7.8	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
2.7.9	Tests according to *VII-5 Technical Specification*	yes/no	yes	
2.8	**132 kV Tubular Busbar**			
2.8.1	Applicable standard	-	DIN 43670	
			DIN 46276-1	
			EN 755-1	
			EN 755-2	
			EN 755-7	
2.8.2	Manufacturer	-		
2.8.3	Place of manufacture	-		
2.8.4	Type	-		
2.8.6	Rated current	A		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
2.8.7	Rated short time current (3s)	kA		
2.8.9	Tubular type:	-	Al 3inch SC80	
2.8.11	Internal diameter	mm	-	
2.8.12	Tube weight	kg/m	-	
2.8.13	Theoretical breaking force	kN	-	
2.8.14	Ohmic resistance at 20°C	Ω/km	-	
2.8.15	Tests according to *VII-5 Technical Specification*	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3	**220 kV Gas Insulated Switchgear (GIS)**			
3.1	**General**			
3.1.1	Manufacturer	-		
3.1.2	Place of manufacture	-		
3.1.3	Model designation	-		
3.1.4	Type	-	Metal enclosed, gas insulated GIS- indoor	
3.1.5	Applicable standard	-	IEC 62271-203, 62271-1, 60270, 60376, 60480	
3.1.6	Nominal voltage of system	kV_{rms}	220	
3.1.7	Rated voltage of system	kV_{rms}	245	
3.1.8	Rated frequency	Hz	50	
3.1.9	Rated short-duration power frequency withstand voltage:			
3.1.10	- Common Value	kV_{rms}	460	
3.1.11	- Across the isolating distance	kV_{rms}	530	
3.1.12	Rated lightning impulse withstand voltage:			
3.1.13	- Common Value	kV_{peak}	1050	
3.1.14	- Across the isolating distance	kV_{peak}	1200	
3.1.15	Rated short-time withstand current (3s)	kA	40	
3.1.16	Rated peak withstand current	kA	100	
3.1.17	Rated current (busbar)			
3.1.18	Lekhnath	A	3150	
3.1.19	Damauli	A	4000	
3.1.20	Rated current (feeders)			
3.1.21	Lekhnath	A	2500	
3.1.22	Damauli	A	3150	
3.1.23	Rated current (bus coupler / bus section)			
3.1.24	Lekhnath	A	3150	
3.1.25	Damauli	A	4000	
3.1.26	Type of busbars	-	Double	
3.1.27	Type of enclosure (bus bar/feeder)	-	1-phase / 1-phase	
3.1.28	Material of enclosure for:			
3.1.29	- Circuit breaker	-	Al	
3.1.30	- Busbars	-	Al	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.1.31	- Other compartments	-	Al	
3.1.32	Applicable standard for SF6 pressurized enclosures	-	EN 50052, 50064, 50068, 50069, 50089	
3.1.33	Minimum safety factor for switchgear (GIS housings/steel supports)	-	≥ 2,5	
3.1.34	Seismic factor according to IEEE 693 figure A.1	g	0,5	
3.1.35	Suitability for the site climate/temperature range:			
3.1.36	Lekhnath	°C	0 - 40	
3.1.37	Damauli	°C	0 - 40	
3.1.38	Material and cross-section of bus bar conductor	.../ mm2		
3.1.39	Material and cross-section of feeder bus-duct conductor	.../ mm2		
3.1.40	Material of contacts (indicate bi-metallic where used)	-	Cu/Ag	
3.1.41	Type of contact	-	Tulip/plug-in	
3.1.42	Surface treatment of GIS housings:			
3.1.43	- Indoor paint / layer thickness	RAL / µm		
3.1.44	- Outdoor paint / layer thickness	RAL / µm		
3.1.45	- Flange treatment (outdoor)	-	Add number of technical description	
3.1.46	Colour of partition insulators	RAL		
3.1.47	Colour of local control cubicle	RAL		
3.1.48	Minimum subdivision of GIS switchgear (partition):			
3.1.49	- Busbars per each feeder	-	Yes	
3.1.50	- Busbar isolator	-	Yes	
3.1.51	- Circuit breaker	-	Yes	
3.1.52	- Feeder disconnector and cable end unit	-	Yes	
3.1.53	- Voltage transformer	-	Yes	
3.1.54	- Current transformer	-	Yes	
3.1.55	- Surge arrster (if any)	-	Yes	
3.1.56	- Max. lenght/volume of gas insulated bus duct	Meter/Litre	…/…	
3.1.57	Maximum size of gas compartment	Litre		
3.1.58	Maximum evaquation time of gas compartment	hrs	< 2	
3.1.59	Method of compensation of expansion and contraction:			

Technical Data Sheets				
BIDDER’S / CONTRACTOR’S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.1.60	- For busbar conductors	-	Expansion	
3.1.61	- For busbar enclosures	-	Expansion	
3.1.62	Type/ material of pressure relief device	-	Rupture disc / …	
3.1.63	Rupturing pressure of pressure relief device (circuit breaker/others)	MPa	…/…	
3.1.64	Type of filter employed for moisture absorption	-	Molecular Sieve	
3.1.65	Design lifetime of moisture absorbent	Years	> 10	
3.1.66	Total mass of switchgear / haviest transportation unit	kg	…/…	
3.1.67	Size of maximum transportation unit (L x W x H)	m		
3.1.68	Mass of heaviest single component to be handled during erection	kg		
3.1.69	Mass of heaviest single indoor component to be handled during erection with the indoor crane	kg		
3.1.70	Bay width (centre to centre)	m		
3.1.71	Indoor footprint of initial GIS	m x m		
3.1.72	Indoor footprint including extension	m x m		
3.1.73	Minimum indoor crane hook height	m		
3.1.74	Indoor crane lifting force	t	≥ 6	
3.1.75	Crane with 2 speeds suitable for GIS installation	-	Yes	
3.1.76	Applicable standard for new SF6 gas	-	IEC 60376	
3.1.77	Density of gas in:			
3.1.78	- Circuit breaker compartment	g/l		
3.1.79	- Other than circuit breaker compartment	g/l		
3.1.80	Rated filling pressure at 20ºC (CB/others)	MPa		
3.1.81	1st alarm pressure at 20ºC (CB/others)	MPa		
3.1.82	Circuit breaker blocking pressure at 20ºC (Close/Open)	MPa		
3.1.83	Maximum SF_6 leakage rate	% / year	< 0,1	
3.1.84	Design pressure of enclosures (circuit breaker/ others)	MPa	…/…	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.1.85	Type test presure of enclosures (circuit breaker/others	MPa	…/…	
3.1.86	Routine test pressure of casted enclosures (circuit breaker/others)	MPa	…/…	
3.1.87	Routine test pressure of welded enclosures (circuit breaker/others)	MPa		
3.1.88	Design pressure of gas tight barrier insulator	MPA		
3.1.89	Routine test pressure of gas tight barrier insulator	MPa		
3.1.90	Withstand voltage at SF6 gas atmospheric pressure	kV	245	
3.1.91	Minimum gas service period	years	> 10	
3.1.92	Document number showing maximum allowable dewpoint depending on temperature for different gas filling/compartments	-	to be provided with Tender	
3.1.93	Recommended inspection/maintenance intervals	years		
3.1.94	Neutral earthing	-	solidly	
3.1.95	Document number showing the Inspection and Test Plan for the complete GIS scope of supply including FAT	-	to be provided with Tender	
3.2	**Circuit breaker**			
3.2.1	Manufacturer	-		
3.2.2	Place of manufacture	-		
3.2.3	Model designation	-		
3.2.4	Type	-	Self-blast pressure buffer,SF_6	
3.2.5	Applicable standard	-	IEC 62271-1 IEC 62271-203, IEC 62271-100	
3.2.6	Type of quenching medium		SF_6	
3.2.7	Interrupter units per pole	pcs	1	
3.2.8	Rated voltage	kV	245	
3.2.9	Rated short-duration power frequency withstand voltage:			
3.2.10	- Common Value	kV_{rms}	460	
3.2.11	- Across the isolating distance	kV_{rms}	530	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.2.12	Rated lightning impulse withstand voltage:			
3.2.13	- Common Value	kV_{peak}	1050	
3.2.14	- Across the isolating distance	kV_{peak}	1200	
3.2.15	Rated frequency	Hz	50	
3.2.16	Number of phases	-	3	
3.2.17	Rated current (bus coupler/feeders)			
3.2.18	Lekhnath	A	3150/2500	
3.2.19	Damauli	A	4000/3150	
3.2.20	Rated short-time withstand current (3s)	kA	40	
3.2.21	Rated peak withstand current	kA	100	
3.2.22	Rated making current	kA	100	
3.2.23	Rated cable charging breaking current	A		
3.2.24	Maximum capacitive breaking current:	A	to IEC 62271-100	
3.2.25	- Rated line charging breaking current	A	125	
3.2.26	- Rated cable charging breaking current	A	250	
3.2.27	- Rated Single/Back to Back Capacitor bank breaking current	A	400	
3.2.28	- Rated single capacitor bank breaking current	A	400	
3.2.29	Rated breaking current asymmetrical	kA		
3.2.30	- %dc	%dc		
3.2.31	Rated breaking current under out-of-phase conditions	kA		
3.2.32	Terminal fault	k_{pp} / p.u.	1,3	
3.2.33	Short-Line-fault	k_{pp} / p.u.	1	
3.2.34	Out-of-phase	k_{pp} / p.u.	2	
3.2.35	Rated small inductive/reactor breaking currents of:		to IEC 62271-100	
3.2.36	- Small inductive loads	A		
3.2.37	- Reactor	A		
3.2.38	Maximum overvoltage factor when interrupting rated line/cable/ capacitor bank charging currents	pu	2,5 (or restrike free)	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.2.39	Maximum overvoltage factor when switching small inductive/reactor currents	pu	2,5	
3.2.40	Number of tripping coils	-	2	
3.2.41	Number of closing coils	-	1	
3.2.42	Type of operation	-	single and three phase	
3.2.43	Rated operating sequence	-	0 - 0,3 s - CO - 3 min - CO	
3.2.44	Opening time	ms	< 30	
3.2.45	Breaking time	ms	< 50	
3.2.46	Closing time	ms	< 60	
3.2.47	Dead time	ms	300	
3.2.48	Maximum time interval between opening of first and last phase of three phase circuit breakers	ms	≤ 3	
3.2.49	Closing time from energization of close coil to latching of circuit breaker in fully closed position	ms		
3.2.50	Making time (energization of close coil to contact touch):			
3.2.51	- Without current	ms		
3.2.52	- 100% making current	ms		
3.2.53	Minimum time from extinction of main arc to contact make during auto-reclosing duty	ms	300	
3.2.54	Mechanical life of circuit breaker	-	M2	
3.2.55	Electrical contact life in number of operations at:			
3.2.56	- Rated current- 4000/4000A	-	10 000	
3.2.57	- Fault current - 40 kA	-	15	
3.2.58	- Cumulative ampere rating	-		
3.2.59	Number of current interrupting break units in series per phase	-	One	
3.2.60	Type of operating mechanism	-	Spring-charged	
3.2.61	Type of power device (motor-charged)			
3.2.62	- For closing	-	Spring-charged	
3.2.63	- For opening	-	Spring-charged	
3.2.64	Motor power	W		
3.2.65	Hand operating facility	-	Yes	
3.2.66	Hand charging facility	-	Yes	
3.2.67	Manual spring release	-	Yes	
3.2.68	Mechanical on/off indicator	-	Yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.2.69	Mechanical spring charge/discharge indication	-	Yes	
3.2.70	Charging time	s		
3.2.71	Number of tripping coils	-	2	
3.2.72	Number of closing coils	-	1	
3.2.73	Rated power of close coil	W		
3.2.74	Rated power of trip coil	W		
3.2.75	Number of auxiliary contacts (NO/NC)	-		
3.2.76	Mechanical endurance	-	M2	
3.2.77	Capasitive current switching	-	C2	
3.2.78	Nominal control and operating voltage	V DC	220	
3.2.79	Nominal heater voltage	V AC	230	
3.2.80	Total load of heaters for circuit breaker	W		
3.2.81	Total SF_6 gas weight of circuit breaker	kg		
3.2.82	Total weight of the circuit breaker (three phases)	kg		
3.2.83	Emergency Trip Facility during failure of DC supply	-	Yes	
3.2.84	Protection class of drive mechanism box	-	IP 55	
3.3	**Disconnectors**			
3.3.1	Manufacturer	-		
3.3.2	Place of manufacturing	-		
3.3.3	Model designation	-		
3.3.4	Type	-	single equipment /not combined	
3.3.5	Applicable standard	-	IEC 62271-1 IEC 62271-102 62271-203	
3.3.6	Type of operating mechanism	-	Motor & Manual	
3.3.7	Rated voltage	kV	245	
3.3.8	Rated current bus bar, bus coupler			
3.3.9	Lekhnath	A	3150	
3.3.10	Damauli	A	4000	
3.3.11	Rated current feeders			
3.3.12	Lekhnath	A	2500	
3.3.13	Damauli	A	3150	
3.3.14	Rated lightning impulse withstand voltage			

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.3.15	- Common Value	kV_{peak}	1050	
3.3.16	- Across the isolating distance	kV_{peak}	1200	
3.3.17	Rated power frequency withstand voltage			
3.3.18	- Common Value	kV_{rms}	460	
3.3.19	- Across the isolating distance	kV_{rms}	530	
3.3.20	Rated frequency	Hz	50	
3.3.21	Rated short time withstand current (3s)	kA	40	
3.3.22	Rated short-circuit peak withstand current	kA	100	
3.3.23	Maximum capacitive current that can be interrupted by the isolator	A		
3.3.24	Total time from initiation of opening operation to isolator in fully open position	s		
3.3.25	Time from contact separation to extinct of capacitive arc	s		
3.3.26	Total time from initiation of opening operation to time when isolator gap can withstand phase voltage	s		
3.3.27	Bus-transfer current switching ability:			
3.3.28	- bus-transfer current	A	1600	
3.3.29	- bus transfer voltage	V	20	
3.3.30	Hand operating facility	-	Yes	
3.3.31	Locking arrangement in on/off position	-	Yes	
3.3.32	Number of auxiliary contacts (NO/NC/others)	-		
3.3.33	Nominal control and operating voltage	V DC	220	
3.3.34	Automatic isolation of control supplies when DS locked in open position	-	Yes	
3.3.35	Accessibility to operating mechanism from ground level or catwalk	-	Yes	
3.3.36	Nominal heater voltage	V AC	230	
3.3.37	Total load of heaters for isolator	W		
3.3.38	Rated motor power	W		
3.3.39	Total mass of three phase disconnector complete	kg		
3.3.40	Contact type	-	Tulip/plug-in	

Technical Data Sheets				
BIDDER’S / CONTRACTOR’S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.3.41	Mechanical endurance	-	M2	
3.3.42	Viewing windows		Yes	
3.3.43	Protection class of drive mechanism box	-	IP 55	
3.4	**Maintenance earthing switch**			
3.4.1	Manufacturer	-		
3.4.2	Place of manufacturing	-		
3.4.3	Model designation	-		
3.4.4	Type	-	single equipment /not combined	
3.4.5	Type of operating mechanism	-	Motor & Manual	
3.4.6	Applicable standard	-	IEC 62271-1 IEC 62271-102 62271-203	
3.4.7	Rated voltage	kV	245	
3.4.8	Rated lightning impulse withstand voltage phase to earth	kV_{peak}	1050	
3.4.9	Rated power frequency withstand voltage phase to earth	kV_{rms}	460	
3.4.10	Rated frequency	Hz	50	
3.4.11	Rated short time withstand current (3s)	kA	40	
3.4.12	Rated short-circuit peak withstand current	kA	100	
3.4.13	Total opening time	s		
3.4.14	Total closing time	s		
3.4.15	Hand operating facility	-	Yes	
3.4.16	Locking arrangement in on/off position	-	Yes	
3.4.17	Number of auxiliary contacts (NO/NC)	-		
3.4.18	Nominal control and operating voltage	V DC	220	
3.4.19	Automatic isolation of control supplies when DS locked in open position	-	Yes	
3.4.20	Accessibility to operating mechanism from ground level or catwalk	-	Yes	
3.4.21	Nominal heater voltage	V AC	230	
3.4.22	Total load of heaters for isolator	W		
3.4.23	Rated motor power	W		
3.4.24	Rated power of operation coil	W		

Technical Data Sheets

BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	**Description**			
3.4.25	Rated insulation of brought out connection	kV	10	
3.4.26	Total mass of maintenance earthing switch	kg		
3.4.27	Contact type		Tulip/plug-in	
3.4.28	Viewing windows		Yes	
3.4.29	Protection class of drive mechanism box	-	IP 55	
3.5	**High speed earthing switch**			
3.5.1	Manufacturer	-		
3.5.2	Place of manufacturing	-		
3.5.3	Model designation	-		
3.5.4	Type	-	attached unit	
3.5.5	Type of operating mechanism	-	Motor & Manual spring charged	
3.5.6	Applicable standard	-	IEC 62271-1 IEC 62271-102 62271-203	
3.5.7	Rated voltage	kV	245	
3.5.8	Rated lightning impulse withstand voltage phase to earth	kV_{peak}	1050	
3.5.9	Rated power frequency withstand voltage phase to earth	kV_{rms}	460	
3.5.10	Rated frequency	Hz	50	
3.5.11	Rated short time withstand current (3s)	kA	40	
3.5.12	Rated short-circuit peak withstand current	kA	100	
3.5.13	Mechanical endurance / Number of making operations at rated making current (40kA)		E1	
3.5.14	Rated capacitive symmetrical making current	A		
3.5.15	Rated inductive symmetrical making current	A		
3.5.16	Total time from initiation of opening operation to earth switch in fully open position	s		
3.5.17	Making time	ms		
3.5.18	Charging time	s		
3.5.19	Hand operating facility	-	Yes	
3.5.20	Locking arrangement in on/off position	-	Yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.5.21	Number of auxiliary contacts (NO/NC)	-		
3.5.22	Nominal control and operating voltage	V DC	220	
3.5.23	Automatic isolation of control supplies when HES locked in open position	-	Yes	
3.5.24	Accessibility to operating mechanism from ground level or catwalk	-	Yes	
3.5.25	Nominal heater voltage	V AC	230	
3.5.26	Total load of heaters for isolator	W		
3.5.27	Rated motor power	W		
3.5.28	Rated power of operation coil	W		
3.5.29	Rated insulation of brought out connection	kV	10	
3.5.30	Total mass of high speed earthing switch	kg		
3.5.31	Contact type		Tulip/plug-in	
3.5.32	Viewing windows		Yes	
3.5.33	Protection class of drive mechanism box	-	IP 55	
3.6	**Current transformer**		integrated	
3.6.1	Manufacturer	-		
3.6.2	Place of manufacturing	-		
3.6.3	Type	-		
3.6.4	Applicable standard	-	IEC 61869-1 IEC 61869-2 IEC 62271-1 IEC 62271-203	
3.6.5	Rated voltage	kV	245	
3.6.6	Rated power frequency withstand voltage phase to earth (GIS)		460	
3.6.7	Rated lightning impulse withstand voltage Phase to earth (GIS)		1050	
3.6.8	Rated power frequency voltage of secondary winding	kV	3	
3.6.9	Inter-turn test	kV_{peak}	4,5	
3.6.10	Rated frequency	Hz	50	
3.6.11	Rated short-time withstand current (3 s)	kA	40	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
3.6.12	Rated short-circuit peak withstand current	kA	100	
3.6.13	Rated extended primary current in percentage of rated primary current	%	120	
3.6.14	**Lekhnath & Damauli Overhead line bay current transformer**			
3.6.14.1	- number of cores	-		
3.6.14.2	Metering		1	
3.6.14.3	Measuring		1	
3.6.14.4	Protetction		2	
3.6.14.5	Busbar Protection		1	
3.6.14.6	- Ratio			
3.6.14.7	Metering / measuring / protection	A	1000-1500-2000/1	
3.6.14.8	Busbar Protection Leknath Damauli	A	 3000/1 4000/1	
3.6.14.9	- Class			
3.6.14.10	Metering	-	0.2S	
3.6.14.11	Measuring	-	0,5 FS 5	
3.6.14.12	Protetction	-	5P20	
3.6.14.13	Busbar Protection	-	5P20	
3.6.14.14	- Rated output (burden to be 25-100 % rated burden)			
3.6.14.15	Metering	VA	15	
3.6.14.16	Measuring	VA	15	
3.6.14.17	Protetction	VA	30	
3.6.14.18	Busbar Protection	VA	30	
3.6.15	**Lekhnath Bus coupler bay current transformer (both sides)**			
3.6.15.1	- number of cores	-		
3.6.15.2	Metering		-	
3.6.15.3	Measuring		1	
3.6.15.4	Protetction		1	
3.6.15.5	Busbar Protection		1	
3.6.15.6	- Ratio			
3.6.15.7	Metering / measuring / protection	A	2000-2500-3000/1	
3.6.15.8	Busbar Protection	A	3000/1	
3.6.15.9	- Class			
3.6.15.10	Metering	-	-	
3.6.15.11	Measuring	-	0,5 FS 5	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.6.15.12	Protetction	-	5P20	
3.6.15.13	Busbar Protection	-	5P20	
3.6.15.14	- Rated output (burden to be 25-100 % rated burden)			
3.6.15.15	Metering	VA	-	
3.6.15.16	Measuring	VA	15	
3.6.15.17	Protetction	VA	30	
3.6.15.18	Busbar Protection	VA	30	
3.6.16	**Damauli Bus coupler bay / Bus Sectionaliser bay current transformer (both sides**			
3.6.16.1	- number of cores	-		
3.6.16.2	Metering		-	
3.6.16.3	Measuring		1	
3.6.16.4	Protetction		1	
3.6.16.5	Busbar Protection		1	
3.6.16.6	- Ratio			
3.6.16.7	Metering / measuring / protection	A	1500-2500-4000/1	
3.6.16.8	Busbar Protection	A	4000/1	
3.6.16.9	- Class			
3.6.16.10	Metering	-	-	
3.6.16.11	Measuring	-	0,5 FS 5	
3.6.16.12	Protetction	-	5P20	
3.6.16.13	Busbar Protection	-	5P20	
3.6.16.14	- Rated output (burden to be 25-100 % rated burden)			
3.6.16.15	Metering	VA	-	
3.6.16.16	Measuring	VA	15	
3.6.16.17	Protetction	VA	30	
3.6.16.18	Busbar Protection	VA	30	
3.6.17	**Lekhnath 220/132/33kV Auto-transformer bay current transformer**			
3.6.17.1	- number of cores	-		
3.6.17.2	Metering		1	
3.6.17.3	Measuring		1	
3.6.17.4	Protetction		2	
3.6.17.5	Busbar Protection		1	
3.6.17.6	- Ratio			
3.6.17.7	Metering / measuring / protection	A	500-750-1250/1	
3.6.17.8	Busbar Protection	A	3000/1	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.6.17.9	- Class			
3.6.17.10	Metering	-	0.2S	
3.6.17.11	Measuring	-	0,5 FS 5	
3.6.17.12	Protetction	-	5P20	
3.6.17.13	Busbar Protection	-	5P20	
3.6.17.14	- Rated output (burden to be 25-100 % rated burden)			
3.6.17.15	Metering	VA	15	
3.6.17.16	Measuring	VA	15	
3.6.17.17	Protetction	VA	30	
3.6.17.18	Busbar Protection	VA	30	
3.6.18	**Damauli 220/132 kV Power-transformer bay current transformer**			
3.6.18.1	- number of cores	-		
3.6.18.2	Metering		1	
3.6.18.3	Measuring		1	
3.6.18.4	Protetction		2	
3.6.18.5	Busbar Protection		1	
3.6.18.6	- Ratio			
3.6.18.7	Metering / measuring / protection	A	200-400-600/1	
3.6.18.8	Busbar Protection	A	4000	
3.6.18.9	- Class			
3.6.18.10	Metering	-	0.2S	
3.6.18.11	Measuring	-	0,5 FS 5	
3.6.18.12	Protetction	-	5P20	
3.6.18.13	Busbar Protection	-	5P20	
3.6.18.14	- Rated output (burden to be 25-100 % rated burden)			
3.6.18.15	Metering	VA	15	
3.6.18.16	Measuring	VA	15	
3.6.18.17	Protetction	VA	30	
3.6.18.18	Busbar Protection	VA	30	
3.7	**Inductive voltage transformer (bus bars)**			
3.7.1	Manufacturer			
3.7.2	Place of manufacturing			
3.7.3	Type		Inductive, SF_6 gas insulated	
3.7.4	Applicable standard		IEC 62271-1 IEC 62271-203 IEC 61869-1 IEC 61869-3	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.7.5	Separated from the bus bar with disconnector		Yes	
3.7.6	Rated primary voltage	kV	245	
3.7.7	Rated frequency	HZ	50	
3.7.8	Rated lightning impulse phase to earth	kV_{peak}	1050	
3.7.9	Rated power frequency withstand voltage phase to earth	kV_{rms}	460	
3.7.10	Maximum permissible partial discharge level Um	pC	10	
3.7.11	Maximum permissible partial discharge level 1.2Um/√3	pC	5	
3.7.12	Method of suppressing Ferro-resonance phenomena	-		
3.7.13	Bus bar voltage transformer			
3.7.14	- Number of secondary	-	2	
3.7.15	- Rated transformation ratio	kV	220/√3 /0.11/√3/0.11/√3	
3.7.16	- Rated accuracy class			
3.7.17	Secondary winding 1	-	0,2 / 3P	
3.7.18	Secondary winding 2	-	0,2 / 3P	
3.7.19	- Rated output			
3.7.20	Secondary winding 1	VA	100	
3.7.21	Secondary winding 2	VA	100	
3.7.22	- Mass of voltage transformer	kg		
3.7.23	- Quantity of SF6 gas at rated filling pressure	kg		
3.7.24	Rated voltage factor			
3.7.25	- continuous		1,2	
3.7.26	- 30 s		1,5	
3.8	**Bus ducts**			
3.8.1	Manufacturer			
3.8.2	Place of manufacturing			
3.8.3	Type			
3.8.4	Applicable standard		IEC 62271-1 IEC 62271-203	
3.8.5	Common enclosed phases	pcs	single phase	
3.8.6	Rated current at max. ambient temperature and sun radiation			
3.8.7	Lekhnath		2000 A at 40 ºC	
3.8.8	Damauli		3150 A at 40 ºC	

Technical Data Sheets				
BIDDER’S / CONTRACTOR’S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.8.9	Inductance	H/m		
3.8.10	Capacitance	pF/m		
3.8.11	Resistance of enclosure	Ohm/m		
3.8.12	Resistance of conductor	Ohm/m		
3.8.13	Surge impedance	Ohm		
3.8.14	Quantity of SF6 gas at rated filling pressure (single phase):			
3.8.15	- shortest bus duct	kg		
3.8.16	- maximum gas compartment	kg		
3.8.17	- longest complete feeder bus duct	kg		
3.9	**GIS SF6 air bushing**			
3.9.1	Manufacturer	-		
3.9.2	Place of manufacturing	-		
3.9.3	Type	-		
3.9.4	Model designation	-		
3.9.5	Applicable standard	-	IEC 62271-1 IEC 62271-203 IEC 60137 IEC 61643	
3.9.6	Type of internal insulation		Gas-insulated	
3.9.7	Type of external insulation		Composite	
3.9.8	Shed profile	-	alternating	
3.9.9	Highest voltage for equipment U_m	kV	245	
3.9.10	Rated phase-to-earth voltage		0,8 x U_m	
3.9.11	Rated lightning impulse withstand voltage	kV_{peak}	1050	
3.9.12	Power-frequency withstand voltage	kV_{rms}	460	
3.9.13	Rated current at max. ambient temperature and sun radiation			
3.9.14	Lekhnath		2000 A at 40 ºC	
3.9.15	Damauli		3150 A at 40 ºC	
3.9.16	Rated short time current (3s)	kA	40	
3.9.17	Rated dynamic current	kA	100	
3.9.18	Inner filling of the bushing		SF_6	
3.9.19	Rated design pressure	MPa		
3.9.20	SF6 filling; pressure at 20ºC	Mpa		
3.9.21	Min. SF6 service pressure	MPa		
3.9.22	Routine test pressure	MPa		

Technical Data Sheets				
BIDDER’S / CONTRACTOR’S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.9.23	Bursting pressure	MPa		
3.9.24	Max. leakage rate at filling pressure	%	≤ 0,1	
3.9.25	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43,3	
3.9.26	Current conductor material	-		
3.9.27	Current conductor diameter	mm		
3.9.28	Cantilever test load	N		
3.9.29	Cantilever opertion load	N		
3.9.30	Type of line termination	-		
3.9.31	Seismic acceleration according to IEEE 693 figure A.1	g	0.5	
3.9.32	Seismic qualification according IEC 61643	-	Yes	
3.9.33	Quantity of SF6 gas (if any) at rated filling pressure	kg		
3.9.34	Weight	kg		
3.10	**GIS lightning arrester - gapless zinc-oxide type (if any)**			
3.10.1	Manufacturer	-		
3.10.2	Place of manufacturing			
3.10.3	Type	-	MO	
3.10.4	Applicable standard		IEC 60099-4 IEC 60099-5 IEC 62271-1 IEC 62271-203	
3.10.5	Nominal voltage	kV_{rms}	220	
3.10.6	Rated voltage	kV_{rms}	245	
3.10.7	Rated frequency	Hz	50	
3.10.8	Rated lightning impulse withstand voltage phase to earth	kV_{peak}	1050	
3.10.9	Rated power frequency withstand voltage phase to earth	kV_{rms}	460	
3.10.10	Nominal discharge current	kA	20	
3.10.11	Line discharge class		4	
3.10.12	Rated voltage (Ur)	kV	180	
3.10.13	Max. continuous operating voltage (Uc)	kV	144	
3.10.14	Temporary overvoltage withstand capability for 1 sec.	kV		
3.10.15	Temporary overvoltage withstand capability for 10 sec.	kV		
3.10.16	Maximum residual voltage at:			

Technical Data Sheets				
BIDDER’S / CONTRACTOR’S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.10.17	- 5 kA 8/20 µs	kV		
3.10.18	- 10 kA 8/20 µs	kV		
3.10.19	- 20 kA 8/20 µs	kV		
3.10.20	- 40 kA 8/20 µs	kV		
3.10.21	- 500 A 30/60 µs	kV		
3.10.22	- 1 kA 30/60 µs	kV		
3.10.23	- 2 kA 30/60 µs	kV		
3.10.24	Short circuit strength 0.2 sec.	kA		
3.10.25	Equipped with surge counter with leakage current meter		Yes	
3.10.26	Quantity of SF6 gas at rated filling pressure	kg		
3.10.27	Pressure relief device		Yes	
3.12	**Density guard**			
3.12.1	Manufacturer	-		
3.12.2	Place of manufacturing			
3.12.3	Type	-		
3.12.4	Protection class indoor/outdoor	-	IP65	
3.12.5	Amount of contact	-		
3.12.6	Scale (red/green)	-	Yes	
3.14	**PD sensors and site testing**			
3.14.1	Manufacturer	-		
3.14.2	Place of manufacturing	-		
3.14.3	Type	-		
3.14.4	Test voltage	kV		
3.14.5	Amount of PD sensors			
3.14.6	Document number for description of PD measurement (method and testing equipments including typical test reports)	Document number	Document to be provided with tender.	
3.15	**GIS local control cubicles**			
3.15.1	Manufacturer	-		
3.15.2	Place of manufacturing	-		
3.15.3	Type		free standing or in bay integreated	
3.15.4	Standards			
3.15.5	Material			
3.15.6	Sheet thickness (minimum)	mm	2	
3.15.7	Minimum paint thickness	µm	80	
3.15.8	Dimensions (H x W x D)	mm		
3.15.9	Total weight	kg		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.15.10	Maximum heat emission of one cubicle	W		
3.16	**Internal control and signalling cabling of the GIS (between HV bay equipment and local control cubile)**			
3.16.1	Control, supervision and interlocking (HV switching equipments)			
3.16.2	Manufacturer			
3.16.3	Place of manufacturing			
3.16.4	Type			
3.16.5	Core amount and size	no/sqmm		
3.16.6	Shielded / if yes, percentage of minimum shielding	Yes/No	... / %	
3.16.7	Halogen free	Yes/No		
3.16.8	Premanufactured with coded sockets for CB, DE, ES and HSES	Yes/No		
3.16.9	Type of socket (if any)			
3.16.10	Current transformer			
3.16.11	Manufacturer			
3.16.12	Place of manufacturing			
3.16.13	Type			
3.16.14	Core amount and size	no/sqmm		
3.16.15	Shielded / if yes, percentage of minimum shielding	Yes/No	... / %	
3.16.16	Halogen free	Yes/No		
3.16.17	Voltage transformer			
3.16.18	Manufacturer			
3.16.19	Place of manufacturing			
3.16.20	Type			
3.16.21	Core amount and size	no/sqmm		
3.16.22	Shielded / if yes, percentage of minimum shielding	Yes/No	... / %	
3.16.23	Halogen free	Yes/No		
3.16.24	Density guard			
3.16.25	Manufacturer			
3.16.26	Place of manufacturing			
3.16.27	Type			
3.16.28	Core amount and size	no/sqmm		
3.16.29	Shielded / if yes, percentage of minimum shielding	Yes/No	... / %	
3.16.30	Halogen free	Yes/No		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.16.31	Heating of drive meachism and CT and VT boxes			
3.16.32	Manufacturer			
3.16.33	Place of manufacturing			
3.16.34	Type			
3.16.35	Core amount and size	no/sqmm		
3.16.36	Shielded / if yes, percentage of minimum shielding	Yes/No	... / %	
3.16.37	Halogen free	Yes/No		
3.16.38	AC/DC ring circuits between local control cubicles			
3.16.39	Manufacturer			
3.16.40	Place of manufacturing			
3.16.41	Type			
3.16.42	Core amount and size	no/sqmm		
3.16.43	Shielded / if yes, percentage of minimum shielding	Yes/No	... / %	
3.16.44	Halogen free	Yes/No		
3.16.45	Type of cable channels / conduits for bay cabling			
3.16.46	- indoor installation	-		
3.16.47	- outdoor installation	-		
3.16.48	- channels with cover	-	Yes/No	
3.17	**Walkways or platforms where needed to reach the drive meachism units for control and operation**	-	Yes/No	
3.18	**Crane for 220 kV GIS room**			
3.18.1	Manufacturer			
3.18.2	Type	-	Overhead travelling	
3.18.3	Capacity	t	≥ 6	
3.18.4	Operating speed			
3.18.5	- Hoist low/fast	M/min	…/…	
3.18.6	- Trolley travel	M/min		
3.18.7	- Bridge travel	M/min		
3.18.8	Operating power source and terminal voltage			
3.18.9	- Voltage	V AC	400/230	
3.18.10	- Frequency	Hz	50	
3.18.11	Dimensions			
3.18.12	- Span	m		
3.18.13	- Length of runway	m		
3.18.14	- Total lift of hook	m		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.18.15	Crane drive motor			

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
3.18.16	- Manufacturer			
3.18.17	- Type			
3.18.18	Trolley drive motors			
3.18.19	- Manufactuerer			
3.18.20	- Type			
3.18.21	Operator/Maintenance cage provided with trolley		Yes	
3.18.22	Enclosed current collector		Yes	
3.18.23	Hoist			
3.18.24	- Manufacturer			
3.18.25	- Type			
3.18.26	- Type of control		pendant	
3.18.27	Total required power	KW		
3.18.28	Weights			
3.18.29	- Bridge complete	t		
3.18.30	- Trolley complete	t		
3.18.31	- Runaway complete	t		
3.18.32	Type test Certificates (to be issued by independent laboratory or independent witnessed type test certificate	-	Yes	
3.18.33	Standards for manufacturing and testing	-	to be given	
3.19	**Earthing connections for GIS**			
3.19.1	Size of main copper earthing conductor for GIS bays	mm^2	≥ 120	
3.19.2	Size of main copper earthing conductor for local control cubicles	mm^2	≥ 16	
3.20	**Steel structures for GIS**			
3.20.1	Manufacturer	-		
3.20.2	Place of manufacture	-		
3.20.3	Applicable standard	-		
3.20.4	Material	-		
3.20.5	Factor of safety in calculation	-		
3.20.6	Galvanization thickness:			
3.20.7	- Steel sections thicker than 5 mm	µm		
3.20.8	- Steel sections 2 mm-5 mm µm	µm		
3.20.9	- Bolts and nuts µm	µm		

Technical Data Sheets				
BIDDER’S / CONTRACTOR’S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.20.10	Bolts and nuts:			
3.20.11	- Securing with plain and spring washers	yes/no		
3.20.12	- yes/no			
3.20.13	- Minimum quality			
3.20.14	Tests according to relevant standards and *Employer's Requirements*	yes/no	yes	
3.21	**Gas service cart**	-		
3.21.1	Manufacturer	-		
3.21.2	Place of manufacture	-		
3.21.3	Model designation	-		
3.21.4	Type of gas storage	-	cylinder or tank	
3.21.5	Size of gas strorage	kg	≥ 200	
3.21.6	Final recovery vacuum	mbar	< 1	
3.21.7	Evacuation time for biggest gas compartment	h	< 2	
3.21.8	Revocerey time for biggest gas compartment	h	< 8	
3.21.9	Including specified and necessaey additives (filters, couplings, valves, manifolds, hoses etc.)	-	yes	
3.21.10	Minimum length of the SF_6 gas hoses	m		
3.21.11	Supply voltage 400/230 V 50 Hz	-	3-phase	
3.21.12	Maximum 3-phase current	A		
3.22	**SF6 gas filling cart with wire-braided hoses**			
3.22.1	Manufacturer	-		
3.22.2	Place of manufacture	-		
3.22.3	Model designation	-		
3.22.4	Hose reel	-	yes	
3.22.5	Amount of different bottle connections	-	≥ 2	
3.22.6	Self closing couplings	-	yes	
3.22.7	Couplings suitable for all used filling ports of GIS	-	yes	
3.22.8	Hose lenght	m	≥ 6	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
3.23	**Analizer for gas meassurement**			
3.23.1	Manufacturer	-		
3.23.2	Place of manufacture	-		
3.23.3	Model designation	-		
3.23.4	Applicable standard	-	IEC 62271-4	
3.23.5	Measuring functions:			
3.23.6	- Dew point meter	-	yes	
3.23.7	- SF_6 percentage measuring	-	yes	
3.23.8	- Analyser for by-products	-	yes	
3.23.9	- SF_6 pressure gauge	-	yes	
3.23.10	- Thermometer	-	yes	
3.23.11	Suitable connection additives for all used GIS filling ports	-	yes	
3.24	**Portable SF6 gas leakage detector in case**			
3.24.1	Manufacturer			
3.24.2	Type			
3.25	**Density guard testing device in a case**			
3.25.1	Manufacturer			
3.25.2	Type			
3.25.3	Including calibrated manometer and necessary additives	-	yes	
3.26	**Precision gauge with hose in transport case**			
3.26.1	Manufacturer	-		
3.26.2	Type	-		
3.26.3	Indicating range	kPa	0 - 1000	
3.26.4	Class	-	0.6	
3.26.5	Teflon hose (length ≥1m) with additives	-	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
3.27	**Tests according to relevant standards and *Employer's Requirements* for service and testing equipments**		yes	
3.28	**SF6 gas**			
3.28.1	Manufacturer	-		
3.28.2	Applicable standard	-	IEC 60376	
3.28.3	Amount as spare for the use of Employer	kg		
3.29	**Documentation and wall boards for 220 kV GIS**			
3.29.1	As specified in local language	-	yes	
3.29.2	Wall boards/charts as specified in local language	-	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
4	**132 kV Gas Insulated Switchgear (GIS)**			
4.1	**General**			
4.1.1	Manufacturer	-		
4.1.2	Place of manufacture	-		
4.1.3	Model designation	-		
4.1.4	Type	-	Metal enclosed, gas insulated GIS- indoor	
4.1.5	Applicable standard	-	IEC 62271-203, 62271-1, 60270, 60376, 60480	
4.1.6	Nominal voltage of system	kV_{rms}	132	
4.1.7	Rated voltage of system	kV_{rms}	145	
4.1.8	Rated frequency	Hz	50	
4.1.9	Rated short-duration power frequency withstand voltage:			
4.1.10	- Common Value	kV_{rms}	275	
4.1.11	- Across the isolating distance	kV_{rms}	315	
4.1.12	Rated lightning impulse withstand voltage:			
4.1.13	- Phase to earth	kV_{peak}	650	
4.1.14	- Across the isolating distance	kV_{peak}	750	
4.1.15	Rated short-time withstand current (3s)	kA	40	
4.1.16	Rated peak withstand current	kA	100	
4.1.17	Rated current (busbar)	A	2500	
4.1.18	Rated current (bus coupler)	A	2500	
4.1.19	Rated current (feeders)	A	2500	
4.1.20	Type of busbars	-	Double	
4.1.21	Type of enclosure	-	Three phase enclosures	
4.1.22	Material of enclosure for:			
4.1.23	- Circuit breaker	-	Al	
4.1.24	- Busbars	-	Al	
4.1.25	- Other compartments	-	Al	
4.1.26	Applicable standard for SF6 pressurized enclosures	-	EN 50052, 50064, 50068, 50069, 50089	
4.1.27	Minimum safety factor for switchgear (GIS housings/steel supports)	-	≥ 2,5	
4.1.28	Seismic factor according to IEEE 693 figure A.1	g	0,5	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.1.29	Suitability for the site climate/temperature range:	°C	0 - 40	
4.1.30	Material and cross-section of bus bar conductor	.../ mm2		
4.1.31	Material and cross-section of feeder bus-duct conductor	.../ mm2		
4.1.32	Material of contacts (indicate bi-metallic where used)	-	Cu/Ag	
4.1.33	Type of contact	-	Tulip/plug-in	
4.1.34	Surface treatment of GIS housings:			
4.1.35	- Indoor paint / layer thickness	RAL / µm		
4.1.36	- Outdoor paint / layer thickness	RAL / µm		
4.1.37	- Flange treatment (outdoor)	-	Add number of technical description	
4.1.38	Colour of partition insulators	RAL		
4.1.39	Colour of local control cubicle	RAL		
4.1.40	Minimum subdivision of GIS switchgear (partition):			
4.1.41	- Busbars per each feeder	-	Yes	
4.1.42	- Busbar isolator	-	Yes	
4.1.43	- Circuit breaker	-	Yes	
4.1.44	- Feeder disconnector and cable end unit	-	Yes	
4.1.45	- Voltage transformer	-	Yes	
4.1.46	- Current transformer	-	Yes/No	
4.1.47	- Surge arrester (if any)	-	Yes	
4.1.48	- Max. lenght/volume of gas insulated bus duct	Meter/Litre	…/…	
4.1.49	Maximum size of gas compartment	Litre		
4.1.50	Maximum evaquation time of gas compartment	hrs	< 2	
4.1.51	Method of compensation of expansion and contraction:			
4.1.52	- For busbar conductors	-	Expansion	
4.1.53	- For busbar enclosures	-	Expansion	
4.1.54	Type/ material of pressure relief device	-	Rupture disc / …	
4.1.55	Rupturing pressure of pressure relief device (circuit breaker/others)	MPa	…/…	
4.1.56	Type of filter employed for moisture absorption	-	Molecular Sieve	
4.1.57	Design lifetime of moisture absorbent	Years	> 10	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.1.58	Total mass of switchgear / haviest transportation unit	kg	…/…	
4.1.59	Size of maximum transportation unit (L x W x H)	m		
4.1.60	Mass of heaviest single component to be handled during erection	kg		
4.1.61	Mass of heaviest single indoor component to be handled during erection with the indoor crane	kg		
4.1.62	Bay width (centre to centre)	m		
4.1.63	Indoor foorprint of initial GIS	m x m		
4.1.64	Indoor fortprint including extension	m x m		
4.1.65	Minimum indoor crane hook height	m		
4.1.66	Indoor crane lifting force	t	≥ 6	
4.1.67	Crane with 2 speeds suitable for GIS installation	-	Yes	
4.1.68	Applicable standard for new SF6 gas	-	IEC 60376	
4.1.69	Density of gas in:			
4.1.70	- Circuit breaker compartment	g/l		
4.1.71	- Other than circuit breaker compartment	g/l		
4.1.72	Rated filling pressure at 20ºC (CB/others)	MPa	… / …	
4.1.73	1st alarm pressure at 20ºC (CB/others)	MPa	… / …	
4.1.74	Circuit breaker blocking pressure at 20ºC (Close/Open)	MPa	… / …	
4.1.75	Maximum SF_6 leakage rate	% / year	< 0,1	
4.1.76	Design pressure of enclosures (circuit breaker/ others)	MPa	…/…	
4.1.77	Type test presure of enclosures (circuit breaker/others	MPa	…/…	
4.1.78	Routine test pressure of casted enclosures (circuit breaker/others)	MPa	…/…	
4.1.79	Routine test pressure of welded enclosures (circuit breaker/others)	MPa	…/…	
4.1.80	Design pressure of gas tight barrier insulator	MPa		
4.1.81	Routine test pressure of gas tight barrier insulator	MPa		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.1.82	Withstand voltage at SF6 gas atmospheric pressure	kV	145	
4.1.83	Minimum gas service period	years	> 10	
4.1.84	Document number showing maximum allowable dewpoint depending on temperature for different gas filling/compartments	-	to be provided with Tender	
4.1.85	Recommended inspection/maintenance intervals	years		
4.1.86	Neutral earthing	-	solidly	
4.1.87	Document number showing the Inspection and Test Plan for the complete GIS scope of supply including FAT.	-	to be provided with Tender	
4.2	**Circuit breaker**			
4.2.1	Manufacturer	-		
4.2.2	Place of manufacture	-		
4.2.3	Model designation	-		
4.2.4	Type	-	Self-blast pressure buffer,SF_6	
4.2.5	Applicable standard	-	IEC 62271-1 IEC 62271-203, IEC 62271-100	
4.2.6	Type of quenching medium		SF_6	
4.2.7	Interrupter units per pole	pcs	1	
4.2.8	Rated voltage	kV	145	
4.2.9	Rated short-duration power frequency withstand voltage:			
4.2.10	- Common Value	kV_{rms}	275	
4.2.11	- Across the isolating distance	kV_{rms}	315	
4.2.12	Rated lightning impulse withstand voltage:			
4.2.13	- Common Value	kV_{peak}	650	
4.2.14	- Across the isolating distance	kV_{peak}	750	
4.2.15	Rated frequency	Hz	50	
4.2.16	Number of phases	-	3	
4.2.17	Rated current (bus coupler/feeders)	A	2500/2500	
4.2.18	Rated short-time withstand current (3s)	kA	40	
4.2.19	Rated peak withstand current	kA	100	
4.2.20	Rated making current	kA	100	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.2.21	Rated cable charging breaking current	A		
4.2.22	Maximum capacitive breaking current:	A	to IEC 62271-100	
4.2.23	- Rated line charging breaking current	A	50	
4.2.24	- Rated cable charging breaking current	A	160	
4.2.25	- Rated Single/Back to Back Capacitor bank breaking current	A	400	
4.2.26	- Rated single capacitor bank breaking current	A	400	
4.2.27	Rated breaking current asymmetrical	kA		
4.2.28	- %dc	%dc		
4.2.29	Rated breaking current under out-of-phase conditions	kA		
4.2.30	Terminal fault	k_{pp} / p.u.	1,3	
4.2.31	Short-Line-fault	k_{pp} / p.u.	1	
4.2.32	Out-of-phase	k_{pp} / p.u.	2	
4.2.33	Rated small inductive/reactor breaking currents of:		to IEC 62271-100	
4.2.34	- Small inductive loads	A		
4.2.35	- Reactor	A		
4.2.36	Maximum overvoltage factor when interrupting rated line/cable/ capacitor bank charging currents	pu	(2.5 or) restrike free	
4.2.37	Maximum overvoltage factor when switching small inductive/reactor currents	pu	2.5	
4.2.38	Number of tripping coils	-	2	
4.2.39	Number of closing coils	-	1	
4.2.40	Type of operation	-	OHL feeders: single phase / other feeders three phase	
4.2.41	Rated operating sequence	-	0 - 0,3 s - CO - 3 min - CO	
4.2.42	Opening time	ms	< 30	
4.2.43	Breaking time	ms	< 50	
4.2.44	Closing time	ms	< 60	
4.2.45	Dead time	ms	300	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.2.46	Maximum time interval between opening of first and last phase of three phase circuit breakers	ms	≤ 3	
4.2.47	Closing time from energization of close coil to latching of circuit breaker in fully closed position	ms		
4.2.48	Making time (energization of close coil to contact touch):			
4.2.49	- Without current	ms		
4.2.50	- 100% making current	ms		
4.2.51	Minimum time from extinction of main arc to contact make during auto-reclosing duty	ms	300	
4.2.52	Mechanical life of circuit breaker	-	M2	
4.2.53	Electrical contact life in number of operations at:			
4.2.54	- Rated current- 2500/2500A	-	10 000	
4.2.55	- Fault current - 40 kA	-	9	
4.2.56	- Cumulative ampere rating	-		
4.2.57	Number of current interrupting break units in series per phase	-	One	
4.2.58	Type of operating mechanism	-	Spring-charged	
4.2.59	Type of power device (motor-charged)			
4.2.60	- For closing	-	Spring-charged	
4.2.61	- For opening	-	Spring-charged	
4.2.62	Motor power	W		
4.2.63	Hand operating facility	-	Yes	
4.2.64	Hand charging facility	-	Yes	
4.2.65	Manual spring release	-	Yes	
4.2.66	Mechanical on/off indicator	-	Yes	
4.2.67	Mechanical spring charge/discharge indication	-	Yes	
4.2.68	Charging time	s		
4.2.69	Number of tripping coils	-	2	
4.2.70	Number of closing coils	-	1	
4.2.71	Rated power of close coil	W		
4.2.72	Rated power of trip coil	W		
4.2.73	Number of auxiliary contacts (NO/NC)	-		
4.2.74	Mechanical endurance	-	M2	
4.2.75	Capasitive current switching	-	C2	
4.2.76	Nominal control and operating voltage	V DC	220	
4.2.77	Nominal heater voltage	V AC	230	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.2.78	Total load of heaters for circuit breaker	W		
4.2.79	Total SF_6 gas weight of circuit breaker	kg		
4.2.80	Total weight of the circuit breaker (three phases)	kg		
4.2.81	Emergency Trip Facility during failure of DC supply	-	Yes	
4.2.82	Protection class of drive mechanism box	-	IP55	
4.3	**Disconnectors**			
4.3.1	Manufacturer	-		
4.3.2	Place of manufacturing	-		
4.3.3	Model designation	-		
4.3.4	Type	-	three position switch	
4.3.5	Applicable standard	-	IEC 62271-1 IEC 62271-102 62271-203	
4.3.6	Type of operating mechanism	-	Motor & Manual	
4.3.7	Rated voltage	kV	132	
4.3.8	Rated current bus bar, bus coupler	A	2500	
4.3.9	Rated current feeders	A	2500	
4.3.10	Rated lightning impulse withstand voltage			
4.3.11	- Common Value	kV_{peak}	650	
4.3.12	- Across the isolating distance	kV_{peak}	750	
4.3.13	Rated power frequency withstand voltage			
4.3.14	- Common Value	kV_{rms}	275	
4.3.15	- Across the isolating distance	kV_{rms}	315	
4.3.16	Rated frequency	Hz	50	
4.3.17	Rated short time withstand current (3s)	kA	40	
4.3.18	Rated short-circuit peak withstand current	kA	100	
4.3.19	Maximum capacitive current that can be interrupted by the isolator	A		
4.3.20	Total time from initiation of opening operation to isolator in fully open position	s		
4.3.21	Time from contact separation to extinct of capacitive arc	s		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
4.3.22	Total time from initiation of opening operation to time when isolator gap can withstand phase voltage	s		
4.3.23	Bus-transfer current switching ability:			
4.3.24	- bus-transfer current	A	1600	
4.3.25	- bus transfer voltage	V	10	
4.3.26	Hand operating facility	-	Yes	
4.3.27	Locking arrangement in on/off position	-	Yes	
4.3.28	Number of auxiliary contacts (NO/NC/others)	-		
4.3.29	Nominal control and operating voltage	V DC	220	
4.3.30	Automatic isolation of control supplies when DS locked in open position	-	Yes	
4.3.31	Accessibility to operating mechanism from ground level or catwalk	-	Yes	
4.3.32	Nominal heater voltage	V AC	230	
4.3.33	Total load of heaters for isolator	W		
4.3.34	Rated motor power	W		
4.3.35	Total mass of three phase disconnector complete	kg		
4.3.36	Contact type	-	Tulip/plug-in	
4.3.37	Mechanical endurance	-	M2	
4.3.38	Viewing windows		Yes	
4.3.39	Protection class of drive mechanism box	-	IP 55	
4.4	**Maintenance earthing switch**			
4.4.1	Manufacturer	-		
4.4.2	Place of manufacturing	-		
4.4.3	Model designation	-		
4.4.4	Type	-	three position switch	
4.4.5	Type of operating mechanism	-	Motor & Manual	
4.4.6	Applicable standard	-	IEC 62271-1 IEC 62271-102 62271-203	
4.4.7	Rated voltage	kV	145	
4.4.8	Rated lightning impulse withstand voltage phase to earth	kV_{peak}	650	
4.4.9	Rated power frequency withstand voltage phase to earth	kV_{rms}	275	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.4.10	Rated frequency	Hz	50	
4.4.11	Rated short time withstand current (3s)	kA	40	
4.4.12	Rated short-circuit peak withstand current	kA	100	
4.4.13	Total opening time	s		
4.4.14	Total closing time	s		
4.4.15	Hand operating facility	-	Yes	
4.4.16	Locking arrangement in on/off position	-	Yes	
4.4.17	Number of auxiliary contacts (NO/NC)	-		
4.4.18	Nominal control and operating voltage	V DC	220	
4.4.19	Automatic isolation of control supplies when DS locked in open position	-	Yes	
4.4.20	Accessibility to operating mechanism from ground level or catwalk	-	Yes	
4.4.21	Nominal heater voltage	V AC	230	
4.4.22	Total load of heaters for isolator	W		
4.4.23	Rated motor power	W		
4.4.24	Rated power of operation coil	W		
4.4.25	Rated insulation of brought out connection	kV	10	
4.4.26	Total mass of maintenance earthing switch	kg		
4.4.27	Contact type		Tulip/plug-in	
4.4.28	Viewing windows		Yes	
4.4.29	Protection class of drive mechanism box	-	IP 55	
4.5	**High speed earthing switch**			
4.5.1	Manufacturer	-		
4.5.2	Place of manufacturing	-		
4.5.3	Model designation	-		
4.5.4	Type	-	attached unit	
4.5.5	Type of operating mechanism	-	Motor & Manual spring charged	
4.5.6	Applicable standard	-	IEC 62271-1 IEC 62271-102 62271-203	
4.5.7	Rated voltage	kV	145	
4.5.8	Rated lightning impulse withstand voltage phase to earth	kV_{peak}	650	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.5.9	Rated power frequency withstand voltage phase to earth	kV_{rms}	275	
4.5.10	Rated frequency	Hz	50	
4.5.11	Rated short time withstand current (3s)	kA	40	
4.5.12	Rated short-circuit peak withstand current	kA	100	
4.5.13	Mechanical endurance / Number of making operations at rated making current (40kA)		E1	
4.5.14	Rated capacitive symmetrical making current	A		
4.5.15	Rated inductive symmetrical making current	A		
4.5.16	Total time from initiation of opening operation to earth switch in fully open position	s		
4.5.17	Making time	ms		
4.5.18	Charging time	s		
4.5.19	Hand operating facility	-	Yes	
4.5.20	Locking arrangement in on/off position	-	Yes	
4.5.21	Number of auxiliary contacts (NO/NC)	-		
4.5.22	Nominal control and operating voltage	V DC	220	
4.5.23	Automatic isolation of control supplies when HES locked in open position	-	Yes	
4.5.24	Accessibility to operating mechanism from ground level or catwalk	-	Yes	
4.5.25	Nominal heater voltage	V AC	230	
4.5.26	Total load of heaters for isolator	W		
4.5.27	Rated motor power	W		
4.5.28	Rated power of operation coil	W		
4.5.29	Rated insulation of brought out connection	kV	10	
4.5.30	Total mass of high speed earthing switch	kg		
4.5.31	Contact type		Tulip/plug-in	
4.5.32	Viewing windows		Yes	
4.5.33	Protection class of drive mechanism box	-	IP 55	

Technical Data Sheets				
BIDDER’S / CONTRACTOR’S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.6	**Current transformer**		integrated	
4.6.1	Manufacturer	-		
4.6.2	Place of manufacturing	-		
4.6.3	Type	-		
4.6.4	Applicable standard	-	IEC 61869-1 IEC 61869-2 IEC 62271-1 IEC 62271-203	
4.6.5	Rated voltage	kV	145	
4.6.6	Rated power frequency withstand voltage phase to earth (GIS)	kV	275	
4.6.7	Rated lightning impulse withstand voltage Phase to earth (GIS)		650	
4.6.8	Rated power frequency voltage of secondary winding	kV	3	
4.6.9	Inter-turn test	kV_{peak}	4.5	
4.6.10	Rated frequency	Hz	50	
4.6.11	Rated short-time withstand current (3 s)	kA	40	
4.6.12	Rated short-circuit peak withstand current	kA	100	
4.6.13	Rated extended primary current in percentage of rated primary current	%	120	
4.6.14	**220/132 kV Power-transformer bay current transformer**			
4.6.14.1	- number of cores	-		
4.6.14.2	Metering		1	
4.6.14.3	Measuring		1	
4.6.14.4	Protetction		2	
4.6.14.5	Busbar Protection		1	
4.6.14.6	- Ratio			
4.6.14.7	Metering / measuring / protection	A	400-600-800/1	
4.6.14.8	Busbar Protection	A	2500/1	
4.6.14.9	- Class			
4.6.14.10	Metering	-	0.2S	
4.6.14.11	Measuring	-	0,5 FS 5	
4.6.14.12	Protetction	-	5P20	
4.6.14.13	Busbar Protection	-	5P20	
4.6.14.14	- Rated output (burden to be 25-100 % rated burden)			
4.6.14.15	Metering	VA	15	
4.6.14.16	Measuring	VA	15	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.6.14.17	Protetction	VA	30	
4.6.14.18	Busbar Protection	VA	30	
4.6.15	**Overhead line bay current transformer**			
4.6.15.1	- number of cores	-		
4.6.15.2	Metering		1	
4.6.15.3	Measuring		1	
4.6.15.4	Protetction		2	
4.6.15.5	Busbar Protection		1	
4.6.15.6	- Ratio			
4.6.15.7	Metering / measuring / protection	A	1000-1250-1500/1	
4.6.15.8	Busbar Protection	A	2500/1	
4.6.15.9	- Class			
4.6.15.10	Metering	-	0.2S	
4.6.15.11	Measuring	-	0,5 FS 5	
4.6.15.12	Protetction	-	5P20	
4.6.15.13	Busbar Protection	-	5P20	
4.6.15.14	- Rated output (burden to be 25-100 % rated burden)			
4.6.15.15	Metering	VA	15	
4.6.15.16	Measuring	VA	15	
4.6.15.17	Protetction	VA	30	
4.6.15.18	Busbar Protection	VA	30	
4.6.16	**132/33 kV Transformer bay current transformer**			
4.6.16.1	- number of cores	-		
4.6.16.2	Metering		1	
4.6.16.3	Measuring		1	
4.6.16.4	Protetction		2	
4.6.16.5	Busbar Protection		1	
4.6.16.6	- Ratio			
4.6.16.7	Metering / measuring / protection	A	150-300-600/1	
4.6.16.8	Busbar Protection	A	2500/1	
4.6.16.9	- Class			
4.6.16.10	Metering	-	0.2S	
4.6.16.11	Measuring	-	0,5 FS 5	
4.6.16.12	Protetction	-	5P20	
4.6.16.13	Busbar Protection	-	5P20	
4.6.16.14	- Rated output (burden to be 25-100 % rated burden)			
4.6.16.15	Metering	VA	15	
4.6.16.16	Measuring	VA	15	
4.6.16.17	Protetction	VA	30	
4.6.16.18	Busbar Protection	VA	30	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
4.6.17	**Bus coupler bay current transformer (both sides)**			
4.6.17.1	- number of cores	-		
4.6.17.2	Metering		-	
4.6.17.3	Measuring		1	
4.6.17.4	Protetction		1	
4.6.17.5	Busbar Protection		1	
4.6.17.6	- Ratio			
4.6.17.7	Metering / measuring / protection	A	1000-1500-2500/1	
4.6.17.8	Busbar Protection	A	2500/1	
4.6.17.9	- Class			
4.6.17.10	Metering	-	-	
4.6.17.11	Measuring	-	0,5 FS 5	
4.6.17.12	Protetction	-	5P20	
4.6.17.13	Busbar Protection	-	5P20	
4.6.17.14	- Rated output (burden to be 25-100 % rated burden)			
4.6.17.15	Metering	VA	-	
4.6.17.16	Measuring	VA	15	
4.6.17.17	Protetction	VA	30	
4.6.17.18	Busbar Protection	VA	30	
4.7	**Inductive voltage transformer (bus bars)**			
4.7.1	Manufacturer			
4.7.2	Place of manufacturing			
4.7.3	Type		Inductive, SF_6 gas insulated	
4.7.4	Applicable standard		IEC 62271-1 IEC 62271-203 IEC 61869-1 IEC 61869-3	
4.7.5	Separated from the bus bar with disconnector		Yes	
4.7.6	Rated primary voltage	kV	145	
4.7.7	Rated frequency	HZ	50	
4.7.8	Rated lightning impulse phase to earth	kV_{peak}	650	
4.7.9	Rated power frequency withstand voltage phase to earth	kV_{rms}	275	
4.7.10	Maximum permissible partial discharge level Um	pC	10	
4.7.11	Maximum permissible partial discharge level 1.2Um/√3	pC	5	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.7.12	Method of suppressing Ferro-resonance phenomena	-		
4.7.13	Bus bar voltage transformer			
4.7.14	- Number of secondary	-	2	
4.7.15	- Rated transformation ratio	kV	132/√3 /0.11/√3/ 0.11/√3	
4.7.16	- Rated accuracy class			
4.7.17	Secondary winding 1	-	0,2 / 3P	
4.7.18	Secondary winding 2	-	0,2 / 3P	
4.7.19	- Rated output			
4.7.20	Secondary winding 1	VA	100	
4.7.21	Secondary winding 2	VA	100	
4.7.22	- Mass of voltage transformer	kg		
4.7.23	- Quantity of SF6 gas at rated filling pressure	kg		
4.7.24	Rated voltage factor			
4.7.25	- continuous		1,2	
4.7.26	- 30 s		1,5	
4.8	**GIS cabel end unit housing**			
4.8.1	Manufacturer	-		
4.8.2	Place of manufacturing	-		
4.8.3	Type	-	plug-in	
4.8.4	Applicable standard	-	IEC 62271-1 IEC 62271-203 IEC 62271-209	
4.8.5	Rated voltage of main circuit	kV	145	
4.8.6	Rated lightning impulse withstand voltage phase to earth of main circuit	kV	650	
4.8.7	Rated power frequency withstand voltage phase to earth of main circuit	kV	275	
4.8.8	Cable HV test withstand capability (maximum cable test AC voltage)	kV		
4.8.9	Rated frequency	Hz	50	
4.8.10	Type of cable	-	XLPE	
4.8.11	Cable cross section (minimum)	mm^2	300	
4.8.12	Quantity of SF6 gas at rated filling pressure	kg		
4.8.13	Total mass of three phase cable end unit box	kg		
4.8.14	Type of cable socket	-		
4.8.15	Manufacturer of the socket	-		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.9	**Bus ducts**			
4.9.1	Manufacturer			
4.9.2	Place of manufacturing			
4.9.3	Type			
4.9.4	Applicable standard		IEC 62271-1 IEC 62271-203	
4.9.5	Common enclosed phases	pcs	3	
4.9.6	Rated current at max. ambient temperature and sun radiation	A	1500 A at 50 ºC	
4.9.7	Inductance	H/m		
4.9.8	Capacitance	pF/m		
4.9.9	Resistance of enclosure	Ohm/m		
4.9.10	Resistance of conductor	Ohm/m		
4.9.11	Surge impedance	Ohm		
4.9.12	Quantity of SF6 gas at rated filling pressure:			
4.9.13	- shortest bus duct	kg		
4.9.14	- maximum gas compartment	kg		
4.9.15	- longest complete feeder bus duct	kg		
4.10	**GIS SF6 air bushing**			
4.10.1	Manufacturer	-		
4.10.2	Place of manufacturing	-		
4.10.3	Type	-		
4.10.4	Model designation	-		
4.10.5	Applicable standard	-	IEC 62271-1 IEC 62271-203 IEC 60137 IEC 61643	
4.10.6	Type of internal insulation		Gas-insulated	
4.10.7	Type of external insulation		Composite	
4.10.8	Shed profile	-	alternating	
4.10.9	Highest voltage for equipment U_m	kV	145	
4.10.10	Rated phase-to-earth voltage		0,8 x U_m	
4.10.11	Rated lightning impulse withstand voltage	kV_{peak}	650	
4.10.12	Power-frequency withstand voltage	kV_{rms}	275	
4.10.13	Rated current at max. ambient temperature and sun radiation	A	1500 A at 50 ºC	
4.10.14	Rated short time current (3s)	kA	40	
4.10.15	Rated dynamic current	kA	100	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.10.16	Inner filling of the bushing		SF_6	
4.10.17	Rated design pressure	MPa		
4.10.18	SF6 filling; pressure at 20ºC	Mpa		
4.10.19	Min. SF6 service pressure	MPa		
4.10.20	Routine test pressure	MPa		
4.10.21	Bursting pressure	MPa		
4.10.22	Max. leakage rate at filling pressure	%	≤ 0,1	
4.10.23	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43,3	
4.10.24	Current conductor material	-		
4.10.25	Current conductor diameter	mm		
4.10.26	Cantilever test load	N		
4.10.27	Cantilever opertion load	N		
4.10.28	Type of line termination	-		
4.10.29	Seismic acceleration according to IEEE 693 figure A.1	g	0,5	
4.10.30	Quantity of SF6 gas (if any) at rated filling pressure	kg		
4.10.31	Quantity of SF6 gas (if any) at rated filling pressure	kg		
4.10.32	Weight	kg		
4.11	**GIS lightning arrester - gapless zinc-oxide type (if any)**			
4.11.1	Manufacturer	-		
4.11.2	Place of manufacturing			
4.11.3	Type	-	MO	
4.11.4	Applicable standard		IEC 60099-4 IEC 60099-5 IEC 62271-1 IEC 62271-203	
4.11.5	Nominal voltage	kV_{rms}	110	
4.11.6	Rated voltage	kV_{rms}	123	
4.11.7	Rated frequency	Hz	50	
4.11.8	Rated lightning impulse withstand voltage phase to earth	kV_{peak}	550	
4.11.9	Rated power frequency withstand voltage phase to earth	kV_{rms}	230	
4.11.10	Nominal discharge current	kA	20	
4.11.11	Line discharge class		4	
4.11.12	Rated voltage (Ur)	kV	108	
4.11.13	Max. continuous operating voltage (Uc)	kV	86	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.11.14	Temporary overvoltage withstand capability for 1 sec.	kV		
4.11.15	Temporary overvoltage withstand capability for 10 sec.	kV		
4.11.16	Maximum residual voltage at:			
4.11.17	- 5 kA 8/20 µs	kV		
4.11.18	- 10 kA 8/20 µs	kV		
4.11.19	- 20 kA 8/20 µs	kV		
4.11.20	- 40 kA 8/20 µs	kV		
4.11.21	- 500 A 30/60 µs	kV		
4.11.22	- 1 kA 30/60 µs	kV		
4.11.23	- 2 kA 30/60 µs	kV		
4.11.24	Short circuit strength 0.2 sec.	kA		
4.11.25	Equipped with surge counter with leakage current meter		Yes	
4.11.26	Quantity of SF6 gas at rated filling pressure	kg		
4.11.27	Pressure relief device		Yes	
4.12	**Density guard**			
4.12.1	Manufacturer	-		
4.12.2	Place of manufacturing	-		
4.12.3	Type	-		
4.12.4	Protection class indoor/outdoor	-	IP65	
4.12.5	Amount of contact	-		
4.12.6	Scale (red/green)	-	Yes	
4.13	**PD sensors and site testing**			
4.13.1	Manufacturer	-		
4.13.2	Place of manufacturing	-		
4.13.3	Type	-		
4.13.4	Test voltage	kV		
4.13.5	Amount of PD sensors			
4.13.6	Document number for description of PD measurement (method and testing equipments including typical test reports)	Document number	Document to be provided with tender.	
4.14	**GIS local control cubicles**			
4.14.1	Manufacturer	-		
4.14.2	Place of manufacturing	-		
4.14.3	Type		in bay integreated	
4.14.4	Standards			
4.14.5	Material			
4.14.6	Sheet thickness (minimum)	mm	2	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.14.7	Minimum paint thickness	µm	80	
4.14.8	Dimensions (H x W x D)	mm		
4.14.9	Total weight	kg		
4.14.10	Maximum heat emission of one cubicle	W		
4.15	**Internal control and signalling cabling of the GIS (between HV bay equipment and local control cubile)**			
4.15.1	Control, supervision and interlocking (HV switching equipments)			
4.15.2	Manufacturer			
4.15.3	Place of manufacturing			
4.15.4	Type			
4.15.5	Core amount and size	no/sqmm		
4.15.6	Shielded / if yes, percentage of minimum shielding	Yes/No	... / %	
4.15.7	Halogen free	Yes/No		
4.15.8	Premanufactured with coded sockets for CB, DE, ES and HSES	Yes/No		
4.15.9	Type of socket (if any)			
4.15.10	Density guard			
4.15.11	Manufacturer			
4.15.12	Place of manufacturing			
4.15.13	Type			
4.15.14	Core amount and size	no/sqmm		
4.15.15	Shielded / if yes, percentage of minimum shielding	Yes/No	... / %	
4.15.16	Halogen free	Yes/No		
4.15.17	Current transformer			
4.15.18	Manufacturer			
4.15.19	Place of manufacturing			
4.15.20	Type			
4.15.21	Core amount and size	no/sqmm		
4.15.22	Shielded / if yes, percentage of minimum shielding	Yes/No	... / %	
4.15.23	Halogen free	Yes/No		
4.15.24	Voltage transformer			
4.15.25	Manufacturer			
4.15.26	Place of manufacturing			
4.15.27	Type			
4.15.28	Core amount and size	no/sqmm		

Technical Data Sheets				
BIDDER’S / CONTRACTOR’S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.15.29	Shielded / if yes, percentage of minimum shielding	Yes/No	... / %	
4.15.30	Halogen free	Yes/No		
4.15.31	Density guard			
4.15.32	Manufacturer			
4.15.33	Place of manufacturing			
4.15.34	Type			
4.15.35	Core amount and size	no/sqmm		
4.15.36	Shielded / if yes, percentage of minimum shielding	Yes/No	... / %	
4.15.37	Halogen free	Yes/No		
4.15.38	Heating of drive meachism and CT and VT boxes			
4.15.39	Manufacturer			
4.15.40	Place of manufacturing			
4.15.41	Type			
4.15.42	Core amount and size	no/sqmm		
4.15.43	Shielded / if yes, percentage of minimum shielding	Yes/No	... / %	
4.15.44	Halogen free	Yes/No		
4.15.45	AC/DC ring circuits between local control cubicles			
4.15.46	Manufacturer			
4.15.47	Place of manufacturing			
4.15.48	Type			
4.15.49	Core amount and size	no/sqmm		
4.15.50	Shielded / if yes, percentage of minimum shielding	Yes/No	... / %	
4.15.51	Halogen free	Yes/No		
4.15.52	Type of cable channels / conduits for bay cabling			
4.15.53	- indoor installation	-		
4.15.54	- outdoor installation	-		
4.15.55	- channels with cover	-	Yes/No	
4.16	**Walkways or platforms where needed to reach the drive meachism units for control and operation**	-	Yes/No	
4.17	**Crane for 132 kV GIS room**			
4.17.1	Manufacturer			
4.17.2	Type	-	Overhead travelling	
4.17.3	Capacity	t	≥ 6	
4.17.4	Operating speed			

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.17.5	- Hoist low/fast	M/min	…/…	
4.17.6	- Trolley travel	M/min		
4.17.7	- Bridge travel	M/min		
4.17.8	Operating power source and terminal voltage			
4.17.9	- Voltage	V AC	400/230	
4.17.10	- Frequency	Hz	50	
4.17.11	Dimensions			
4.17.12	- Span	m		
4.17.13	- Length of runway	m		
4.17.14	- Total lift of hook	m		
4.17.15	Crane drive motor			
4.17.16	- Manufacturer			
4.17.17	- Type			
4.17.18	Trolley drive motors			
4.17.19	- Manufactuerer			
4.17.20	- Type			
4.17.21	Operator/Maintenance cage provided with trolley		Yes	
4.17.22	Enclosed current collector		Yes	
4.17.23	Hoist			
4.17.24	- Manufacturer			
4.17.25	- Type			
4.17.26	- Type of control		pendant	
4.17.27	Total required power	KW		
4.17.28	Weights			
4.17.29	- Bridge complete	t		
4.17.30	- Trolley complete	t		
4.17.31	- Runaway complete	t		
4.17.32	Type test Certificates (to be issued by independent laboratory or independent witnessed type test certificate	-	Yes	
4.17.33	Standards for manufacturing and testing	-	to be given	
4.17.34				
4.17.35	**Earthing connections for GIS**			
4.17.36	Size of main copper earthing conductor for GIS bays	mm^2	≥ 120	
4.17.37	Size of main copper earthing conductor for local control cubicles	mm^2	≥ 16	
4.17.38				
4.17.39	**Steel structures for GIS**			
4.17.40	Manufacturer	-		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.17.41	Place of manufacture	-		
4.17.42	Applicable standard	-		
4.17.43	Material	-		
4.17.44	Factor of safety in calculation	-		
4.17.45	Galvanization thickness:			
4.17.46	- Steel sections thicker than 5 mm	μm		
4.17.47	- Steel sections 2 mm-5 mm μm	μm		
4.17.48	- Bolts and nuts μm	μm		
4.17.49	Bolts and nuts:			
4.17.50	- Securing with plain and spring washers	yes/no		
4.17.51	- yes/no			
4.17.52	- Minimum quality			
4.17.53	Tests according to relevant standards and *Employer's Requirements*	yes/no	yes	
4.18	**Gas service cart (see 220kV GIS)**	-		
4.18.1	Suitable to use for 132kV GIS	-	yes	
4.19	**SF6 gas filling cart with wire-braided hoses (see 220kV GIS)**			
4.19.1	Suitable to use for 132kV GIS	-	yes	
4.20	**Analyzer for gas meassurement (see 220kV GIS)**			
4.20.1	Suitable to use for 132kV GIS	-	yes	
4.21	**Portable SF6 gas leakage detector in case (see 220kV GIS)**			
4.21.1	Suitable to use for 132kV GIS	-	yes	
4.22	**Density guard testing device in a case (see 220kV GIS)**			
4.22.1	Suitable to use for 132kV GIS	-	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.23	**Precision gauge with hose in transport case (see 220kV GIS)**			
4.23.1	Suitable to use for 132kV GIS	-	yes	
4.24	**Tests according to relevant standards and *Employer's Requirements* for SF_6 service and testing equipments**		yes	
4.25	**SF_6 gas**			
4.25.1	Manufacturer	-		
4.25.2	Applicable standard	-	IEC 60376	
4.25.3	Amount as spare for the use of Employer	kg		
4.26	**Documentation and wall boards for 132 kV GIS**			
4.26.1	As specified in local language	-	yes	
4.26.2	Wall boards/charts as specified in local language	-	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
5.	**Medium Voltage (MV) Metal Clad Switchgear**			
5.1	**33 kV Switchgear Lekhnath**			
5.1.1	**General Assembly**			
5.1.1.1	Manufacturer	-		
5.1.1.2	Place of manufacture	-		
5.1.1.3	Model designation	-		
5.1.1.4	Applicable standard	-	IEC 62271-200	
5.1.1.5	Type	-	Metal-clad	
5.1.1.6	Insulation	-	Air-insulated	
5.1.1.7	Facility provided with pressure relief	yes/no	yes	
5.1.1.8	Location of installation	-	Indoor	
5.1.1.9	Number of phases	-	3	
5.1.1.10	Number of busbars	-	1	
5.1.1.11	Busbar arrangement	-	single busbar	
5.1.1.12	Expected operating lifetime	year	30	
5.1.1.13	Loss of service continuity category	-	LSC 2B	
5.1.1.14	Switchgear partition class		PM	
5.1.1.15	Internal arc classification		IAC AFLR	
			25kA 1sec	
5.1.1.16	Pressure relief out of the switchgear room through a pressure relief duct		yes	
5.1.2	**Degree of Protection**			
5.1.2.1	High voltage live parts	-	IP51	
5.1.2.2	Front cover mechanism	-	IP3X	
5.1.2.3	Cable compartment	-	IP3X	
5.1.2.4	LV compartment	-	IP3X	
5.1.2.5	Overall enclosure	-	IP51	
5.1.3	**Basic Electrical Data**			
5.1.3.1	Nominal voltage	kV	33	
5.1.3.2	Rated voltage U_r	kV	36	
5.1.3.3	Rated frequency	Hz	50	
5.1.3.4	Rated busbar current	A	2000	
5.1.3.5	Rated short-circuit current (3 s)	kA	25	
5.1.3.6	Rated lightning impulse withstand voltage	kV_{peak}	170	
5.1.3.7	Rated power frequency short duration withstand voltage	kV_{rms}	70	
5.1.3.8	Power supply for drive	V DC	220	
5.1.3.9	Power supply for auxiliary contacts	V DC	220	
5.1.3.10	Power supply for heaters	V AC	230	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
5.1.4	**Withdrawable vacuum circuit breaker unit with earthing switch**			
5.1.4.1	Manufacturer	-		
5.1.4.2	Applicable standard	-	IEC 62271-100	
5.1.4.3	Dielectric medium	-	Air	
5.1.4.4	Arc distinguishing medium	-	Vacuum	
5.1.4.5	Rated current	A	800	
5.1.4.6	Rated lightning impulse withstand voltage	kV_{peak}	170	
5.1.4.7	Rated power frequency short duration withstand voltage	kV_{rms}	70	
5.1.4.8	Rated short-time withstand current (3 s)	kA	25	
5.1.4.9	Rated short-circuit breaking current (CB)	kA	25	
5.1.4.10	Rated short-circuit making current (CB)	kA	62.5	
5.1.4.11	Rated peak withstands current	kA	62.5	
5.1.4.12	Endurance class	-		
5.1.4.13	• breaker		E2, M2, C2	
5.1.4.14	• earthing switch		M0, E1	
5.1.4.15	Rated operating cycle	-	0-3 min.-C0-3 min.-C0	
5.1.4.16	Drive	-	3-pole	
5.1.4.17	Type of drive	-	Spring, motor and manual charging	
5.1.5	**Direct incoming and earthing switch unit**			
5.1.5.1	Manufacturer	-		
5.1.5.2	Applicable standard	-	IEC 62271-102	
5.1.5.3	Dielectric medium	-	Air	
5.1.5.4	Rated current (incoming feeder from transformer):	A	2000	
5.1.5.5	Rated lightning impulse withstand voltage	kV_{peak}	170	
5.1.5.6	Rated power frequency short duration withstand voltage	kV_{rms}	70	
5.1.5.7	Rated short-time withstand current (3 s)	kA	25	
5.1.5.8	Rated peak withstands current	kA	62.5	
5.1.5.9	Endurance class (earthing switch)	-	M0, E1	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
5.1.6	**Current transformer**			
5.1.6.1	Manufacturer	-		
5.1.6.2	Applicable standard	-	IEC 61869-1 IEC 61869-2	
5.1.6.3	Highest voltage for equipment U_m	kV	36	
5.1.6.4	Rated lightning impulse withstand voltage	kV_{peak}	170	
5.1.6.5	Rated power frequency withstand voltage	kV_{rms}	70	
5.1.6.6	Rated primary current incomer and earthing switch unit	-	-	
5.1.6.7	for measuring/metering/prot.	A	150-300-600	
5.1.6.8	for busbar protection	A	N/A	
5.1.6.9	Rated primary current auxiiliary transformer feeder	-	-	
5.1.6.10	for measuring/metering/prot.	A	150-300-600	
5.1.6.11	for busbar protection	A	N/A	
5.1.6.12	Number of cores for incomer and earthing switch unit	-	-	
5.1.6.13	for metering	-	N/A	
5.1.6.14	for protection	-	2	
5.1.6.15	for busbar protection	-	N/A	
5.1.6.16	Number of cores for auxiliary transformer feeder	-	-	
5.1.6.17	for metering	-	1	
5.1.6.18	for protection	-	1	
5.1.6.19	for busbar protection	-	N/A	
5.1.6.20	Rated secondary current:	A	1	
5.1.6.21	Accuracy class:	-	-	
5.1.6.22	for metering	-	0.2S	
5.1.6.23	for protection	-	5P 20	
5.1.6.24	for busbar protection	-	N/A	
5.1.6.25	Rated burden:			
5.1.6.26	for metering core	VA	15	
5.1.6.27	for protection cores	VA	30	
5.1.6.28	for busbar protection cores	VA	N/A	
5.1.7	**Core Balance CT (CBCT)**			
5.1.7.1	Manufacturer	-		
5.1.7.2	Applicable standard	-	IEC 61869-1 IEC 61869-2	
5.1.7.3	Ratio		300/1	
5.1.7.4	Accuracy class:		5P20	
5.1.7.5	Burden	VA	30	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
5.1.8	**Voltage transformer (metering unit)**	-		
5.1.8.1	Manufacturer	-		
5.1.8.2	Applicable standard	-	IEC 61869-1	
			IEC 61869-3	
5.1.8.3	Type		Inductive	
5.1.8.4	Ferro resonance damper		No	
5.1.8.5	Withdrawable		yes	
5.1.8.6	Protected by fuse		yes	
5.1.8.7	Highest voltage for equipment U_m	kV	36	
5.1.8.8	Rated lightning impulse withstand voltage	kV_{peak}	170	
5.1.8.9	Rated power frequency withstand voltage	kV_{rms}	70	
5.1.8.10	Primary voltage	kV	33 / √3	
5.1.8.11	Number of secondary windings	-	3	
5.1.8.12	Secondary voltage	V	0.110 / √3	
		V	0.110 / √3	
		V	0.110 / 3	
5.1.8.13	Accuracy class metering	-	0.5	
5.1.8.14	Accuracy class protection	-	3P	
5.1.8.15	Burden	VA	50	
5.1.9	**Lightning Arresters**	-		
5.1.9.1	Manufacturer	-		
5.1.9.2	Model designation	-		
5.1.9.3	Applicable standard	-	IEC 60099-4	
			IEC 60099-5	
5.1.9.4	Type		Indoor	
5.1.9.5	System data:	kV		
5.1.9.6	· Nominal system voltage	kV	33	
5.1.9.7	· Highest system voltage	Hz	36	
5.1.9.8	· System frequency		50	
5.1.9.9	Nominal discharge current	kA	10 / 20 subject to calculation	
5.1.9.10	Line discharge class		subject to calculation	
5.1.9.11	Rated voltage U_r	kV	27	
5.1.9.12	Maximum continuous operating voltage U_c	kV	21	
5.1.10	**Capacitive voltage indicator**			
5.1.10.1	Type of capacitive voltage indicator			
5.1.11	**Main Dimensions**	-		
5.1.11.1	Number of individual panels	-		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
5.1.11.2	Dimensions of the individual panels L x W x H	mm		
5.1.11.3	Weight of the individual panels	kg		
5.1.12	**Tests**			
5.1.12.1	Circuit-breaker		E2, M2, C2	
5.1.12.2	Earthing switch	yes/no	M0, E1	
5.1.12.3	Tests according to *VII-5 Technical Specification*	yes/no	yes	
5.2	**33 kV Switchgear Damauli**			
5.2.1	**General Assembly**			
5.2.1.1	Manufacturer	-		
5.2.1.2	Place of manufacture	-		
5.2.1.3	Model designation	-		
5.2.1.4	Applicable standard	-	IEC 62271-200	
5.2.1.5	Type	-	Metal-clad	
5.2.1.6	Insulation	-	Air-insulated	
5.2.1.7	Facility provided with pressure relief	yes/no	yes	
5.2.1.8	Location of installation	-	Indoor	
5.2.1.9	Number of phases	-	3	
5.2.1.10	Number of busbars	-	1	
5.2.1.11	Busbar arrangement	-	single busbar	
5.2.1.12	Expected operating lifetime	year	30	
5.2.1.13	Loss of service continuity category	-	LSC 2B	
5.2.1.14	Switchgear partition class		PM	
5.2.1.15	Internal arc classification		IAC AFLR	
			25kA 1sec	
5.2.1.16	Pressure relief out of the switchgear room through a pressure relief duct		yes	
5.2.2	**Degree of Protection**			
5.2.2.1	High voltage live parts	-	IP51	
5.2.2.2	Front cover mechanism	-	IP3X	
5.2.2.3	Cable compartment	-	IP3X	
5.2.2.4	LV compartment	-	IP3X	
5.2.2.5	Overall enclosure	-	IP51	
5.2.3	**Basic Electrical Data**			
5.2.3.1	Nominal voltage	kV	33	
5.2.3.2	Rated voltage U_r	kV	36	
5.2.3.3	Rated frequency	Hz	50	
5.2.3.4	Rated busbar current	A	2000	
5.2.3.5	Rated short-circuit current (3 s)	kA	25	
5.2.3.6	Rated lightning impulse withstand voltage	kV_{peak}	170	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
5.2.3.7	Rated power frequency short duration withstand voltage	kV_{rms}	70	
5.2.3.8	Power supply for drive	V DC	220	
5.2.3.9	Power supply for auxiliary contacts	V DC	220	
5.2.3.10	Power supply for heaters	V AC	230	
5.2.4	**Withdrawable vacuum circuit breaker unit with earthing switch**			
5.2.4.1	Manufacturer	-		
5.2.4.2	Applicable standard	-	IEC 62271-100	
5.2.4.3	Dielectric medium	-	Air	
5.2.4.4	Arc distinguishing medium	-	Vacuum	
5.2.4.5	Rated current incomer / buscoupler	A	2000	
5.2.4.6	Rated current outgoing feeder	A	800	
5.2.4.7	Rated lightning impulse withstand voltage	kV_{peak}	170	
5.2.4.8	Rated power frequency short duration withstand voltage	kV_{rms}	70	
5.2.4.9	Rated short-time withstand current (3 s)	kA	25	
5.2.4.10	Rated short-circuit breaking current (CB)	kA	25	
5.2.4.11	Rated short-circuit making current (CB)	kA	62.5	
5.2.4.12	Rated peak withstands current	kA	62.5	
5.2.4.13	Endurance class	-		
5.2.4.14	• breaker		E2, M2, C2	
5.2.4.15	• earthing switch		M0, E1	
5.2.4.16	Rated operating cycle	-	0-3 min.-C0-3 min.-C0	
5.2.4.17	Drive	-	3-pole	
5.2.4.18	Type of drive	-	Spring, motor and manual charging	
5.2.5	**Current transformer**			
5.2.5.1	Manufacturer	-		
5.2.5.2	Applicable standard	-	IEC 61869-1 IEC 61869-2	
5.2.5.3	Highest voltage for equipment U_m	kV	36	
5.2.5.4	Rated lightning impulse withstand voltage	kV_{peak}	170	
5.2.5.5	Rated power frequency withstand voltage	kV_{rms}	70	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
5.2.5.6	Rated primary current incomer / buscoupler	-	-	
5.2.5.7	for measuring/metering/prot.	A	600-1200	
5.2.5.8	for busbar protection	A	1600	
5.2.5.9	Rated primary current outgoing feeder	-	-	
5.2.5.10	for measuring/metering/prot.	A	200-400-800	
5.2.5.11	for busbar protection	A	1600	
5.2.5.12	Number of cores for incomer	-	-	
5.2.5.13	for metering	-	1	
5.2.5.14	for protection	-	2	
5.2.5.15	for busbar protection	-	1	
5.2.5.16	Number of cores for buscoupler			
5.2.5.17	for protection	-	1	
5.2.5.18	for busbar protection	-	1	
5.2.5.19	Number of cores for outgoing feeder	-	-	
5.2.5.20	for metering	-	1	
5.2.5.21	for protection	-	1	
5.2.5.22	for busbar protection	-	1	
5.2.5.23	Rated secondary current:	A	1	
5.2.5.24	Accuracy class:	-	-	
5.2.5.25	for metering	-	0.5	
5.2.5.26	for protection	-	5P 20	
5.2.5.27	for busbar protection	-	5P 20	
5.2.5.28	Rated burden:			
5.2.5.29	for metering core	VA	15	
5.2.5.30	for protection cores	VA	30	
5.2.5.31	for busbar protection cores	VA	30	
5.2.6	**Core Balance CT (CBCT)**			
5.2.6.1	Manufacturer	-		
5.2.6.2	Applicable standard	-	IEC 61869-1 IEC 61869-2	
5.2.6.3	Ratio		300/1	
5.2.6.4	Accuracy class:		5P20	
5.2.6.5	Burden	VA	30	
5.2.7	**Voltage transformer (metering unit) Damauli**	-		
5.2.7.1	Manufacturer	-		
5.2.7.2	Applicable standard	-	IEC 61869-1 IEC 61869-3	
5.2.7.3	Type		Inductive	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
5.2.7.4	Ferro resonance damper		No	
5.2.7.5	Withdrawable		yes	
5.2.7.6	Protected by fuse		yes	
5.2.7.7	Highest voltage for equipment U_m	kV	36	
5.2.7.8	Rated lightning impulse withstand voltage	kV_{peak}	170	
5.2.7.9	Rated power frequency withstand voltage	kV_{rms}	70	
5.2.7.10	Primary voltage	kV	33 / √3	
5.2.7.11	Number of secondary windings	-	2	
5.2.7.12	Secondary voltage	V	0.110 / √3	
		V	0.110 / √3	
5.2.7.13	Accuracy class metering	-	0,5	
5.2.7.14	Accuracy class protection	-	3P	
5.2.7.15	Burden	VA	50	
5.2.8	**Lightning Arresters**	-		
5.2.8.1	Manufacturer	-		
5.2.8.3	Model designation	-		
5.2.8.4	Applicable standard	-	IEC 60099-4	
			IEC 60099-5	
5.2.8.5	Type		Indoor	
5.2.8.6	System data:	kV		
5.2.8.7	· Nominal system voltage	kV	33	
5.2.8.8	· Highest system voltage	Hz	36	
5.2.8.9	· System frequency		50	
5.2.8.10	Nominal discharge current	kA	10 / 20 subject to calculation	
5.2.8.11	Line discharge class		subject to calculation	
5.2.8.12	Rated voltage U_r	kV	27	
5.2.8.13	Maximum continuous operating voltage U_c	kV	21	
5.2.9	**Capacitive voltage indicator**			
5.2.9.1	Type of capacitive voltage indicator			
5.2.10	**Main Dimensions Damauli**	-		
5.2.10.1	Number of individual panels	-		
5.2.10.2	Dimensions of the individual panels L x W x H	mm		
5.2.10.3	Weight of the individual panels	kg		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
5.2.11	**Tests**			
5.2.11.1	Circuit-breaker		E2, M2, C2	
5.2.11.2	Earthing switch	yes/no	M0, E1	
5.2.11.3	Tests according to *VII-5 Technical Specification*	yes/no	yes	
5.3	**11 kV Switchgear Damauli**			
5.3.1	**General Assembly**			
5.3.1.1	Manufacturer	-		
5.3.1.2	Place of manufacture	-		
5.3.1.3	Model designation	-		
5.3.1.4	Applicable standard	-	IEC 62271-200	
5.3.1.5	Type	-	Metal-clad	
5.3.1.6	Insulation	-	Air-insulated	
5.3.1.7	Facility provided with pressure relief	yes/no	yes	
5.3.1.8	Location of installation	-	Indoor	
5.3.1.9	Number of phases	-	3	
5.3.1.10	Number of busbars	-	1	
5.3.1.11	Busbar arrangement	-	single busbar	
5.3.1.12	Expected operating lifetime	year	30	
5.3.1.13	Loss of service continuity category	-	LSC 2B	
5.3.1.14	Switchgear partition class		PM	
5.3.1.15	Internal arc classification		IAC AFLR	
			25kA 1sec	
5.3.1.16	Pressure relief out of the switchgear room through a pressure relief duct		yes	
5.3.2	**Degree of Protection**			
5.3.2.1	High voltage live parts	-	IP51	
5.3.2.2	Front cover mechanism	-	IP3X	
5.3.2.3	Cable compartment	-	IP3X	
5.3.2.4	LV compartment	-	IP3X	
5.3.2.5	Overall enclosure	-	IP51	
5.3.3	**Basic Electrical Data**			
5.3.3.1	Nominal voltage	kV	11	
5.3.3.2	Rated voltage U_r	kV	12	
5.3.3.3	Rated frequency	Hz	50	
5.3.3.4	Rated busbar current	A	1250	
5.3.3.5	Rated short-circuit current (3 s)	kA	25	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
5.3.3.6	Rated lightning impulse withstand voltage	kV_{peak}	75	
5.3.3.7	Rated power frequency short duration withstand voltage	kV_{rms}	28	
5.3.3.8	Power supply for drive	V DC	220	
5.3.3.9	Power supply for auxiliary contacts	V DC	220	
5.3.3.10	Power supply for heaters	V AC	230	
5.3.4	**Withdrawable vacuum circuit breaker unit with earthing switch**			
5.3.4.1	Manufacturer	-		
5.3.4.2	Applicable standard	-	IEC 62271-100	
5.3.4.3	Dielectric medium	-	Air	
5.3.4.4	Arc distinguishing medium	-	Vacuum	
5.3.4.5	Rated current incomer / buscoupler	A	1250	
5.3.4.6	Rated current outgoing feeder	A	800	
5.3.4.7	Rated lightning impulse withstand voltage	kV_{peak}	75	
5.3.4.8	Rated power frequency short duration withstand voltage	kV_{rms}	28	
5.3.4.9	Rated short-time withstand current (3 s)	kA	25	
5.3.4.10	Rated short-circuit breaking current (CB)	kA	25	
5.3.4.11	Rated short-circuit making current (CB)	kA	62.5	
5.3.4.12	Rated peak withstands current	kA	62.5	
5.3.4.13	Endurance class	-		
5.3.4.14	• breaker		E2, M2, C2	
5.3.4.15	• earthing switch		M0, E1	
5.3.4.16	Rated operating cycle	-	0-3 min.-C0-3 min.-C0	
5.3.4.17	Drive	-	3-pole	
5.3.4.18	Type of drive	-	Spring, motor and manual charging	
5.3.5	**Current transformer**			
5.3.5.1	Manufacturer	-		
5.3.5.3	Applicable standard	-	IEC 61869-1 IEC 61869-2	
5.3.5.3	Highest voltage for equipment U_m	kV	12	
5.3.5.4	Rated lightning impulse withstand voltage	kV_{peak}	75	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
5.3.5.5	Rated power frequency withstand voltage	kV_{rms}	28	
5.3.5.6	Rated primary current incomer / buscoupler	-	-	
5.3.5.7	for measuring/metering/prot.	A	600-900-1200/1	
5.3.5.8	for busbar protection	A	N/A	
5.3.5.9	Rated primary current outgoing feeder	-	-	
5.3.5.10	for measuring/metering/prot.	A	200-400/1	
5.3.5.11	for busbar protection	A	N/A	
5.3.5.12	Number of cores for incomer	-	-	
5.3.5.13	for metering	-	1	
5.3.5.14	for protection	-	2	
5.3.5.15	Number of cores for buscoupler			
5.3.5.16	for protection	-	1	
5.3.5.17	Number of cores for outgoing feeder	-	-	
5.3.5.18	for metering	-	1	
5.3.5.19	for protection	-	1	
5.3.5.30	Rated secondary current:	-	-	
5.3.5.31	for metering	A	1	
5.3.5.32	for protection	A	1	
5.3.5.33	Accuracy class:	-	-	
5.3.5.34	for metering	-	0.5	
5.3.5.35	for protection	-	5P 20	
5.3.5.36	Rated burden:			
5.3.5.37	for metering core	VA	15	
5.3.5.38	for protection cores	VA	30	
5.3.6	**Core Balance CT (CBCT)**			
5.3.6.1	Manufacturer	-		
5.3.6.2	Applicable standard	-	IEC 61869-1 IEC 61869-2	
5.3.6.3	Ratio		300/1	
5.3.6.4	Accuracy class:		5P20	
5.3.6.5	Burden	VA	30	
5.3.7	**Voltage transformer (metering unit)**	-		
5.3.7.1	Manufacturer	-		
5.3.7.2	Applicable standard	-	IEC 61869-1 IEC 61869-3	
5.3.7.3	Type		Inductive	
5.3.7.4	Ferro resonance damper		yes	
5.3.7.5	Withdrawable		yes	
5.3.7.6	Protected by fuse		yes	
5.3.7.7	Highest voltage for equipment U_m	kV	12	
5.3.7.8	Rated lightning impulse withstand voltage	kV_{peak}	75	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
5.3.7.9	Rated power frequency withstand voltage	kV_{rms}	28	
5.3.7.10	Primary voltage	kV	11 / √3	
5.3.7.11	Number of secondary windings	-	2	
5.3.7.12	Secondary voltage	V	0.110 / √3	
		V	0.110 / √3	
5.3.7.13	Accuracy class metering	-	0.5	
5.3.7.14	Accuracy class protection	-	3P	
5.3.7.15	Burden	VA	50	
5.3.8	**Lightning Arresters**	-		
5.3.8.1	Manufacturer	-		
5.3.8.2	Place of manufacture	-		
5.3.8.3	Model designation	-		
5.3.8.4	Applicable standard		IEC 60099-4	
		-	IEC 60099-5	
5.3.8.5	Type		Indoor	
5.3.8.6	System data:	kV		
5.3.8.7	· Nominal system voltage	kV	11	
5.3.8.8	· Highest system voltage	Hz	12	
5.3.8.9	· System frequency		50	
5.3.8.10	Nominal discharge current	kA	10 / 20 subject to calculation	
5.3.8.11	Line discharge class		subject to calculation	
5.3.8.12	Rated voltage U_r	kV	9	
5.3.8.13	Maximum continuous operating voltage U_c	kV	7.2	
5.3.9	**Capacitive voltage indicator**			
5.3.9.1	Type of capacitive voltage indicator			
5.3.10	**Main Dimensions**	-		
5.3.10.1	Number of individual panels	-		
5.3.10.2	Dimensions of the individual panels L x W x H	mm		
5.3.10.3	Weight of the individual panels	kg		
5.3.11	**Tests**			
5.3.11.1	Circuit-breaker		E2, M2, C2	
5.3.11.2	Earthing switch	yes/no	M0, E1	
5.3.11.3	Tests according to *VII-5 Technical Specification*	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.	**Transformers**			
6.1	**Power Transformers and Autotransformers**			
6.1.1	**Autotransformer 220/132/33 kV for Lekhnath**			
6.1.1.1	**General Data**			
6.1.1.1.1	Manufacturer	-		
6.1.1.1.2	Place of manufacture	-		
6.1.1.1.3	Applicable standard	-	IEC 60076 etc., as per *VII-5 Technical Specifications*	
6.1.1.1.4	6 Sigma Quality Certification for Transformer Manufacturing Facilities	Yes/no	Yes	
6.1.1.1.5	Painting as per ISO 12944 C5-M	Yes/no	Yes	
6.1.1.1.6	Service altitude	m	<1000	
6.1.1.1.7	Ambient temperature (max.)	°C	40	
6.1.1.1.8	Type	-	Autotransformer Single-Phase	
6.1.1.1.9	Rated voltage	kV	220/√3 / 132/√3 / 33	
6.1.1.1.10	Vector group single phase transformer	-	Ia0i0	
6.1.1.1.11	Vector group three phase bank	-	YNa0d11	
6.1.1.1.12	Type of Cooling		ONAN/ONAF	
6.1.1.1.13	Type of insulation:	-	-	
6.1.1.1.14	• primary	-	Graded	
6.1.1.1.15	• secondary		Graded	
6.1.1.1.16	• tertiary	-	Uniform	
6.1.1.1.17	Location of use	-	outdoor	
6.1.1.1.18	Tank type	-	Upper flange	
6.1.1.1.19	Max noise level (LPA) - according to IEC 60076-10 - at a measuring distance of 2m with all forced cooling in operation	dB (A)	70	
6.1.1.1.20	Rated frequency	Hz	50	
6.1.1.2	**Characteristics of magnetic circuit**			
6.1.1.2.1	Type	-	Core type	
6.1.1.2.2	Material	-	Cold rolled grain silicon steel	
6.1.1.2.3	Maximum flux density at rated voltage and frequency	T	≤1,65	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.1.1.3	**Temperature rise**			
6.1.1.3.1	Top oil	K	60	
6.1.1.3.2	Average winding	K	65	
6.1.1.3.3	Hot spot winding	K	78	
6.1.1.4	**Rated power**			
6.1.1.4.1	220 kV level:			
6.1.1.4.2	• ONAN	MVA	80	
6.1.1.4.3	• ONAF	MVA	105	
6.1.1.4.4	132 kV level:			
6.1.1.4.5	• ONAN	MVA	80	
6.1.1.4.6	• ONAF	MVA	105	
6.1.1.4.7	33kV level:			
6.1.1.4.8	• ONAN	MVA	25	
6.1.1.4.9	• ONAF	MVA	33	
6.1.1.5	**Rated withstand voltages for transformer windings**			
6.1.1.5.1	220 kV winding (U_m=245 kV):			
6.1.1.5.2	• Rated lightning impulse withstand voltage	kV_{peak}	1050	
6.1.1.5.3	• Rated short-duration induced or separate source AC withstand voltage	kV_{rms}	460	
6.1.1.5.4	132 kV winding (U_m=145kV):			
6.1.1.5.5	• Rated lightning impulse withstand voltage	kV_{peak}	650	
6.1.1.5.6	• Rated short-duration induced or separate source AC withstand voltage	kV_{rms}	275	
6.1.1.5.7	33 kV winding (U_m=36 kV):			
6.1.1.5.8	• Rated lightning impulse withstand voltage	kV_{peak}	250	
6.1.1.5.9	• Rated short-duration induced or separate source AC withstand voltage	kV_{rms}	95	
6.1.1.5.10	Neutral (U_m=52 kV):			
6.1.1.5.11	• Rated lightning impulse withstand voltage	kV_{peak}	250	
6.1.1.5.12	• Rated short-duration induced or separate source AC withstand voltage	kV_{rms}	95	
6.1.1.6	**Short circuit level (3 s) of the system**			
6.1.1.6.1	• 220 kV level	kA	40	
6.1.1.6.2	• 132 kV level	kA	31,5	
6.1.1.6.3	• 33 kV level	kA	N/A	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.1.1.7	**Impedance voltage in % at 75°C winding temperature on middle tap position at full loading, ONAF**			
6.1.1.7.1	• 220 to 132 kV	%	13	
6.1.1.7.2	• 132 to 33 kV	%	20	
6.1.1.7.3	• 220 to 33 kV	%	32	
6.1.1.8	**Oil characteristics**			
6.1.1.8.1	Mineral oil standard	-	IEC 60296	
6.1.1.8.2	Corrosive Sulphur test		IEC 62535 ASTM D 1275 method B	
6.1.1.8.3	Dryness of the oil after on-site installation		Water Content ≤5ppm	
6.1.1.8.4	Inhibited	Yes / No		
6.1.1.8.5	Manufacturer	-		
6.1.1.8.6	Oil type	inhibited/		
6.1.1.8.7	Type designation	-		
6.1.1.8.8	Minimum flash point	°C	140	
6.1.1.8.9	Viscosity at 80°C	mm^2/s		
6.1.1.8.10	Max. dielectric strength (1min.)	kV		
6.1.1.8.11	Total oil required	l		
6.1.1.8.12	Tests according to *VII-5 Technical Specifications*	yes/no	yes	
6.1.1.9	**Bushings**			
6.1.1.9.1	Applicable standard	-	IEC 60137	
6.1.1.10	**220 kV bushing**	-		
6.1.1.10.1	• Manufacturer			
6.1.1.10.2	• Place of manufacture	-		
6.1.1.10.3	Type of bushing	-	RIP or RIS	
6.1.1.10.4	Type of bushing insulator	-	silicon	
6.1.1.10.5	Type designation	-		
6.1.1.10.6	Highest rated voltage	kV	245	
6.1.1.10.7	Rated current	A	1000	
6.1.1.10.8	Rated thermal short time current (3 s)	kA	40	
6.1.1.10.9	Rated dynamic current	kA	100	
6.1.1.10.10	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
6.1.1.10.11	Rated lightning impulse withstand voltage	kV_{peak}	1050	
6.1.1.10.12	Rated switching impulse withstand voltage	kV_{peak}	850	
6.1.1.10.13	Power frequency withstand voltage (dry)	kV_{rms}	460	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.1.1.11	**132 kV bushing**	-		
6.1.1.11.1	• Manufacturer			
6.1.1.11.2	• Place of manufacture	-		
6.1.1.11.3	Type of bushing	-	RIP or RIS	
6.1.1.11.4	Type of bushing insulator	-	silicon	
6.1.1.11.5	Type designation	-		
6.1.1.11.6	Highest rated voltage	kV	145	
6.1.1.11.7	Rated current	A	2000	
6.1.1.11.8	Rated thermal short time current (3 s)	kA	40	
6.1.1.11.9	Rated dynamic current	kA	100	
6.1.1.11.10	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
6.1.1.11.11	Rated lightning impulse withstand voltage	kV_{peak}	650	
6.1.1.11.12	Power frequency withstand voltage (dry)	kV_{rms}	275	
6.1.1.12	**33 kV bushing**			
6.1.1.12.1	• Manufacturer	-		
6.1.1.12.2	• Place of manufacture	-		
6.1.1.12.3	Type of bushing insulator	-	porcelain	
6.1.1.12.4	Type designation	-		
6.1.1.12.5	Highest rated voltage	kV	36	
6.1.1.12.6	Rated current	A	2500	
6.1.1.12.7	Rated thermal short time current (3 s)	kA	50	
6.1.1.12.8	Rated dynamic current	kA	125	
6.1.1.12.9	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
6.1.1.12.10	Rated lightning impulse withstand voltage	kV_{peak}	250	
6.1.1.12.11	Power frequency withstand voltage (dry)	kV_{rms}	95	
6.1.1.12.12	Minimum cantilever withstand load	N	500	
6.1.1.13	**Neutral bushing**	-		
6.1.1.13.1	Manufacturer			
6.1.1.13.2	Place of manufacture	-		
6.1.1.13.3	Type of bushing	-	RIP or RIS	
6.1.1.13.4	Type of bushing insulator	-	silicon	
6.1.1.13.5	Type designation	-		
6.1.1.13.6	Highest rated voltage	kV	52	
6.1.1.13.7	Rated current	A	1000	
6.1.1.13.8	Rated thermal short time current (3 s)	kA	40	
6.1.1.13.9	Rated dynamic current	kA	100	
6.1.1.13.10	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.1.1.13.11	Rated lightning impulse withstand voltage	kV_{peak}	250	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.1.1.13.12	Power frequency withstand voltage (dry)	kV_{rms}	95	
6.1.1.13.13	Minimum cantilever withstand load	N	500	
6.1.1.14	**Bushing current transformers**			
6.1.1.14.1	220 kV:			
6.1.1.14.2	• Ratio	A	500-750-1250/1	
6.1.1.14.3	• Core 1 burden and accuracy	-	5P20 30 VA	
6.1.1.14.4	• Core 2 burden and accuracy	-	5P20 30 VA	
6.1.1.14.5	• Core 3 burden and accuracy	-	N/A	
6.1.1.14.6	132 kV:			
6.1.1.14.7	• Ratio	A	1250/1500/2000/1	
6.1.1.14.8	• Core 1 burden and accuracy	-	5P20 30 VA	
6.1.1.14.9	• Core 2 burden and accuracy	-	5P20 30 VA	
6.1.1.14.10	• Core 3 burden and accuracy	-	N/A	
6.1.1.14.11	33 kV (both bushings):			
6.1.1.14.12	• Ratio	A	300-600/1	
6.1.1.14.13	• Core 1 burden and accuracy	-	5P20 30 VA	
6.1.1.14.14	• Core 2 burden and accuracy	-	5P20 30 VA	
6.1.1.14.15	• Core 3 burden and accuracy	-	N/A	
6.1.1.14.16	Neutral:			
6.1.1.14.17	• Ratio	A	500-750-1250/1	
6.1.1.14.18	• Core 1 burden and accuracy	-	5P20 30 VA	
6.1.1.14.19	• Core 2 burden and accuracy	-	5P20 30 VA	
6.1.1.15	**Cooling system**			
6.1.1.15.1	Type of cooling	-	ONAN/ONAF	
6.1.1.15.2	Number of coolers	pcs		
6.1.1.15.3	Cooling operation	-	Auto/Manual	
6.1.1.15.4	Control voltage for cooling and heating	V AC	230	
6.1.1.15.5	Supply voltage of protective devices	V DC	220	
6.1.1.15.6	Supply voltage of fans and pumps	V AC	230/400	
6.1.1.15.7	Power demand of fans	kW		
6.1.1.15.8	Power demand of oil pumps	kW		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.1.1.16	**No load current**			
6.1.1.16.1	No load current	%		
6.1.1.16.2	Magnetic flux density at rated voltage and frequency	Tesla	Max 1,65	
6.1.1.16.3	Core losses	W/kg	Max 1,05	
6.1.1.17	**Losses**			
6.1.1.17.1	No load losses at nominal voltage position	kW		
6.1.1.17.2	No load losses at lowest tap position	kW		
6.1.1.17.3	No load losses at highest tap position	kW		
6.1.1.17.4	Load losses at nominal tap at ONAN:			
6.1.1.17.5	Primary/Secondary	kW		
6.1.1.17.6	Primary/Tertiary	kW		
6.1.1.17.7	Secondary/Tertiary	kW		
6.1.1.17.8	Load losses at nominal tap at ONAF:			
6.1.1.17.9	Primary/Secondary	kW		
6.1.1.17.10	Primary/Tertiary	kW		
6.1.1.17.11	Secondary/Tertiary	kW		
6.1.1.18	**OLTC (On-load tap-changer)**			
6.1.1.18.1	Manufacturer	-	MR Germany or ABB Sweden, or equivalent	
6.1.1.18.2	Type designation	-		
6.1.1.18.3	Applicable standard	-	IEC 60214-1	
6.1.1.18.4	Type	-	vacuum	
6.1.1.18.5	Type of connection	-	line-end (constant flux)	
6.1.1.18.6	Tapping on 220kV side	%	+8 x 1,25 / -8 x 1,25	
6.1.1.18.7	Rated through current	A	-	
6.1.1.18.8	Rated short-time current:			
6.1.1.18.9	maximum (peak)	kA	-	
6.1.1.18.10	3 seconds	kA	-	
6.1.1.18.11	Rated power frequency withstand voltage	kV_{rms}	275	
6.1.1.18.12	Rated lightning impulse withstand voltage	kV_{peak}	650	
6.1.1.18.13	Rated operations duty (min.)	-	600,000	
6.1.1.19	**Automatic Voltage Regulation**			
6.1.1.19.1	Manufacturer	-		
6.1.1.19.2	Type / designation			
6.1.1.19.3	Sensitivity	-%,+%	± 0,4 to 6% of transformer voltage	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.1.1.19.4	Response time	s	0-15 sec to 4 min. referred to 1% deviation from desired value	
6.1.1.19.5	Range of set point adjustment	% of Un	90 to 115% U_N	
6.1.1.19.6	Current-responsive rising	% of Un	0 to 16% U_N	
6.1.1.19.7	Limitation of current effect	% of Un	0 to 16% U_N	
6.1.1.19.8	Overvoltage U_{max}	% of Un	100 to 135% U_N	
6.1.1.19.9	Under voltage U_{min}.	% of Un	50 to 100% U_N	
6.1.1.19.10	Under/Overcurrent $I_{min/max}$	x In	60 to 120 I_N	
6.1.1.19.11	Line drop compensation		Yes	
6.1.1.19.12	Parallel operation with other transformer	-	Yes	
6.1.1.20	**Neutral Treatment**			
6.1.1.20.1	Brought up to bushings and grounded	yes/no	yes	
6.1.1.20.2	Neutral surge arrester	yes/no	no	
6.1.1.20.3	Neutral disconnector	yes/no	no	
6.1.1.20.4	Neutral current transformer	yes/no	yes	
6.1.1.20.5	Solidly grounded	yes/no	yes	
6.1.1.21	**Accessories**			
6.1.1.21.1	Accessories according to *VII-5 Technical Specification*	yes/no	yes	
6.1.1.21.2	Online transformer condition monitoring system according to *VII-5 Technical Specification*	yes/no	yes	
6.1.1.22	**Marshalling kiosks**			
6.1.1.22.1	Degree of protection	-	IP55	
6.1.1.22.2	Marshalling kiosks according to *VII-5 Technical Specification*	yes/no	yes	
6.1.1.23	**Tank mounted Surge Arrestors**			
6.1.1.23.1	**220 kV Surge Arrester and Discharge Counter**			
6.1.1.23.1.1	Manufacturer	-	-	
6.1.1.23.1.2	Place of manufacture	-	-	
6.1.1.23.1.3	Model designation	-	-	
6.1.1.23.1.4	Applicable standard	-	IEC 60071-1	
			IEC 60071-2	
			IEC 60099-4	
			IEC 60099-5	
			IEC 60529	
			IEC 60815	
6.1.1.23.1.5	Type	-	Outdoor, silicon-housed	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.1.1.23.1.6	System data:			
6.1.1.23.1.7	• Nominal system voltage	kV	220	
6.1.1.23.1.8	• Highest system voltage	kV	245	
6.1.1.23.1.9	• System frequency	Hz	50	
6.1.1.23.1.10	Rated voltage U_r	kV	180	
6.1.1.23.1.11	Maximum continuous operating voltage U_c	kV	144	
6.1.1.23.1.12	Rated discharge current	kA	10 / 20 subject to calculation	
6.1.1.23.1.13	Thermal energy rating	kJ/kV	10	
6.1.1.23.1.14	Separate earthing rod per SA, 150 mm^2	yes/no	yes	
6.1.1.23.1.15	Discharge Counter:			
6.1.1.23.1.16	Manufacturer	-		
6.1.1.23.1.17	Model designation	-		
6.1.1.23.1.18	Display	-		
6.1.1.23.1.19	Number of impulses	yes/no	yes	
6.1.1.23.1.20	Leakage current measurement, total current	yes/no	yes	
6.1.1.23.1.21	Protection class	-	IP55 W	
6.1.1.23.1.22	Number of counters per three (3) 1-ph arresters	-	3	
6.1.1.23.2	**132 kV Surge Arrester and Discharge Counter**			
6.1.1.23.2.1	Manufacturer	-	-	
6.1.1.23.2.2	Place of manufacture	-	-	
6.1.1.23.2.3	Model designation	-	-	
6.1.1.23.2.4	Applicable standard	-	IEC 60071-1	
			IEC 60071-2	
			IEC 60099-4	
			IEC 60099-5	
			IEC 60529	
			IEC 60815	
6.1.1.23.2.5	Type	-	Outdoor, silicon-housed	
6.1.1.23.2.6	System data:			
6.1.1.23.2.7	• Nominal system voltage	kV	132	
6.1.1.23.2.8	• Highest system voltage	kV	145	
6.1.1.23.2.9	• System frequency	Hz	50	
6.1.1.23.2.10	Rated voltage U_r	kV	108	
6.1.1.23.2.11	Maximum continuous operating voltage U_c	kV	86	
6.1.1.23.2.12	Rated discharge current	kA	10 / 20 subject to calculation	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.1.1.23.2.13	Thermal energy rating	kJ/kV	10	
6.1.1.23.2.14	Separate earthing rod per SA, 150 mm^2	yes/no	yes	
6.1.1.23.2.15	Discharge Counter:			
6.1.1.23.2.16	Manufacturer	-		
6.1.1.23.2.17	Model designation	-		
6.1.1.23.2.18	Display	-		
6.1.1.23.2.19	Number of impulses	yes/no	yes	
6.1.1.23.2.20	Leakage current measurement, total current	yes/no	yes	
6.1.1.23.2.21	Protection class	-	IP 55 W	
6.1.1.23.2.22	Number of counters per three (3) 1-ph arresters	-	3	
6.1.1.23.3	**33 kV Surge Arrester**			
6.1.1.23.3.1	Manufacturer	-	-	
6.1.1.23.3.2	Place of manufacture	-	-	
6.1.1.23.3.3	Model designation	-	-	
6.1.1.23.3.4	Applicable standard	-	IEC 60071-1	
			IEC 60071-2	
			IEC 60099-4	
			IEC 60099-5	
			IEC 60529	
			IEC 60815	
6.1.1.23.3.5	Type	-	Outdoor, silicon-housed	
6.1.1.23.3.6	System data:			
6.1.1.23.3.7	• Nominal system voltage	kV	33	
6.1.1.23.3.8	• Highest system voltage	kV	36	
6.1.1.23.3.9	• System frequency	Hz	50	
6.1.1.23.3.10	Rated voltage U_r	kV	27	
6.1.1.23.3.11	Maximum continuous operating voltage U_c	kV	21	
6.1.1.23.3.12	Rated discharge current	kA	10 / 20 subject to calculation	
6.1.1.23.3.13	Thermal energy rating	kJ/kV	10	
6.1.1.24	**Transformer Main dimensions**			
6.1.1.24.1	Total length x width x height	m	-	
6.1.1.24.2	Tank length x width x height	m	-	
6.1.1.24.3	Gross weight	kg	-	
6.1.1.24.4	Transport weight	kg	-	
6.1.1.24.5	Volume of oil	m^3	-	
6.1.1.24.6	Weight of oil	kg	-	
6.1.1.24.7	Max. admitted accelerations in XYZ-directions during transport	g	-	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.1.1.25	**Tests**			
6.1.1.25.1	Tests according to *VII-5 Technical Specification*	yes/no	yes	
6.1.2	**Power Transformer 220/132 kV for Damauli**			
6.1.2.1	**General Data**			
6.1.2.1.1	Manufacturer	-		
6.1.2.1.2	Place of manufacture	-		
6.1.2.1.3	Applicable standard	-	IEC 60076 etc., as per *VII-5 Technical Specifications*	
6.1.2.1.4	6 Sigma Quality Certification for Transformer Manufacturing Facilities	Yes/no	Yes	
6.1.2.1.5	Painting as per ISO 12944 C5-M	Yes/no	Yes	
6.1.2.1.6	Service altitude	m	<1000	
6.1.2.1.7	Ambient temperature (max.)	°C	50	
6.1.2.1.8	Type	-	Power Transformer three-Phase	
6.1.2.1.9	Rated voltage	kV	220 / 132	
6.1.2.1.10	Vector group	-	YNyn0+d	
6.1.2.1.11	Type of Cooling		ONAN/ONAF	
6.1.2.1.12	Type of insulation:	-	-	
6.1.2.1.13	• primary	-	Uniform	
6.1.2.1.14	• secondary		Uniform	
6.1.2.1.15	• tertiary	-	Uniform	
6.1.2.1.16	Location of use	-	outdoor	
6.1.2.1.17	Tank type	-	Upper flange	
6.1.2.1.18	Max noise level (LPA) - according to IEC 60076-10 - at a measuring distance of 2m with all forced cooling in operation	dB (A)	70	
6.1.2.1.19	Rated frequency	Hz	50	
6.1.2.2	**Characteristics of magnetic circuit**			
6.1.2.2.1	Type	-	Core type	
6.1.2.2.2	Material	-	Cold rolled grain silicon steel	
6.1.2.2.3	Maximum flux density at rated voltage and frequency	T	≤1,65	
6.1.2.3	**Temperature rise**			
6.1.2.3.1	Top oil	K	50	
6.1.2.3.2	Average winding	K	55	
6.1.2.3.3	Hot spot winding	K	68	
6.1.2.4	**Rated power**			

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.1.2.4.1	• ONAN	MVA	50	
6.1.2.4.2	• ONAF	MVA	63	
6.1.2.5	**Rated withstand voltages for transformer windings**			
6.1.2.5.1	220 kV winding (U_m=245 kV):			
6.1.2.5.2	• Rated lightning impulse withstand voltage	kV_{peak}	1050	
6.1.2.5.3	• Rated short-duration induced or separate source AC withstand voltage	kV_{rms}	460	
6.1.2.5.4	132 kV winding (U_m=123 kV):			
6.1.2.5.5	• Rated lightning impulse withstand voltage	kV_{peak}	650	
6.1.2.5.6	• Rated short-duration induced or separate source AC withstand voltage	kV_{rms}	275	
6.1.2.5.7	Neutral (U_m=52 kV):			
6.1.2.5.8	• Rated lightning impulse withstand voltage	kV_{peak}	N/A	
6.1.2.5.9	• Rated short-duration induced or separate source AC withstand voltage	kV_{rms}	N/A	
6.1.2.6	**Short circuit level (3 s) of the system**			
6.1.2.6.1	• 220 kV level	kA	40	
6.1.2.6.2	• 132 kV level	kA	40	
6.1.2.7	**Impedance voltage in % at 75°C winding temperature on middle tap position at full loading, ONAF**	%	12	
6.1.2.8	**Oil characteristics**			
6.1.2.8.1	Mineral oil standard	-	IEC 60296	
6.1.2.8.2	Corrosive Sulphur test		IEC 62535 ASTM D 1275 method B	
6.1.2.8.3	Dryness of the oil after on-site installation		Water Content ≤5ppm	
6.1.2.8.4	Inhibited	Yes / No		
6.1.2.8.5	Manufacturer	-		
6.1.2.8.6	Oil type	inhibited/		
6.1.2.8.7	Type designation	-		
6.1.2.8.8	Minimum flash point	°C	140	
6.1.2.8.9	Viscosity at 80°C	mm^2/s		
6.1.2.8.10	Max. dielectric strength (1min.)	kV		
6.1.2.8.11	Total oil required	l		
6.1.2.8.12	Tests according to *VII-5 Technical Specifications*	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.1.2.9	**Bushings**			
6.1.2.9.1	Applicable standard	-	IEC 60137	
6.1.2.10	**220 kV bushing**	-		
6.1.2.10.1	• Manufacturer			
6.1.2.10.2	• Place of manufacture	-		
6.1.2.10.3	Type of bushing	-	RIP or RIS	
6.1.2.10.4	Type of bushing insulator	-	silicon	
6.1.2.10.5	Type designation	-		
6.1.2.10.6	Highest rated voltage	kV	245	
6.1.2.10.7	Rated current	A	800	
6.1.2.10.8	Rated thermal short time current (3 s)	kA	40	
6.1.2.10.9	Rated dynamic current	kA	100	
6.1.2.10.10	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
6.1.2.10.11	Rated lightning impulse withstand voltage	kV_{peak}	1050	
6.1.2.10.12	Rated switching impulse withstand voltage	kV_{peak}	850	
6.1.2.10.13	Power frequency withstand voltage (dry)	kV_{rms}	460	
6.1.2.11	**132 kV bushing**	-		
6.1.2.11.1	• Manufacturer			
6.1.2.11.2	• Place of manufacture	-		
6.1.2.11.3	Type designation	-		
6.1.2.11.4	Type of bushing	-	RIP or RIS	
6.1.2.11.5	Type of bushing insulator	-	silicon	
6.1.2.11.6	Highest rated voltage	kV	145	
6.1.2.11.7	Rated current	A	800	
6.1.2.11.8	Rated thermal short time current (3 s)	kA	40	
6.1.2.11.9	Rated dynamic current	kA	100	
6.1.2.11.10	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
6.1.2.11.11	Rated lightning impulse withstand voltage	kV_{peak}	650	
6.1.2.11.12	Power frequency withstand voltage (dry)	kV_{rms}	275	
6.1.2.13	**Neutral bushings**	-		
6.1.2.13.1	Manufacturer			
6.1.2.13.2	Place of manufacture	-		
6.1.2.13.3	Type of bushing	-	RIP or RIS	
6.1.2.13.4	Type of bushing insulator	-	silicon	
6.1.2.13.5	Type designation	-		
6.1.2.13.6	Highest rated voltage	kV	52	
6.1.2.13.7	Rated current	A	800	
6.1.2.13.8	Rated thermal short time current (3 s)	kA	40	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.1.2.13.9	Rated dynamic current	kA	100	
6.1.2.13.10	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
6.1.2.13.11	Rated lightning impulse withstand voltage	kV_{peak}	250	
6.1.2.13.12	Power frequency withstand voltage (dry)	kV_{rms}	95	
6.1.2.13.13	Minimum cantilever withstand load	N	500	
6.1.2.14	**Bushing current transformers**			
6.1.2.14.1	220 kV:			
6.1.2.14.2	• Ratio	A	200/400/600/1	
6.1.2.14.3	• Core 1 burden and accuracy	-	5P20 30 VA	
6.1.2.14.4	• Core 2 burden and accuracy	-	5P20 30 VA	
6.1.2.14.5	• Core 3 burden and accuracy	-	N/A	
6.1.2.14.6	132 kV:			
6.1.2.14.7	• Ratio	A	400/600/800/1	
6.1.2.14.8	• Core 1 burden and accuracy	-	5P20 30 VA	
6.1.2.14.9	• Core 2 burden and accuracy	-	5P20 30 VA	
6.1.2.14.10	• Core 3 burden and accuracy	-	N/A	
6.1.2.14.11	Neutral 220 kV side:			
6.1.2.14.12	• Ratio	A	200/400/600/1	
6.1.2.14.13	• Core 1 burden and accuracy	-	5P20 30 VA	
6.1.2.14.14	• Core 2 burden and accuracy	-	5P20 30 VA	
6.1.2.14.15	Neutral 132 kV side:			
6.1.2.14.16	• Ratio	A	400/600/800/1	
6.1.2.14.17	• Core 1 burden and accuracy	-	5P20 30 VA	
6.1.2.14.18	• Core 2 burden and accuracy	-	5P20 30 VA	
6.1.2.15	**Cooling system**			
6.1.2.15.1	Type of cooling	-	ONAN/ONAF	
6.1.2.15.2	Number of coolers	pcs		
6.1.2.15.3	Cooling operation	-	Auto/Manual	
6.1.2.15.4	Control voltage for cooling and heating	V AC	230	
6.1.2.15.5	Supply voltage of protective devices	V DC	220	
6.1.2.15.6	Supply voltage of fans and pumps	V AC	230/400	
6.1.2.15.7	Power demand of fans	kW		

Technical Data Sheets				
BIDDER’S / CONTRACTOR’S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.1.2.15.8	Power demand of oil pumps	kW		
6.1.2.16	**No load current**			
6.1.2.16.1	No load current	%		
6.1.2.16.2	Magnetic flux density at rated voltage and frequency	Tesla	Max 1,65	
6.1.2.16.3	Core losses	W/kg	Max 1,05	
6.1.2.17	**Losses**			
6.1.2.17.1	No load losses at nominal voltage position	kW		
6.1.2.17.2	No load losses at lowest tap position	kW		
6.1.2.17.3	No load losses at highest tap position	kW		
6.1.2.17.4	Load losses at nominal tap at ONAN:	kW		
6.1.2.17.5	Load losses at nominal tap at ONAF:	kW		
6.1.2.18	**OLTC (On-load tap-changer)**			
6.1.2.18.1	Manufacturer	-	MR Germany or ABB Sweden, or equivalent	
6.1.2.18.2	Type designation	-		
6.1.2.18.3	Applicable standard	-	IEC 60214-1	
6.1.2.18.4	Type	-	vacuum	
6.1.2.18.5	Tapping on 220kV side	%	+8 x 1,25 / - 8 x 1,25	
6.1.2.18.6	Rated through current	A	-	
6.1.2.18.7	Rated short-time current:			
6.1.2.18.8	maximum (peak)	kA	-	
6.1.2.18.9	3 seconds	kA	-	
6.1.2.18.10	Rated power frequency withstand voltage	kV_{rms}	-	
6.1.2.18.11	Rated lightning impulse withstand voltage	kV_{peak}	-	
6.1.2.18.12	Rated operations duty (min.)	-	600 000	
6.1.2.19	**Automatic Voltage Regulation**			
6.1.2.19.1	Manufacturer	-		
6.1.2.19.2	Type / designation			
6.1.2.19.3	Sensitivity	-%,+%	± 0,4 to 6% of transformer voltage	
6.1.2.19.4	Response time	s	0-15 sec to 4 min. referred to 1% deviation from desired value	
6.1.2.19.5	Range of set point adjustment	% of Un	90 to 115% U_N	
6.1.2.19.6	Current-responsive rising	% of Un	0 to 16% U_N	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.1.2.19.7	Limitation of current effect	% of Un	0 to 16% U_N	
6.1.2.19.8	Overvoltage U_{max}	% of Un	100 to 135% U_N	
6.1.2.19.9	Under voltage U_{min}.	% of Un	50 to 100% U_N	
6.1.2.19.10	Under/Overcurrent $I_{min/max}$	x In	60 to 120 I_N	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.1.2.19.11	Line drop compensation		Yes	
6.1.2.19.12	Parallel operation with other transformer	-	Yes	
6.1.2.20	**Neutral Treatment**			
6.1.2.20.1	Brought up to bushings and grounded	yes/no	yes	
6.1.2.20.2	Neutral surge arrester	yes/no	no	
6.1.2.20.3	Neutral disconnector	yes/no	no	
6.1.2.20.4	Neutral current transformer	yes/no	yes	
6.1.2.20.5	Solidly grounded	yes/no	yes	
6.1.2.21	**Accessories**			
6.1.2.21.1	Accessories according to *VII-5 Technical Specification*	yes/no	yes	
6.1.2.21.2	Online transformer condition monitoring system according to *VII-5 Technical Specification*	yes/no	no	
6.1.2.22	**Marshalling kiosks**			
6.1.2.22.1	Degree of protection	-	IP55	
6.1.2.22.2	Marshalling kiosks according to *VII-5 Technical Specification*	yes/no	yes	
6.1.2.23	**Tank mounted Surge Arrestors**			
6.1.2.23.1	**220 kV Surge Arrester and Discharge Counter**			
6.1.2.23.1.1	Manufacturer	-	-	
6.1.2.23.1.2	Place of manufacture	-	-	
6.1.2.23.1.3	Model designation	-	-	
6.1.2.23.1.4	Applicable standard	-	IEC 60071-1	
			IEC 60071-2	
			IEC 60099-4	
			IEC 60099-5	
			IEC 60529	
			IEC 60815	
6.1.2.23.1.5	Type	-	Outdoor, silicon-housed	
6.1.2.23.1.6	System data:			
6.1.2.23.1.7	• Nominal system voltage	kV	220	
6.1.2.23.1.8	• Highest system voltage	kV	245	
6.1.2.23.1.9	• System frequency	Hz	50	
6.1.2.23.1.10	Rated voltage U_r	kV	180	
6.1.2.23.1.11	Maximum continuous operating voltage U_c	kV	144	
6.1.2.23.1.12	Rated discharge current	kA	10 / 20 subject to calculation	
6.1.2.23.1.13	Thermal energy rating	kJ/kV	10	
6.1.2.23.1.14	Separate earthing rod per SA, 150 mm^2	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.1.2.23.1.15	Discharge Counter:			
6.1.2.23.1.16	Manufacturer	-		
6.1.2.23.1.17	Model designation	-		
6.1.2.23.1.18	Display	-		
6.1.2.23.1.19	Number of impulses	yes/no	yes	
6.1.2.23.1.20	Leakage current measurement, total current	yes/no	yes	
6.1.2.23.1.21	Protection class	-	IP55 W	
6.1.2.23.1.22	Number of counters per three (3) 1-ph arresters	-	3	
6.1.2.23.2	**132 kV Surge Arrester and Discharge Counter**			
6.1.2.23.2.1	Manufacturer	-	-	
6.1.2.23.2.2	Place of manufacture	-	-	
6.1.2.23.2.3	Model designation	-	-	
6.1.2.23.2.4	Applicable standard	-	IEC 60071-1	
			IEC 60071-2	
			IEC 60099-4	
			IEC 60099-5	
			IEC 60529	
			IEC 60815	
6.1.2.23.2.5	Type	-	Outdoor, silicon-housed	
6.1.2.23.2.6	System data:			
6.1.2.23.2.7	• Nominal system voltage	kV	132	
6.1.2.23.2.8	• Highest system voltage	kV	145	
6.1.2.23.2.9	• System frequency	Hz	50	
6.1.2.23.2.10	Rated voltage U_r	kV	108	
6.1.2.23.2.11	Maximum continuous operating voltage U_c	kV	86	
6.1.2.23.2.12	Rated discharge current	kA	10 / 20 subject to calculation	
6.1.2.23.2.13	Thermal energy rating	kJ/kV	10	
6.1.2.23.2.14	Separate earthing rod per SA, 150 mm^2	yes/no	yes	
6.1.2.23.2.15	Discharge Counter:			
6.1.2.23.2.16	Manufacturer	-		
6.1.2.23.2.17	Model designation	-		
6.1.2.23.2.18	Display	-		
6.1.2.23.2.19	Number of impulses	yes/no	yes	
6.1.2.23.2.20	Leakage current measurement, total current	yes/no	yes	
6.1.2.23.2.21	Protection class	-	IP 55 W	
6.1.2.23.2.22	Number of counters per three (3) 1-ph arresters	-	3	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.1.2.24	**Transformer Main dimensions**			
6.1.2.24.1	Total length x width x height	m		
6.1.2.24.2	Tank length x width x height	m		
6.1.2.24.3	Gross weight	kg		
6.1.2.24.4	Transport weight	kg		
6.1.2.24.5	Volume of oil	m^3		
6.1.2.24.6	Weight of oil	kg		
6.1.2.24.7	Max. admitted accelerations in XYZ-directions during transport	g		
6.1.2.25	**Tests**			
6.1.2.25.1	Tests according to *VII-5 Technical Specification*	yes/no	yes	
6.1.3	**Power Transformer 132/33 kV**			
6.1.3.1	**General Data**			
6.1.3.1.1	Manufacturer	-		
6.1.3.1.2	Place of manufacture	-		
6.1.3.1.3	Applicable standard	-	IEC 60076 etc., as per *VII-5 Technical Specifications*	
6.1.3.1.4	6 Sigma Quality Certification for Transformer Manufacturing Facilities	Yes/no	No	
6.1.3.1.5	Painting as per ISO 12944 C5-M	Yes/no	Yes	
6.1.3.1.6	Service altitude	m	<1000	
6.1.3.1.7	Ambient temperature (max.)	°C	50	
6.1.3.1.8	Type	-	Power Transformer three-Phase	
6.1.3.1.9	Rated voltage	kV	132/33	
6.1.3.1.10	Vector group	-	YNyn0+d	
6.1.3.1.11	Type of Cooling		ONAN/ONAF	
6.1.3.1.12	Type of insulation:	-	-	
6.1.3.1.13	• primary	-	Uniform	
6.1.3.1.14	• secondary		Uniform	
6.1.3.1.15	• tertiary	-	Uniform	
6.1.3.1.16	Location of use	-	outdoor	
6.1.3.1.17	Tank type	-	Upper flange	
6.1.3.1.18	Max noise level (LPA) - according to IEC 60076-10 - at a measuring distance of 2m with all forced cooling in operation	dB (A)	70	
6.1.3.1.19	Rated frequency	Hz	50	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.1.3.2	**Characteristics of magnetic circuit**			
6.1.3.2.1	Type	-	Core type	
6.1.3.2.2	Material	-	Cold rolled grain silicon steel	
6.1.3.2.3	Maximum flux density at rated voltage and frequency	T	≤1,65	
6.1.3.3	**Temperature rise**			
6.1.3.3.1	Top oil	K	50	
6.1.3.3.2	Average winding	K	55	
6.1.3.3.3	Hot spot winding	K	68	
6.1.3.4	**Rated power**			
6.1.3.4.1	• ONAN	MVA	24	
6.1.3.4.2	• ONAF	MVA	30	
6.1.3.5	**Rated withstand voltages for transformer windings**			
6.1.3.5.1	132 kV winding (U_m=145 kV):			
6.1.3.5.2	• Rated lightning impulse withstand voltage	kV_{peak}	650	
6.1.3.5.3	• Rated short-duration induced or separate source AC withstand voltage	kV_{rms}	275	
6.1.3.5.4	33 kV winding (U_m=36kV):			
6.1.3.5.5	• Rated lightning impulse withstand voltage	kV_{peak}	170	
6.1.3.5.6	• Rated short-duration induced or separate source AC withstand voltage	kV_{rms}	70	
6.1.3.5.7	Neutral 132 kV winding (U_m=52 kV):			
6.1.3.5.8	• Rated lightning impulse withstand voltage	kV_{peak}	N/A	
6.1.3.5.9	• Rated short-duration induced or separate source AC withstand voltage	kV_{rms}	N/A	
6.1.3.5.10	Neutral 33 kV winding (U_m=36 kV):			
6.1.3.5.11	• Rated lightning impulse withstand voltage	kV_{peak}	170	
6.1.3.5.12	• Rated short-duration induced or separate source AC withstand voltage	kV_{rms}	70	
6.1.3.6	**Short circuit level (3 s) of the system**			
6.1.3.6.1	• 132 kV level	kA	40	
6.1.3.6.2	• 33 kV level	kA	25	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.1.3.7	**Impedance voltage in % at 75°C winding temperatureat full loading, ONAF, on:**			
6.1.3.7.1	Nominal tap	%	10.5	
6.1.3.8	**Oil characteristics**			
6.1.3.8.1	Mineral oil standard	-	IEC 60296	
6.1.3.8.2	Corrosive Sulphur test		IEC 62535 ASTM D 1275 method B	
6.1.3.8.3	Dryness of the oil after on-site installation		Water Content ≤5ppm	
6.1.3.8.4	Inhibited	Yes / No		
6.1.3.8.5	Manufacturer	-		
6.1.3.8.6	Oil type	inhibited/		
6.1.3.8.7	Type designation	-		
6.1.3.8.8	Minimum flash point	°C	140	
6.1.3.8.9	Viscosity at 80°C	mm²/s		
6.1.3.8.10	Max. dielectric strength (1min.)	kV		
6.1.3.8.11	Total oil required	l		
6.1.3.8.12	Tests according to *VII-5 Technical Specifications*	yes/no	yes	
6.1.3.9	**Bushings**			
6.1.3.9.1	Applicable standard	-	IEC 60137	
6.1.3.10	**132 kV bushing**	-		
6.1.3.10.1	• Manufacturer			
6.1.3.10.2	• Place of manufacture	-		
6.1.3.10.3	Type of bushing	-	RIP or RIS	
6.1.3.10.4	Type of bushing insulator	-	silicon	
6.1.3.10.5	Type designation	-		
6.1.3.10.6	Highest rated voltage	kV	145	
6.1.3.10.7	Rated current	A	800	
6.1.3.10.8	Rated thermal short time current (3 s)	kA	40	
6.1.3.10.9	Rated dynamic current	kA	100	
6.1.3.10.10	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
6.1.3.10.11	Rated lightning impulse withstand voltage	kV_{peak}	650	
6.1.3.10.12	Power frequency withstand voltage (dry)	kV_{rms}	275	
6.1.3.11	**33 kV bushing**	-		
6.1.3.11.1	• Manufacturer			
6.1.3.11.2	• Place of manufacture	-		
6.1.3.11.4	Type of bushing insulator	-	porcelain	
6.1.3.11.5	Type designation	-		
6.1.3.11.6	Highest rated voltage	kV	36	
6.1.3.11.7	Rated current	A	800	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.1.3.11.8	Rated thermal short time current (3 s)	kA	40	
6.1.3.11.9	Rated dynamic current	kA	100	
6.1.3.11.10	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
6.1.3.11.11	Rated lightning impulse withstand voltage	kV_{peak}	170	
6.1.3.11.12	Power frequency withstand voltage (dry)	kV_{rms}	70	
6.1.3.12	**Neutral bushing 132 kV**	-		
6.1.3.12.1	Manufacturer			
6.1.3.12.2	Place of manufacture	-		
6.1.3.12.3	Type of bushing	-	RIP or RIS	
6.1.3.12.4	Type of bushing insulator	-	silicon	
6.1.3.12.5	Type designation	-		
6.1.3.12.6	Highest rated voltage	kV	52	
6.1.3.12.7	Rated current	A	800	
6.1.3.12.8	Rated thermal short time current (3 s)	kA	40	
6.1.3.12.9	Rated dynamic current	kA	100	
6.1.3.12.10	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
6.1.3.12.11	Rated lightning impulse withstand voltage	kV_{peak}	250	
6.1.3.12.12	Power frequency withstand voltage (dry)	kV_{rms}	95	
6.1.3.12.13	Minimum cantilever withstand load	N	500	
6.1.3.13	**Neutral bushing 33 kV**	-		
6.1.3.13.1	Manufacturer			
6.1.3.13.2	Place of manufacture	-		
6.1.3.13.3	Type of bushing insulator	-	porcelain	
6.1.3.13.4	Type designation	-		
6.1.3.13.5	Highest rated voltage	kV	36	
6.1.3.13.6	Rated current	A	800	
6.1.3.13.7	Rated thermal short time current (3 s)	kA	40	
6.1.3.13.8	Rated dynamic current	kA	100	
6.1.3.13.9	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
6.1.3.13.10	Rated lightning impulse withstand voltage	kV_{peak}	170	
6.1.3.13.11	Power frequency withstand voltage (dry)	kV_{rms}	70	
6.1.3.13.12	Minimum cantilever withstand load	N	500	
6.1.3.14	**Bushing current transformers**			
6.1.3.14.1	132 kV:			
6.1.3.14.2	• Ratio	A	150/300/1/1	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.1.3.14.3	• Core 1 burden and accuracy	-	5P20 30 VA	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.1.3.14.4	• Core 2 burden and accuracy	-	5P20 30 VA	
6.1.3.14.5	• Core 3 burden and accuracy	-	N/A	
6.1.3.14.6	33 kV:			
6.1.3.14.7	• Ratio	A	600/800/1	
6.1.3.14.8	• Core 1 burden and accuracy	-	5P20 30 VA	
6.1.3.14.9	• Core 2 burden and accuracy	-	5P20 30 VA	
6.1.3.14.10	• Core 3 burden and accuracy	-	N/A	
6.1.3.14.11	Neutral 132 kV side:			
6.1.3.14.12	• Ratio	A	150/300/1	
6.1.3.14.13	• Core 1 burden and accuracy	-	5P20 30 VA	
6.1.3.14.14	• Core 2 burden and accuracy	-	5P20 30 VA	
6.1.3.14.15	Neutral 33 kV side:			
6.1.3.14.16	• Ratio	A	600/800/1	
6.1.3.14.17	• Core 1 burden and accuracy	-	5P20 30 VA	
6.1.3.14.18	• Core 2 burden and accuracy	-	5P20 30 VA	
6.1.3.15	**Cooling system**			
6.1.3.15.1	Type of cooling	-	ONAN/ONAF	
6.1.3.15.2	Number of coolers	pcs		
6.1.3.15.3	Cooling operation	-	Auto/Manual	
6.1.3.15.4	Control voltage for cooling and heating	V AC	230	
6.1.3.15.5	Supply voltage of protective devices	V DC	220	
6.1.3.15.6	Supply voltage of fans and pumps	V AC	230/400	
6.1.3.15.7	Power demand of fans	kW		
6.1.3.15.8	Power demand of oil pumps	kW		
6.1.3.16	**No load current**			
6.1.3.16.1	No load current	%		
6.1.3.16.2	Magnetic flux density at rated voltage and frequency	Tesla	Max 1,65	
6.1.3.16.3	Core losses	W/kg	Max 1,05	
6.1.3.17	**Losses**			
6.1.3.17.1	No load losses at nominal voltage position	kW		
6.1.3.17.2	No load losses at lowest tap position	kW		
6.1.3.17.3	No load losses at highest tap position	kW		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.1.3.17.4	Load losses at nominal tap at ONAN:	kW		
6.1.3.17.5	Load losses at nominal tap at ONAF:	kW		
6.1.3.18	**OLTC (On-load tap-changer)**			
6.1.3.18.1	Manufacturer	-	MR Germany or ABB Sweden, or equivalent	
6.1.3.18.2	Type designation	-		
6.1.3.18.3	Applicable standard	-	IEC 60214-1	
6.1.3.18.4	Type	-	vacuum	
6.1.3.18.5	Tapping on 132 kV side	%	$\pm$ 8 x 1,25	
6.1.3.18.6	Rated through current	A	-	
6.1.3.18.7	Rated short-time current:			
6.1.3.18.8	maximum (peak)	kA	-	
6.1.3.18.9	3 seconds	kA	-	
6.1.3.18.10	Rated power frequency withstand voltage	kV_{rms}	-	
6.1.3.18.11	Rated lightning impulse withstand voltage	kV_{peak}	-	
6.1.3.18.12	Rated operations duty (min.)	-	600,000	
6.1.3.19	**Automatic Voltage Regulation**			
6.1.3.19.1	Manufacturer	-		
6.1.3.19.2	Type / designation			
6.1.3.19.3	Sensitivity	-%,+%	$\pm$ 0,4 to 6% of transformer voltage	
6.1.3.19.4	Response time	s	0-15 sec to 4 min. referred to 1% deviation from desired value	
6.1.3.19.5	Range of set point adjustment	% of Un	90 to 115% U_N	
6.1.3.19.6	Current-responsive rising	% of Un	0 to 16% U_N	
6.1.3.19.7	Limitation of current effect	% of Un	0 to 16% U_N	
6.1.3.19.8	Overvoltage U_{max}	% of Un	100 to 135% U_N	
6.1.3.19.9	Under voltage U_{min}.	% of Un	50 to 100% U_N	
6.1.3.19.10	Under/Overcurrent $I_{min/max}$	x In	60 to 120 I_N	
6.1.3.19.11	Line drop compensation		Yes	
6.1.3.19.12	Parallel operation with other transformer	-	Yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.1.3.20	**Neutral Treatment**			
6.1.3.20.1	Brought up to bushings and grounded	yes/no	yes	
6.1.3.20.2	Neutral surge arrester	yes/no	no	
6.1.3.20.3	Neutral disconnector	yes/no	no	
6.1.3.20.4	Neutral current transformer	yes/no	yes	
6.1.3.20.5	Solidly grounded	yes/no	yes	
6.1.3.21	**Accessories**			
6.1.3.21.1	Accessories according to *VII-5 Technical Specification*	yes/no	yes	
6.1.3.21.2	Online transformer condition monitoring system according to *VII-5 Technical Specification*	yes/no	no	
6.1.3.22	**Marshalling kiosks**			
6.1.3.22.1	Degree of protection	-	IP55	
6.1.3.22.2	Marshalling kiosks according to *VII-5 Technical Specification*	yes/no	yes	
6.1.3.23	**Tank mounted Surge Arrestors**			
6.1.3.23.1	**132 kV Surge Arrester and Discharge Counter**			
6.1.3.23.1.1	Manufacturer	-	-	
6.1.3.23.1.2	Place of manufacture	-	-	
6.1.3.23.1.3	Model designation	-	-	
6.1.3.23.1.4	Applicable standard	-	IEC 60071-1	
			IEC 60071-2	
			IEC 60099-4	
			IEC 60099-5	
			IEC 60529	
			IEC 60815	
6.1.3.23.1.5	Type	-	Outdoor, silicon-housed	
6.1.3.23.1.6	System data:			
6.1.3.23.1.7	• Nominal system voltage	kV	132	
6.1.3.23.1.8	• Highest system voltage	kV	145	
6.1.3.23.1.9	• System frequency	Hz	50	
6.1.3.23.1.10	Rated voltage U_r	kV	108	
6.1.3.23.1.11	Maximum continuous operating voltage U_c	kV	86	
6.1.3.23.1.12	Rated discharge current	kA	10 / 20 subject to calculation	
6.1.3.23.1.13	Thermal energy rating	kJ/kV	10	
6.1.3.23.1.14	Separate earthing rod per SA, 150 mm^2	yes/no	yes	
6.1.3.23.1.15	Discharge Counter:			
6.1.3.23.1.16	Manufacturer	-		
6.1.3.23.1.17	Model designation	-		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.1.3.23.1.18	Display	-		
6.1.3.23.1.19	Number of impulses	yes/no	yes	
6.1.3.23.1.20	Leakage current measurement, total current	yes/no	yes	
6.1.3.23.1.21	Protection class	-	IP 55 W	
6.1.3.23.1.22	Number of counters per three (3) 1-ph arresters	-	3	
6.1.3.23.2	**33 kV Surge Arrester**			
6.1.3.23.2.1	Manufacturer	-	-	
6.1.3.23.2.2	Place of manufacture	-	-	
6.1.3.23.2.3	Model designation	-	-	
6.1.3.23.2.4	Applicable standard	-	IEC 60071-1	
			IEC 60071-2	
			IEC 60099-4	
			IEC 60099-5	
			IEC 60529	
			IEC 60815	
6.1.3.23.2.5	Type	-	Outdoor, silicon-housed	
6.1.3.23.2.6	System data:			
6.1.3.23.2.7	• Nominal system voltage	kV	33	
6.1.3.23.2.8	• Highest system voltage	kV	36	
6.1.3.23.2.9	• System frequency	Hz	50	
6.1.3.23.2.10	Rated voltage U_r	kV	27	
6.1.3.23.2.11	Maximum continuous operating voltage U_c	kV	21	
6.1.3.23.2.12	Rated discharge current	kA	10 / 20 subject to calculation	
6.1.3.23.2.13	Thermal energy rating	kJ/kV	10	
6.1.3.24	**Transformer Main dimensions**			
6.1.3.24.1	Total length x width x height	m		
6.1.3.24.2	Tank length x width x height	m		
6.1.3.24.3	Gross weight	kg		
6.1.3.24.4	Transport weight	kg		
6.1.3.24.5	Volume of oil	m^3		
6.1.3.24.6	Weight of oil	kg		
6.1.3.24.7	Max. admitted accelerations in XYZ-directions during transport	g		
6.1.3.25	**Tests**			
6.1.3.25.1	Tests according to *VII-5 Technical Specification*	yes/no	yes	
6.1.4	**Power Transformer 33/11 kV**			
6.1.4.1	**General Data**			
6.1.4.1.1	Manufacturer	-		
6.1.4.1.2	Place of manufacture	-		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.1.4.1.3	Applicable standard	-	IEC 60076 etc., as per *VII-5 Technical Specifications*	
6.1.4.1.4	6 Sigma Quality Certification for Transformer Manufacturing Facilities	Yes/no	No	
6.1.4.1.5	Painting as per ISO 12944 C5-M	Yes/no	Yes	
6.1.4.1.6	Service altitude	m	<1000	
6.1.4.1.7	Ambient temperature (max.)	°C	50	
6.1.4.1.8	Type	-	Power Transformer three-Phase	
6.1.4.1.9	Rated voltage	kV	33/11	
6.1.4.1.10	Vector group	-	Dyn11	
6.1.4.1.11	Type of Cooling		ONAN/ONAF	
6.1.4.1.12	Type of insulation:	-	-	
6.1.4.1.13	• primary	-	Uniform	
6.1.4.1.14	• secondary		Uniform	
6.1.4.1.15	Location of use	-	outdoor	
6.1.4.1.16	Tank type	-	Upper flange	
6.1.4.1.17	Max noise level (LPA) - according to IEC 60076-10 - at a measuring distance of 2m with all forced cooling in operation	dB (A)	<69	
6.1.4.1.18	Rated frequency	Hz	50	
6.1.4.2	**Characteristics of magnetic circuit**			
6.1.4.2.1	Type	-	Core type	
6.1.4.2.2	Material	-	Cold rolled grain silicon steel	
6.1.4.2.3	Maximum flux density at rated voltage and frequency	T	≤1,65	
6.1.4.3	**Temperature rise**			
6.1.4.3.1	Top oil	K	50	
6.1.4.3.2	Average winding	K	55	
6.1.4.3.3	Hot spot winding	K	68	
6.1.4.4	**Rated power**			
6.1.4.4.1	• ONAN	MVA	6	
6.1.4.4.2	• ONAF	MVA	8	
6.1.4.5	**Rated withstand voltages for transformer windings**			
6.1.4.5.1	33 kV winding (U_m=36kV):			
6.1.4.5.2	• Rated lightning impulse withstand voltage	kV_{peak}	170	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.1.4.5.3	• Rated short-duration induced or separate source AC withstand voltage	kV_{rms}	70	
6.1.4.5.4	11 kV winding (U_m=12 kV):			
6.1.4.5.5	• Rated lightning impulse withstand voltage	kV_{peak}	75	
6.1.4.5.6	• Rated short-duration induced or separate source AC withstand voltage	kV_{rms}	28	
6.1.4.5.7	Neutral winding (U_m=11 kV):			
6.1.4.5.8	• Rated lightning impulse withstand voltage	kV_{peak}	75	
6.1.4.5.9	• Rated short-duration induced or separate source AC withstand voltage	kV_{rms}	28	
6.1.4.6	**Short circuit level (3 s) of the system**			
6.1.4.6.1	• 33 kV level	kA	25	
6.1.4.6.2	• 11 kV level	kA	-	
6.1.4.7	**Impedance voltage in % at 75°C winding temperature on middle tap position at full loading, ONAF**	%	6	
6.1.4.8	**Oil characteristics**			
6.1.4.8.1	Mineral oil standard	-	IEC 60296	
6.1.4.8.2	Corrosive Sulphur test		IEC 62535 ASTM D 1275 method B	
6.1.4.8.3	Dryness of the oil after on-site installation		Water Content ≤5ppm	
6.1.4.8.4	Inhibited	Yes / No		
6.1.4.8.5	Manufacturer	-		
6.1.4.8.6	Oil type	inhibited/		
6.1.4.8.7	Type designation	-		
6.1.4.8.8	Minimum flash point	°C	140	
6.1.4.8.9	Viscosity at 80°C	mm²/s		
6.1.4.8.10	Max. dielectric strength (1min.)	kV		
6.1.4.8.11	Total oil required	l		
6.1.4.8.12	Tests according to *VII-5 Technical Specifications*	yes/no	yes	
6.1.4.9	**Bushings**			
6.1.4.9.1	Applicable standard	-	IEC 60137	
6.1.4.10	**33 kV bushing**	-		
6.1.4.10.1	• Manufacturer			
6.1.4.10.2	• Place of manufacture	-		
6.1.4.11.3	Type of bushing insulator	-	porcelain	
6.1.4.10.3	Type designation	-		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.1.4.10.4	Highest rated voltage	kV	36	
6.1.4.10.5	Rated current	A	800	
6.1.4.10.6	Rated thermal short time current (3 s)	kA	40	
6.1.4.10.7	Rated dynamic current	kA	100	
6.1.4.10.8	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
6.1.4.10.9	Rated lightning impulse withstand voltage	kV_{peak}	170	
6.1.4.10.10	Power frequency withstand voltage (dry)	kV_{rms}	70	
6.1.4.11	**11 kV bushing**	-		
6.1.4.11.1	• Manufacturer			
6.1.4.11.2	• Place of manufacture	-		
6.1.4.11.3	Type of bushing insulator	-	porcelain	
6.1.4.11.4	Type designation	-		
6.1.4.11.5	Highest rated voltage	kV	12	
6.1.4.11.6	Rated current	A	800	
6.1.4.11.7	Rated thermal short time current (3 s)	kA	40	
6.1.4.11.8	Rated dynamic current	kA	100	
6.1.4.11.9	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
6.1.4.11.10	Rated lightning impulse withstand voltage	kV_{peak}	95	
6.1.4.11.11	Power frequency withstand voltage (dry)	kV_{rms}	28	
6.1.4.12	**Neutral bushing 11 kV**	-		
6.1.4.12.1	Manufacturer			
6.1.4.12.2	Place of manufacture	-		
6.1.4.12.3	Type of bushing insulator	-	porcelain	
6.1.4.12.4	Type designation	-		
6.1.4.12.5	Highest rated voltage	kV	12	
6.1.4.12.6	Rated current	A	800	
6.1.4.12.7	Rated thermal short time current (3 s)	kA	40	
6.1.4.12.8	Rated dynamic current	kA	100	
6.1.4.12.9	Minimum Unified Specific Creepage Distance (USCD)	mm/kV	43.3	
6.1.4.12.10	Rated lightning impulse withstand voltage	kV_{peak}	95	
6.1.4.12.11	Power frequency withstand voltage (dry)	kV_{rms}	28	
6.1.4.13	**Bushing current transformers**			
6.1.4.13.1	33 kV:			
6.1.4.13.2	• Ratio	A	150-300/1	
6.1.4.13.3	• Core 1 burden and accuracy	-	5P20 30 VA	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.1.4.13.4	• Core 2 burden and accuracy	-	5P20 30 VA	
6.1.4.13.5	• Core 3 burden and accuracy	-	N/A	
6.1.4.13.6	11 kV:			
6.1.4.13.7	• Ratio	A	450-900/1	
6.1.4.13.8	• Core 1 burden and accuracy	-	5P20 30 VA	
6.1.4.13.9	• Core 2 burden and accuracy	-	5P20 30 VA	
6.1.4.13.10	• Core 3 burden and accuracy	-	N/A	
6.1.4.13.11	Neutral 11 kV side:			
6.1.4.13.12	• Ratio	A	450-900/1	
6.1.4.13.13	• Core 1 burden and accuracy	-	5P20 30 VA	
6.1.4.13.14	• Core 2 burden and accuracy	-	5P20 30 VA	
6.1.4.14	**Cooling system**			
6.1.4.14.1	Type of cooling	-	ONAN/ONAF	
6.1.4.14.2	Number of coolers	pcs		
6.1.4.14.3	Cooling operation	-	Auto/Manual	
6.1.4.14.4	Control voltage for cooling and heating	V AC	230	
6.1.4.14.5	Supply voltage of protective devices	V DC	220	
6.1.4.14.6	Supply voltage of fans and pumps	V AC	230/400	
6.1.4.14.7	Power demand of fans	kW		
6.1.4.14.8	Power demand of oil pumps	kW		
6.1.4.15	**No load current**			
6.1.4.15.1	No load current	%		
6.1.4.15.2	Magnetic flux density at rated voltage and frequency	Tesla	≤1,65	
6.1.4.15.3	Core losses	W/kg	Max 1,05	
6.1.4.16	**Losses**			
6.1.4.16.1	No load losses at nominal voltage position	kW		
6.1.4.16.2	No load losses at lowest tap position	kW		
6.1.4.16.3	No load losses at highest tap position	kW		
6.1.4.16.4	Load losses at nominal tap at ONAN:	kW		
6.1.4.16.5	Load losses at nominal tap at ONAF:	kW		
6.1.4.17	**OLTC (On-load tap-changer)**			

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.1.4.17.1	Manufacturer	-	MR Germany or ABB Sweden, or equivalent	
6.1.4.17.2	Type designation	-		
6.1.4.17.3	Applicable standard	-	IEC 60214-1	
6.1.4.17.4	Type	-	vacuum	
6.1.4.17.5	Tapping on 132 kV side	%	$\pm$ 8 x 1,25	
6.1.4.17.6	Rated through current	A	-	
6.1.4.17.7	Rated short-time current:			
6.1.4.17.8	maximum (peak)	kA	-	
6.1.4.17.9	3 seconds	kA	-	
6.1.4.17.10	Rated power frequency withstand voltage	kV_{rms}	-	
6.1.4.17.11	Rated lightning impulse withstand voltage	kV_{peak}	-	
6.1.4.17.12	Rated operations duty (min.)	-	600,000	
6.1.4.18	**Automatic Voltage Regulation**			
6.1.4.18.1	Manufacturer	-		
6.1.4.18.2	Type / designation			
6.1.4.18.3	Sensitivity	-%,+%	± 0,4 to 6% of transformer voltage	
6.1.4.18.4	Response time	s	0-15 sec to 4 min. referred to 1% deviation from desired value	
6.1.4.18.5	Range of set point adjustment	% of Un	90 to 115% U_N	
6.1.4.18.6	Current-responsive rising	% of Un	0 to 16% U_N	
6.1.4.18.7	Limitation of current effect	% of Un	0 to 16% U_N	
6.1.4.18.8	Overvoltage U_{max}	% of Un	100 to 135% U_N	
6.1.4.18.9	Under voltage U_{min}.	% of Un	50 to 100% U_N	
6.1.4.18.10	Under/Overcurrent $I_{min/max}$	x In	60 to 120 I_N	
6.1.4.18.11	Line drop compensation		Yes	
6.1.4.18.12	Parallel operation with other transformer	-	Yes	
6.1.4.19	**Neutral Treatment**			
6.1.4.19.1	Brought up to bushings and grounded	yes/no	yes	
6.1.4.19.2	Neutral surge arrester	yes/no	no	
6.1.4.19.3	Neutral disconnector	yes/no	no	
6.1.4.19.4	Neutral current transformer	yes/no	yes	
6.1.4.19.5	Solidly grounded	yes/no	yes	
6.1.4.20	**Accessories**			
6.1.4.20.1	Accessories according to *VII-5 Technical Specification*	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.1.4.20.2	Online transformer condition monitoring system according to *VII-5 Technical Specification*	yes/no	no	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.1.4.21	**Marshalling kiosks**			
6.1.4.21.1	Degree of protection	-	IP55	
6.1.4.21.2	Marshalling kiosks according to *VII-5 Technical Specification*	yes/no	yes	
6.1.4.22	**Tank mounted Surge Arrestors**			
6.1.4.22.1	**33 kV Surge Arrester**			
6.1.4.22.1.1	Manufacturer	-	-	
6.1.4.22.1.2	Place of manufacture	-	-	
6.1.4.22.1.3	Model designation	-	-	
6.1.4.22.1.4	Applicable standard	-	IEC 60071-1	
			IEC 60071-2	
			IEC 60099-4	
			IEC 60099-5	
			IEC 60529	
			IEC 60815	
6.1.4.22.1.5	Type	-	Outdoor, silicon-housed	
6.1.4.22.1.6	System data:			
6.1.4.22.1.7	• Nominal system voltage	kV	33	
6.1.4.22.1.8	• Highest system voltage	kV	36	
6.1.4.22.1.9	• System frequency	Hz	50	
6.1.4.22.1.10	Rated voltage U_r	kV	27	
6.1.4.22.1.11	Maximum continuous operating voltage U_c	kV	21	
6.1.4.22.1.12	Rated discharge current	kA	10 / 20 subject to calculation	
6.1.4.22.1.13	Thermal energy rating	kJ/kV	10	
6.1.4.22.2	**11 kV Surge Arrester**			
6.1.4.22.2.1	Manufacturer	-	-	
6.1.4.22.2.2	Place of manufacture	-	-	
6.1.4.22.2.3	Model designation	-	-	
6.1.4.22.2.4	Applicable standard	-	IEC 60071-1	
			IEC 60071-2	
			IEC 60099-4	
			IEC 60099-5	
			IEC 60529	
			IEC 60815	
6.1.4.22.2.5	Type	-	Outdoor, silicon-housed	
6.1.4.22.2.6	System data:			
6.1.4.22.2.7	• Nominal system voltage	kV	11	
6.1.4.22.2.8	• Highest system voltage	kV	12	
6.1.4.22.2.9	• System frequency	Hz	50	
6.1.4.22.2.10	Rated voltage U_r	kV	9	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.1.4.22.2.11	Maximum continuous operating voltage U_c	kV	7.2	
6.1.4.22.2.12	Rated discharge current	kA	10 / 20 subject to calculation	
6.1.4.22.2.13	Thermal energy rating	kJ/kV	10	
6.1.4.23	**TransformerMain dimensions**			
6.1.4.23.1	Total length x width x height	m		
6.1.4.23.2	Tank length x width x height	m		
6.1.4.23.3	Gross weight	kg		
6.1.4.23.4	Transport weight	kg		
6.1.4.23.5	Volume of oil	m^3		
6.1.4.23.6	Weight of oil	kg		
6.1.4.23.7	Max. admitted accelerations in XYZ-directions during transport	g		
6.1.4.24	**Tests**			
6.1.4.24.1	Tests according to *VII-5 Technical Specification*	yes/no	yes	
6.2	**Auxiliary Transformers**			
6.2.1	**Auxiliary Transformer 33/0.4 kV for Damauli**			
6.2.1.1	**General Data**			
6.2.1.1.1	Manufacturer	-		
6.2.1.1.2	Place of manufacture	-		
6.2.1.1.3	Applicable standard	-	IEC 60076 etc., as per *VII-5 Technical Specification*	
6.2.1.1.4	Service altitude:	m	<1000	
6.2.1.1.5	Ambient temperature	°C	50	
6.2.1.1.6	Transformer winding configuration	-	2-winding	
6.2.1.1.7	Nominal voltage	kV	33/0,4	
6.2.1.1.8	Rated maximum voltage	kV		
6.2.1.1.9	Type of insulation	-	3-phase oil immersed, uniform	
6.2.1.1.10	Location of use	-	outdoor	
6.2.1.1.11	Tank type	-	Upper flange	
6.2.1.1.12	Vector group	-	Dyn11	
6.2.1.1.13	Type of cooling	-	ONAN	
6.2.1.1.14	Construction Type	-	hermetically sealed	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.2.1.1.15	Max noise level (LPA) - according to IEC 60076-10 - at a measuring distance of 2m with all forced cooling in operation	dB (A)	60	
6.2.1.1.16	Rated frequency	Hz	50	
6.2.1.1.17	Rated power:	kVA	1250	
6.2.1.2	**Characteristics of magnetic circuit**			
6.2.1.2.1	Type	-	Core type	
6.2.1.2.2	Material	-	Cold rolled grain silicon steel	
6.2.1.2.3	Maximum flux density at rated voltage and frequency	T	≤1,65	
6.2.1.3	**Temperature rise**			
6.2.1.2.3	Top oil:	K	50	
6.2.1.2.4	Average winding:	K	55	
6.2.1.2.5	Hot spot winding:	K	68	
6.2.1.3	**Rated withstand voltages for transformer windings**			
6.2.1.3.1	33 kV winding (U_m=36 kV):			
6.2.1.3.2	• Rated lightning impulse withstand voltage	kV_{peak}	170	
6.2.1.3.3	• Rated short-duration induced or separate source AC withstand voltage	kV_{rms}	70	
6.2.1.3.4	0.4 kV winding:			
6.2.1.3.5	Power frequency withstand voltage	kV_{rms}	1,1	
6.2.1.4	**Rated nominal current**			
6.2.1.4.1	Rated nominal current MV	A		
	Rated nominal current LV	A		
6.2.1.5	**Impedance voltage in % at 75°C winding temperature at full loading**			
6.2.1.5.1	MV-LV	%	6	
6.2.1.6	**Off load tap changer**			
6.2.1.6.1	Voltage ratio and taps	%	+/-2 x 2,5%	
6.2.1.6.2	Installation	-	on the MV winding	
6.2.1.6.3	Dial type indicator for the selected tap position	yes/no	yes	
6.2.1.7	**Accessories**			
6.2.1.7.1	Accessories according to the Tender Documents	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
6.2.1.8	**No load current**			
6.2.1.8.1	No load current	%		
6.2.1.8.2	Magnetic flux density at rated voltage and frequency	Tesla	Max 1,65	
6.2.1.8.3	Core losses	W/kg	Max 1,05	
6.2.1.9	**Losses**			
6.2.1.9.1	No load losses at nominal voltage position	kW		
6.2.1.9.2	Load losses at nominal tap at ONAN:	kW		
6.2.1.10	**Tank mounted Surge 33 kV Arrestors**			
6.2.1.10.1	Manufacturer	-	-	
6.2.1.10.2	Place of manufacture	-	-	
6.2.1.10.3	Model designation	-	-	
6.2.1.10.4	Applicable standard	-	IEC 60071-1	
			IEC 60071-2	
			IEC 60099-4	
			IEC 60099-5	
			IEC 60529	
			IEC 60815	
6.2.1.10.5	Type	-	Outdoor, silicon-housed	
6.2.1.10.6	System data:			
6.2.1.10.7	• Nominal system voltage	kV	33	
6.2.1.10.8	• Highest system voltage	kV	36	
6.2.1.10.9	• System frequency	Hz	50	
6.2.1.10.10	Rated voltage U_r	kV	27	
6.2.1.10.11	Maximum continuous operating voltage U_c	kV	21	
6.2.1.10.12	Rated discharge current	kA	10 / 20 subject to calculation	
6.2.1.10.13	Thermal energy rating	kJ/kV	10	
6.2.1.11	**Transformer Main dimensions**			
6.2.1.11.1	Total length x width x height	m		
6.2.1.11.2	Gross weight	kg		
6.2.1.11.3	Volume of oil	m^3		
6.2.1.11.4	Weight of oil	kg		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.2.1.12	**Tests**			
6.2.1.12.1	Tests according to *VII-5 Technical Specification*	yes/no	yes	
6.2.2	**Earthing Auxiliary Transformer 33/0.4 kV for Lekhnath**			
6.2.2.1	**General Data**			
6.2.2.1.1	Manufacturer	-		
6.2.2.1.2	Place of manufacture	-		
6.2.2.1.3	Applicable standard	-	IEC 60076 etc., as per *VII-5 Technical Specification*	
6.2.2.1.4	Service altitude:	m	<1000	
6.2.2.1.5	Ambient temperature	°C	40	
6.2.2.1.6	Transformer winding configuration	-	2-winding	
6.2.2.1.7	Nominal voltage	kV	33/0,4	
6.2.2.1.8	Rated maximum voltage	kV		
6.2.2.1.9	Type of insulation	-	3-phase oil immersed, uniform	
6.2.2.1.10	Location of use	-	outdoor	
6.2.2.1.11	Tank type	-	Upper flange	
6.2.2.1.12	Vector group	-	ZNyn11	
6.2.2.1.13	Type of cooling	-	ONAN	
6.2.2.1.14	Construction Type	-	hermetically sealed	
6.2.2.1.15	Max noise level (LPA) - according to IEC 60076-10 - at a measuring distance of 2m with all forced cooling in operation	dB (A)	60	
6.2.2.1.16	Rated frequency	Hz	50	
6.2.2.1.17	Rated power:	kVA	630	
6.2.2.2	**Characteristics of magnetic circuit**			
6.2.2.2.1	Type	-	Core type	
6.2.2.2.2	Material	-	Cold rolled grain silicon steel	
6.2.2.2.3	Maximum flux density at rated voltage and frequency	T	≤1,65	
6.2.2.3	**Temperature rise**			
6.2.2.2.3	Top oil:	K	60	
6.2.2.2.4	Average winding:	K	65	
6.2.2.2.5	Hot spot winding:	K	78	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.2.2.3	**Rated withstand voltages for transformer windings**			
6.2.2.3.1	33 kV winding (U_m=36 kV):			
6.2.2.3.2	• Rated lightning impulse withstand voltage	kV_{peak}	170	
6.2.2.3.3	• Rated short-duration induced or separate source AC withstand voltage	kV_{rms}	70	
6.2.2.3.4	0.4 kV winding:			
6.2.2.3.5	Power frequency withstand voltage	kV_{rms}	1,1	
6.2.2.4	**Rated nominal current**			
6.2.2.4.1	Rated nominal current MV	A		
	Rated nominal current LV	A		
6.2.2.5	**Impedance voltage in % at 75°C winding temperature at full loading**			
6.2.2.5.1	MV-LV	%	6	
6.2.2.5.2	Zero sequence current primary side	A	300	
6.2.2.5.3	Zero sequence impedance primay side	Ohm		
6.2.2.6	**Off load tap changer**			
6.2.2.6.1	Voltage ratio and taps	%	+/-2 x 2,5%	
6.2.2.6.2	Installation	-	on the MV winding	
6.2.2.6.3	Dial type indicator for the selected tap position	yes/no	yes	
6.2.2.7	**Accessories**			
6.2.2.7.1	Accessories according to the Tender Documents	yes/no	yes	
6.2.2.8	**No load current**			
6.2.2.8.1	No load current	%		
6.2.2.8.2	Magnetic flux density at rated voltage and frequency	Tesla	Max 1,65	
6.2.2.8.3	Core losses	W/kg	Max 1,05	
6.2.2.9	**Losses**			
6.2.2.9.1	No load losses at nominal voltage position	kW		
6.2.2.9.2	Load losses at nominal tap at ONAN:	kW		
6.2.2.10	**Bushing current transformers**			
6.2.2.10.1	Neutral 33 kV side:			
6.2.2.10.2	• Ratio	A	300/1	
6.2.2.10.3	• Core 1 burden and accuracy	-	5P20 30 VA	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
6.2.2.11	**Tank mounted Surge 33 kV Arrestors**			
6.2.2.11.1	Manufacturer	-	-	
6.2.2.11.2	Place of manufacture	-	-	
6.2.2.11.3	Model designation	-	-	
6.2.2.11.4	Applicable standard	-	IEC 60071-1	
			IEC 60071-2	
			IEC 60099-4	
			IEC 60099-5	
			IEC 60529	
			IEC 60815	
6.2.2.11.5	Type	-	Outdoor, silicon-housed	
6.2.2.11.6	System data:			
6.2.2.11.7	• Nominal system voltage	kV	33	
6.2.2.11.8	• Highest system voltage	kV	36	
6.2.2.11.9	• System frequency	Hz	50	
6.2.2.11.10	Rated voltage U_r	kV	27	
6.2.2.11.11	Maximum continuous operating voltage U_c	kV	21	
6.2.2.11.12	Rated discharge current	kA	10 / 20 subject to calculation	
6.2.2.11.13	Thermal energy rating	kJ/kV	10	
6.2.2.12	**Transformer Main dimensions**			
6.2.2.12.1	Total length x width x height	m		
6.2.2.12.2	Gross weight	kg		
6.2.2.12.3	Volume of oil	m^3		
6.2.2.12.4	Weight of oil	kg		
6.2.2.13	**Tests**			
6.2.2.13.1	Tests according to *VII-5 Technical Specification*	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
7	**AC & DC Installations**			
7.1	**LV AC Main Switchgear**			
7.1.1	**General data**			
7.1.1.1	Manufacturer	-		
7.1.1.2	Place of manufacture	-		
7.1.1.3	Model designation	-		
7.1.1.4	Applicable standard	-	IEC 61439, IEC 60947 etc. as per *Employer's Requirements*	
7.1.1.5	Internal separation Incomer / Buscouplers	-	Form 4b	
7.1.1.6	Internal separation outgoing feeders	-	Form 3b	
7.1.1.7	Location of installation	-	indoor	
7.1.1.8	Number of phases	-	3+N+PE	
7.1.1.9	Number of busbars	-	1	
7.1.1.10	Nominal voltage	kV	0.4	
7.1.1.11	Rated voltage	kV	1	
7.1.1.12	Rated frequency	Hz	50	
7.1.1.13	Rated power frequency withstand voltage	kV_{rms}	1.1	
7.1.1.14	Rated lightning impulse withstand voltage (1.2/50 µs)	kV_{peak}	3.3	
7.1.1.15	Rated current (Lekhnath / Damauli)	A	≥1000 / ≥2000	
7.1.1.16	Rated short-time current, 3 s (Lekhnath / Damauli)	kA	≥25 / ≥31.5	
7.1.1.17	Rated peak withstand current (Lekhnath / Damauli)	kA	≥62.5 / ≥78.75	
7.1.1.18	Power supply for auxiliary contacts	V DC	220	
7.1.1.19	Power supply for heaters	V AC	230	
7.1.1.20	Degree of Protection	-	IP54	
7.1.1.21	Instruments and accessories in accordance with the *Employer's Requirements*	yes/no	yes	
7.1.2	**Circuit breaker for incomers and buscoupler**			
7.1.2.1	Manufacturer	-		
7.1.2.2	Place of manufacture	-		
7.1.2.3	Model designation	-		
7.1.2.4	Type	-	Air circuit breaker (ACB)	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
7.1.2.5	Type of drive	-	Spring, motor & manual charging	
7.1.2.6	Power supply for drive	V AC	230	
7.1.2.7	Integrated protection	yes/no	yes	
7.1.2.8	Interface to SCADA	yes/no	yes	
7.1.3	**Outgoing feeders**			
7.1.3.1	Manufacturer	-		
7.1.3.2	Place of manufacture	-		
7.1.3.3	Model designation	-		
7.1.3.4	Type	-	MCCB	
7.1.3.5	Operation	-	manual	
7.1.3.6	Auxilairy contacts	yes/no	yes	
7.1.4	**Current transformers**			
7.1.4.1	Rated primary current:			
7.1.4.2	Aux transformer feeder incomers	A	≥1000 / ≥2000	
7.1.4.3	Diesel generator Set feeder incomer			
7.1.4.4	Lekhnath	A	150	
7.1.4.5	Damauli	A	250	
7.1.4.6	Secondary currents	A	1	
7.1.4.7	Number of secondary windings	-	2	
7.1.4.8	Accuracy class	-	10 VA Cl. 0,5	
7.1.3	**Voltage transformer**			
7.1.3.1	Rated primary voltage	V	400/√3	
7.1.3.2	Secondary voltage	V	110/√3	
7.1.3.3	Number of secondary windings	-	1	
7.1.3.4	Accuracy class	-	20VACl. 0,5	
7.1.4	**Automatic Transfer device**			
7.1.4.1	Manufacturer	-		
7.1.4.2	Type	-		
7.1.4.3	Function display	yes/no	yes	
7.1.4.4	Programmable	yes/no	yes	
7.1.4.5	Local/remote switch	yes/no	yes	
7.1.4.6	Operation via display and SCADA	yes/no	yes	
7.1.4.7	Trigger circuit supervision	yes/no	yes	
7.1.4.8	Measurement of operation values (U/I/f.)	yes/no	yes	
7.1.5	**Main dimensions**			
7.1.5.1	Number of individual panels	-		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
7.1.5.2	Dimensions of the individual panels L x W x H	mm		
7.1.5.3	Weight of the individual panels	kg		
7.1.6	**Tests**			
7.1.6.1	Tests as per the relevant standards and Employer's Requirements	yes/no	yes	
7.2	**LV AC Distribution Panels**			
7.2.1	**General data**			
7.2.1.1	Manufacturer	-		
7.2.1.2	Place of manufacture	-		
7.2.1.3	Model designation	-		
7.2.1.4	Applicable standard	-	IEC 61439, IEC 60947 etc. as per *Employer's Requirements*	
7.2.1.5	Internal separation	-	Form 2b	
7.2.1.6	Location of installation	-	indoor	
7.2.1.7	Number of phases	-	3+N+PE	
7.2.1.8	Number of busbars	-	1	
7.2.1.9	Nominal voltage	kV	0.4	
7.2.1.10	Rated voltage	kV	1	
7.2.1.11	Rated frequency	Hz	50	
7.2.1.12	Rated power frequency withstand voltage	kV_{rms}	1.1	
7.2.1.13	Rated lightning impulse withstand voltage (1.2/50 µs)	kV_{peak}	3.3	
7.2.1.14	Rated short-time current, 1 s	kA	25	
7.2.1.15	Rated peak withstand current	kA	62.5	
7.2.1.16	Rated current	A	160	
7.2.1.17	Degree of Protection	-	IP54	
7.2.1.18	Instruments and accessories as per the Employer's Requirements	yes/no	yes	
7.2.2	**Automatic Transfer device**			
7.2.2.1	Manufacturer	-		
7.2.2.2	Type	-		
7.2.2.3	Function display	yes/no	yes	
7.2.2.4	Programmable	yes/no	yes	
7.2.2.5	Local/remote switch	yes/no	yes	
7.2.2.6	Operation via MMD and SCADA	yes/no	yes	
7.2.2.7	Trigger circuit supervision	yes/no	yes	
7.2.2.8	Measurement of operation values (U/I/f.)	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
7.2.3	**Main dimensions**			
7.2.3.1	Number of individual panels	-		
7.2.3.2	Dimensions of the individual panels L x W x H	mm		
7.2.3.3	Weight of the individual panels	kg		
7.2.4	**Tests**			
7.2.4.1	Tests as per the relevant standards and Employer's Requirements	yes/no	yes	
7.3	**Main 220 V DC Switchgear**			
7.3.1	**General data**			
7.3.1.1	Manufacturer	-		
7.3.1.2	Place of manufacture	-		
7.3.1.3	Model designation	-		
7.3.1.4	Applicable standard	-	IEC 61439, IEC 60947 etc. as per *Employer's Requirements*	
7.3.1.5	Internal separation outgoing feeders	-	Form 2b	
7.3.1.6	Location of installation	-	indoor	
7.3.1.7	Number of phases	-	L+/L-	
7.3.1.8	Number of busbars	-	1	
7.3.1.9	Nominal voltage	V DC	220	
7.3.1.10	Rated power frequency withstand voltage	kV rms	1.1	
7.3.1.11	Rated short-time current, 3s	kA	3.3	
7.3.1.12	Rated peak withstand current	kA		
7.3.1.13	Rated current for busbar	A		
7.3.1.14	Power supply for heaters	VAC	230	
7.3.1.15	Insulation resistance	MΩ	0.5	
7.3.1.16	Degree of protection	-	IP54	
7.3.1.17	Instruments and accessories in accordance with the *Employer's Requirements*	yes/no	yes	
7.3.2	**Main dimensions**			
7.3.2.1	Number of individual panels	-		
7.3.2.2	Dimensions of the individual panels L x W x H	mm		
7.3.2.3	Weight of the individual panels	kg		
7.3.3	**Tests**			
7.3.3.1	Tests as per the relevant standards and Employer's Requirements	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
7.4	**220V DC Battery Charger**			
7.4.1	Manufacturer	-		
7.4.2	Place of manufacture	-		
7.4.3	Applicable standard	-	IEC 60146	
7.4.4	Location of installation	-	indoor	
7.4.5	Type of controls	-	thyristor control	
7.4.6	Type of cooling	-	self-ventilating	
7.4.7	Rated voltage primary	V	400	
7.4.8	Rated voltage secondary	V DC	220±10%	
7.4.9	Rated current	A		
7.4.10	Rated capacity	kVA		
7.4.11	IP protection	IP	43	
7.4.12	Mounted in metal cabinet	-	yes	
7.4.13	Charging characteristics:			
7.4.14	- Constant voltage range	V		
7.4.15	- Continuous charging voltage per cell and tolerances	V +/-		
7.4.16	- Residual ripple (without connected battery)	%	< 5 % rms	
7.4.17	- Voltage stability with both rectifiers connected to the load	%	+/-1,5	
7.4.18	Noise level	dB (A)		
7.4.19	Blocking diodes in the output circuit of each rectifier	yes/no	yes	
7.4.20	Main dimensions L x W x H	mm		
7.4.21	Weight	kg		
7.4.22	Tests as per the relevant standards and Employer's Requirements	yes/no	yes	
7.5	**220V DC Batteries**			
7.5.1	Applicable standard	-	IEC 60623, IEC 62259, IEC 62485-1, IEC 62485-2	
7.5.2	Manufacturer	-		
7.5.3	Place of manufacture	-		
7.5.4	Type	-	valve-regulated Ni-Cd	
7.5.5	Nominal voltage per cell	V DC		
7.5.6	Number of cells	-	102	
7.5.7	Nominal voltage of the battery	V DC	220	
7.5.8	Minimum capacity	Ah	600	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
7.5.9	Capacity corresponding to a discharge time of	h	10	
7.5.10	Suitable for float and boost charging	yes/no	yes	
7.5.11	Operating lifetime	years	20	
7.5.12	Installed on corrosion resistant rack	yes/no	yes	
7.5.13	Set of maintenance tools	yes/no	yes	
7.5.14	Dimensions of the battery rack L x W x H	mm		
7.5.15	Weight of the battery	kg		
7.5.16	Accessories as per the Employer's Requirements	yes/no	yes	
7.6	**Main 48 V DC Switchgear**			
7.6.1	**General data**			
7.6.1.1	Manufacturer	-		
7.6.1.2	Place of manufacture	-		
7.6.1.3	Model designation	-		
7.6.1.4	Applicable standard	-	IEC 61439, IEC 60947 etc. as per *Employer's Requirements*	
7.6.1.5	Internal separation outgoing feeders	-	Form 2b	
7.6.1.6	Location of installation	-	indoor	
7.6.1.7	Number of phases	-	L+/L-	
7.6.1.8	Number of busbars	-	1	
7.6.1.9	Nominal voltage	V DC	48	
7.6.1.10	Rated power frequency withstand voltage	kV rms	1.1	
7.6.1.11	Rated short-time current, 3s	kA	3.3	
7.6.1.12	Rated peak withstand current	kA		
7.6.1.13	Rated current for busbar	A		
7.6.1.14	Power supply for heaters	VAC	230	
7.6.1.15	Insulation resistance	MΩ	0.5	
7.6.1.16	Degree of protection	-	IP54	
7.6.1.17	Instruments and accessories in accordance with the *Employer's Requirements*	yes/no	yes	
7.6.2	**Main dimensions**			
7.6.2.1	Number of individual panels	-		
7.6.2.2	Dimensions of the individual panels L x W x H	mm		
7.6.2.3	Weight of the individual panels	kg		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
7.6.3	**Tests**			
7.6.3.1	Tests as per the relevant standards and Employer's Requirements	yes/no	yes	
7.7	**48V DC Battery Charger**			
7.7.1	Manufacturer	-		
7.7.2	Place of manufacture	-		
7.7.3	Applicable standard	-	IEC 60146	
7.7.4	Location of installation	-	indoor	
7.7.5	Type of controls	-	thyristor control	
7.7.6	Type of cooling	-	self-ventilating	
7.7.7	Rated voltage primary	V	400	
7.7.8	Rated voltage secondary	V DC	48±10%	
7.7.9	Rated current	A		
7.7.10	Rated capacity	kVA		
7.7.11	IP protection	IP	43	
7.7.12	Mounted in metal cabinet	-	yes	
7.7.13	Charging characteristics:			
7.7.14	- Constant voltage range	V		
7.7.15	- Continuous charging voltage per cell and tolerances	V +/-		
7.7.16	- Residual ripple (without connected battery)	%	< 5 % rms	
7.7.17	- Voltage stability with both rectifiers connected to the load	%	+/-1,5	
7.7.18	Noise level	dB (A)		
7.7.19	Blocking diodes in the output circuit of each rectifier	yes/no	yes	
7.7.20	Main dimensions L x W x H	mm		
7.7.21	Weight	kg		
7.7.22	Tests as per the relevant standards and Employer's Requirements	yes/no	yes	
7.8	**48 DC Batteries**			
7.8.1	Applicable standard	-	IEC 60623, IEC 62259, IEC 62485-1, IEC 62485-2	
7.8.2	Manufacturer	-		
7.8.3	Place of manufacture	-		
7.8.4	Type	-	valve-regulated Ni-Cd	
7.8.5	Nominal voltage per cell	V DC		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
7.8.6	Number of cells	-	22	
7.8.7	Nominal voltage of the battery	V DC	48	
7.8.8	Minimum capacity	Ah	150	
7.8.9	Capacity corresponding to a discharge time of	h	10	
7.8.10	Suitable for float and boost charging	yes/no	yes	
7.8.11	Operating lifetime	years	20	
7.8.12	Installed on corrosion resistant rack	yes/no	yes	
7.8.13	Set of maintenance tools	yes/no	yes	
7.8.14	Dimensions of the battery rack L x W x H	mm		
7.8.15	Weight of the battery	kg		
7.8.16	Accessories as per the Employer's Requirements	yes/no	yes	
7.9	**AC UPS Inverter**			
7.9.1	**General data**	-	-	
7.9.1.1	Applicable standard	-	IEC 62040	
7.9.1.2	Manufacturer	-		
7.9.1.3	Place of manufacture	-		
7.9.1.4	Type	-		
7.9.1.5	Rated output power at cos phi =0,8 ind	kVA		
7.9.1.6	Rated supply voltage	V DC	220	
7.9.1.7	Rated output voltage	V AC	230	
7.9.1.8	Voltage control:	%		
7.9.1.9	- static	%	< +/- 1	
7.9.1.10	- dynamic with 100 % load change	Hz	<5	
7.9.1.11	Frequency	Hz	50	
7.9.1.12	Frequency stability (mains synchronized)	%	+/- 0,05	
7.9.1.13	Frequency tolerance self synchronized		+/- 0,1	
7.9.1.14	Overload capability		125 % - 10 min 150 % - 60 sec	
7.9.1.15	Short circuit capability		300% 3s	
7.9.1.16	Maximum heat loss at rated load	W	-	
7.9.1.17	Acoustic level on 100 % load	dB(A)	< 65 (in 1m)	
7.9.1.18	Efficiency at 100 % load, cos phi 0.8	%	> 90	
7.9.1.19	Total Harmonic Distortion of Current (THDI):			

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
7.9.1.20	- linear load	%	<1	
7.9.1.21	- non linear load	%	<5	
7.9.1.22	Static transfer switch	yes / no	yes	
7.9.1.23	Manual bypass switch	yes / no	yes	
7.9.1.24	Network card	yes / no	yes	
7.9.1.25	Interfaces:			
7.9.1.26	RS-232, RJ 45, ModBus	yes / no	yes	
7.9.1.27	Relay cards for operating and fail messages	yes / no	yes	
7.9.1.28	Main dimensions L x W x H	mm		
7.9.1.29	Weight	kg		
7.9.1.30	Tests as per the relevant standards and Employer's Requirements	yes/no	yes	
7.10	**Emergency diesel generator**			
7.10.1	**General**			
7.10.1.1	Manufacturer	-	-	
7.10.1.2	Type	-	-	
7.10.1.3	Standard	-	ISO 8528	
7.10.1.4	Performance class	-	G3	
7.10.1.5	Power rating category	-	standby	
7.10.1.6	Single and parallel opertaion with other generating sets and with mains	yes/no	no	
7.10.1.7	Rated output at guarantee site conditions			
7.10.1.8	Lekhnath	kW/kVA	50/63,5	
7.10.1.9	Damauli	kW	100/120	
7.10.1.10	Rated speed (max.)	rpm	-	
7.10.1.11	Cooling system	-	water-cooled with closed circuit radiator and fan	
7.10.1.12	Starting mode	-	automatic	
7.10.1.13	Start-up time	sec.	max. 10	
7.10.1.14	Starter	-	battery fed electric starter motor	
7.10.1.15	Type of fuel	-	HSD	
7.10.1.16	Fuel consumption at rated load	-	-	
7.10.1.17	Lekhnath	l/h	-	
7.10.1.18	Damauli	l/h	-	
7.10.1.19	Capacity of fuel oil day tank	-	-	
7.10.1.20	Lekhnath	l	-	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
7.10.1.21	Damauli	l	-	
7.10.1.22	Containerised unit	(yes/no)	yes	
7.10.1.23	Sound pressure level (7m)	-	-	
7.10.1.17	Lekhnath	dB(A)	68	
7.10.1.18	Damauli	dB(A)	70	
7.10.1.24	Main dimension (HxWxD)	-	-	
7.10.1.26	Lekhnath	mm		
7.10.1.27	Damauli	mm		
7.10.1.25	Weight	-	-	
7.10.1.26	Lekhnath	kg		
7.10.1.27	Damauli	kg		
7.10.2	**Generator**			
7.10.2.1	Manufacturer	-		
7.10.2.2	Type	-		
7.10.2.3	Standard	-	IEC 60034-22	
7.10.2.4	Apparent power at guarantee site conditions measured at generator terminals			
7.10.2.5	Lekhnath	kVA	50	
7.10.2.6	Damauli	kVA	100	
7.10.2.7	Power factor	-	0.8	
7.10.2.8	Generator cooling system	-	air	
7.10.2.9	Frequency	Hz	50	
7.10.2.10	Terminals	-	L1, L2, L3 & N	
7.10.2.11	Voltage	V	400/230	
7.10.2.12	Type of system earthing	-	TN-S	
7.10.2.13	Voltage regulator	-	AVR with a range of ±10%	
7.10.2.14	Protection class of generator	-	min. IP44	
7.10.2.15	Insulation class of generator and exciter	-	F	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
8.	**Control & Protection System**			
8.1	**General Requirements**			
8.1.1	**General**			
8.1.1.1	Maximum ambient temperature for rated accuracy	°C	IEC 60255-1 –10°C ... +55°C	
8.1.1.2	Maximum storage temperature	°C	IEC 60255-1 -40°C….+70°C	
8.1.1.3	Maximum temp. influence on setting values	%/°C	0.02	
8.1.1.4	Maximum humidity	%	IEC 60255-1 0-95%	
8.1.1.5	Radiated electromagnetic field	-	IEC 60255-26, Class III	
8.1.1.6	Conducted field disturbance	-	IEC 60255-26 10V 80MHz	
8.1.1.7	Radiated emissions	-	IEC 60255-26 30-1000MHz	
8.1.1.8	Conducted emissions	-	IEC 60255-26 0,15-30 MHz	
8.1.1.9	Insulation tests	-	IEC 60255-27 2 kV 50 Hz, 1 min 2,8 kV DC. 1 min >100M0hm 0,5kV DC	
8.1.1.10	HV Impulse test	-	IEC 60255-27 test voltage 5 kV	
8.1.1.11	Slow damped oscillator wave immunity		IEC 60255-26 Level 3	
8.1.1.12	Electrostatic discharge immunity	-	IEC 60255-26 Cl. 3	
8.1.1.13	Fast transients / Burst immunity / Surge immunity	-	IEC 60255-26 Zone A	
8.1.1.14	Power freq. magnetic field test	-	IEC 60255-26 cl. V	
8.1.1.15	Enclosure	-	IEC 60529, IP 50	
8.1.1.16	Mechanical tests (vibration, shock, bump, seismic)	-	IEC 60255-21-1,2,3 Class 1	
8.1.2	**Auxiliary Supply**			
8.1.2.1	DC supply rated voltage *	V	220 V DC (+10% ... -20%)	
	* Existing Lekhnath Substation	V	110 V DC (+10% ... -20%)	
8.1.2.2	DC supply ripple	%	2% ref. value 10% nom. range	
8.1.3	**Analogue Input**	-		
8.1.3.1	VT phase secondary voltage	V	110/ √3	
8.1.3.2	Frequency range	Hz	50 (-5%...+5%)	
8.1.3.3	Frequency dependency of operating value (each protection function or groups)	%/Hz	<1	
8.1.3.4	Dependency of main protection functions operation from harmonic distortion (2,3,5th, 10% or 20% from fundamental)	%	<5	
8.1.3.5	Voltage withstand			

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
8.1.3.6	- permanent	x U_N	2	
8.1.3.7	- 10 sec (operative range)	x U_N	4	
8.1.3.8	Secondary current	A	1	
8.1.3.9	Current withstand (valid for test plugs also)			
8.1.3.10	- permanent	I_N	4	
8.1.3.11	- 1 sec (operative range)	I_N	100	
8.1.3.12	AC burdens			
8.1.3.13	- current circuit	VA(phase	<0,15	
8.1.3.14	- voltage circuit	VA/phase	<0,15	
8.1.4	**Binary Inputs**			
8.1.4.1	Number	-	16	
8.1.4.2	Max DC voltage	V		
8.1.4.3	Pulse discrimination	Hz		
8.1.5	**Binary Output**			
8.1.5.1	For indication or trip	-	IEC 61810-2 min. 16	
8.1.5.2	- max. service voltage	V DC		
8.1.5.3	- max. making current (1s)	A	10	
8.1.5.4	- continuous current	A	5	
8.1.5.5	- making current at rated V DC	A	10	
8.1.5.6	For fast tripping (reed)			
8.1.5.7	- Number	-	4	
8.1.5.8	- max. service voltage	V DC		
8.1.5.9	- max. making current	A	0,4 A	
8.1.5.10	- continuous current	A		
8.1.5.11	- making power at rated V DC	W		
8.1.5.12	- breaking power at rated V DC L/R < 40 ms	W		
8.1.6	**Cubicles**			
8.1.6.1	Protection class	-	IP54	
8.1.6.2	Pre-wired	yes/no	yes	
8.1.6.3	Floor-mounted	yes/no	yes	
8.1.6.4	Steel sheet thickness	mm		
8.1.6.5	Maximum height	mm		
8.1.6.6	Maximum width	mm		
8.1.6.7	Maximum depth	mm		
8.1.6.8	Front-door material	-	glass	
8.1.6.9	Coloring	-		
8.1.6.10	Ventilation	-	forced	
8.2	**Transformer Differential Protection - Main 1 and Main 2**			
8.2.1	**Transformer Differential Protection (87)**	-		
8.2.1.1	Manufacturer	-	Bidder to declare	
8.2.1.2	Place of manufacture	-	Bidder to declare	
8.2.1.3	Type / complete designation/ software / firmware version	-	Bidder to declare	
8.2.1.4	Type	-	Biased, dual slope	
8.2.1.5	Ratings			
8.2.1.6	Range of operating coil settings	% of C.T. rating	1 to 10%	
8.2.1.7	Number of windings	-	3	
8.2.1.8	Operating time	ms	20	
8.2.1.9	Range of bias settings	% of C.T. rating	0,05 to 200	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
8.2.1.10	Minimum sensitivity:			
8.2.1.11	- earth faults	% of C.T. rating		
8.2.1.12	- phase faults	% of C.T. rating		
8.2.2	**Restricted Earth Fault Protection (87N)**			
8.2.2.1	- Type	-	low impedance	
8.2.2.2	- Tripping current range	x IN		
8.2.2.3	- Tripping time range	ms		
8.2.2.4	- Trip criteria	-	2	
8.2.3	**Distance Protection (21)**			
8.2.3.1	Number of independent impedance measuring loops	-	6	
8.2.3.2	Ranges of positive sequence phase reactance setting	Ohm/ph		
8.2.3.3	Ranges of zero sequence reactance setting	Ohm/ph		
8.2.3.4	Ranges of positive sequence phase resistance setting	Ohm/ph		
8.2.3.5	Ranges of zero sequence resistance setting	Ohm/ph		
8.2.3.6	Ranges of timers for all zones	ms	0-50000	
8.2.3.7	Number of independent impedance zones	-	4	
8.2.3.8	Type of trip characteristic	-	quadrilateral phase and E/F	
8.2.3.9	- teleprotection features		Yes	
8.2.3.10	- type of characteristic of teleprotection	-	PUTT, POTT	
8.2.3.11	- minimum number of auto-reclose cycles (AR-cycles)	-	3	
8.2.3.12	- fault locator and event (disturbance) recorder	-	Yes	
8.2.3.13	Remote communication			
8.2.3.14	- protocol	-	IEC 61850	
8.2.3.15	- transmission rate	Kbaud	2048	
8.2.3.16	Selectable trip direction	-	for each zone	
8.2.3.17	Trip mode	-	1/3- phase	
8.2.3.18	Directional sensitivity	-	unlimited	
8.2.3.19	Phase Current sensitivity	x In	0,05-0,3	
8.2.3.20	Earth Fault Current sensitivity	x In	0,05-0,3	
8.2.3.21	Separate adjustment of dead times for 1-ph and multi-phase cycles	yes/no	yes	
8.2.3.22	Setting range of zero sequence compensation factor :			
8.2.3.23	- amplitude	Ohm		
8.2.3.24	- angle	degree		
8.2.3.25	Typical tripping time	ms	25	
8.2.3.26	Reset time	ms	30	
8.2.3.27	Typical reset ratio	%	105	
8.2.3.28	Signaling modes	-	permissive, blocking, intertrip	
8.2.3.29	Load encroachment criteria	-	2	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
8.2.4	**Directional Phase Overcurrent (67)**			
8.2.4.1	Number of time-current stages	-	2	
8.2.4.2	Signaling to remote end	-	permissive, blocking for all stages	
8.2.4.3	Current setting range	x I_N	0,1…40	
8.2.4.4	Measuring accuracy	%	1,5	
8.2.4.5	Reset ratio	-		
8.2.4.6	Directional element:			
8.2.4.7	- measuring angle	degrees	-179…+180	
8.2.4.8	- min operating current	x I_N	0.01	
8.2.4.9	- min operating voltage	x U_N	0.01	
8.2.4.10	- pick-up time	ms	30	
8.2.5	**Overcurrent Protection (50/51, 50N/51N)**			
8.2.5.1	Current setting range (from-to)	X I_N	0,10 – 35,00	
8.2.5.2	Measuring accuracy	%	1,5 % for <10In 5% for >10In	
8.2.5.3	Reset ratio	-	>0,95	
8.2.5.4	Trip characteristics	s	IEC, IEEE, user defined	
8.2.5.5	Start time	ms	30	
8.2.5.6	Minimum number of DMT stages for 50/51	-	2	
8.2.5.7	Minimum number of IDMT stages for 50	-	2	
8.2.5.8	Minimum number of DMT stages for 50N/51N	-	2	
8.2.5.9	Minimum number of IDMT stages for 50N	-	2	
8.2.5.10	Measurement Mode	-	RMS, peak-to-peak, DFT	
8.2.5.11	Suppression of harmonics	-	RMS, Peak no suppression, DFT < -30dB	
8.2.6	**Overexcitation protection (V/Hz)**			
8.2.6.1	- Number of stages	-	2	
8.2.6.2	- Trip characteristics	-	DMT, IDMT, user defined	
8.2.6.3	- Accuracy	%	1.5	
8.2.6.4	- Start time	ms	25	
8.2.6.5	- Reset ratio	-	0.95	
8.2.7	**Breaker failure protection (50BF)**			
8.2.7.1	Settings			
8.2.7.2	- ranges of current flow monitoring	A	0,05 – 20,00	
8.2.7.3	- ranges of times	s	0,00 – 30,00	
8.2.8	**Trip Circuit Supervision**			
8.2.8.1	- Continuous supervision of complete trip circuit independent of CB position		Yes for all trip circuits	
8.2.8.2	- Operation indication and output contacts for remote alarm		Yes	
8.2.9	**Power swing blocking (for all zones)**	yes/no	yes	
8.2.10	**Load unbalance protection (46)**			
8.2.10.1	Settings			
8.2.10.2	- setting range current stage 1	A	0,10 – 35,00	
8.2.10.3	- setting range current stage 2	A	0,10 - 35,00	
8.2.10.4	- setting range time delay stage 1	sec	0,00 – 30,00	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
4.2.10.5	- setting range time delay stage 2	sec	0,00 – 30,00	
8.2.11	**Overload protection (49)**			
8.2.11.1	- k-factor		0,1 – 4,0	
8.2.11.2	- time constant	min	1,0 – 999,0	
8.2.12	**Switch-on to fault**	yes/no	yes	
8.2.13	**Binary Inputs Transformer protection**	yes/no	yes	
8.2.14	**Fault Recorder**	yes/no	yes	
8.2.15	**Measurement Functions**	yes/no	yes	
8.2.15.1	3-ph voltage	yes/no	yes	
8.2.15.2	3-ph current	yes/no	yes	
8.2.15.3	Residual current	yes/no	yes	
8.2.15.4	Sequence current	yes/no	yes	
8.2.15.5	Sequence voltage	yes/no	yes	
8.2.15.6	3-ph power	yes/no	yes	
8.2.15.7	Energy monitoring	yes/no	yes	
8.3	**Busbar differential protection (87BB) - Main 1 and Main 2**			
8.3.1	**Busbar differential protection (87BB)**			
8.3.1.1	Type	-		
8.3.1.2	Manufacturer	-		
8.3.1.3	Place of manufacture	-		
8.3.1.4	- Centralized/decentralized	-	decentralized or centralized (ref. to scope)	
8.3.1.5	- Type	-	biased low impedance	
8.3.1.6	- Number of zones	-	4	
8.3.1.7	- Typical operating time	ms	15	
8.3.1.8	- Accuracy	%pick-up	5	
8.3.1.9	- Trip criteria	-	min 2	
8.3.1.10	Settings			
8.3.1.11	- ranges of values of restrained protection	I/I_{nO}	0,05 – 2,00	
8.3.1.12	- ranges of values of unrestrained protection	I/I_{nO}	0,5 – 35,00	
8.3.1.13	- ranges of times	sec	0,00 – 30,00	
8.3.1.14	CT supervision	-	yes	
8.3.1.15	Stub function	-	yes	
8.3.1.16	- Saturation detector	yes/no	yes	
8.3.1.17	- Dead zone protection	yes/no	yes	
8.3.1.18	- Earth fault sensitivity enhancement	yes/no	yes	
8.3.1.19	DC burden	W		
8.3.1.20	AC burden	Ohm		
8.3.1.21	Remote communication			
8.3.1.22	- protocol	-	IEC 61850	
8.3.1.23	- transmission rate	Kbaud	2048	
8.3.2	**Breaker failure protection (50BF)**			
8.3.2.1	Settings			
8.3.2.2	- ranges of current flow monitoring	A	0,05 – 20,00	
8.3.2.3	- ranges of times	s	0,00 – 30,00	
8.3.2.4	- Number of stages	-	2	
8.3.2.5	- External trip	yes/no	yes	
8.3.2.6	- Protection trip pulse length	s	0,05 -2	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
8.3.4	**End fault Protection (50EF)**	yes/no	yes	
8.3.5	**Trip Circuit Supervision**			
8.3.5.1	- Continuous supervision of complete trip circuit independent of CB position		Yes for all trip circuits	
8.3.5.2	- Operation indication and output contacts for remote alarm		Yes	
8.3.6	**Fault Locator (FL)**			
8.3.6.1	Principle	-	impedance based or travelling wave	
8.3.6.2	Measurement in the AR cycle		required	
8.3.6.3	Accuracy of measurement for fault currents	(% of line length)	<2,5%	
8.4	**Multifunctional Protection Terminal for 220 kV OHL Feeders**			
8.4.1	**Main 1 - Line Current Differential (87L)**			
8.4.1.1	**Line Current Differential (87L)**			
8.4.1.1.1	Manufacturer	-	Bidder to declare	
8.4.1.1.2	Place of manufacture	-	Bidder to declare	
8.4.1.1.3	Type / complete designation/ software / firmware version	-	Bidder to declare	
8.4.1.1.4	Communication			
8.4.1.1.5	Setting ranges			
8.4.1.1.6	- minimum operating current	x I_{BASE}	0,1-2,0	
8.4.1.1.7	- slope sections	-	min 2	
8.4.1.1.8	- biased operation	x I_{BASE}	0,1-10,0	
8.4.1.1.9	- unrestrained operation	x I_{BASE}	1,0-50,0	
8.4.1.1.10	Second harmonic blocking	-	Required	
8.4.1.1.11	Fifth harmonic blocking	-	Required	
8.4.1.1.12	Operate time (typical)	ms	20	
8.4.1.1.13	Reset time	ms	15	
8.4.1.1.14	Critical impulse time	ms	2	
8.4.1.1.15	Trip mode	-	1-/3 pole	
8.4.1.1.16	Minimum number of auto-reclose cycles (AR-cycles)	-	3	
8.4.1.1.17	Fault locator and event (disturbance) recorder	-	Required	
8.4.1.1.18	Remote communication protocol	-	IEC 61850	
8.4.1.1.19	Remote communication transmission rate	Kbaud	2048	
8.4.1.1.20	Charging current compensation	-	Required	
8.4.1.1.21	Charging current comparison	-	Required	
8.4.1.1.22	Weak end intertrip	-	Required	
8.4.1.1.23	Direct intertrip from binary input	-	Required	
8.4.1.1.24	Time delay	-	IDMT and DT	
8.4.1.1.25	Communication delay compensation	-	describe method	
8.4.1.1.26	In-zone reactor	-	required	
8.4.1.2	**Distance Protection (21)**			
8.4.1.2.1	Manufacturer	-	Bidder to declare	
8.4.1.2.2	Place of manufacture	-	Bidder to declare	
8.4.1.2.3	Type / complete designation/ software / firmware version	-	Bidder to declare	
8.4.1.2.4	Number of independent impedance measuring loops	-	6	
8.4.1.2.5	Ranges of positive sequence phase reactance setting	Ohm/ph		
8.4.1.2.6	Ranges of zero sequence reactance setting	Ohm/ph		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
8.4.1.2.7	Ranges of positive sequence phase resistance setting	Ohm/ph		
8.4.1.2.8	Ranges of zero sequence resistance setting	Ohm/ph		
8.4.1.2.9	Ranges of timers for all zones	ms	0-50000	
8.4.1.2.10	Number of independent impedance zones	-	4	
8.4.1.2.11	Type of trip characteristic	-	quadrilateral phase and E/F	
8.4.1.2.12	- teleprotection features		Yes	
8.4.1.2.13	- type of characteristic of teleprotection	-	PUTT, POTT	
8.4.1.2.14	- minimum number of auto-reclose cycles (AR-cycles)	-	3	
8.4.1.2.15	- fault locator and event (disturbance) recorder	-	Yes	
8.4.1.2.16	Remote communication			
8.4.1.2.17	- protocol	-	IEC 61850	
8.4.1.2.18	- transmission rate	Kbaud	2048	
8.4.1.2.19	Selectable trip direction	-	for each zone	
8.4.1.2.20	Trip mode	-	1/3- phase	
8.4.1.2.21	Directional sensitivity	-	unlimited	
8.4.1.2.22	Phase Current sensitivity	x In	0,05-0,3	
8.4.1.2.23	Earth Fault Current sensitivity	x In	0,05-0,3	
8.4.1.2.24	Separate adjustment of dead times for 1-ph and multi-phase cycles	yes/no	yes	
8.4.1.2.25	Setting range of zero sequence compensation factor :			
8.4.1.2.26	- amplitude	Ohm		
8.4.1.2.27	- angle	degree		
8.4.1.2.28	Typical tripping time	ms	25	
8.4.1.2.29	Reset time	ms	30	
8.4.1.2.30	Typical reset ratio	%	105	
8.4.1.2.31	Signaling modes	-	permissive, blocking, intertrip	
8.4.1.2.32	Load encroachment criteria	-	2	
8.4.1.2.33	Power swing blocking (for all zones)	yes/no	yes	
8.4.1.2.34	Switch-on to fault	yes/no	yes	
8.4.1.2.35	Fuse failure blocking	yes/no	yes	
8.4.1.2.36	Out of step tripping	yes/no	yes	
8.4.1.3	**Overcurrent Protection (50/51, 50N/51N)**			
8.4.1.3.1	Current setting range (from-to)	X I_N	0,10 – 35,00	
8.4.1.3.2	Measuring accuracy	%	1,5 % for <10In 5% for >10In	
8.4.1.3.3	Reset ratio	-	>0,95	
8.4.1.3.4	Trip characteristics	s	IEC, IEEE, user defined	
8.4.1.3.5	Start time	ms	30	
8.4.1.3.6	Minimum number of DTL stages for 50/51	-	2	
8.4.1.3.7	Minimum number of IDMT stages for 50/51	-	2	
8.4.1.3.8	Minimum number of DTL stages for 50N/51N	-	2	
8.4.1.3.9	Minimum number of IDMT stages for 50N/51N	-	2	
8.4.1.3.10	Measurement Mode	-	RMS, peak-to-peak, DFT	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
8.4.1.3.11	Suppression of harmonics	-	RMS, Peak no suppression, DFT < -30dB	
8.4.1.4	**Power swing blocking (for all zones)**	yes/no	yes	
8.4.1.5	**Directional Earth Fault (67N)**			
8.4.1.5.1	Number of time-current stages	-	2	
8.4.1.5.2	Signaling to remote end	-	permissive, blocking for all stages	
8.4.1.5.3	Current setting range (earth fault)	x I_N	0,1…40	
8.4.1.5.4	Measuring accuracy	%		
8.4.1.5.5	Reset ratio	-		
8.4.1.5.6	Settings			
8.4.1.5.7	- ranges of times	sec	0,00 – 30,00	
8.4.1.5.8	- ranges of voltage values	V	0.10 – 120	
8.4.1.5.9	- minimum number of DTL stages for 67	-	2	
8.4.1.5.10	- minimum number of IDMT stages for 67	-	2	
8.4.1.5.11	- minimum number of DTL stages for 67N	-	2	
8.4.1.5.12	- minimum number of IDMT stages for 67N	-	2	
8.4.1.5.13	- teleprotection features	-	Yes	
8.4.1.5.14	- trip mode	-	1-/3 pole	
8.4.1.5.15	Remote communication protocol	-	IEC 61850	
8.4.1.5.16	Remote communication transmission rate	Kbaud	2048	
8.4.1.5.17	Directional element:			
8.4.1.5.18	- measuring angle	degrees	-179…+180	
8.4.1.5.19	- min operating current	x I_N	0.01	
8.4.1.5.20	- min operating voltage	x U_N	0.01	
8.4.1.5.21	- pick-up time	ms	<30	
8.4.1.6	**Directional Phase Overcurrent (67)**			
8.4.1.6.1	Number of time-current stages	-	2	
8.4.1.6.2	Signaling to remote end	-	permissive, blocking for all stages	
8.4.1.6.3	Current setting range	x I_N	0,1…40	
8.4.1.6.4	Measuring accuracy	%		
8.4.1.6.5	Reset ratio	-		
8.4.1.6.6	Directional element:			
8.4.1.6.7	- measuring angle	degrees	-179…+180	
8.4.1.6.8	- min operating current	x I_N	0.01	
8.4.1.6.9	- min operating voltage	x U_N	0.01	
8.4.1.6.10	- pick-up time	ms	30	
8.4.1.7	**Out of step Protection**	yes/no	yes	
8.4.1.8	**Load unbalance protection (46)**			
8.4.1.8.1	Settings			
8.4.1.8.2	- setting range current stage 1	A	0,10 – 35,00	
8.4.1.8.3	- setting range current stage 2	A	0,10 - 35,00	
8.4.1.8.4	- setting range time delay stage 1	sec	0,00 – 30,00	
8.4.1.8.5	- setting range time delay stage 2	sec	0,00 – 30,00	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
8.4.1.9	**Auto-reclosing (79)**			
8.4.1.9.1	Number of shots	-	3	
8.4.1.9.2	Single -phase cycle	-	3	
8.4.1.9.3	Three-phase cycle	-	3	
8.4.1.9.4	Dead time for 3-phase cycle	s		
8.4.1.9.5	Reclaim time	s		
8.4.1.9.6	Type		1-pole, 3-pole or 1-/3-pole	
8.4.1.9.7	Settings			
8.4.1.9.8	- ranges of times	s	0,01 – 30,00	
8.4.1.10	**Synchrocheck (25)**			
8.4.1.10.1	Operation modes	-	DLDB, DBDL, Synch, Override	
8.4.1.10.2	Voltage setting	V		
8.4.1.10.3	∆U measurement	V	1…60	
8.4.1.10.4	∆φ measurement	degree	2…80	
8.4.1.11	**Breaker failure protection (50BF)**			
8.4.1.11.1	Settings			
8.4.1.11.2	- ranges of current flow monitoring	A	0,05 – 20,00	
8.4.1.11.3	- ranges of times	s	0,00 – 30,00	
8.4.1.12	**Switch-on to fault**	yes/no	yes	
8.4.1.13	**Trip Circuit Supervision**			
8.4.1.13.1	- Continuous supervision of complete trip circuit independent of CB position		Yes for all trip circuits	
8.4.1.13.2	- Operation indication and output contacts for remote alarm		Yes	
8.4.1.14	**Fault Locator (FL)**			
8.4.1.14.1	Measurement Principle	-	impedance based or travelling wave	
8.4.1.14.2	Measurement in the AR cycle		required	
8.4.1.14.3	Accuracy of measurement for fault currents	(% of line length)	<2,5%	
8.4.1.15	**Measurement Functions**			
8.4.1.15.1	3-ph voltage		yes	
8.4.1.15.2	3-ph current		yes	
8.4.1.15.3	Residual current		yes	
8.4.1.15.4	Sequence current		yes	
8.4.1.15.5	Sequence voltage		yes	
8.4.1.15.6	3-ph power		yes	
8.4.1.15.7	Energy monitoring		yes	
8.4.1.16	**Fault Recorder**	yes/no	yes	
8.4.2	**Main 2**			
8.4.2.1	**Distance Protection (21)**			
8.4.2.1.1	Manufacturer	-	Bidder to declare	
8.4.2.1.2	Place of manufacture	-	Bidder to declare	
8.4.2.1.3	Type / complete designation/ software / firmware version	-	Bidder to declare	
8.4.2.1.4	Number of independent impedance measuring loops	-	6	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
8.4.2.1.5	Ranges of positive sequence phase reactance setting	Ohm/ph		
8.4.2.1.6	Ranges of zero sequence reactance setting	Ohm/ph		
8.4.2.1.7	Ranges of positive sequence phase resistance setting	Ohm/ph		
8.4.2.1.8	Ranges of zero sequence resistance setting	Ohm/ph		
8.4.2.1.9	Ranges of timers for all zones	s	min 0-50	
8.4.2.1.10	Number of independent impedance zones	-	4	
8.4.2.1.11	Type of trip characteristic	-	quadrilateral phase and E/F	
8.4.2.1.12	- teleprotection features		Yes	
8.4.2.1.13	- type of characteristic of teleprotection	-	PUTT, POTT	
8.4.2.1.14	- minimum number of auto-reclose cycles (AR-cycles)	-	3	
8.4.2.1.15	- fault locator and event (disturbance) recorder	-	Yes	
8.4.2.1.16	Remote communication			
8.4.2.1.17	- protocol	-	IEC 61850	
8.4.2.1.18	- transmission rate	Kbaud	2048	
8.4.2.1.19	Selectable trip direction	-	for each zone	
8.4.2.1.20	Trip mode	-	1/3- phase	
8.4.2.1.21	Directional sensitivity	-	unlimited	
8.4.2.1.22	Phase Current sensitivity	x In	0,05-0,3	
8.4.2.1.23	Earth Fault Current sensitivity	x In	0,05-0,3	
8.4.2.1.24	Separate adjustment of dead times for 1-ph and multi-phase cycles	yes/no	yes	
8.4.2.1.25	Setting range of zero sequence compensation factor :			
8.4.2.1.26	- amplitude	Ohm		
8.4.2.1.27	- angle	degree		
8.4.2.1.28	Typical tripping time	ms	25	
8.4.2.1.29	Reset time	ms	30	
8.4.2.1.30	Typical reset ratio	%	105	
8.4.2.1.31	Signaling modes	-	permissive, blocking, intertrip	
8.4.2.1.32	Load encroachment criteria	-	2	
8.4.2.1.33	Power swing blocking (for all zones)	yes/no	yes	
8.4.2.1.34	Switch-on to fault	yes/no	yes	
8.4.2.1.35	Fuse failure blocking	yes/no	yes	
8.4.2.1.36	Out of step tripping	yes/no	yes	
8.4.2.2	**Overcurrent Protection (50/51, 50N/51N)**			
8.4.2.2.1	Current setting range (from-to)	X I_N	0,10 – 35,00	
8.4.2.2.2	Measuring accuracy	%	1,5 % for <10In 5% for >10In	
8.4.2.2.3	Reset ratio	-	>0,95	
8.4.2.2.4	Trip characteristics	s	IEC, IEEE, user defined	
8.4.2.2.5	Start time	ms	30	
8.4.2.2.6	Minimum number of DTL stages for 50/51	-	2	
8.4.2.2.7	Minimum number of IDMT stages for 50/51	-	2	
8.4.2.2.8	Minimum number of DTL stages for 50N/51N	-	2	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
8.4.2.2.9	Minimum number of IDMT stages for 50N/51N	-	2	
8.4.2.2.10	Measurement Mode	-	RMS, peak-to-peak, DFT	
8.4.2.2.11	Suppression of harmonics	-	RMS, Peak no suppression, DFT < -30dB	
8.4.2.3	**Directional Earth Fault (67N)**			
8.4.2.3.1	Number of time-current stages	-	2	
8.4.2.3.2	Signaling to remote end	-	permissive, blocking for all stages	
8.4.2.3.3	Current setting range (earth fault)	x I_N	0,1…40	
8.4.2.3.4	Measuring accuracy	%		
8.4.2.3.5	Reset ratio	-		
8.4.2.3.6	Settings			
8.4.2.3.7	- ranges of times	sec	0,00 – 30,00	
8.4.2.3.8	- ranges of voltage values	V	0,10 – 120	
8.4.2.3.9	- minimum number of DTL stages for 67	-	2	
8.4.2.3.10	- minimum number of IDMT stages for 67	-	2	
8.4.2.3.11	- minimum number of DTL stages for 67N	-	2	
8.4.2.3.12	- minimum number of IDMT stages for 67N	-	2	
8.4.2.3.13	- teleprotection features	-	Yes	
8.4.2.3.14	- trip mode	-	1-/3 pole	
8.4.2.3.15	Remote communication protocol	-	IEC 61850	
8.4.2.3.16	Remote communication transmission rate	Kbaud	2048	
8.4.2.3.17	Directional element:			
8.4.2.3.18	- measuring angle	degrees	-179…+180	
8.4.2.3.19	- min operating current	x I_N	0.01	
8.4.2.3.20	- min operating voltage	x U_N	0.01	
8.4.2.3.21	- pick-up time	ms	<30	
8.4.2.4	**Directional Phase Overcurrent (67)**			
8.4.2.4.1	Number of time-current stages	-	2	
8.4.2.4.2	Signaling to remote end	-	permissive, blocking for all stages	
8.4.2.4.3	Current setting range	x I_N	0,1…40	
8.4.2.4.4	Measuring accuracy	%		
8.4.2.4.5	Reset ratio	-		
8.4.2.4.6	Directional element:			
8.4.2.4.7	- measuring angle	degrees	-179…+180	
8.4.2.4.8	- min operating current	x I_N	0.01	
8.4.2.4.9	- min operating voltage	x U_N	0.01	
8.4.2.4.10	- pick-up time	ms	30	
8.4.2.5	**Synchrocheck (25)**			
8.4.2.5.1	Operation modes	-	DLDB, DBDL, Synch, Override	
8.4.2.5.2	Voltage setting	V		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
8.4.2.5.3	∆U measurement	V	1…60	
8.4.2.5.4	∆φ measurement	degree	2…80	
8.4.2.6	**Breaker failure protection (50BF)**			
8.4.2.6.1	Settings			
8.4.2.6.2	- ranges of current flow monitoring	A	0,05 – 20,00	
8.4.2.6.3	- ranges of times	s	0,00 – 30,00	
8.4.2.7	**Switch-on to fault**	yes/no	yes	
8.4.2.8	**Trip Circuit Supervision**			
8.4.2.8.1	- Continuous supervision of complete trip circuit independent of CB position		Yes for all trip circuits	
8.4.2.8.2	- Operation indication and output contacts for remote alarm		Yes	
8.4.2.9	**Fault Locator (FL)**			
8.4.2.9.1	Principle	-	impedance based or travelling wave	
8.4.2.9.2	Measurement in the AR cycle		required	
8.4.2.9.3	Accuracy of measurement for fault currents	(% of line length)	<2,5%	
8.4.2.10	**Measurement Functions**			
8.4.2.10.1	3-ph voltage		yes	
8.4.2.10.2	3-ph current		yes	
8.4.2.10.3	Residual current		yes	
8.4.2.10.4	Sequence current		yes	
8.4.2.10.5	Sequence voltage		yes	
8.4.2.10.6	3-ph power		yes	
8.4.2.10.7	Energy monitoring		yes	
8.5	**Multifunctional Protection Terminal for 132 kV OHL Feeders**			
8.5.1	**Distance Protection (21)**			
8.5.1.1	Manufacturer	-	Bidder to declare	
8.5.1.2	Place of manufacture	-	Bidder to declare	
8.5.1.3	Type / complete designation/ software / firmware version	-	Bidder to declare	
8.5.1.4	Number of independent impedance measuring loops	-	6	
8.5.1.5	Ranges of positive sequence phase reactance setting	Ohm/ph		
8.5.1.6	Ranges of zero sequence reactance setting	Ohm/ph		
8.5.1.7	Ranges of positive sequence phase resistance setting	Ohm/ph		
8.5.1.8	Ranges of zero sequence resistance setting	Ohm/ph		
8.5.1.9	Ranges of timers for all zones	s	min 0-50	
8.5.1.10	Number of independent impedance zones	-	4	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
8.5.1.11	Type of trip characteristic	-	quadrilateral phase and E/F	
8.5.1.12	- teleprotection features		Yes	
8.5.1.13	- type of characteristic of teleprotection	-	PUTT, POTT	
8.5.1.14	- minimum number of auto-reclose cycles (AR-cycles)	-	3	
8.5.1.15	- fault locator and event (disturbance) recorder	-	Yes	
8.5.1.16	Remote communication			
8.5.1.17	- protocol	-	IEC 61850	
8.5.1.18	- transmission rate	Kbaud	2048	
8.5.1.19	Selectable trip direction	-	for each zone	
8.5.1.20	Trip mode	-	1/3- phase	
8.5.1.21	Directional sensitivity	-	unlimited	
8.5.1.22	Phase Current sensitivity	x In	0,05-0,3	
8.5.1.23	Earth Fault Current sensitivity	x In	0,05-0,3	
8.5.1.24	Separate adjustment of dead times for 1-ph and multi-phase cycles	yes/no	yes	
8.5.1.25	Setting range of zero sequence compensation factor :			
8.5.1.26	- amplitude	Ohm		
8.5.1.27	- angle	degree		
8.5.1.28	Typical tripping time	ms	25	
8.5.1.29	Reset time	ms	30	
8.5.1.30	Typical reset ratio	%	105	
8.5.1.31	Signaling modes	-	permissive, blocking, intertrip	
8.5.1.32	Load encroachment criteria	-	2	
8.5.1.33	Power swing blocking (for all zones)	yes/no	yes	
8.5.1.34	Switch-on to fault	yes/no	yes	
8.5.1.35	Fuse failure blocking	yes/no	yes	
8.5.1.36	Out of step tripping	yes/no	yes	
8.5.2	**Overcurrent Protection (50/51, 50N/51N)**			
8.5.2.1	Current setting range (from-to)	X I_N	0,10 – 35,00	
8.5.2.2	Measuring accuracy	%	1,5 % for <10In 5% for >10In	
8.5.2.3	Reset ratio	-	>0,95	
8.5.2.4	Trip characteristics	s	IEC, IEEE, user defined	
8.5.2.5	Start time	ms	30	
8.5.2.6	Minimum number of DMT stages for 50/51	-	2	
8.5.2.7	Minimum number of IDMT stages for 50/51	-	2	
8.5.2.8	Minimum number of DMT stages for 50N/51N	-	2	
8.5.2.9	Minimum number of IDMT stages for 50N/51N	-	2	
8.5.2.10	Measurement Mode	-	RMS, peak-to-peak, DFT	
8.5.2.11	Suppression of harmonics	-	RMS, Peak no suppression, DFT < -30dB	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
8.5.3	**Directional Earth Fault (67N)**			
8.5.3.1	Number of time-current stages	-	2	
8.5.3.2	Signaling to remote end	-	permissive, blocking for all stages	
8.5.3.3	Current setting range (earth fault)	x I_N	0,1…40	
8.5.3.4	Measuring accuracy	%		
8.5.3.5	Reset ratio	-		
8.5.3.6	Settings			
8.5.3.7	- ranges of times	sec	0,00 – 30,00	
8.5.3.8	- ranges of voltage values	V	0,10 – 120	
8.5.3.9	- minimum number of DTL stages for 67	-	2	
8.5.3.10	- minimum number of IDMT stages for 67	-	2	
8.5.3.11	- minimum number of DTL stages for 67N	-	2	
8.5.3.12	- minimum number of IDMT stages for 67N	-	2	
8.5.3.13	- teleprotection features	-	Yes	
8.5.3.14	- trip mode	-	1-/3 pole	
8.5.3.15	Remote communication protocol	-	IEC 61850	
8.5.3.16	Remote communication transmission rate	Kbaud	2048	
8.5.3.17	Directional element:			
8.5.3.18	- measuring angle	degrees	-179…+180	
8.5.3.19	- min operating current	x I_N	0.01	
8.5.3.20	- min operating voltage	x U_N	0.01	
8.5.3.21	- pick-up time	ms	<30	
8.5.4	**Directional Phase Overcurrent (67)**			
8.5.4.1	Number of time-current stages	-	2	
8.5.4.2	Signaling to remote end	-	permissive, blocking for all stages	
8.5.4.3	Current setting range	x I_N	0,1…40	
8.5.4.4	Measuring accuracy	%		
8.5.4.5	Reset ratio	-		
8.5.4.6	Directional element:			
8.5.4.7	- measuring angle	degrees	-179…+180	
8.5.4.8	- min operating current	x I_N	0.01	
8.5.4.9	- min operating voltage	x U_N	0.01	
8.5.4.10	- pick-up time	ms	30	
8.5.5	**Out of step Protection**	yes/no	yes	
8.5.6	**Load unbalance protection (46)**			
8.5.6.1	Settings			
8.5.6.2	- setting range current stage 1	A	0,10 – 35,00	
8.5.6.3	- setting range current stage 2	A	0,10 - 35,00	
8.5.6.4	- setting range time delay stage 1	sec	0,00 – 30,00	
8.5.6.5	- setting range time delay stage 2	sec	0,00 – 30,00	
8.5.7	**Auto-reclosing (79)**			
8.5.7.1	Number of shots	-	2	
8.5.7.2	Single -phase cycle	-	2	
8.5.7.3	Three-phase cycle	-	2	
8.5.7.4	Dead time for 3-phase cycle	s		
8.5.7.5	Reclaim time	s		
8.5.7.6	Type		1-pole, 3-pole or 1-/3-pole	
8.5.7.7	Settings			
8.5.7.8	- ranges of times	s	0,01 – 30,00	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
8.5.8	**Synchrocheck (25)**			
8.5.8.1	Operation modes	-	DLDB, DBDL, Synch, Override	
8.5.8.2	Voltage setting	V		
8.5.8.3	∆U measurement	V	1…60	
8.5.8.4	∆φ measurement	degree	2…80	
8.5.9	**Breaker failure protection (50BF)**			
8.5.9.1	Settings			
8.5.9.2	- ranges of current flow monitoring	A	0,05 – 20,00	
8.5.9.3	- ranges of times	s	0,00 – 30,00	
8.5.10	**Switch-on to fault**	yes/no	yes	
8.5.11	**Trip Circuit Supervision**			
8.5.11.1	- Continuous supervision of complete trip circuit independent of CB position		Yes for all trip circuits	
8.5.11.2	- Operation indication and output contacts for remote alarm		Yes	
8.5.12	**Fault Locator (FL)**			
8.5.12.1	Principle	-	impedance based or travelling wave	
8.5.12.2	Measurement in the AR cycle		required	
8.5.12.3	Accuracy of measurement for fault currents	(% of line length)	<2,5%	
8.5.13	**Measurement Functions**			
8.5.13.1	3-ph voltage		yes	
8.5.13.2	3-ph current		yes	
8.5.13.3	Residual current		yes	
8.5.13.4	Sequence current		yes	
8.5.13.5	Sequence voltage		yes	
8.5.13.6	3-ph power		yes	
8.5.13.7	Energy monitoring		yes	
8.6	**Bay Control Unit**			
8.6.1.1	Manufacturer	-	Bidder to declare	
8.6.1.2	Place of manufacture	-	Bidder to declare	
8.6.1.3	Type / complete designation/ software / firmware version	-	Bidder to declare	
8.6.1.4	a) Configurable man-machine interface.		Yes for all circuits and auxiliary functions	
8.6.1.5	b) Custom metering and status displays with direct access.		Yes	
8.6.1.6	c) Critical information alarms.		Yes	
8.6.1.7	d) High accuracy time stamped events recorder		Yes	
8.6.1.8	e) Digital fault recording		Yes	
8.6.1.9	f) Programmable for indication/control of substation auxiliary devices.		Yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
8.6.1.10	g) IEC 61850 Communication protocol		Yes	
8.7	**Synchrophasor Measurement Unit**			
8.7.1.1	Manufacturer	-	Bidder to declare	
8.7.1.2	Place of manufacture	-	Bidder to declare	
8.7.1.3	Type / complete designation/ software / firmware version	-	Bidder to declare	
8.7.1.4	Standard	-	IEEE C37.118	
8.7.1.5	Message rate	/s	50	
8.7.1.6	Multicast capability	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
9	**Digital Substation Control & Monitoring System (SCMS)**			
9.1	**General**			
9.1.1	Manufacturer	-		
9.1.2	Type / designation	-		
9.1.3	Availability class according to IEC 60870-4	-	A3	
9.1.4	System availability	%	>99,95	
9.1.5	MTBF	h	>8760	
9.1.6	Reliability class according to IEC 60870-4	-	R3	
9.1.7	MTTR	h	<12 h	
9.1.8	Data integrity class	-	I3	
9.1.9	Information error probability	-	IE < 10^{-14}	
9.1.10	Automatic time synchronization at all nodes of the network	yes/no	yes	
9.1.11	Time resolution events	ms	1	
9.1.12	Fault indication LEDs on modules	yes/no	yes	
9.1.13	Spare function capacity	%	50	
9.1.14	Spare parts	%	20	
9.2	**Station Bus**			
9.2.1	Number of station buses	-	at least two per voltage level	
9.2.2	Protocol	-	IEC 61850-8-1	
9.2.3	Transmission medium	-	fiber	
9.2.4	Transmission rate	MBit/s	min. 100	
9.3	**Ethernet Switches**			
9.3.1	Number of Ethernet switches	-		
9.3.2	Manufacturer	-		
9.3.3	Type	-		
9.3.4	Power supply:			
9.3.5	- on bay level from station battery	V DC	220	
9.3.6	- on station level from UPS	V AC	230	
9.4	**Clock System**			
9.4.1	Number of clock systems	-	1	
9.4.2	Manufacturer	-		
9.4.3	Type	-		
9.4.4	Synchronization source	-	GPS	
9.4.5	Synchronization interval	-		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
9.5	**Station Computer**			
9.5.1	Redundant set-up	yes/no	yes	
9.5.2	Manufacturer	-		
9.5.3	Type	-		
9.5.4	Power supply from UPS	V AC	230	
9.6	**Common Bay Unit**			
9.6.1	Number of common bay units	-	min. 1 per voltage level	
9.6.2	Manufacturer	-		
9.6.3	Type	-		
9.6.4	Power supply from station battery	V DC	220	
9.7	**Gateways**			
9.7.1	**Gateways to Remote Control Centers**			
9.7.1.1	Manufacturer	-	-	
9.7.1.2	Type/Model	-	-	
9.7.1.3	Number of remote control centers to be interfaced simultaneously	-	≥2	
9.7.1.4	Serial interface	-		
9.7.1.5	Transmission medium	-	fiber (for IEC 60870-5-104) copper (for IEC 60870-5-101)	
9.7.1.6	Data transmission rate for IEC 61870-5-101 channels	Bit/s	min. 9,6 kBit/s	
9.7.1.7	Data transmission rate for IEC 61870-5-104 channels	Bit/s	min. 64 kBit/s	
9.7.1.8	LAN Interface	-		
9.7.1.9	Transmission medium	-		
9.7.1.10	Minimum data transmission rate	MBit/s	≥100	
9.7.2	**Gateways to interfacing Substation (Existing Lekhnath, future New Damauli 400 kV)**			
9.7.2.1	Manufacturer	-	-	
9.7.2.2	Type/Model	-	-	
9.7.2.3	Number of Substations to be interfaced simultaneously	-	1	
9.7.2.4	Serial interface	-		
9.7.2.5	Transmission medium	-	fiber (for IEC 60870-5-104)	
9.7.2.6	Data transmission rate for IEC 61870-5-104 channels	Bit/s	min. 64 kBit/s	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
9.7.2.7	LAN Interface	-		
9.7.2.8	Transmission medium	-		
9.7.2.9	Minimum data transmission rate	MBit/s	≥100	
9.8	**Emergency HMI and maintenance service Computer (notebook/laptop)**			
9.8.1	Number	-	1	
9.8.2	Manufacturer	-		
9.8.3	Type	-		
9.8.4	Hard Disk	GB	>= 160 GB	
9.8.5	Operating System			
9.8.6	Monitor Size	inch		
9.9	**Operator Workstations (HMI)**			
9.9.1	Number of operator workstations	-	2	
9.9.2	Manufacturer	-		
9.9.3	Type	-		
9.9.4	Power supply from UPS	V AC	230	
9.9.5	CPU	-		
9.9.6	Working memory	-		
9.9.7	Hard disk	-		
9.9.8	RAID-System	-		
9.9.9	External memory	-		
9.9.10	Operating system	-		
9.9.11	Monitors per operator stations	-	2	
9.9.12	Monitor size	inch	32	
9.9.13	Pixels / Resolution	-	3840 × 2160 pixels (UHD 4K)	
9.9.14	Desks	-	2	
9.9.15	Chairs	-	4	
9.10	**MMI-Software**			
9.10.1	Manufacturer	-		
9.10.2	Type	-		
9.11	**System Performance**			
9.11.1	Exchange of display	s	< 1	
9.11.2	Presentation of a binary change in the process display	s	< 0,5	
9.11.3	Presentation of an analogue change in the process display	s	< 1	
9.11.4	From order to process output	s	< 0,5	
9.11.5	From order to updating the display	s	< 1,5	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
9.12	**Hardcopy Printer**			
9.12.1	Number of hardcopy printers	-	2	
9.12.2	Power supply from UPS	V AC		
9.12.3	Format	DIN	1 x A3 1 x A4	
9.12.4	Color	yes/no	yes	
9.12.5	Pages / min.	-	10	
9.13	**Service Analysis Software**			
9.13.1	Manufacturer	-		
9.13.2	Type	-		
9.14	**Control Cubicles**			
9.14.1	Pre-wired	yes/no	yes	
9.14.2	Floor-mounted	yes/no	yes	
9.14.3	Steel sheet thickness	mm		
9.14.4	Protection class	-	IP 54	
9.14.5	Maximum height	mm	2200	
9.14.6	Maximum width	mm	900	
9.14.7	Maximum depth	mm	900	
9.14.8	Front-door material	-	glass	
9.14.9	Color	light grey	RAL 7035	
9.15	**Weather Station** for monitoring main weather parameters: Temperature, Humidity, Lightness (Luminosity, Wind Speed, Wind direction, Rainfall)			
9.15.1	Manufacturer	-		
9.15.2	Type	-		
9.15.3	Standard	-	IEC 61724 for Class A Systems	
9.15.4	Sensors for:	-	-	
9.15.5	Wind direction	-	yes	
9.15.6	Wind speed	-	yes	
9.15.7	Temperature	-	yes	
9.15.8	Telative humidity	-	yes	
9.15.9	Barometric pressure	-	yes	
9.15.10	Solar radiation	-	yes	
9.15.11	Precipitation	-	yes	
9.15.12	communication interface for integration to the SCADA and for remote transmission to the LDC	-	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
9.14.4	Protection class outdoor enclosure	-	IP 55 W	
8.7.1.6	Multicast capability	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
10.	**Telecommunication System**			
10.1	**Fiber optic ducted cable**			
10.1.1	Manufacturer	-		
10.1.2	Place of manufacture	-		
10.1.3	Cable designation	-		
10.1.4	Type of cable	-	underground FOC	
10.1.5	Non-metallic cable design/construction	yes/no	yes	
10.1.6	Number of single mode optical fibers per cable	-	48	
10.1.7	Transmission characteristic as defined in ITU-T G.652D	yes/no	yes	
10.1.8	Loose tube configuration	yes/no	yes	
10.1.9	All dielectric	yes/no	yes	
10.1.10	Rodent protection	yes/no	yes	
10.1.11	Flame retardant	yes/no	yes	
10.1.12	Low smoke zero Halogen	yes/no	yes	
10.1.13	Tensile strength during pulling	N	3000	
10.1.14	Tensile strength during operation	N	1500	
10.1.15	Operation temperature range	°C	-20 to +70	
10.1.16	Peripheral strength members	-	glass yarns	
10.1.17	Fibers			
10.1.18	Type	-	single mode	
10.1.19	Fiber characteristics according to	-	ITU.T G.652D	
10.1.20	Main transmission wavelengths	nm	1310, 1550	
10.1.21	Cut-off wave length λ_{cc}	nm	≤ 1260	
10.1.22	Mode field diameter	µm	8,8 – 9,6 µm @ 1310 nm, 9,9 – 10,9 µm @ 1550 nm	
10.1.23	Optical cladding diameter	µm	125 ± 0,7	
10.1.24	Concentricity error	µm	≤ 0,5	
10.1.25	Cladding non-circularity	%	≤ 1	
10.1.26	Maximum attenuation @ 1550 nm	dB/km	≤ 0,21	
10.1.27	Maximum attenuation @ 1310 nm	dB/km	≤ 0,34	
10.1.28	Bending test, additional loss, 1 turn on 32 mm mandrel, @ 1550 n	dB	0.03	
10.1.29	Bending test, additional loss, 100 turns on 60mm mandrel, @ 1550 nm	dB	0.03	
10.1.30	Maximum chromatic dispersion @ 1550 nm	ps/(nm.km)	≤ 18	
10.1.31	Maximum chromatic dispersion @ 1310 nm	ps/(nm.km)	≤ 3,5	
10.1.32	Maximum Polarisation Mode Dispersion (PMD) per individual fiber	ps/√km	0.1	
10.2	**Pigtails**			
10.2.1	Manufacturer	-		
10.2.2	Designation	-		
10.2.3	Fiber type	-	Single mode ITU-T G.652D	
10.2.4	Connector type	-	FC/UPC	
10.2.5	Insertion loss	dB	≤ 0,2	
10.2.6	Return loss	dB	≥ 50	
10.2.7	Minimum length	m	1	
10.2.8	Diameter	mm		
10.2.9	Halogen free	yes/no	yes	
10.2.10	Mechanical and thermal certification in accordance with Telcordia GR-326-Core	yes/no	yes	
10.2.11	Maximum Polarisation Mode Dispersion (PMD) per individual fiber	ps/√km	0.1	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
10.2.12	Operation temperature range	°C	-20 to +70	
10.3	**Fiber optic patch-cords**			
10.3.1	Manufacturer	-		
10.3.2	Designation	-		
10.3.3	Applicable standards/recommendations	-	IEC 60189-1, IEC 60304, ITU-T G.652D	
10.3.4	Fiber type	-	Single mode ITU-T G.652D	
10.3.5	Connector / plug type	-	FC/UPC	
10.3.6	Insertion loss	dB	≤ 0,2	
10.3.7	Return loss	dB	≥ 50	
10.3.8	Minimum length	m	1	
10.3.9	Diameter	mm		
10.3.10	Minimum boot length (measured from ferrule's end)	mm	≥ 49	
10.3.11	Nominal thickness of the sheath	mm	≥ 1,4	
10.3.12	Tensile strength	N	≥ 100	
10.3.13	Minimum allowed bending radius	mm	≤ 30	
10.3.14	Halogen free	yes/no	yes	
10.3.15	Mechanical and thermal certification in accordance with Telcordia GR-326-Core	yes/no	yes	
10.3.16	Maximum Polarisation Mode Dispersion (PMD) per individual fiber	ps/√km	0.1	
10.3.17	Refractive index of the optical fibers @ λ = 1550 nm and @ λ = 1625 nm	-		
10.3.18	Operation temperature range	°C	-20 to +70	
10.4	**Patch Panels**			
10.4.1	Manufacturer	-		
10.4.2	Place of manufacture	-		
10.4.3	Designation	-		
10.4.4	Type	-	Sliding type	
10.4.5	Material	-	anodized aluminum	
10.4.6	Height	-	2U	
10.4.7	Minimum number of SC adapter per panel	-		
10.4.8	Connector / plug type (min. two (2) per panel)	-	FC/UPC	
10.5	**Hybrid technology SDH and MPLS - TP equipment**			
10.5.1	Multiplexer Manufacturer	-		
10.5.2	Multiplexer type	-		
10.5.3	Access Multiplexer Manufacturer	-		
10.5.4	Acess Multiplexer type	-		
10.5.5	Terminal equipment Manufacturer	-		
10.5.6	Teleprotection equipment manufacturer	-		
10.5.7	Teleprotection equipment type	-	TEBIT	
10.5.8	Maximum extension of transmission capacity of individual terminal by adding plug-in cards	-	60%	
10.5.9	Ditto for multiplexer based on 2 Mbit-hierarchy	-	60%	
10.5.10	Maximum extension for multiplexer and terminal equipment racks	-	60%	
10.5.11	Protection class(es) of terminal equipment racks	-	50%	
10.5.12	Operating range of fiber optic terminals, depending of the site	MBit/s	STM-4 and 10G for MPLS – TP	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
10.5.13	Operating principle of optical transmitter	-		
10.5.14	Nominal operating wavelength	nm	1550	
10.5.15	Remaining overall system margin at start of life/end of life	-		
10.5.16	Receiver sensitivity (@ BER of 10^{-10}) at start of life/end of life	BER		
10.5.17	Bit error rate (path including terminals) at:			
10.5.18	- n x 2 MBit/s	BER		
10.5.19	- Jitter performance	-	B1: ≤ 1,5 B2: ≤ 0,2	
10.5.20	- n x 2 MBit/s	-		
10.5.21	- Accuracy of internal clock	ppm	± 4,6	
10.5.22	- Line code (optical)	-	NRZ	
10.5.23	- Line code (electrical)	-	HDB2 or AMI	
10.6	**IP-PBX**			
10.6.1	Manufacturer	-		
10.6.2	Place of manufacture	-		
10.6.3	Designation	-		
10.6.4	Number of subscribers	-	≥ 300	
10.6.5	Integrated VoIP functionalities	yes/no	yes	
10.6.6	Integrable into Customer's existing telephony system as well as into the existing telecommunication system	yes/no	yes	
10.7	**Telecommunication Cubicles**			
10.7.1	Manufacturer	-		
10.7.2	Type	-	free standing, anchoring to floor	
10.7.3	Steel sheet thickness	mm		
10.7.4	Protection class	-	IP 54	
10.7.5	Maximum width	mm	800	
10.7.6	Maximum height	mm	2200	
10.7.7	Maximum depth	mm	800	
10.7.8	Color	light grey	RAL 000 70 00	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
11.	**Cable Systems**			
11.1	**132 kV Cable System**			
11.1.1	**General**			
11.1.1.1	Highest voltage for equipment	kV	145	
11.1.1.2	Rated frequency	Hz	50	
11.1.1.3	Nominal voltage	kV	132	
11.1.1.4	Rated lightning impulse withstand voltage	kV, peak	650	
11.1.1.5	Rated power frequency withstand voltage	kV, r.m.s.	190	
11.1.1.6	System neutral	-	Solidly earthed	
11.1.1.7	System highest 3-phase short-circuit current level (1 s)	kA	23	
11.1.1.8	System highest single-phase short-circuit current level (1 s)	kA	23	
11.1.2	**Main Design Parameters**			
11.1.2.1	Max. ambient temperature	°C	50	
11.1.2.2	Max. thermal resistivity of the pre-cast concrete	K.m/W	1	
11.1.3	**132 kV cables**			
11.1.3.1	**General**			
11.1.3.1.1	Voltage designation (U_o/U/Um)	kV	76/132/145	
11.1.3.1.2	Conductor details:			
11.1.3.1.3	Minimum cross section	mm^2	300	
11.1.3.1.4	Material	-	Copper	
11.1.3.1.5	Construction	-	Circular stranded Class 2-compacted (IEC 60228)	
11.1.3.1.6	Water blocking mechanism	-	swelling tapes and yarns	
11.1.3.2	**Conductor screen**			
11.1.3.2.1	Material	-	Extruded semi-conductive compound cross-linked (super smooth)	
11.1.3.2.2	Nominal thickness	mm	1,2	
11.1.3.2.3	Minimum thickness	mm	0.8	
11.1.3.2.4	Maximum allowed protrusion into insulation	mm	0.1	
11.1.3.2.5	Maximum electric stress over conductor screen (at U_o)	kV/mm	7,8	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
11.1.3.3	**Insulation**			
11.1.3.3.1	Material	-	Cross-Linked Polyethylene (XLPE)	
11.1.3.3.2	Nominal thickness	mm	17.0	
11.1.3.3.3	Minimum thickness	mm	15,3	
11.1.3.4	**Insulation screen**			
11.1.3.4.1	Material	-	Extruded semi-conductive compound cross-linked (super smooth)	
11.1.3.4.2	Nominal thickness	mm	1,2	
11.1.3.4.3	Minimum thickness	mm	0,8	
11.1.3.4.4	Maximum electric stress over insulation screen (at U_o)	kV/mm	3,4	
11.1.3.5	**Extrusion process**			
11.1.3.5.1	Type		Simultaneous triple extrusion	
11.1.3.5.2	Curing environment		Dry Nitrogen	
11.1.3.5.3	Curing temperature/pressure	°C/Bar	210-250/10	
11.1.3.5.4	Cooling environment	-	Dry Nitrogen	
11.1.3.5.5	Cooling pressure	Bar	10	
11.1.3.6	**Degassing**			
11.1.3.6.1	Temperature/duration	°C/days		
11.1.3.7	**Maximum tangent of dielectric loss angle**		0.0	
11.1.3.8	**Bedding/longitudinal water blocking mechanism**			
11.1.3.8.1	Material	-	semi-conductive water swelling tapes	
11.1.3.8.2	Number of tapes	#	2 (50% overlap)	
11.1.3.8.3	Approximate thickness of the tapes	mm	0.6	
11.1.3.9	**Metallic screen/sheath**			
11.1.3.9.1	Material	-	Copper wires	
11.1.3.9.2	Minimum copper wire screen cross-section	mm^2	85.0	
11.1.3.9.3	Indicative number of wires x wire diameter	# x mm	72 x 1,23	
11.1.3.9.4	Material of equalizing tapes	-	Copper	
11.1.3.9.5	Number and cross-section of equalizing tapes		1 x $1mm^2$	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
11.1.3.10	**Radial water blocking mechanism**			
11.1.3.10.1	Material		Aluminum tape with co-polymer	
11.1.3.10.2	Application method		welded or overlapped and glued	
11.1.3.10.3	Tape thickness: aluminum/PE	mm	0,2/0,06	
11.1.3.10.4	For overlapped tapes: overlap strength		> 0,5 N/mm	
11.1.3.11	**Outer sheath**			
11.1.3.11.1	Material		High Density Polyethylene (ST7)	
11.1.3.11.2	Nominal thickness	mm	4.0	
11.1.3.11.3	Thickness of the extruded outer semi-conductive layer	mm		
11.1.3.11.4	Outer diameter	mm		
11.1.3.12	**Other characteristics**			
11.1.3.12.1	Cable weight	kg/m		
11.1.3.12.2	Maximum DC resistance of conductor at 20°C	OHM/km	0.1	
11.1.3.12.3	Maximum AC resistance of conductor at 90°C	OHM/km		
11.1.3.12.4	Maximum DC resistance of metallic screen at 20°C	OHM/km	0.2	
11.1.3.12.5	Maximum capacitance	pF/m		
11.1.3.12.6	Minimum full load permanent (100%) operation electric current rating	A	331.0	
11.1.3.12.7	Minimum short-circuit current capacity for the copper wire screen assuming that the conductor start temperature is 90°C and a final temperature of 250°C (during 1 s)	kA	12.0	
11.1.4	**Cable trough**			
11.1.4.1	Material	-	Pre-Cast Concrete	
11.1.4.2	Minimum traffic load requirement (DIN 1072)	-	SLW 60	
11.1.4.3	Maximum length of the pre-cast elements	m	6.0	
11.1.4.4	Maximum width of the cover slab	m	1.0	
11.1.4.5	Provisions for lifting the cover slab	-	Yes	
11.1.4.6	Minimum thickness of the concrete	mm	150.0	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
11.1.5	**Outdoor Terminations**			
11.1.5.1	Type	-	Outdoor Prefabricated, insulating filling compound, composite insulator	
11.1.5.2	Voltage designation (U_o/U (Um)	-	76/132/145	
11.1.5.3	Pollution class	-	IEC 60815/IV (43 mm/kV)	
11.1.5.4	Conductor connection - minimum cross-section	mm^2	300.0	
11.1.5.5	Top bolt connection	-	shear bolt	
11.1.5.6	Base plate	-	Aluminum	
11.1.5.7	Number of post insulators	#	4	
11.1.5.8	Type of post insulators	-	epoxy resin	
11.1.5.9	Dielectric strength of the post insulators	kV/mm	20.0	
11.1.5.10	Lightning impulse voltage test	kV	650	
11.1.5.11	Power frequency AC voltage test (30 minutes)	kV	190	
11.1.5.12	Maximum partial discharge test at 1.5 x U_0	pC	5	
11.1.5.13	Minimum electric current rating	-	exceeding the minimum electric current rating of the 132 kV cable	
11.1.5.14	Minimum single phase Short-circuit current capacity for assuming that the conductor start temperature is 90°C and a final temperature of 250°C (during 1 s)	kA	12.0	
11.1.5.15	All stress control elements PD routine tested	yes/no	Yes	
11.1.6	**Clamps for connection to the outdoor terminations top-bolt**			
11.1.6.1	Voltage level	kV	132	
11.1.6.2	Type	-	Bolted straight or 90°	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
11.1.6.3	Cross-section	-	Suitable to withstand without any mechanical or electrical degradation the cable maximum electric current rating and 3-phase short-circuit current	
11.1.7	**GIS terminations**			
11.1.7.1	Maximum operating voltage (Um)	kV	145	
11.1.7.2	Conductor connection - minimum cross-section	mm^2	300	
11.1.7.3	Lightning impulse voltage	kV	650	
11.1.7.4	Power frequency AC voltage test (1 minute)	kV	275	
11.1.7.5	Maximum partial discharge level at 2 x U_0	pC	2	
11.1.7.6	Minimum electric current rating	-	exceeding the minimum electric current rating of the 132 kV cable	
11.1.7.7	Minimum single phase Short-circuit current capacity for assuming that the conductor start temperature is 90°C and a final temperature of 250°C (during 1 s)	kA	exceeding the minimum short-circuit rating of the 132 kV cable	
11.1.7.8	All stress control elements PD routine tested	yes/no	Yes	
11.1.8	**Link Boxes**			
11.1.8.1	Outer box	-	Stainless steel	
11.1.8.2	Earthing links	-	copper with suitable cross section for the foreseeable short-circuit currents	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
11.1.8.3	Minimum protection class for the buried boxes	-	IP 68	
11.1.8.4	Minimum protection class for the gantry mounted boxes	-	IP 66	
11.1.8.5	Short circuit typed test	yes/no	yes	
11.1.8.6	Water ingression typed test	yes/no	yes	
11.1.9	**Lead bond cables**			
11.1.9.1	Voltage level (U_0/U)	kV	0,6/1	
11.1.9.2	Single core minimum copper cross section	mm^2	95	
11.1.9.3	Coaxial minimum copper cross section	mm^2	2 x 95	
11.1.9.4	Insulation	-	XLPE	
11.1.9.5	Outer sheath	-	PVC (ST_2)	
11.1.10	**Parallel earth cables**			
11.1.10.1	Voltage level (U_0/U)	kV	0,6/1	
11.1.10.2	Minimum copper cross section	mm^2	95.0	
11.1.10.3	Insulation	-	XLPE	
11.1.10.4	Outer sheath	-	PVC (ST_2)	
11.1.11	**Cable cleats/clamps**			
11.1.11.1	Type	-	Single core	
11.1.11.2	Material	-	UV resistant Polymer liner with stainless steel cleat **or** UV resistant Polymer reinforced with glass fiber liner and stainless steel bolts and nuts stand **or** aluminum with adjustable rod	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
11.1.11.3	Stainless steel quality	-	316 L	
11.1.11.4	Mechanical strength - withstand a short circuit current of 23 kA without deformation and maintaining the cable firmly fixed to the attachment point	yes/no	Yes	
11.1.11.5	Fire resistance - compliant with VDE 0304 Part 3 Class IIA	yes/no	Yes	
11.1.11.6	Operation temperature	°C	From 0 to +120	
11.1.11.7	Cable diameter range	-	Suitable for the 132 kV cable outer diameter	
11.1.12	**Support structures for the outdoor terminations**			
11.1.12.1	Material	-	Hot-dip galvanized steel	
11.1.12.2	Minimum zinc thickness	μm	75.0	
11.1.12.3	Foundation - concrete class	-	C25/30 as per BS EN 206-1	
11.1.12.4	Foundation - Minimum quality standard for the steel reinforcement	-	B400SD EN 10080	
11.1.13	**132 kV cable pulling**			
11.1.13.1	Maximum permissible pulling force on conductors	N/mm^2	$50\ N/mm^2$ - Al conductors $60\ N/mm^2$ - Cu conductors	
11.1.13.2	Maximum side wall pressure - inside PVC or PE ducts (for road crossings - if any)	N/m	7000.0	
	Maximum side wall pressure - contact with rollers	N	700.0	
	Minimum bending radius of the PVC or PE ducts (for road crossings - if any)	m	4.0	
11.1.13.3	Minimum bending radius for the cables	-	20 x Cable outer diameter	
11.1.13.4	Lubricant to reduce friction during the cable pulling through the ducts	-	Chemically neutral, biodegradable and compatible with the cable outer sheath	
11.1.13.5	Cable installation temperature range	°C	+5°C to +35°C	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
11.1.14	**Post-installation tests**			
11.1.14.1	Sheath DC test for all cable single lengths immediately before the assembly of joints or sealing ends	-	10 kV during 1 minute	
11.1.14.2	Confirmation of the phase sequence	yes/no	Yes	
11.1.14.3	Measurement of the line impedance	yes/no	Yes	
11.1.14.4	Measurement of the capacitance	yes/no	Yes	
11.1.14.5	AC voltage test with resonant equipment	-	132 kV during 1 hour	
11.1.14.6	PD level for joints and sealing ends with resonant equipment	-	For 96 kV no PD over the background noise level	
11.2	**33 kV Cable Systems**			
11.2.1	**33 kV power cable (Main connections)**			
11.2.1.1	Manufacturer	-		
11.2.1.2	Place of manufacture	-		
11.2.1.3	Type	-	single-core	
11.2.1.4	Waterproof armor			
	• single core		AWA	
11.2.1.5	Insulation material	-	XLPE	
11.2.1.6	Conductor material	-	copper	
11.2.1.7	Applicable standard	-	IEC 60502-2	
11.2.1.8	Screen material	-	copper	
11.2.1.9	Minimum cable voltage rating $U_0/U(U_m)$	kV	18/30(36)	
11.2.1.10	Rated frequency	Hz	50	
11.2.1.11	Cross Section	mm^2	≥300	
11.2.1.12	Minimum bending radius (single core cables)	mm	15 x d	
11.2.1.13	Rated short circuit current (1 s):	kA		
	• conductor		10	
	• screen, min.		10	
11.2.1.14	Maximum conductor temperature normal operation	°C	90	
11.2.1.15	Maximum conductor temperature after short circuit	°C	250	
11.2.1.16	Rated current	A	630 A	
11.2.1.17	Nominal thickness of insulation at rated voltage	mm		
11.2.1.18	Weight	kg/m		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
11.2.1	**33 kV power cable (aux. Transformers 630 kVA)**			
11.2.1.1	Manufacturer	-		
11.2.1.2	Place of manufacture	-		
11.2.1.3	Type	-	single-core	
11.2.1.4	Waterproof armor			
	• single core		AWA	
11.2.1.5	Insulation material	-	XLPE	
11.2.1.6	Conductor material	-	copper	
11.2.1.7	Applicable standard	-	IEC 60502-2	
11.2.1.8	Screen material	-	copper	
11.2.1.9	Minimum cable voltage rating $U_0/U(U_m)$	kV	18/30(36)	
11.2.1.10	Rated frequency	Hz	50	
11.2.1.11	Cross Section	mm^2	≥120	
11.2.1.12	Minimum bending radius (single core cables)	mm	15 x d	
11.2.1.13	Rated short circuit current (1 s):	kA		
	• conductor		10	
	• screen, min.		10	
11.2.1.14	Maximum conductor temperature normal operation	°C	90	
11.2.1.15	Maximum conductor temperature after short circuit	°C	250	
11.2.1.16	Rated current	A		
11.2.1.17	Nominal thickness of insulation at rated voltage	mm		
11.2.1.18	Weight	kg/m		
11.2.2	**Accessories 33 kV cable**			
11.2.2.1	Cable termination	-		
11.2.2.2	Applicable standard	-	IEC 60502-2	
11.2.2.3	Type	-		
11.2.2.4	Insulation material	-		
11.2.2.5	Conductor connection	-		
11.2.3	Tests as per the relevant standards and *Employer's Requirements*	yes/no	yes	
11.3	**11 kV Cable Systems**			
11.3.1	**11 kV single core power cable (8 MVA Transformer - SWG)**			
11.3.1.1	Manufacturer	-		
11.3.1.2	Place of manufacture	-		
11.3.1.3	Type	-	single-core	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
11.3.1.4	Waterproof armor			
	• single core		AWA	
11.3.1.5	Insulation material	-	XLPE	
11.3.1.6	Conductor material	-	copper	
11.3.1.7	Applicable standard	-	IEC 60502-2	
11.3.1.8	Screen material	-	copper	
11.3.1.9	Minimum cable voltage rating $U_0/U(U_m)$	kV	6/10(12)	
11.3.1.10	Rated frequency	Hz	50	
11.3.1.11	Cross Section	mm^2	≥300	
11.3.1.12	Minimum bending radius (single core cables)	mm	15 x d	
11.3.1.13	Rated short circuit current (1 s):	kA		
	• conductor		10	
	• screen, min.		10	
11.3.1.14	Maximum conductor temperature normal operation	°C	90	
11.3.1.15	Maximum conductor temperature after short circuit	°C	250	
11.3.1.16	Rated current	A	505	
11.3.1.17	Nominal thickness of insulation at rated voltage	mm		
11.3.1.18	Weight	kg/m		
11.3	**11 kV Cable Systems**			
11.3.1	**11 kV single core power cable (outgoing feeders)**			
11.3.1.1	Manufacturer	-		
11.3.1.2	Place of manufacture	-		
11.3.1.3	Type	-	single-core	
11.3.1.4	Waterproof armor			
	• single core		AWA	
11.3.1.5	Insulation material	-	XLPE	
11.3.1.6	Conductor material	-	copper	
11.3.1.7	Applicable standard	-	IEC 60502-2	
11.3.1.8	Screen material	-	copper	
11.3.1.9	Minimum cable voltage rating $U_0/U(U_m)$	kV	6/10(12)	
11.3.1.10	Rated frequency	Hz	50	
11.3.1.11	Cross Section	mm^2	≥120	
11.3.1.12	Minimum bending radius (single core cables)	mm	15 x d	
11.3.1.13	Rated short circuit current (1 s):	kA		
	• conductor		10	
	• screen, min.		10	
11.3.1.14	Maximum conductor temperature normal operation	°C	90	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
11.3.1.15	Maximum conductor temperature after short circuit	°C	250	
11.3.1.16	Rated current	A		
11.3.1.17	Nominal thickness of insulation at rated voltage	mm		
11.3.1.18	Weight	kg/m		
11.3.3	**Accessories 11 kV cable**			
11.3.3.1	Cable termination	-		
11.3.3.2	Applicable standard	-	IEC 60502-2	
11.3.3.3	Type	-		
11.3.3.4	Insulation material	-		
11.3.3.5	Conductor connection	-		
11.3.4	Tests as per the relevant standards and *Employer's Requirements*	yes/no	yes	
11.4	**LV Power Cables**			
11.4.1	**LV Power cables single-core**			
11.4.1.1	Applied standard	-	IEC 60502-1	
11.4.1.2	Manufacturer	-		
11.4.1.3	Place of manufacture	-		
11.4.1.4	Fire performance	-	flame retardant LSZH	
11.4.1.5	Insulation material	-		
11.4.1.6	Rated voltage Uo/U	kV	0,6/1	
11.4.1.7	Highest voltage	kV	1.2	
11.4.1.8	Category of cable	-	A	
11.4.1.9	Maximum conductor temperature normal operation	°C		
11.4.1.10	Maximum conductor temperature after short circuit	°C		
11.4.1.11	Conductor material	-	copper	
11.4.1.12	Nominal thickness of insulation at rated voltage	mm		
11.4.1.13	Weight	kg/m		
11.4.1.14	Tests as per the relevant standards and Employer's Requirements	yes/no	yes	
11.4.2	**LV power cables three- & five-core**			
11.4.2.1	Applied standard	IEC	60502-1	
11.4.2.2	Manufacturer	-		
11.4.2.3	Place of manufacture	-		
11.4.2.4	Fire performance	-	flame retardant LSZH	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
11.4.2.5	Insulation material	-	PVC	
11.4.2.6	Rated voltage Uo/U	kV	0,6/1	
11.4.2.7	Highest voltage	kV	1.2	
11.4.2.8	Category of cable	-	A	
11.4.2.9	Maximum conductor temperature normal operation	°C		
11.4.2.10	Maximum conductor temperature after short circuit	°C		
11.4.2.11	Conductor material	-	copper	
11.4.2.12	Nominal thickness of insulation at rated voltage	mm		
11.4.2.13	Weight	kg/m		
11.4.2.14	Tests as per the relevant standards and *Employer's Requirements*	yes/no	yes	
11.4.3	**Control & DC Cables**			
11.4.3.1	Applied standard	IEC	60502-1	
11.4.3.2	Manufacturer	-		
11.4.3.3	Place of manufacture	-		
11.4.3.4	Fire performance	-	flame retardant LSZH	
11.4.3.5	Insulation material	-		
11.4.3.6	Rated voltage Uo/U	kV	0,6/1	
11.4.3.7	Highest voltage	kV	1.2	
11.4.3.8	Category of cable	-	B	
11.4.3.9	Maximum conductor temperature normal operation	°C		
11.4.3.10	Maximum conductor temperature after short circuit	°C		
11.4.3.11	Conductor material	-	copper	
11.4.3.12	Nominal thickness of insulation at rated voltage	mm		
11.4.3.13	Tests as per the relevant standards and *Employer's Requirements*	yes/no	yes	
11.4.4	**Cable Trays**			
11.4.4.1	Applicable standard	-	IEC 61537	
11.4.4.2	Manufacturer	-		
11.4.4.3	Place of manufacture	-		
11.4.4.4	Material	-	steel	
11.4.4.5	Corrosion protection	-	Hot dip galvanization	
11.4.4.6	Thickness of galvanization	µm	≥100	
11.4.4.7	Tests as per the relevant standards and *Employer's Requirements*	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
12.	**Earthing & Lightning Protection System**			
12.1	**Earthing System**			
12.1.1	Manufacturer	-		
12.1.2	Applicable standards	-	IEC 60364, IEC 60479, IEC 60621, IEC 61936-1, IEC 62305, IEEE 80	
12.1.3	Calculation of the length of the earthing mesh conductor according to	-	IEEE 80	
12.1.4	Calculation of step voltage according to	-	IEEE 80	
12.1.5	Calculation of touch voltages according to	-	IEEE 80	
12.1.6	Material for grid	-	stranded copper conductor	
12.1.7	Minimum cross section of the grid conductor	mm^2	≥150	
12.1.8	Material for rods	-	copper clad round steel	
12.1.9	Diameter of rods	mm	16	
8.1.10	Connection method of conductor in the ground	-	exothermic weld	
8.1.11	Material for fixing the earthing conductor clamps	-	by compression	
8.1.12	Clamp material for earthing conductor connections to rods	-	bronze	
8.1.13	Material for bolts and nuts	-	galvanized steel	
8.1.14	Method of connection, earthing conductor to steel structure	-	bolts, nut, washers and lock washers	
8.1.15	Minimum depth of burial	m	0.8	
8.1.16	Earthing resistance of the complete substation	Ω	≤0.5	
12.2	**Lightning Protection System**			
12.2.1	Applied standard	-	IEC 62305 NFPA 780	
12.2.2	Manufacturer	-		
12.2.3	Design	-	Rolling sphere principle	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
12.2.4	Material	-	Copper tape with finials on buildings and overhead conductor for switchyard	
12.2.5	Cross section	mm^2	≥120	
12.3	**Tests**			
12.3.1	Tests according to relevant standards and *Employer's Requirements*	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
13.	**Lighting & Small Power System**			
13.1	**Lighting Installation**			
13.1.1	**General**			
13.1.1.1	Applicable standards	-	IEC 62717 IEC 62722 IEC 60061 IEC 60364 IEC 60598 IEC 61347 IEC 62444 IEC 62560 IEC 63220 IEC 63221 ISO 30061 EN 50171	
13.1.1.2	Rated voltage	V AC	230/400	
13.1.1.3	Frequency	Hz	50	
13.1.1.4	Lighting Type	-	LED	
13.1.2	**Lighting Fixtures**			
13.1.2.1	Manufacturer	-	-	
13.1.2.2	Type:	-	-	
13.1.2.3	Indoor lighting technical rooms	-	-	
13.1.2.4	Indoor lighting high bay	-	-	
13.1.2.5	Indoor lighting offices	-	-	
13.1.2.6	Indoor lighting control room	-	-	
13.1.2.7	Indoor lighting technical rooms	-	-	
13.1.2.8	Escape lights	-	-	
13.1.2.9	Outdoor floodlights	-	-	
13.1.2.10	Outdoor street lights	-	-	
13.1.2.11	Outdoor fence lights	-	-	
13.1.3	**Emergency Lighting Central Unit**			
13.1.3.1	Manufacturer:	-	-	
13.1.3.2	Type:	-	-	
13.1.3.3	Central battery supply system	yes/no	yes	
13.1.3.4	Emergency Duration	h	3	
13.1.3.5	Battery capacity	Ah	-	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
13.1.4	**Distribution boards**			
13.1.4.1	Manufacturer	-		
13.1.4.2	Place of manufacture	-		
13.1.4.3	Model designation	-		
13.1.4.4	Applicable standard	-	IEC 61439, IEC 60947 etc. as per *Employer's Requirements*	
13.1.4.5	Internal separation	-	Form 2b	
13.1.4.6	Location of installation	-	indoor	
13.1.4.7	Number of phases	-	3+N+PE	
13.1.4.8	Number of busbars	-	1	
13.1.4.9	Nominal voltage	V AC	230/400	
13.1.4.10	Rated frequency	Hz	50	
13.1.4.11	Degree of Protection	-	IP54	
13.1.4.12	Instruments and accessories as per the Employer's Requirements	yes/no	yes	
13.2	**Socket outlets, power outlets and plugs**			
13.2.1	Manufacturer	-	-	
13.2.2	Type:	-	-	
13.2.3	15 A, 230 V AC single-phase	-	-	
13.2.4	32 A, 230/400 V AC three-phase	-	-	
13.2.5	Industrial type power outlet combination	-	-	
13.2.6	Power connection point	-	-	
13.3	**Tests**			
13.3.1	Tests according to relevant standards and *Employer's Requirements*	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
14.	**Fire Protection System**			
14.1	**Fire Detection and Alarm System**			
14.1.1	**Fire Detection and Alarm System**			
14.1.1.1	Applicable standard		EN 54 ISO 7240	
14.1.1.2	Manufacturer	-		
14.1.1.3	Origin of manufacture	-		
14.1.1.4	Type	-		
14.1.2	**Fire Alarm and Control Panel**			
14.1.2.1	Dimensions per cubicle L x W x H	mm		
14.1.2.2	Power requirements	VA		
14.1.2.3	Main supply voltage	V	230	
	Battery standby time	h	72	
14.1.2.4	Operating voltage of fire alarm lines	V		
14.1.2.5	Maximum number of alarm lines possible	-		
14.1.2.6	Fault detection system for wire breakage	yes/no	yes	
14.1.2.7	Earth fault, short circuit detection	yes/no	yes	
14.1.2.8	Connection to SCADA	yes/no	yes	
14.1.3	**Detectors**			
14.1.3.1	Manufacturer	-		
14.1.3.2	Type	-		
14.1.3.3	Smoke Detetctor			
14.1.3.4	Heat Detector			
14.1.3.5	Flame Detector			
14.1.3.6	Manual Break Glass Unit			
14.1.3	**Alarm Bells and Sounders**			
14.1.3.1	Manufacturer	-		
14.1.3.2	Type			
14.1.2.3	Supply voltage	V (DC)	-	
14.1.3.3	Sound output at 3 m	dB(A)	85	
14.1.4	**Tests**			
14.1.4.1	Tests according to relevant standards and Employer's Requirements	yes/no	yes	
14.2	**Portable Fire Extinguishers**			
14.2.1	**Type: CO2**	-		
14.2.1.1	Number(s)	-		
14.2.1.2	Capacity of each	liters		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
14.2.2	**Type: dry chemical**			
14.2.2.1	Number(s)	-		
14.2.2.2	Capacity of each	liters		
14.3	**Wet Fire Fightung System**			
14.3.1	**Fire fighting water storage tank**			
14.3.1.1	Applicable standard		BS EN 13280 BS EN 12845	
14.3.1.2	Manufacturer	-		
14.3.1.3	Type	-		
14.3.1.4	Material	-	GRP	
14.3.1.5	Storage Volume	m^3	>300	
14.3.1.6	Size (h x w x d)	mm		
14.3.2	**Fire fighting pump system container**			
14.3.2.1	Manufacturer	-		
14.3.2.2	Type	-		
14.3.2.3	Total weight	kg		
14.3.2.4	Size (h x w x d)	mm		
14.3.3	**Fire pump electrical driven (100%)**			
14.3.3.1	Manufacturer	-		
14.3.3.2	Type	-		
14.3.3.3	Rated capacity	m^3/h	>280	
14.3.3.4	Rated discharge head	bar		
14.3.3.5	Motor voltage	V		
14.3.3.6	Motor rating	kW		
14.3.4	**Fire pump diesel driven (100%)**			
14.3.4.1	Manufacturer (pump)	-		
14.3.4.2	Type (pump)	-		
14.3.4.3	Rated capacity	m^3/h	>280	
14.3.4.4	Rated discharge head	bar		
14.3.4.5	Manufacturer (diesel engine)	-		
14.3.4.6	Type (diesel engine)	-		
14.3.4.7	MCR of diesel engine	kW		
14.3.4.8	Fuel consumption	l/h		
14.3.5	**Jockey pump**			
14.3.5.1	Manufacturer	-		
14.3.5.2	Type	-		
14.3.5.3	Rated capacity	m^3/h		
14.3.5.4	Rated discharge head	bar		
14.3.5.5	Motor voltage	V		
14.3.5.6	Motor rating	kW		

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
14.3.6	**Transformer Spray Water System**			
14.3.6.1	Manufacturer	-		
14.3.6.2	Type	-		
14.3.6.3	Application rate	l/min/m^2	10.2	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
15	**Metering Equipment**			
15.1	**Electricity Meter**			
15.1.1	Compliant to MID	yes/no	yes	
15.1.2	Compliant to IEC 62052-11	yes/no	yes	
15.1.3	Compliant to IEC 62053-22	yes/no	yes	
15.1.4	Compliant to IEC 62053-23	yes/no	yes	
15.1.5	Manufacturer	-		
15.1.6	Origin of manufacture	-		
15.1.7	Type	-		
15.1.8	Specified operating range	°C	-20 to +55	
15.1.9	Limit range of operation	°C	-25 to +60	
15.1.10	Limit range for storage and transport	°C	- 25 to +70	
15.1.11	Protection Class according to IEC 60529	IP	IP54	
15.1.12	Electrostatic discharges acc. to IEC 6100-4-2			
15.1.12.1	· Contact discharge	kV	8	
15.1.12.2	· air discharge	kV	15	
15.1.13	Electromagnetic RF Fields acc. IEC61000-4-3 80 MHz -2 GHz (with current / without any current)	V/m	10/30	
15.1.14	Radio interferences suppression according to IEC/CISPR22 Class B	yes/no	yes	
15.1.15	Fast transient burst acc. to IEC61000-4-4			
15.1.15.1	· Current and voltage circuits	kV	4	
15.1.15.2	· Auxiliary circuits >40V	kV	2	
15.1.16	Standard Reference Voltage Un	V	3x63,5/110	
15.1.17	Extended operating voltage range	V	3x58/100 to 240/415 V	
15.1.18	Nominal frequency fn	Hz	50	
15.1.19	Extended operating frequency range	%	± 2	
15.1.20	Nominal current	A	1	
15.1.21	Maximum current Imax	A	from 6 to 10	
15.1.22	Active energy measurement (according to MID)	-	class C	
15.1.23	Active energy measurement (according to IEC)	-	0,2s	
15.1.24	Re-Active energy measurement (according to IEC)	-	0.5	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
15.1.25	Real-time clock according to IEC 62054-21	yes/no	yes	
15.1.26	Measuring quadrants	-	4	
15.1.27	Number of measuring elements	-	3	
15.1.28	Meter lifecycle	years	≥ 15	
15.1.29	Voltage failure bridging time	s	0.5	
15.1.30	Voltage restoration function standby after	s	< 5	
15.1.31	Power consumption without communication			
15.1.31.1	· in the voltage circuit with power supply connected	W	≤ 2	
		VA	≤ 5	
15.1.31.2	· in the current circuit at basic current Ib	VA	≤ 4	
15.1.32	Insulation strength at 50Hz for 1 min	kV	4	
15.1.33	Pulse voltage 1.2/50µs acc. to IEC62052-11 Current and voltage circuits	kV	≥ 6	
15.1.34	Protection class acc. to IEC62052-11	-	Class II	
15.1.35	Dimensions: Digitize in value field	mm	≥ 8 mm	
15.1.36	Display of values: Programmable display sequence	yes/no	required	
15.1.37	LED test output for active and reactive energy	yes/no	required	
15.1.38	Optical interface acc. to IEC62056-21	yes/no	required	
15.1.39	Optical interface communication ability	Baud	9600	
15.1.40	RS 485 interface	Number	≥ 1	
15.1.41	Communication protocols compliance with IEC 62056-21 and DIN EN 61107 requirements.	yes/no	yes	
15.1.42	DLMSCOSEM protocol (IEC 62056)	yes/no	yes	
15.1.43	Dimensions:	mm		
15.1.43.1	· height	mm		
15.1.43.2	· width	mm		
15.1.43.3	· depth	mm		
15.1.43.4	· Net weight	kg		
15.1.44	Heat resistance			

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
15.1.44.1	The terminal cover and the meter housing has to fulfill the heat resistance with tungsten filament test acc. IEC 60695 (temperature of 960°C)	yes/no	yes	
15.1.45	Meter cover seals			
15.1.45.1	At least one visible seal has to be provided in such a way that the internal parts of the meter are accessible only after breaking the seal(s).	yes/no	yes	
15.1.46	Meter Terminal seals			
15.1.46.1	At least one visible seal has to be provided and no access to the terminals shall be possible without breaking the seal(s) of the terminal cover(s).	yes/no	yes	
15.1.47	Units measured:			
15.1.47.1	kW forward, reverse	yes/no	yes	
15.1.47.2	kWh forward, reverse	yes/no	yes	
15.1.47.3	kWh forward + reverse	yes/no	yes	
15.1.47.4	kWh forward - reverse	yes/no	yes	
15.1.47.5	kVAr import, export	yes/no	yes	
15.1.47.6	kVArh import, export	yes/no	yes	
15.1.47.7	kVA forward, reverse	yes/no	yes	
15.1.47.8	kVAh forward, reverse	yes/no	yes	
15.1.47.9	RMS voltage per phase	yes/no	yes	
15.1.47.10	RMS current per phase	yes/no	yes	
15.1.47.11	Power factor per phase	yes/no	yes	
15.1.47.12	Phase angle for each phase	yes/no	yes	
15.1.47.13	Frequency	yes/no	yes	
15.1.48	Number of channels of remotely configurable load profile data that can be captured at programmable intervals.	-	≥8	
15.1.49	Programmable intervals	yes/no	5 to 60 min. / day	
15.1.50	Load profile storage capacity per channel	values	> 4000	
15.1.51	Long and short outage detection with date/time	yes/no	yes	
15.1.52	Min. voltage level register	yes/no	yes	
15.1.53	Over voltage register	yes/no	yes	
15.1.54	Under voltage register	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
15.1.55	Harmonic analysis up to 30 harmonic	yes/no	yes	
15.1.56	Internal errors	yes/no	yes	
15.1.57	Communication problems	yes/no	yes	
15.1.58	Configuration problems	yes/no	yes	
15.1.59	Clock shift	yes/no	yes	
15.1.60	Power breaks	yes/no	yes	
15.1.61	Phase errors	yes/no	yes	
15.1.62	Overvoltage	yes/no	yes	
15.1.63	Undervoltage	yes/no	yes	
15.1.64	Meter tamper events	yes/no	yes	
15.2	**Communication Equipment**			
15.2.1	Manufacturer	-		
15.2.2	Origin of manufacture	-		
15.2.3	Type	-		
15.2.4	Compliant to IEC 60950	yes/no	yes	
15.2.5	Compliant to IEC 62056-21	yes/no	yes	
15.2.6	Compliant to IEC 61000-4-2	yes/no	yes	
15.2.7	Compliant to IEC 61000-4-3	yes/no	yes	
15.2.8	Compliant to IEC 61000-4-4	yes/no	yes	
15.2.9	Compliant to IEC 61000-4-5	yes/no	yes	
15.2.10	Compliant to IEC 61000-4-6	yes/no	yes	
15.2.11	Compliant to IEC 61000-6-2	yes/no	yes	
15.2.12	Compliant to IEC 61000-6-3	yes/no	yes	
15.2.13	Meter built-in	yes/no	yes	
15.2.14	Antenna	yes/no	yes	
15.2.15	DLMS-COSEM protocol (IEC 62056)	yes/no	yes	
15.3	**Metering panel**			
15.3.1	Manufacturer	-		
15.3.2	Origin of manufacture			
15.3.3	Material	-	Galvanized steel	
15.3.4	Meter reading window material	-	Transparent Polycarbonate	
15.3.5	Overall dimensions			
15.3.5.1	· Height (from floor)	mm	≤ 2000	
15.3.5.2	· Width	mm	≤ 800	
15.3.5.3	· Depth	mm	≥ 600 ≤ 300	
15.3.5.4	· Thickness (box)	mm	2	
15.3.5.5	· Thickness (door)	mm	≥ 1.5	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
15.3.6	Protection degree (according to IEC 60529)	IP	≥ IP 54	
15.3.7	Lockable	yes/no	yes	
15.3.8	Color	-	Light Grey (RAL-7035)	
15.3.9	Terminal blocks according to IEC 60947-7	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
16.	**CCTV System**			
16.1	**Fixed Perimeter Cameras**			
16.1.1	Manufacturer			
16.1.2	Model designation			
16.1.3	Type	-	color	
16.1.4	Image format	-		
16.1.5	Focal length of lens	mm-mm		
16.1.6	Auto-focus lens	yes/no	yes	
16.1.7	Infrared Illumination	yes/no	yes	
16.1.8	Wide dynamic range	yes/no	yes	
16.1.9	Resolution	-		
16.1.10	Minimum sensitivity	lux	0.02	
16.1.11	White balance control	yes/no	yes	
16.1.12	Automatic light control	yes/no	yes	
16.1.13	Back light compensation	yes/no	yes	
16.1.14	Coverage distance	m		
16.1.15	Minimum signal to noise ratio	dB	50	
16.1.16	Exterior housing degree of protection	-	IP 66	
16.1.17	Junction box degree of protection	-	IP 65	
16.2	**PTZ Cameras**			
16.2.1	Manufacturer			
16.2.2	Model designation			
16.2.3	Type	-	color	
16.2.4	Image format	-		
16.2.5	Panning capability	degrees	360º	
16.2.6	Panning speed	degrees/s	6º	
16.2.7	Tilting capability	degrees	180º	
16.2.8	Optical zoom	-	20x	
16.2.9	Digital zoom	-	10x	
16.2.10	Zoom speed	s		
16.2.11	Infrared Illumination	yes/no	yes	
16.2.12	Wide dynamic range	yes/no	yes	
16.2.13	Resolution	-		
16.2.14	Minimum sensitivity	lux	0.02	
16.2.15	White balance control	yes/no	yes	
16.2.16	Automatic light control	yes/no	yes	
16.2.17	Back light compensation	yes/no	yes	
16.2.18	Minimum signal to noise ratio	dB	50	
16.2.19	Exterior housing degree of protection	-	IP 66	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		**Unit**	**Data required**	**Data offered**
No.	**Description**			
16.2.20	Junction box degree of protection	-	IP 65	
16.3	**Ceiling Mounted Dome Cameras**			
16.3.1	Manufacturer	-		
16.3.2	Model designation	-		
16.3.3	Type	-	color	
16.3.4	Focal length of lens	mm-mm		
16.3.5	Auto-focus lens	yes/no	yes	
16.3.6	Image format	-		
16.3.7	Infrared Illumination	yes/no	yes	
16.3.8	Wide dynamic range	yes/no	yes	
16.3.9	Back light compensation	yes/no	yes	
16.3.10	White balance control	yes/no	yes	
16.3.11	Automatic light control	yes/no	yes	
16.3.12	Minimum sensitivity	lux	0.02	
16.3.13	Housing degree of protection	-	IP 42	
16.4	**CCTV LAN**			
16.4.1	LAN speed	Mbit/s	1000	
16.4.2	Substation-hardened switches	yes/no	yes	
16.4.3	Manufacturer of central switch	-		
16.4.4	Model designation	-		
16.4.5	Manufacturer of disbursed switches	-		
16.4.6	Model designation	-		
16.5	**CCTV Server**			
16.5.1	Maximum number of controllable cameras	-		
16.5.2	Video and audio recording protocol	-		
16.5.3	Audio input and output	yes/no	yes	
16.5.4	Password protection	yes/no	yes	
16.5.5	Provision for communication with remote control center	yes/no	yes	
16.5.6	Equipped with all peripherals incl. monitor, keyboards, mouse etc.	yes/no	yes	
16.5.7	Interface for future connection allowing remote control from OST-NDC	yes/no	yes	

Technical Data Sheets				
BIDDER'S / CONTRACTOR'S GUARANTEED DATA		Unit	Data required	Data offered
No.	Description			
16.6	**Digital Network Video Recorder System**			
16.6.1	Video stream and storage management	yes/no	yes	
16.6.2	Period of recordings storage	days	90	
16.6.3	Storage capacity	TB	8	
16.6.4	RAID Configuration	-	RAID 1	
16.7	**CCTV Workstations**			
16.7.1	Number of monitors per workstation	-	2	
16.7.2	Monitor type	-	LED	
16.7.3	Minimum monitor size	inches	32	
16.7.4	Monitor manufacturer	-		
16.7.5	Model designation	-		
16.7.6	Equipped with all peripherals incl. monitor, keyboards, mouse etc.	yes/no	yes	
16.7.7	Color laser printer for video images, logs etc.	yes/no	yes	
16.7.8	Surveillance software:			
16.7.9	• number of displays on one screen	-	16	
16.7.10	• sequential mode and multi-display mode	yes/no	yes	
16.7.11	• picture-in-picture analysis	yes/no	yes	

VII-9

Annexes

List of Annexes